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Adapting Socio-Ecological Systems to Increased Climate Variability

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CLIMATE RESEARCH

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POSTER #1

TRANSCRIPTOMIC SIGNATURES REVEAL BIOMARKERS FOR UNDERSTANDING AMPHIBIAN STRESS

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Global biodiversity is decreasing at an alarming rate and understanding the factors that negatively impact populations is fundamental to addressing this epidemic. Diverse biomarkers have been developed to monitor human physiology and health, yet relatively few of these methods have been applied to wildlife. Plasma glucocorticoids are often used to assess stress in vertebrates, but these hormones can be extremely dynamic and impractical to quantify in small organisms. However, many genes are differentially expressed in response to physiological stressors, offering a potentially rich source of informative biomarkers for stress. We tested for transcriptomic differences in tail tissues of stream-dwelling salamanders chronically exposed to the stress hormone corticosterone at different temperature regimes. We found significant transcriptional differences that were unique in response to temperature or corticosterone. Several of the differentially expressed genes are known to be involved in immune and stress responses in model systems. Furthermore, additional experiments show that their expression patterns were robust to differences in age, life history, and tissue regeneration. Our study suggests that transcriptomic patterns harbor stressor specific signatures that can be highly informative for monitoring the health of wild populations.

POSTER #2

RESISTANCE, RESILIENCE AND SENSITIVITY OF GROSS PRIMARY PRODUCTION OF FORESTS AND GRASSLANDS TO DROUGHT IN THE OUACHITA HIGHLANDS OF OKLAHOMA, USA

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The land cover of the Ouachita Highlands of Oklahoma was once ~99% shortleaf pine forest (*Pinus echinata*). Today, the region is ~70% forest, of which ~42% is evergreen, ~54% is deciduous, and ~4% is mixed forest. The non-forest cover (~30%) is predominately grassland (~60%). The remaining evergreen forest is now composed of loblolly pine plantations (*Pinus taeda*) and shortleaf pine. Currently, it is unknown how the dramatic reduction in forest cover and change in forest species composition has affected the region's resistance, resilience, and sensitivity to drought. Using remote sensing satellite data, this study analyzes the resistance, resilience, and sensitivity of gross primary production (GPP) of commercial pine plantation, evergreen Ouachita National Forest, deciduous forest, and grasslands to drought from 2010-2016. Sensitivity to drought was assessed during the summer (May-August), the growing season (March-November), and annually. The results of the analysis indicated that, regardless of the temporal window used for sensitivity analysis: 1) deciduous forest and grasslands were less resistant but more resilient and sensitive to drought than evergreen forest; and 2) the evergreen Ouachita National Forest was more resistant, resilient, and sensitive to drought than commercial pine plantation. Further research is needed to better understand why drought impacts evergreen Ouachita National Forest and commercial pine plantation differently. The differences may be attributed to genotype, stand age, stand density, species diversity, management practices, fire regime, or any combination thereof. Nevertheless, the results of our study provided insight into how land use and land cover change have affected the resistance, resilience, and sensitivity of the Ouachita Highlands to drought and how vegetation may respond to drought in the future. Such information is vital to the successful development and implementation of sustainable natural resource management practices, especially given that this region is undergoing enhanced climate variability.

POSTER #3

UNMANNED AIRCRAFT SYSTEMS FOR SEVERE WEATHER: DETERMINING SAMPLING SCALES

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The lowest portion of the Earth's atmosphere, known as the atmospheric boundary layer (ABL), plays an important role in the formation of weather events. Meteorological measurements, such as temperature and relative humidity, are key to understanding the exchange of energy in the ABL and its role in the formation of severe local storms. Small unmanned aircraft systems (sUAS) provide a versatile, dynamic platform that can fill the spatio-temporal gaps left by other weather surveillance techniques, but little research has been conducted on the optimal vertical sampling scales to capture these data. While forces influencing the spatial variation of thermodynamic variables in the ABL obey deterministic governing equations, their signals are not repeatable, which necessitates the use of statistics for comparison. Autocorrelations provide fundamental insights about the size and distribution of coherent structures within a turbulent flow and are thus appropriate for determining sampling scales using sUAS. A measure of autocorrelation frequently used in the geographic sciences is the variogram. Variogram analysis provides insight into the distance over which spatial autocorrelation dissipates (i.e., the data become incoherent), providing a measure of the optimal spatial separation between measurements. We found that optimal sampling scales for vertical measurements of temperature taken from sUAS were about 5 m for early morning flights prior to atmospheric mixing. Once mixing had occurred, more frequent sampling was needed (~3 m) to capture the structure. The optimal sampling scales for RH were slightly smaller, with range values of approximately 1.5–2 m after mixing had occurred.

