Chapter 3: Isolated-Wetland Contribute Little to Stream Carbon but Support Lateral Carbon Export: Mapping the Carbon Cycle in “Wetlandscapes”.

Landscape hydrology predicates that hydrologic and biogeochemical changes in one region of a watershed have the potential to cascade across the entire basin. Through the lens of landscape hydrology, the watershed is viewed as a singular, relatively closed system, encompassing micro-ecosystems that collectively contribute to the basin’s distinct biogeochemical and hydrologic fingerprint. However, the relevance of "landscape hydrology" is watershed specific, dependent on the basin's connectedness or how water flows and is stored between inland waters. This landscape "connectedness" is largely dependent on wetland area, namely geographically isolated wetlands (GIWs) density. GIWs disrupt the flow of watershed runoff. Instead of flowing down elevation and being exported to streams, runoff is intercepted and held within GIWs. Here, it is either released into the atmosphere, stored within the watershed, or exchanged with the local surficial aquifer (SAq). Through this wetland-aquifer exchange, GIWs modulate the SAq by sourcing and receiving groundwater, buffering flow extremes, and dictating downstream baseflow. The SAq acts as a vector for hydrologic connectivity, facilitating transport between inland waters even in the absence of overland connectivity. Thus, the chemical and hydrologic fingerprint of a landscape results from the "wetlandscape," or the energy exchange between the SAq and inland waters.

GIWs are global hot spots; the anaerobic conditions, long residence times, and extended hydroperiods of GIWs encourage the re-mineralization and storage of carbon while simultaneously exporting processed waters downstream through groundwater or overland flow ("spill-and-fill"). However, in the literature, direct observations estimate GIWs' contributions to stream carbon is small. Only 20% of total stream carbon is sourced by GIWs, with the remainder assumed to be sourced from riparian wetlands. These studies, though useful for finite carbon budgeting, undermine GIWs' role in global carbon cycling by (1) sampling from overland, intermittent flow paths while excluding subsurface export, and (2) failing to interrogate GIWs' influence on watershed-level carbon export. Despite model estimates, current research has not directly explored the cumulative impacts of landscape hydrology on carbon export, particularly concerning carbon cycling. As mentioned, GIWs modulate the surficial aquifer, performing an ecological function that is integral to the broader energy and water dynamics within the “wetlandscape.” Energy exchange through the wetlandscape functions as a chain reaction: water and its contents runoff into GIWs, where they diffuse into the surficial aquifer. The surficial aquifer then exports water to riparian wetlands and streams as baseflow (FIGURE #). These interactions determine downstream water quality, surface-groundwater exchange, watershed inundation, and carbon export and storage. While the surficial aquifer acts as the transport network of the wetlandscape, GIWs serve as its "capacitors." Even as soils dry, GIWs can sustain the surficial aquifer and its streams into the early seasons of drought. The longer the watershed remains inundated, the greater the potential for carbon storage in wetlands and carbon export to streams.

For the third chapter of my dissertation, I will estimate both direct and indirect carbon contributions from GIWs to streams by longitudinally sampling for DIC, DOC, and POC from three BEF streams within basins of various wetland densities. Thus far in my PhD, I will have explored stream carbon temporal dynamics and RC fluxes in fluctuating hydrologic settings. By coupling my longitudinal sampling results with the findings from Chapters 1 and 2, I can isolate the influence of isolated wetlands. Assuming RC fluxes and stream productivity responses to fluctuating discharge are homogeneous throughout the reach, I can investigate how nearby GIWs influence stream carbon as water accumulates downstream. Research has yet to observe GIW carbon contributions, and none have included observed RC fluxes in addition to stream metabolism models. I hypothesize:

1. I hypothesize that each stream will gain carbon, increasing in DIC, DOC, and POC as water flows downstream.
2. Although I expect depressional wetlands to directly contribute to the stream carbon, I hypothesize the RC will remain the dominant carbon source.
3. However, during flooded conditions, I anticipate GIW contribution will be greatest due to a shallower surficial aquifer and overland flow.
4. Lastly, I expect streams in watersheds with greater wetland areas to have higher total carbon (TC) concentrations across wetland, RC, and stream boundaries.

By synthesizing my results from Chapters 1 and 2 with my results from Chapter 3 I aim to holistically map stream carbon sources and fluxes, allowing me to draw detailed inferences on low-relief, “wetlandscape” carbon budgets. By testing these hypotheses and developing a carbon budget, I aspire for this chapter to offer both an improved understanding of low-relief carbon cycling and practical applications. Specifically, my objective for Chapter 3 is to inform management decisions on how to optimize landscape hydrology for carbon storage.

Methods: