Focus Area 2:
Shifting Terrestrial Water & Carbon Dynamics (TWCD)

Presenter:
Rodney Will, Professor
Natural Resource Ecology and Management
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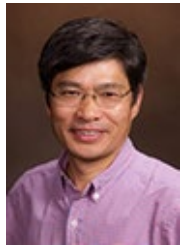
TWCD: REPRESENTING TEAM TODAY

OU: Xiangming Xiao, Xuebin Yang[2], Jorge Celis[1], Hank Jenkins-Smith

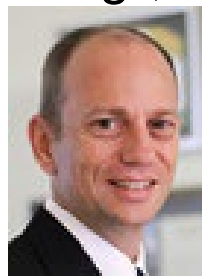



OSU: Rod Will, Chris Zou, Gail Wilson, Ted Primka[2], Aisha Sams[1], Tian Zhang[1], Jia Yang[3], Kevin Wagner







Noble Research Institute: Erin Oliver[2], Myoung-Hwan Chi


1 = Grad student
2 = Post doc
3 = New faculty hire

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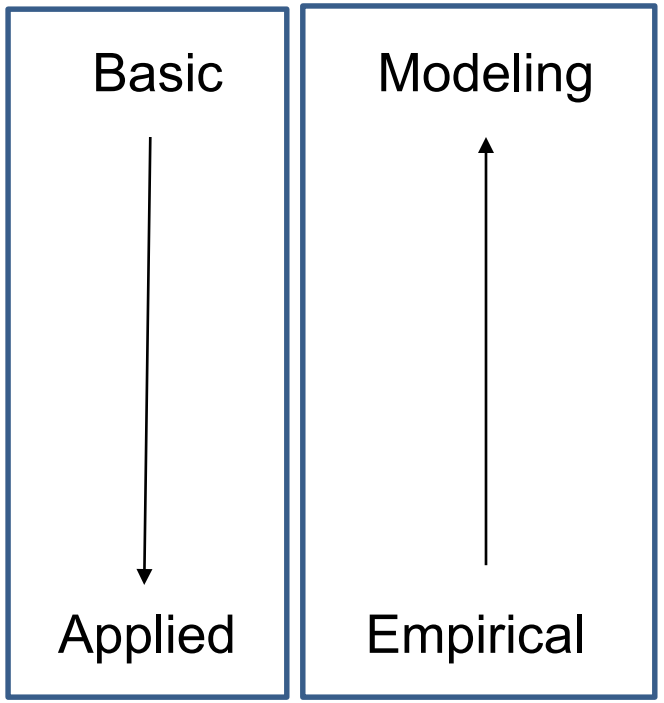
SHIFTING TERRESTRIAL WATER & CARBON DYNAMICS

Goals and Objectives

The overall goal is to understand terrestrial carbon and water dynamics across OK and utilize this knowledge to inform the socially sustainable options for increasing carbon uptake and storage while sustaining water supplies

- Quantify water and carbon dynamics across OK
- Determine trade-offs between ecosystem carbon uptake and water loss and how these are affected by climate and ecosystem type
- Determine the effect of woody plant encroachment on terrestrial carbon and water dynamics in grasslands
- Determine the effect of modifying agricultural management practices on terrestrial carbon and water dynamics while maintaining crop yields