POSTER #4

LIFE HISTORY SHIFTS AND DISTRIBUTIONAL PATTERNS OF AQUATIC ISOPODS

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Understanding the distribution and connectivity of groundwater and its relationship to surface flow is critical for resource management and conservation. As dispersal of freshwater organisms are limited by hydrological networks, the geographic and evolutionary history of aquatic organisms can provide new insights into the associated hydrological systems. This is particularly useful in the study of groundwater, where connectivity is not necessarily correlated with surface relief and can change with fluctuating water tables. Due to their abundance, aquatic life history, and the ease of distinction between surface and subterranean species, isopods present a potentially powerful tool for assessing hydrological hypotheses. The geographic genetic distribution of isopod diversity will likely mirror connectivity and discontinuity within the region under study. This study uses genomic data to reconstruct an evolutionary history of native isopods and examine patterns of dispersal across physiogeographic regions and between surface and subterranean habitats. Our analyses have supported repeated colonization events from the Ouachita Mountains to the Ozark Plateau. The evolutionary history of the group suggests multiple transitions to the surface from groundwater habitats, a rarely observed phenomena in subterranean organisms.

POSTER #5

CLOUD-MAP:
COLLABORATION LEADING OPERATIONAL UAS DEVELOPMENT FOR METEOROLOGY AND ATMOSPHERIC PHYSICS

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CLOUD-MAP is a 4 year, 4 university partnership funded by the National Science Foundation RII EPSCoR grant to develop capabilities that will allow meteorologists and atmospheric scientists to use unmanned aircraft as a common, useful everyday tool following recognized needs as outlined in a 2009 NRC Report:

> *The vertical component of...mesoscale observations is inadequate. Assets required to profile the lower troposphere above the near-surface layer... are too limited in what they measure, too sparsely or unevenly distributed, sometimes too coarse in vertical resolution, sometimes limited to regional areal coverage, and clearly do not qualify as a mesoscale network of national dimensions. Likewise, vertical profiles above the Earth's surface are inadequately measured in both space and time...*

Unmanned Aircraft Systems (UAS) are a potential solution to this problem as they are well suited for the lower atmosphere, namely the lower boundary layer that has a large impact on the atmosphere and where much of the weather phenomena begin.

The CLOUD-MAP team is examining numerous systems including both fixed wing and rotary wing solutions predominantly focused on atmospheric boundary layer measurements. Multiple field campaigns have been conducted over the 3 years the project has been underway with . In June 2016 over 100 paricipating team members from the 4 partner institutions and other collaborating agencies. Selected sites included the Oklahoma State University Unmanned Aircraft Flight Station, the Marena Mesonet, the Kessler Ecological Field Station, and the US Department of Energy Atmospheric Radiation Monitoring Climate Research Facility Southern Great Plains site. Over multiple periods, the team has conducted thousands of individual flights and logged hundreds of total flight hours focused on gathering comprehensive, accurate, and relevant atmospheric data. The exercises are also designed to evaluate operational considerations of a large, multi-institutional teams and effectiveness of various technological systems.

This work is supported by the National Science Foundation under Grant No. 1539070.

POSTER #6

EXAMINING HAZARD VULNERABILITY IN OKLAHOMA USING COMPONENTS OF THE SOCIAL VULNERABILITY INDEX

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A population's vulnerability to a hazard is not fixed solely based on their proximity to a dangerous event. Instead vulnerability to a hazard is the product of the complex combination of the socio-economic, institutional, and environmental systems that affect a group of people and the disruption of those systems by a hazardous event. Traditionally, socially-focused place-based assessments of vulnerability have facilitated risk management and mitigation practices through the weighted aggregation of localized indicators of social system function. Despite the complexity of system interactions and variation in hazard types, resulting social vulnerability indices commonly abstract from specific hazard and environmental conditions. However, different hazards are likely to place different pressures on different socio-economic and institutional systems in different environments. Using the well-established Social Vulnerability Index (SoVI) as a starting point, this work examines hazard vulnerability in 77 Oklahoma counties. We estimate and decompose county-level SoVI in an attempt to identify population- and system-specific susceptible to hazards. Surveys of individuals throughout the counties in Oklahoma reveal self-reported levels of preparedness for hazards, their thoughts on climate change, and overall self-awareness of the factors that leave them vulnerable to hazards. Our assessment has implications for the allocation of government resources and residential preparation measures.

