Tradeoffs in nutrient retention and greenhouse gas fluxes in restored agricultural wetlands

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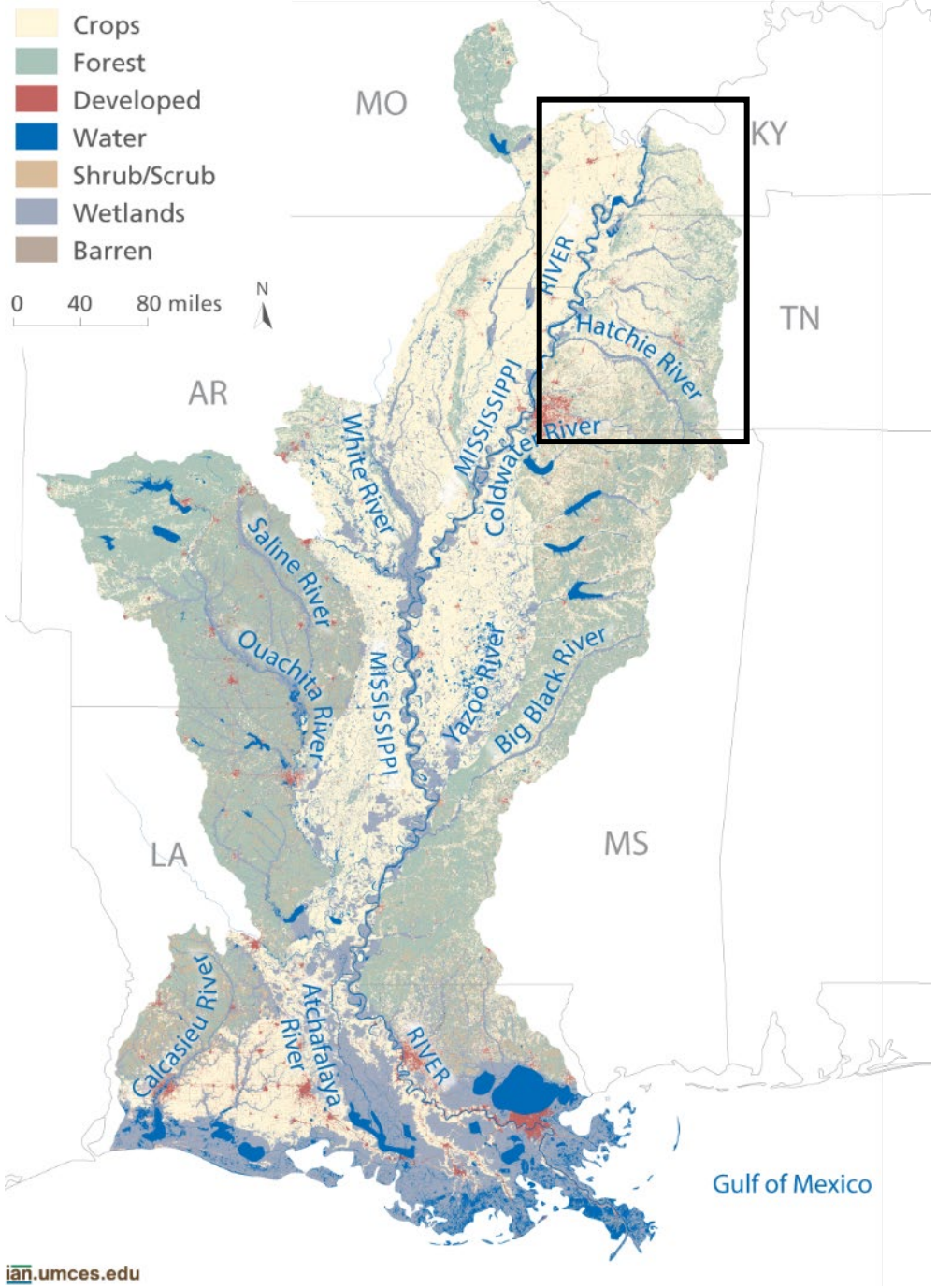
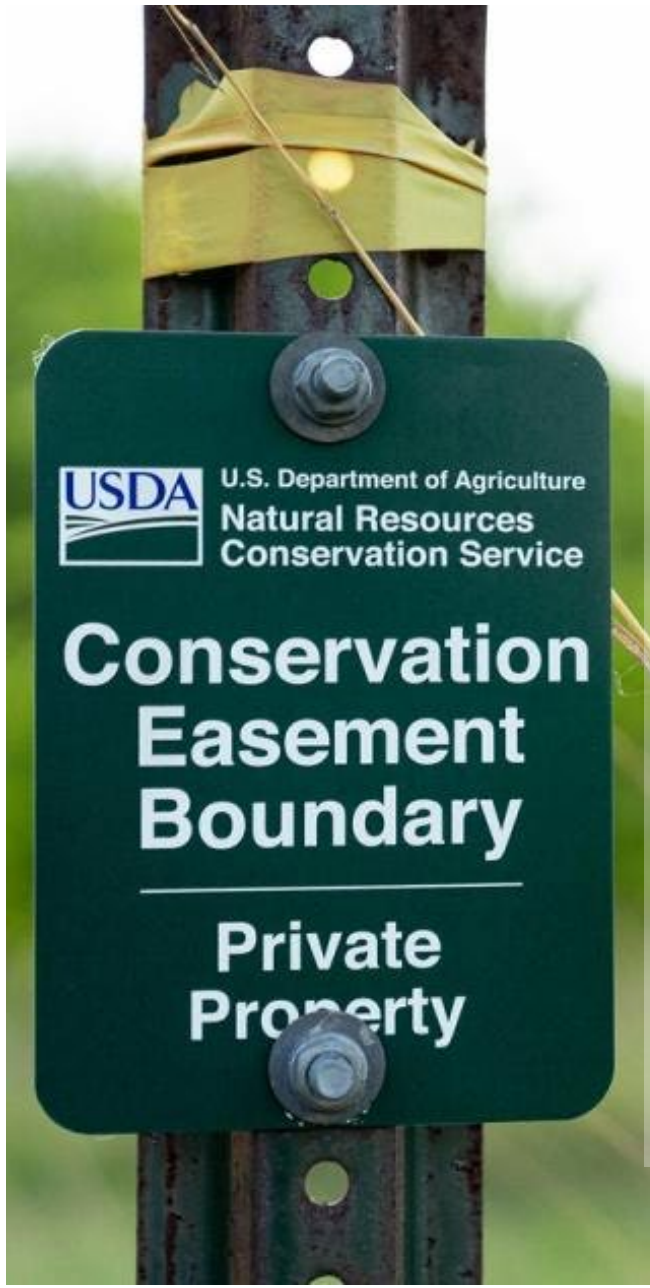


J. Thomas (ian.umces.edu/media-library)

South Fork Forked Deer River, Lauderdale County TN. Google Earth



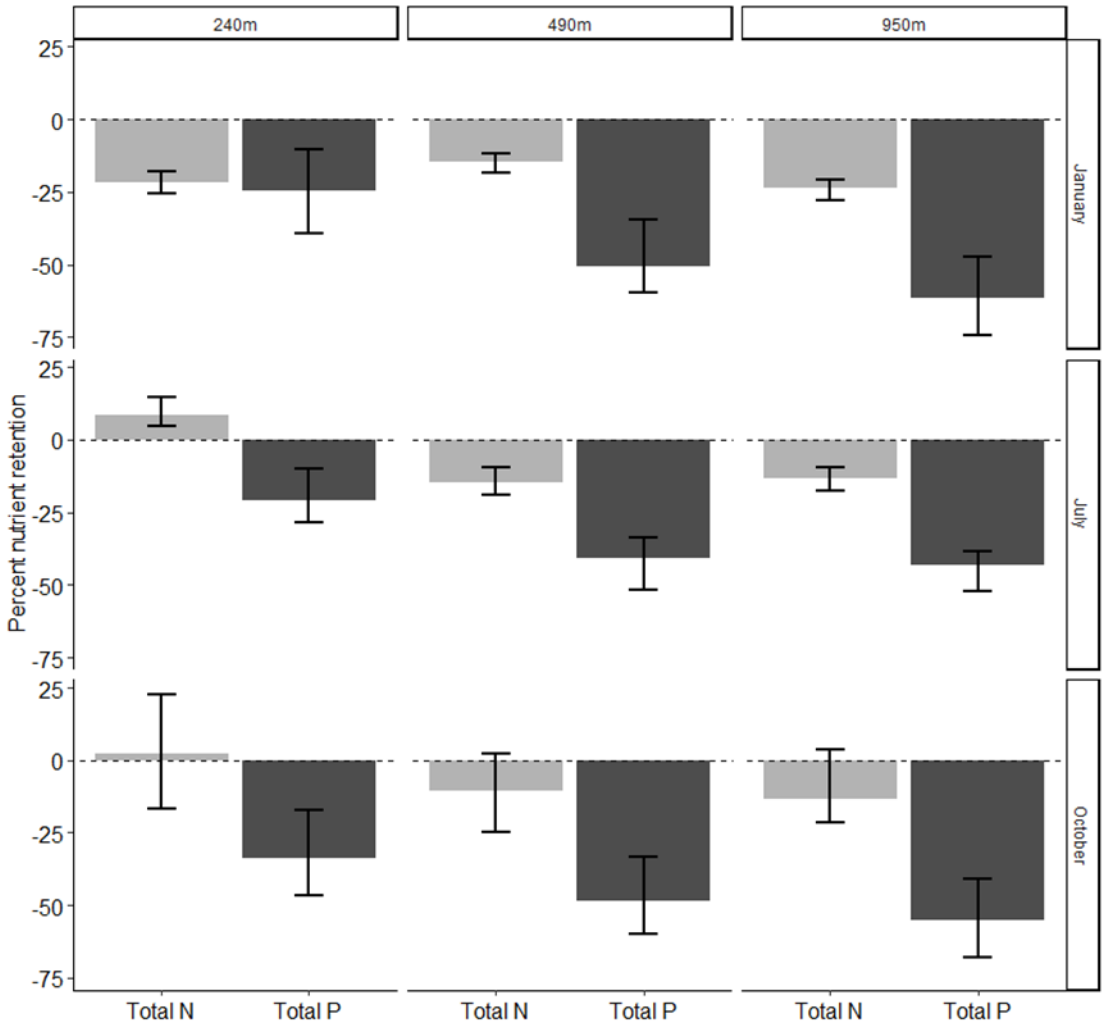
Goals of the USDA Wetlands Reserve Enhancement Partnership (WREP) program: (Previously WRP)