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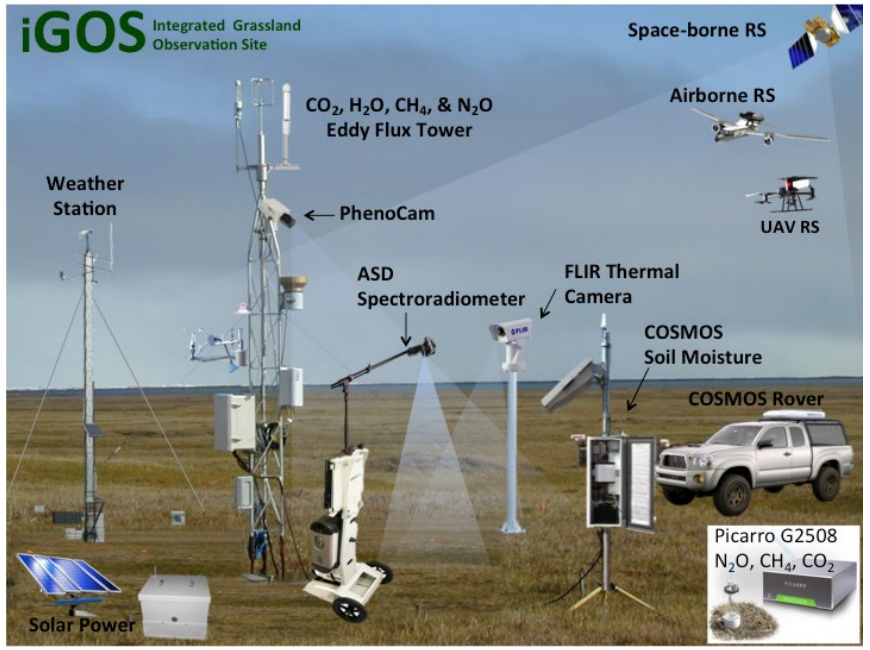
Objective 1- Quantify water and carbon dynamics across OK

Related Tasks

1.1 Develop and operate land/water observatory at selected sites
1.2 Quantify land use and land cover changes
1.3 Develop land/water forecasting capacity

Accomplishments

1. Measuring carbon, water, and energy fluxes from prairie, alfalfa, and winter wheat sites to allow investigation of inter-annual variation in carbon and water dynamics
2. Determined spatial-temporal dynamics of *J. virginiana* encroachment
3. Determined impacts of *J. virginiana* encroachment on local climate and water cycle using remote sensing
4. Improved the Vegetation Photosynthesis Model (VPM) which estimates gross primary production using climate and satellite images



Multi-scale and integrated observation systems – *in-situ*, airborne, and spaceborne sensors

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Objective 2 - Trade-offs between ecosystem carbon uptake and water loss and how these are affected by climate and ecosystem type

Related Tasks

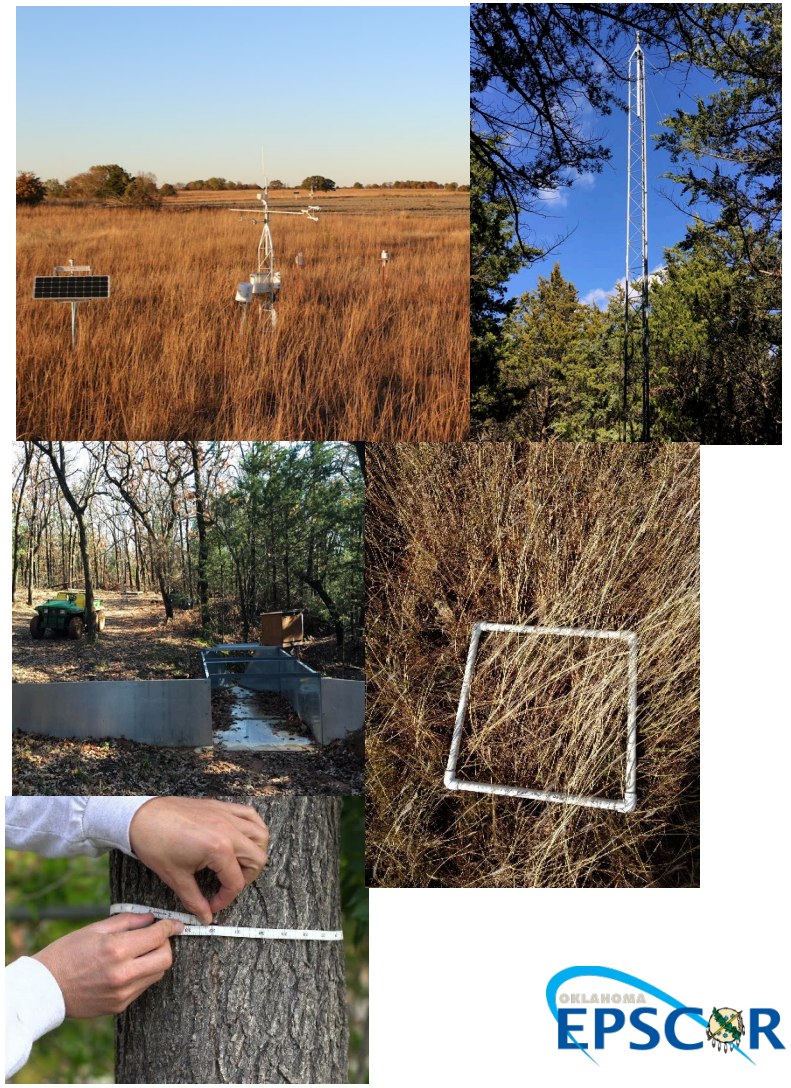
2.1 Quantify watershed-scale water balance and carbon gain related to land cover and climate variability