POSTER #7

ANALYZING THE EVOLUTION OF WINTER STORM ENVIRONMENTS

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When it comes to weather induced destruction and devastation, many in the South Central U.S. first think of tornadoes and thunderstorms. However, impacts due to winter precipitation can be equally as damaging, especially in terms of transportation and power outages. Research has been done to categorize types of winter precipitation and better understand typical lower atmosphere profiles associated with each type. However, it is still not clear as to how the spatial and temporal variability of these different profiles can be forecasted ahead of a system moving in and bringing precipitation. When people do not know if precipitation will come down as rain, ice pellets, snow, or freezing rain, they are not able to adequately prepare for safe travel and operations during the event.

This project addresses the formation and development of winter precipitation, specifically in regards to the evolution of vertical profiles of the atmosphere ahead of a precipitation event. Five case studies of winter weather events were chosen from the state of Oklahoma. Data including surface temperature, pressure, total precipitation, and geopotential height will be analyzed from the North American Regional Reanalysis (NARR), Oklahoma Mesonet, and University of Wyoming sounding data for each event. These events will be compared and analyzed in order to better understand the development of winter precipitation events over Oklahoma and which patterns and trends lead to specific outcomes at the surface. Identifying important trends and variables will provide a better basis from which to sample pre-storm environments using unmanned aircraft systems (UAS) capabilities in the future.

POSTER #8

MAKING HARD-TO-ACCESS WATER DATA IN OKLAHOMA READILY AVAILABLE TO THE PUBLIC

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As a researcher, do you find yourself looking for water data and end up going to three different websites to get the data you need? There is currently an abundance of water data in Oklahoma that is collected for a single purpose/agency, but not easily accessible for others. The Oklahoma Water Survey is developing a procedure to receive/harvest, evaluate and synthesize publicly available water data that are not easily accessible, and provide those datasets via the Oklahoma Water Survey website (OKH2O.org). These data could include water-use data, municipal wastewater discharge data, municipal drinking water-quality data, municipal dry-weather flow data, produced water spills, aquifer water levels, aquifer water-quality data, and other water data. A quality assurance/quality control methodology has also been developed for evaluating these data.

The basic methodology has been developed to test our technique for retrieving and distributing annual municipal wastewater discharge data in Oklahoma from the EPA's Integrated Compliance Information System website. While National Pollution Discharge Elimination System's (NPDES) facility sites names and permitted discharge amounts are easily available from the Oklahoma Department of Environmental Quality's website, the discharge data associated with meeting regulatory requirements are currently not available. Python scripts are currently in development to download this data automatically on an annual basis to share with the public in a more usable format through the OWS website data page. A further proof-of-concept example will also be presented on this poster for data from submitted an outside source (yet to be determined), such as dry-weather stormwater sampling data, managed reservoir data, or academic researcher data.

The Oklahoma Water Survey requests your feedback on types of data that you would like to see more accessible, or if you have a dataset that you would like to be made available through our system.

POSTER #9

BACK TO THE FUTURE: USING TREE-RINGS FROM THE 1950s TO PREDICT PRESENT-DAY TREE MORTALITY IN THE CROSS TIMBERS OF OKLAHOMA

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Tree mortality is escalating in global forests, often driven by drought, heat, and biotic attack. As climate change continues to alter ecosystems for all trees, identifying signals aiding in prediction of tree mortality events is urgently needed. We developed a model using past (1950s) data to predict potential suitability in the present day for codominance of post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) in the Cross Timbers of Oklahoma. To test model predictions, we took increment cores (n=12) of post oak from six sites predicted suitable, and six sites predicted unsuitable, throughout the Cross Timbers ecoregion to test model predictions. Using standard dendrochronological techniques, we cross-dated, measured ring widths, and built site-level chronologies to derive ring-width index (RWI), a proxy for annual growth, at each site. Here, we present our findings for growth, comparing RWI for the total ring-width, earlywood ring-width, and latewood ring-width. We found an increase in mean sensitivity (a measure of year-year variability) as well as series intercorrelation (agreement between trees at a site) in the latewood ring width index, compared to total and earlywood chronologies. We demonstrate the value of building latewood chronologies to determine growth response by comparing site predictions from our model among earlywood, latewood, and total RWI. We set out to identify a growth response to validate our ecological niche model of co-doiminant Cross Timbers oaks. Constructing latewood chronologies for our sites significantly amplified the growth signal compared to using total ring-width chronologies. Latewood chronologies of ring-porous species (such as the oaks of our study) provide a promising path forward to investigate what sites may be most sensitive to increases in tree mortality in the future.