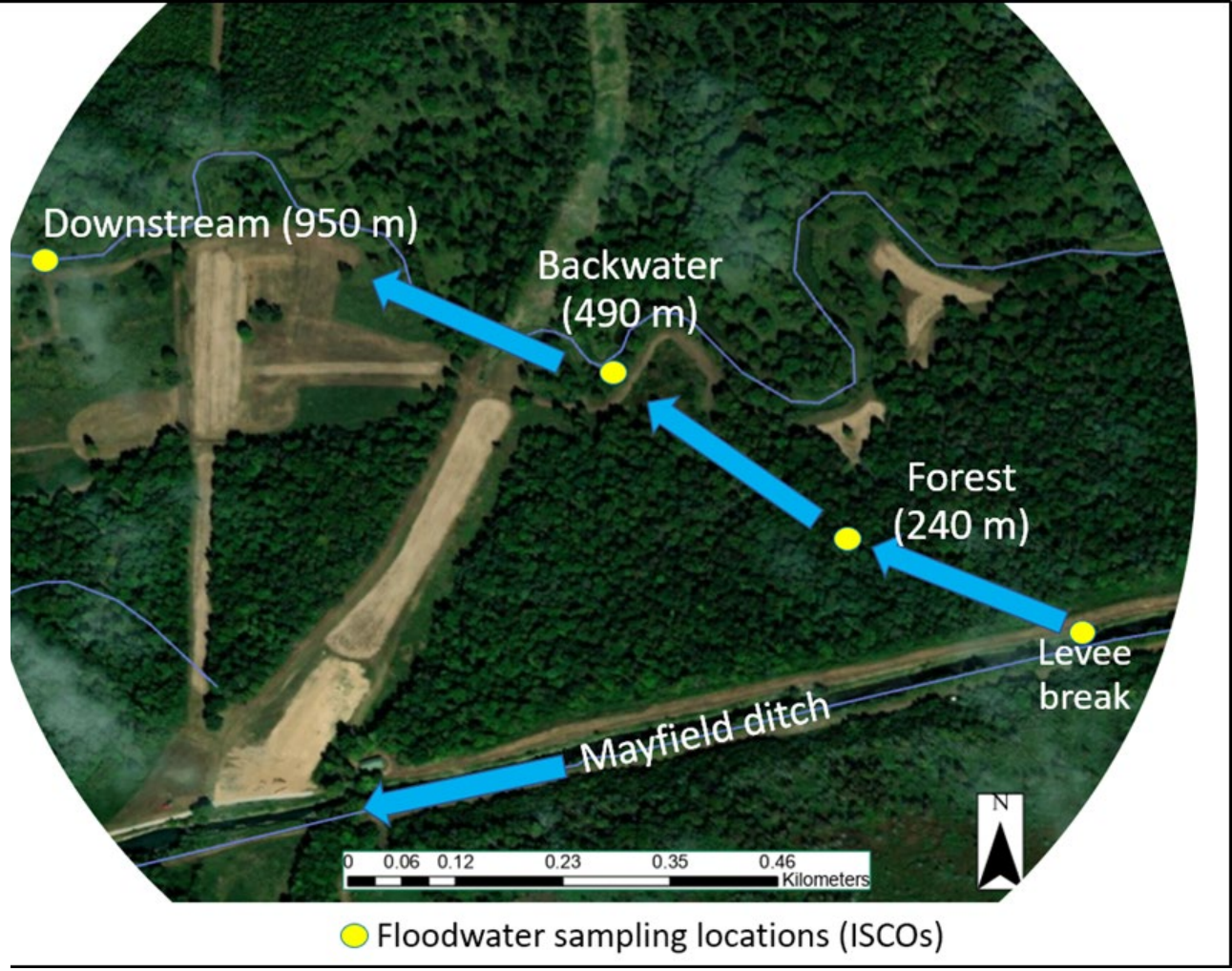
Voluntary program to restore agricultural wetlands –

- Protect habitat that benefits migratory birds and wetland-dependent wildlife; federal and state threatened and endangered species
- Restore wetland function. (Increase nutrient retention and reduce GHG releases)

WREP Function Goal: 2022-present

The Mississippi River Basin Healthy Watershed Initiative (MRBI) Reduce nutrient (nitrogen and phosphorus) and sediment loading into the Gulf





(Brown et al., Freshwater Science in press)

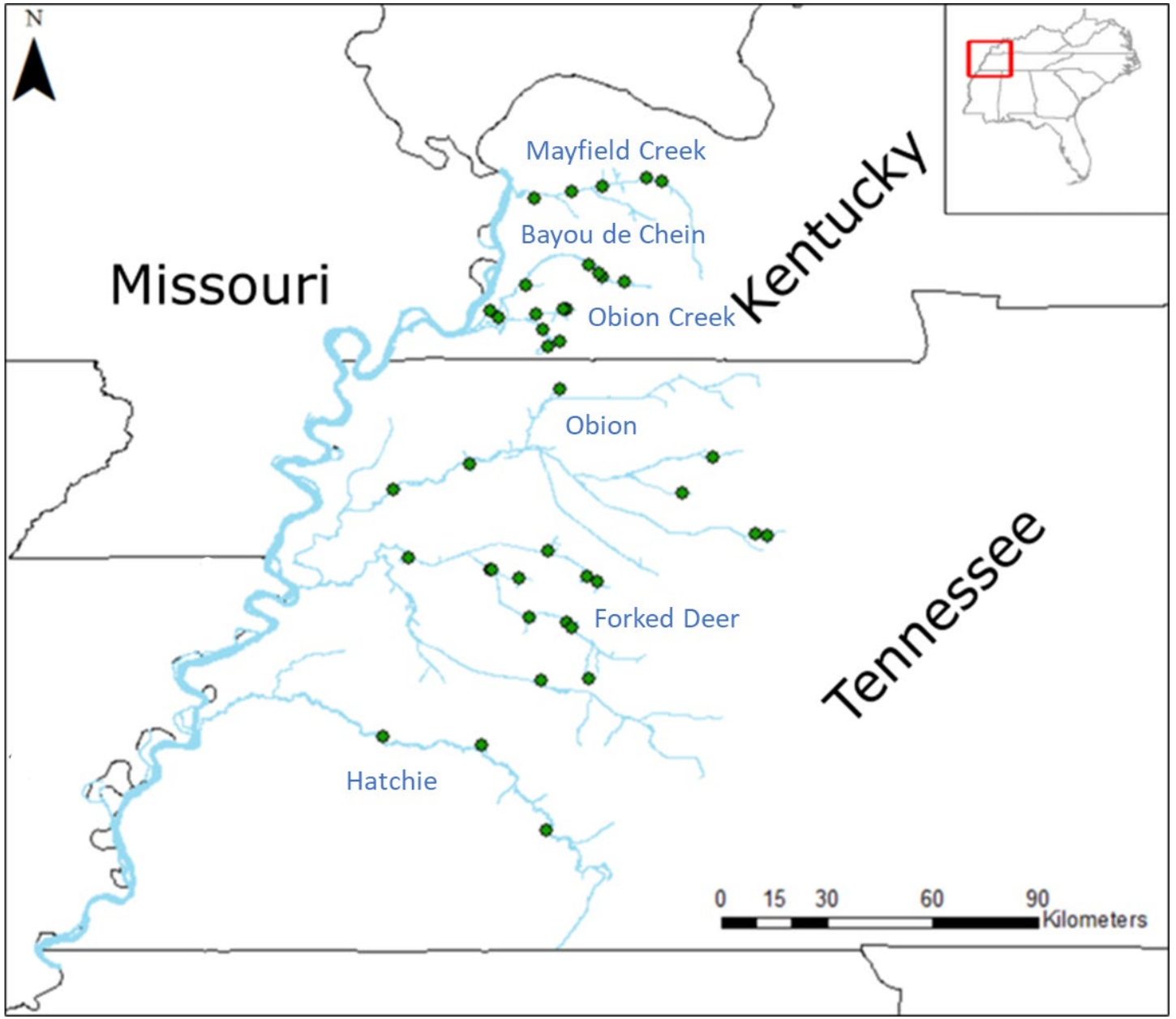
Wetland sub-habitats (veg/hydro)