2.2 Understand tradeoffs between water use and carbon gain for grassland and forest

2.3 Integration and synthesis of water and carbon tradeoffs across OK

Accomplishments

1. Determined effects of converting *J. virginiana* woodland back to grasslands on water and productivity
2. Measuring water use and ANPP from range of land covers
3. Installed eddy flux tower in forest to pair with grassland site



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Objective 3 - Determine the effect of woody plant encroachment on terrestrial carbon and water dynamics in grasslands

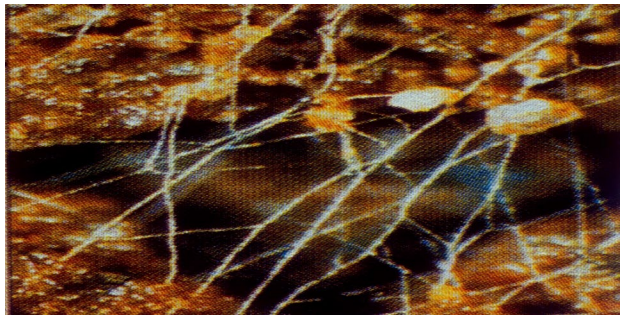
Related Tasks

3.1 Determine effects of *J. virginiana* encroachment on ecosystem carbon

3.2 Determine effects of *J. virginiana* encroachment on mycorrhizae

3.3 Determine effects of *J. virginiana* encroachment on ecosystem services

Mycorrhizal Hyphae



Accomplishments

1. Nine paired sites across precipitation gradient in OK have been identified and sampled for soil carbon and vegetation
2. Samples collected for soil microbial biomass and analyses underway

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Objective 4- Determine the effect of modifying agricultural management practices on terrestrial carbon and water dynamics while maintaining crop yields

This Objective has evolved from crops and annual grasses to grazing management in bermudagrass and native rangelands

Related Tasks

4.1 Determine impacts of regenerative grazing for bermudagrass pasture on soil health and forage yield

4.2 Determine impacts of regenerative grazing for native range on soil health and forage yield

4.3 Measure impacts of adaptive vs. prescriptive grazing management on soil microbiomes and nutrient cycling

Accomplishments

1. Sites have been installed and baseline sampling and analyses have been completed
2. Treatments will begin this spring

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TWCD FOCUS AREA: STATUS OVERVIEW

Objectives	Primary Goals	Key Accomplishments	Status
TWCD 1 - Quantify water and carbon dynamics across OK	1. Develop and operate land/water observatory at selected sites 2. Quantify land use and land cover changes 3. Develop land/water forecasting capacity	1. Measuring carbon, water, and energy fluxes 2. Determined spatial-temporal dynamics of *J. virginiana* encroachment and effects on local climate 3. Improved the Vegetation Photosynthesis Model	On Schedule
TWCD 2 - Trade-offs between ecosystem carbon uptake and water loss and how these are affected by climate and ecosystem type	1. Quantify watershed-scale water balance and carbon gain related to land cover 2. Understand tradeoffs between water use and carbon gain 3. Integration and synthesis of water and carbon tradeoffs across OK	1. Determined effects of converting *J. virginiana* woodland back to grasslands on water and productivity 2. Measuring water use and ANPP from range of land covers 3. Installed eddy flux tower in forest	On Schedule
TWCD 3 - Determine the effect of woody plant encroachment on terrestrial carbon and water dynamics in grasslands	1. Determine effects of *J. virginiana* encroachment on ecosystem carbon 2. Determine effects of *J. virginiana* encroachment on mycorrhizae 3. Determine effects of *J. virginiana* encroachment on ecosystem services	1. Nine paired sites across precipitation gradient in OK have been identified and sampled for soil carbon and vegetation 2. Samples collected for soil microbial biomass and analyses underway	On Schedule
TWCD 4 - Determine the effect of modifying agricultural management practices on terrestrial carbon and water dynamics while maintaining crop yields	1. Determine impacts of regenerative grazing for bermudagrass pasture on soil health 2. Determine impacts of regenerative grazing for native range on soil health 3. Measure impacts of adaptive vs. prescriptive grazing on soil microbiomes	1. Sites have been installed and baseline sampling and analyses have been completed 2. Treatments will begin this spring	Behind Schedule

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Results and Outcomes

- Accurately quantified extent of *J. virginiana* encroachment in OK
- Quantified impacts of land use change on water yield and water quality
- Improved VPM which will facilitate later activities
- Measuring water and carbon dynamics from various land uses which provides new knowledge on these topics and will be used in integrative modeling efforts
- Provided information on ice storm damage for collaborative effort with other teams
- Collaborating with other teams on Little River case study
- Beginning collaborations with V-MQW group to measure greenhouse gas efflux on watersheds
- Working with SD team to better understand stakeholder motivations regarding management that impacts carbon and water through interactions with M-SIS and OLAN

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Major Findings

- The majority of our research is multi-year with many results expected towards the end of the research period
- Woody plant encroachment increases nighttime land surface temperature (LST) and reduces daytime LST

  Wang, J., Xiao, X., Basara, J., Wu, X., Bajgain, R., Qin, Y., Doughty, R.B., Moore, B. III, 2021, Impacts of juniper woody plant encroachment into grasslands on local climate, *Agricultural and Forest Meteorology,* 307, 108508, https://doi.org/10.1016/j.agrformet.2021.108508.

- In the Southern Great Plains, evergreen forest area compose 113,861 km^2, accounting for 38.8% of the total forest area

  Yang, X., Xiao, X., Qin, Y., Wang, J., and Neal, K., 2021, Mapping forest in the southern Great Plains with ALOS-2 PALSAR-2 and Landsat 7/8 data, *International Journal of Applied Earth Observation and Geoinformatics*, https://doi.org/10.1016/j.ag.2021.102578.

- Converting *J. virginiana* woodland to native prairie or a switchgrass biomass production system increased water yield to streams but had a relatively small impact on sediment yield

  Zhong, Y., Will, R.E., Ochsner, T.E., Saenz, A., Zhu, L. and Zou, C.B., 2022. Response of sediment concentration and load to removal of juniper woodland and subsequent establishment of grasslands–A paired experimental watershed study. CATENA, 209, p.105816. https://doi.org/10.1016/j.catena.2021.105816.

- Preliminary result that *J. virginiana* encroachment into native prairie increases soil organic content

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Impacts of the Research

- Increase water quantity and quality available for municipalities, agriculture, industry, and ecological flow; Impact on Great Plains+
- Increase carbon storage (shift from atmosphere to terrestrial ecosystem); Global impact
- Improve sustainability and profitability of agriculture; Impact Great Plains+
- Reduce risk of wildfire; Impact on Great Plains
- Improve wildlife habitat; Impact on Great Plains

Our goals are not controversial, but largely represent public benefits dependent on actions of private landowners who may lack incentive or necessary knowledge to modify behavior and management

Linkages across S^{3}OK project can determine motivations for action to improve land management for landowners and society

Future Plans

- Research is mostly on track. Future plans to complete research are established.
- The data needed for later objectives and modeling efforts are being collected on schedule.
- Start to write proposals to NSF and other funding agencies, for example, Drs. Xiao and Zou are working on a proposal to DOE (3 years, $3.6 million, due on 4/4/2022), “Characterization and modeling of soil microbiome, carbon fluxes and stocks in tallgrass prairie”.
- Link soil carbon and microbial research to efforts to determine the source of microbial carbon acquisition to trees vs grass.
- Expand measurements at watersheds to include greenhouse gas emissions.
- Expand measurements at watersheds to include *E. coli* and water quality.
- Continue and expand work with other teams.