POSTER #10

IMPORTANCE OF ENVIRONMENTAL WEATHER MONITORING FOR EMERGENCY MANAGEMENT IN OKLAHOMA

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The availability of timely and high-quality data provided by mesonets creates opportunities for educated and effective decision-making processes and policy design. An important aspect of the development and usage of mesonet data is in their wide variety of applications in environmental and emergency management agencies, water managers, farmers, energy producers and distributors, the transportation sector, the commercial sector, media, and the general public. These developments are particularly important for emergency management decision-making because the “local scale” of mesonet observations intrinsically allows forecasters to pinpoint the locations of fronts and other boundaries, for convective initiation and wind shifts, among others.

This research is focused on the Oklahoma Mesonet’s OK-First that has been used for many years to support decision-making in the face of many natural and manmade disasters in the state.

Specifically, the purpose of this research is to quantitatively evaluate benefits provided by the OK-First, while also identifying future societal needs, challenges and possible solutions. This research will apply a focused survey with Emergency Managers to derive primary data, while the Mesonet weather information will be used directly as the secondary data source.

The results of this research will quantify economic benefits of the OK-First to the state of Oklahoma and help address specific weather-related needs for future emergency management programs.

Keywords: Mesonet, Emergency Managers, Environmental Weather Monitoring, Oklahoma

POSTER #11

HOW DO THE ECONOMICS OF PERENNIAL SUMMER DORMANT TALL FESCUE AND ANNUAL WHEAT FORAGE GRAZING SYSTEMS COMPARE IN THE SOUTHERN GREAT PLAINS IN RELATION TO CLIMATE VARIATION?

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Grazing annually established cool season cereal pastures with stocker cattle is an important economic activity in the southern Great Plains. Utilization of summer dormant perennial tall fescue has been proposed as an environmentally friendly alternative to conventional annual clean till established cereal pastures such as wheat and rye. The objective was to evaluate the expected net returns of three systems that utilize summer dormant tall fescue, one system that utilizes tall fescue and cereal wheat, and a conventional system that utilizes cereal wheat. Data were collected for each system for four production years (2013/14 – 2016/17) from a completely randomized designed stocker cattle grazing study located near the community of Ardmore in south-central Oklahoma. Enterprise budgeting techniques were used to estimate the expected costs, revenues and net return for each pasture, year and system. Random effects ANOVA models were used to compare animal and economic performance measures across the systems. The results suggest that net returns for the summer dormant tall fescue systems were breakeven with the conventional annually produced cereal wheat grazing system. The results were most sensitive to small differences between systems in grazing days, value of gain, life expectancy of tall fescue, and tall fescue seed price.

POSTER #12

INFRASOUND FROM MAY 11, 2017 TORNADO IN PERKINS OKLAHOMA

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On May 11, 2017 at 2013 UTC an EF0 tornado formed near Perkins, OK, which had a path length of 0.1 miles and a damage path width of 50 yards. There were reports of a possible second tornado, but it was never confirmed because the storm was rain wrapped and radar could not see near ground level. Approximately 19 km NNW of the tornado is the Oklahoma State University 3-microphone infrasonic array. Infrasound is sound below human hearing. Tornado-producing storms emit infrasound up to 2 hours before tornadogenesis, which can be detected up to 160 km away. The infrasonic monitoring is part of the Collaboration Leading Operational UAS Development for Meteorology and Atmospheric Physics (CLOUD-MAP) project, an NSF EPSCoR funded multi-university collaboration focused on the development and implementation of unmanned aerial systems (UAS) and their integration with sensors for atmospheric measurement. A strong infrasonic signal began ~10 minutes before the tornado touched down and existed during the entire life of the tornado. A second nearly identical signal was received during the period coinciding with the unconfirmed second rain-wrapped tornado. This poster shows that the received signals conform to established criteria for source identification (concomitancy, characteristic signature, and coherence) with the exception of directionality due to cross-talk contamination between two of the microphones preventing the identification of signal bearing angle. In addition, tornado properties will be estimated from the infrasonic signal and compared with available observations. [This work was supported by NSF Grant 1539070.]

POSTER #13

FROM PRODUCED WATER TO FRESH WATER: ENERGY'S PERSPECTIVE

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Despite being a blue planet (oceans cover 71% of earth's surface), many regions on earth suffer from the scarcity of fresh water due to a combination of population growth and climate change. Furthermore, the interdependency of energy and water sectors due to recent development of hydraulic fracturing technologies caused further demand on already-stretched water resources. There is a current need to develop cheap water treatment facilities for produced water resulting from oil and gas production facilities. Today the water desalination technologies are still expensive and an energy-intensive endeavors compared to re-injection in disposable wells. In this poster paper an engineer's perspective of different desalination methods are presented including membrane and non-membrane based systems to compare their energy demands. The role of renewable-energies is emphasized.