High potential spatial and temporal variability

M. Wilkinson, The Nature Conservancy

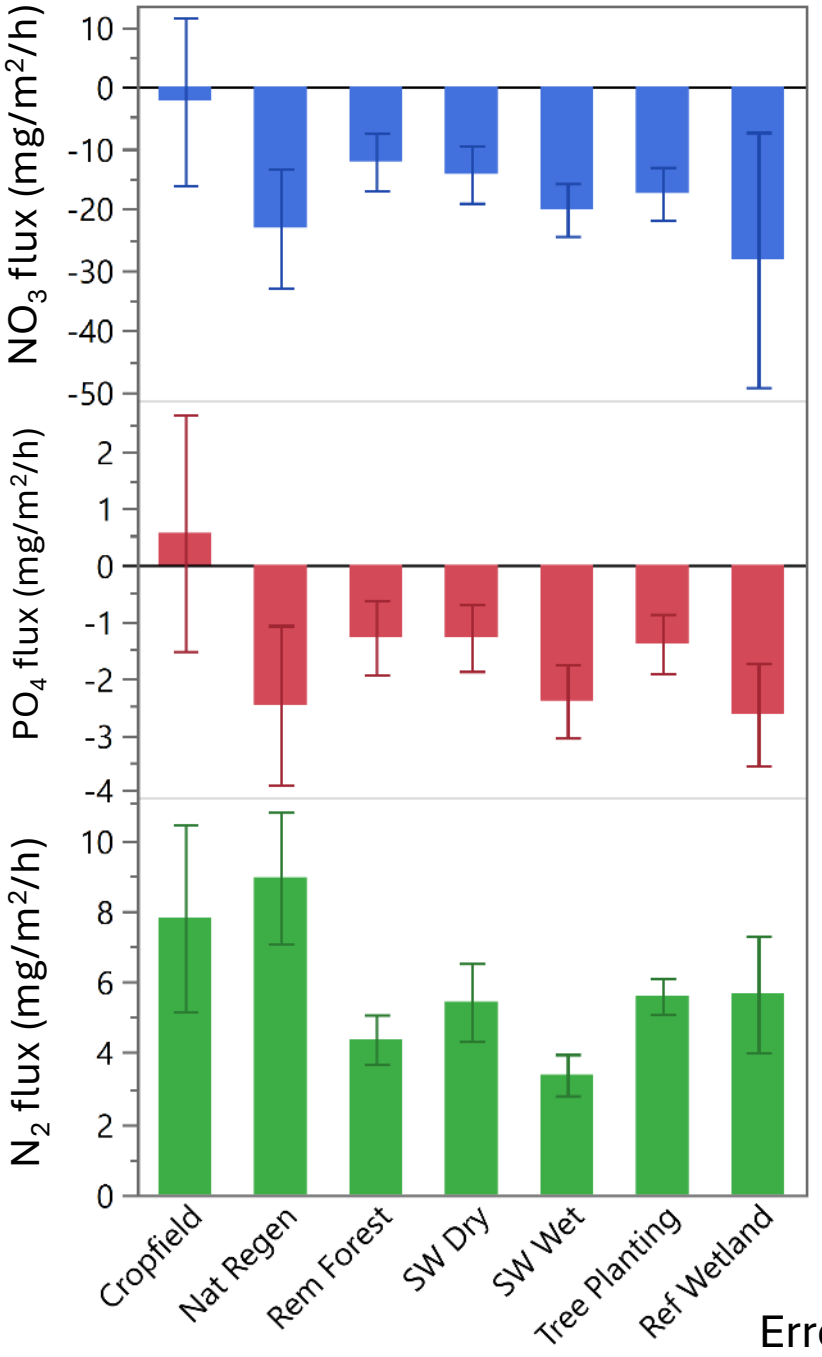
Soil Cores

- 35 easements
- ~1200 cores
- NH_4, NO_2, NO_3, PO_4 retention rates
- Denitrification rates
- Soil properties
- 1-23 years post restoration

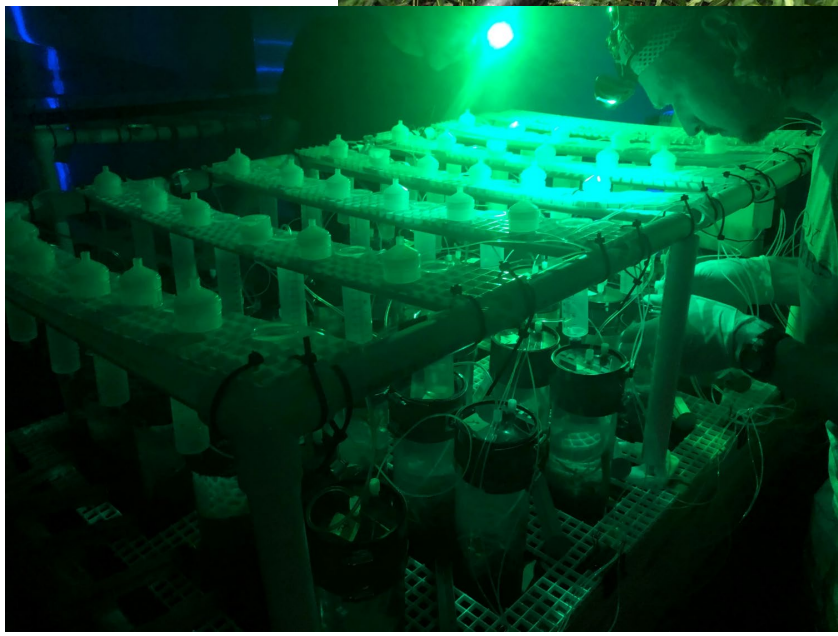


(Womble et al., submitted)

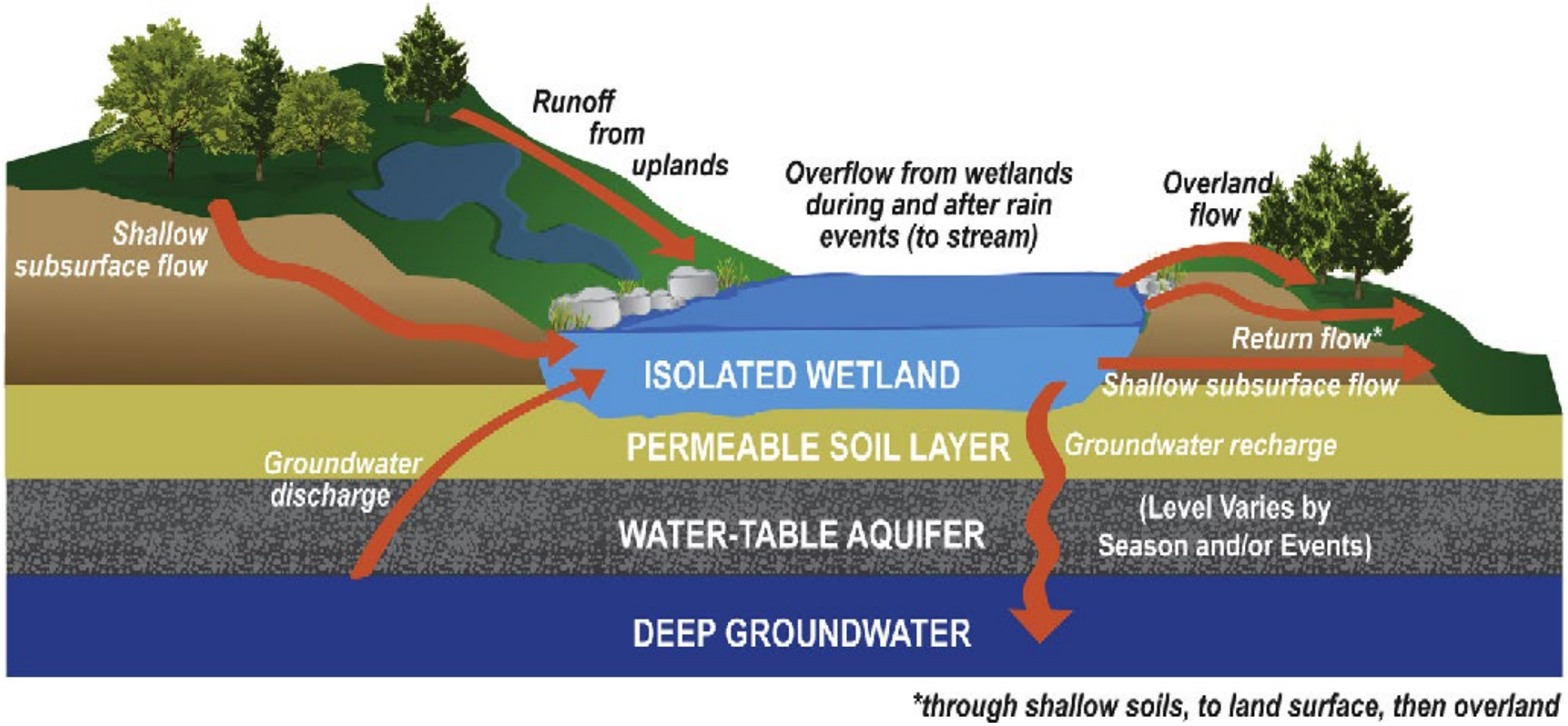
(Murdock et al., in prep)



- 35 wetland easements
- 7 habitats
- 1-23 years old
- 981 cores



Error bars 95% CI



Golden, Heather E. et al. “Hydrologic connectivity between geographically isolated wetlands and surface water systems: A review of select modeling methods.” Environ. Model. Softw. 53 (2014): 190-206.

Project Questions:

What restoration strategies (vegetation and hydrology) optimize nutrient and GHG fluxes across seasons?

Are there tradeoffs in nutrient retention and GHG production?

How do these processes differ in surface waters and shallow groundwaters across restoration strategies?

3 easements in West Tennessee,

- 11-16 years since restoration.