POSTER #14

IMPROVING THE QUALITY AND RELIABILITY OF THE OKLAHOMA RAINFALL ARCHIVE

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The Oklahoma Mesonet, a joint project between the University of Oklahoma and Oklahoma State University, is a dense network of environmental monitoring stations spanning all 77 counties in Oklahoma. Since 1994, the Mesonet has collected over 5 billion observations and has provided critical information to decision makers including farmers, ranchers, emergency managers, weather forecasters, and researchers. In 2008 several Mesonet sites were officially integrated into the Cooperative Observer Program network further enhancing the national climate data archive. On occasion, the rainfall data for a station can become interrupted or incomplete due to rain gauge obstruction, mechanical failure, or other unknown issues. Manual and automated quality assurance procedures are routinely employed to identify potential data quality issues. In the event that data is found to be erroneous, a quality flag is applied to prevent the data from being included in graphical products and the climate archive. Through funding received from NSF-EPSCoR, the Mesonet was able to deploy a second co-located automated Met One tipping bucket rain gauge at each of the 120 sensing stations across the state beginning in 2014. The utilization of dual rain gauges has minimized interruptions to rainfall observations when sensor issues occur. Additionally having a duplicate rain gauge at each site has improved data quality monitoring, decreasing the time required to identify and analyze data issues, and enabling timely response by field technician staff. Improvements to network data quality and reliability continue to enhance situational awareness directly impacting short-term forecasts and decisions while also supporting climate research and drought monitoring.

POSTER #15

DOES ANISOHYDRIC BEHAVIOR/TRAITS ASSIST EASTERN REDCEDAR (*JUNIPERUS VIRGINIANA*) TO SUCCESSFULLY ENCROACH INTO THE CROSS TIMBERS?

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Eastern redcedar (*Juniperus virginiana*) is known to have successfully encroached into the oak-dominated Cross Timbers, changing the composition and dynamics of this ecoregion. The overall objective of this study was to understand the inter- and intraspecific interactions between eastern redcedar and post oak (*Quercus stellata*) for oak-redcedar mixed forests in the Cross Timbers of north-central Oklahoma. Our specific objective was to understand how xylem water potential (Ψ), net photosynthetic rate (P_n), and water use efficiency (WUE) of eastern redcedars and oaks differ among pure oak, pure eastern redcedar, and mixed oak-eastern redcedar stands. P_n, predawn water potential (Ψ_p), midday water potential (Ψ_m), and soil water volumetric content were measured in 24 trees among the three different stands during the 2017 growing season. When soil moisture was low, we found that oaks growing with eastern redcedars had significantly less negative Ψ_p compared with oaks growing in pure stands. The P_n of oaks declined during summer with high temperatures but was always greater than that of eastern redcedars which maintained a relatively constant rate throughout the year. The P_n, WUE, Ψ_p, and Ψ_m of eastern redcedar in the mixed stand were not significantly different from those in the pure eastern redcedar stand. In the mixed stand, P_n and WUE of oaks were significantly greater than those of eastern redcedars, and Ψ_p and Ψ_m of oaks were less negative than those of eastern redcedars with low soil moisture. Our results suggest that eastern redcedars influence Ψ of oaks mixed stands, and that physiological performance of eastern redcedar did not differ in pure vs mixed stands. Moreover, eastern redcedar exhibits anisohydric behavior with a decline in Ψ to sustain P_n during dry periods. These traits may allow eastern redcedar to successfully encroach into the forest midstory under prolonged water-limited conditions in this sub-humid region.

POSTER #16

THE SPATIAL-TEMPORAL DYNAMICS OF OPEN SURFACE WATER BODIES IN THE CONUS DURING 1984-2016

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Open surface water bodies are important sources for water withdrawals in the Contiguous United States (CONUS). The inter-annual variability and changing trends of surface water body areas have various impacts on the human society and ecosystems. This study made use of all Landsat 5, 7, and 8 surface reflectance archives (~370,000 images) during 1984-2016 and a water index- and pixel-based approach to detect and map open surface water bodies in the cloud-based platform of Google Earth Engine. This study generated the dataset of annual and 33-year water body frequency maps at the spatial resolution of 30 m. The year-long water body area were calculated for each of the last 33 years and their inter-annual variations during 1984-2016 were analyzed through anomaly analysis, while their changing trends were analyzed through linear regressions by states, watersheds and 0.5-degree grid cells. These datasets and trend analysis would be useful for water resource managers and stakeholders in water resource planning and management.