Measure nutrient and GHG flux rates

- across different restoration practices
- above and below the soil surface
- across seasons: Spring (Apr), Summer (Jul), Winter (Dec) for 2 years

Release

Removal

n = 981

Restoration Habitats

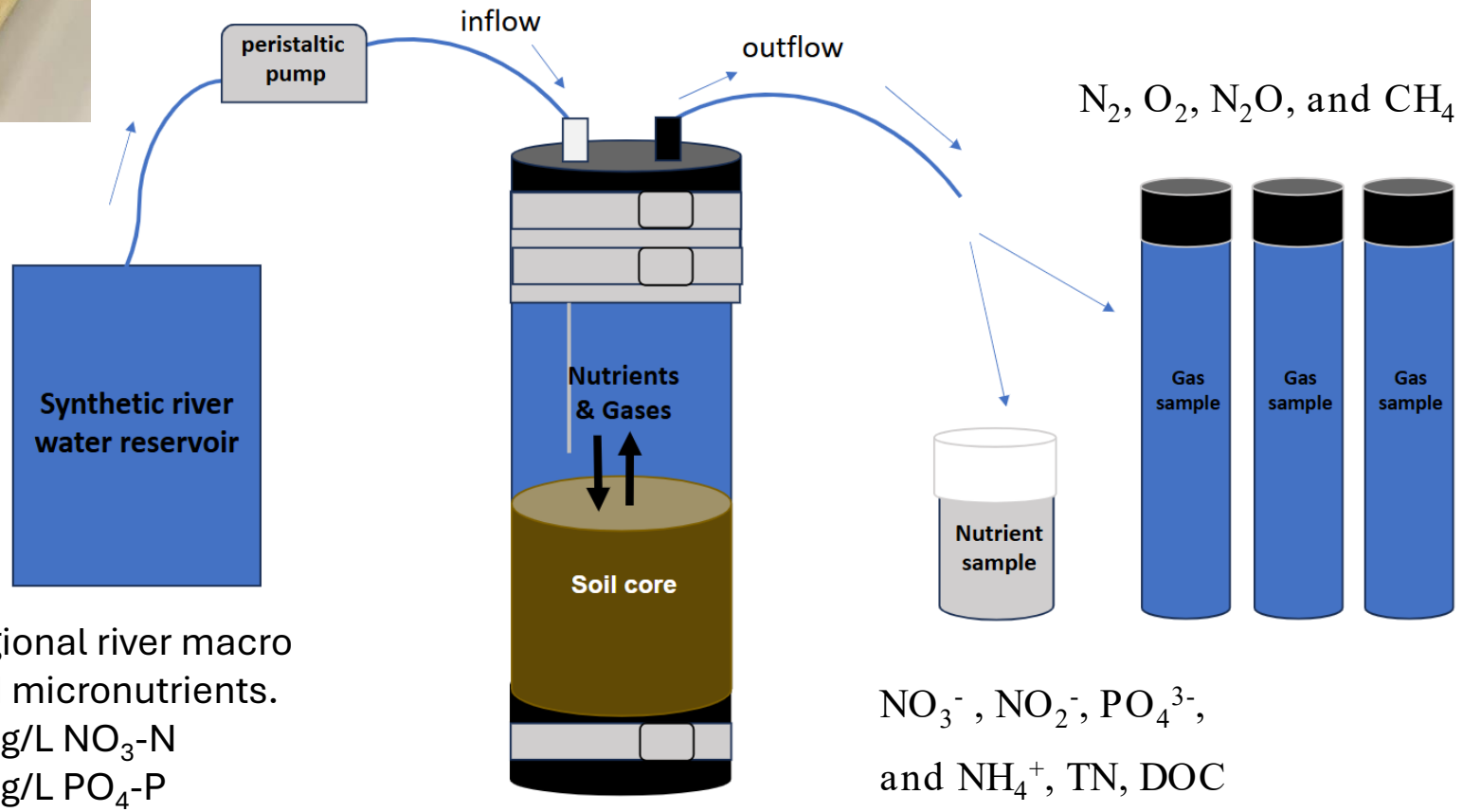
Restoration habitat types are

A. Created shallow water
B. Natural regeneration
C. Remnant forest
D. Tree planting
E. Natural wetland
F. Cropfield

- 3 locations per habitat with paired shallow/deep cores for flux measurements
- 45 shallow, 45 deep cores per season
- Cores for soil structure and chemistry

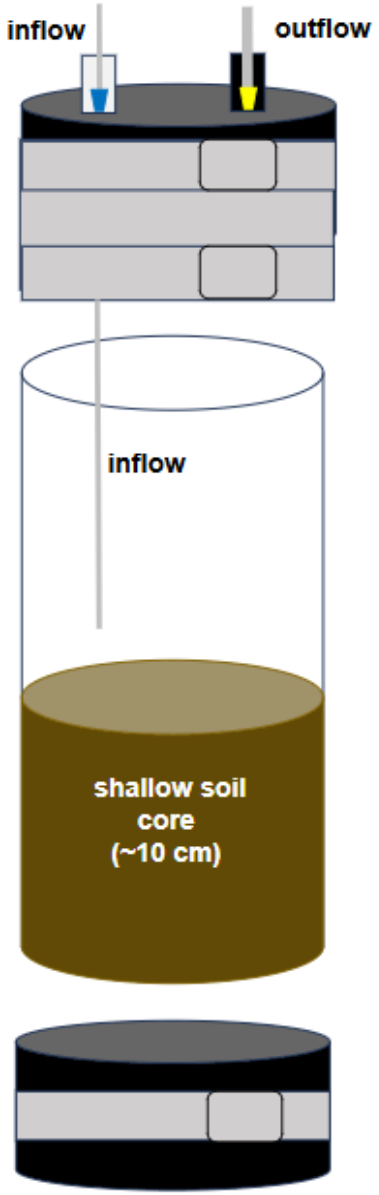
Incubation Procedure

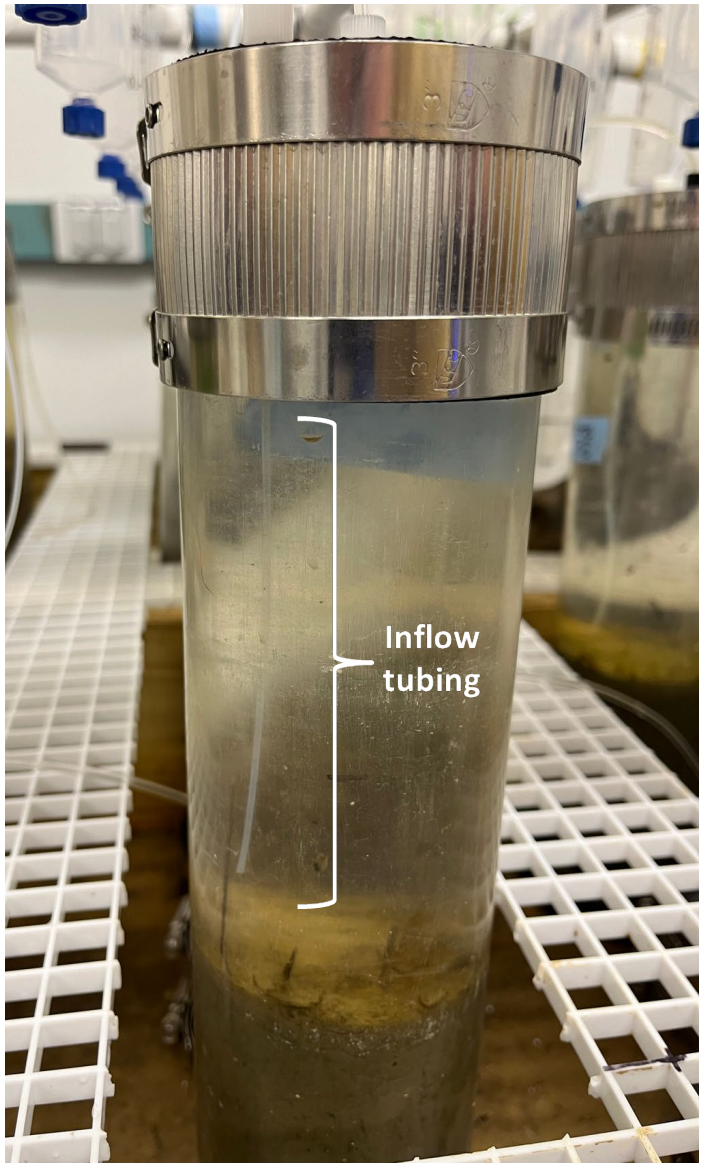
- Nutrients at 6, 24, 48 hours
- Gases at 24, 48 hours



- Regional river macro and micronutrients.
- 5 mg/L NO_3-N
- 1 mg/L PO_4-P

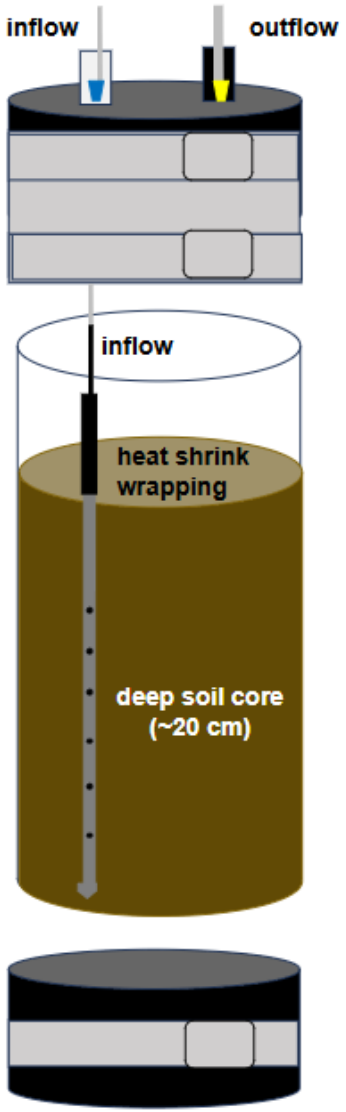
Incubation Core Design





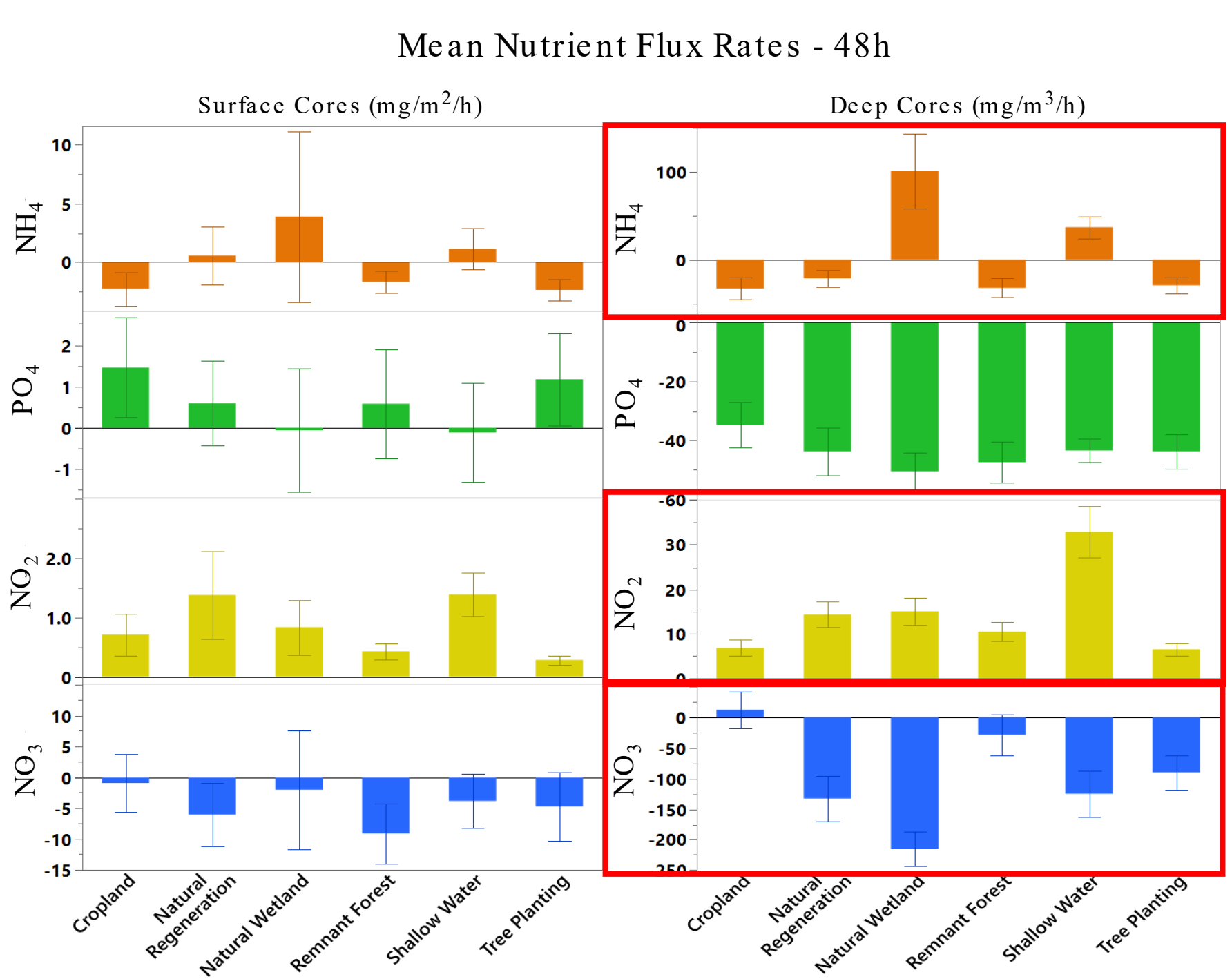
Surface Injection Method – Surface Water

Incubation Core Design



*Rhodamine dye test in a deep injection core following incubation to assess flow distribution through soil.

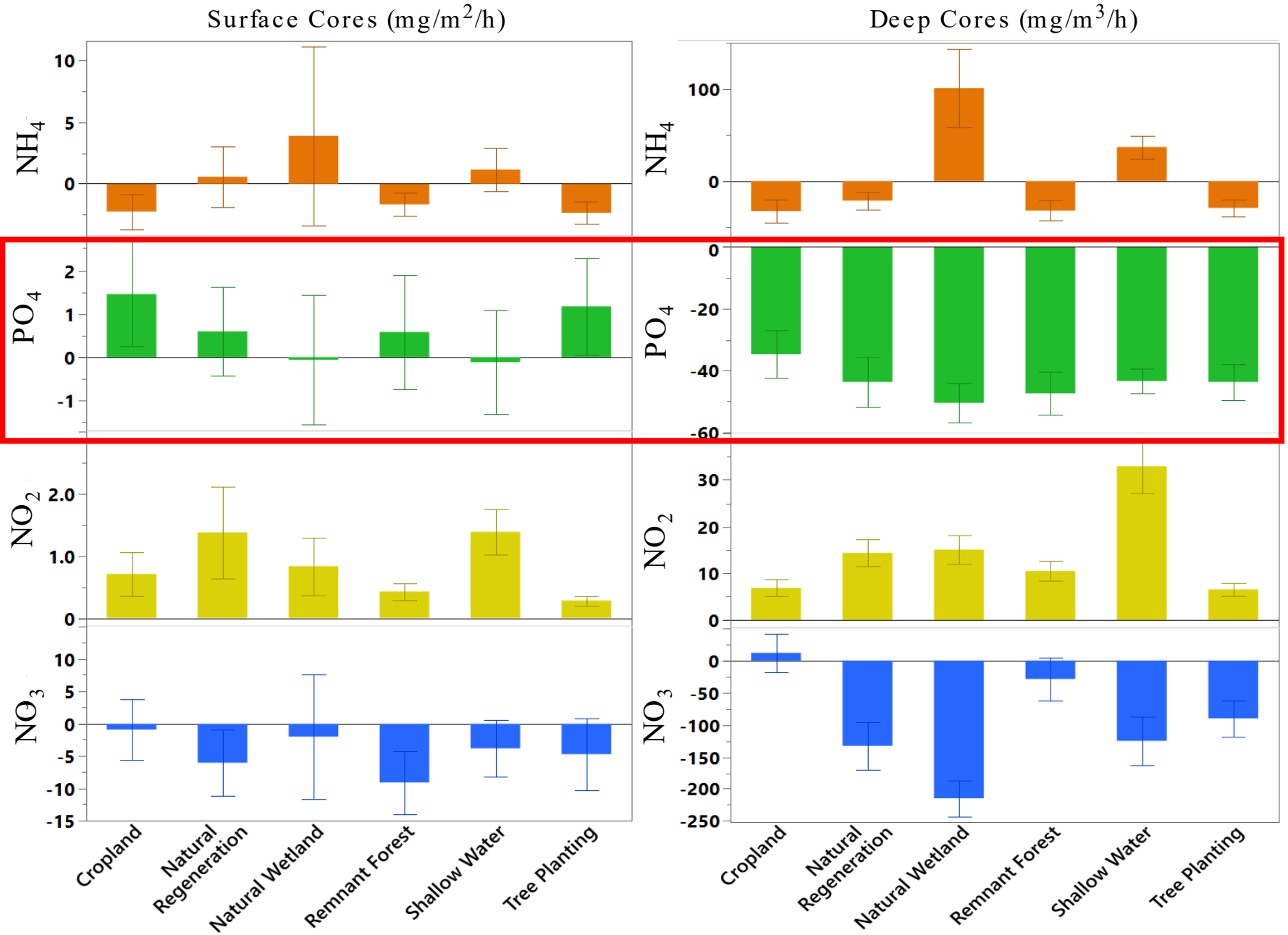
Deep Injection Method – Shallow Groundwater



Nutrients vs. Habitat

- Mean nutrient flux rates at 48h sample timepoint by habitat type (all seasons combined).
- Points of Interest:
  - Mean NH_4, NO_2, & NO_3 flux rates are significantly different between habitat types in deep cores ($F=10.75$; $p<.0001$, $F=9.137$; $p.0001$, $F=3.639$; $p=0.0041$ respectively).

Mean Nutrient Flux Rates - 48h



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  - PO_4 flux in surface (+) vs. deep (-) cores

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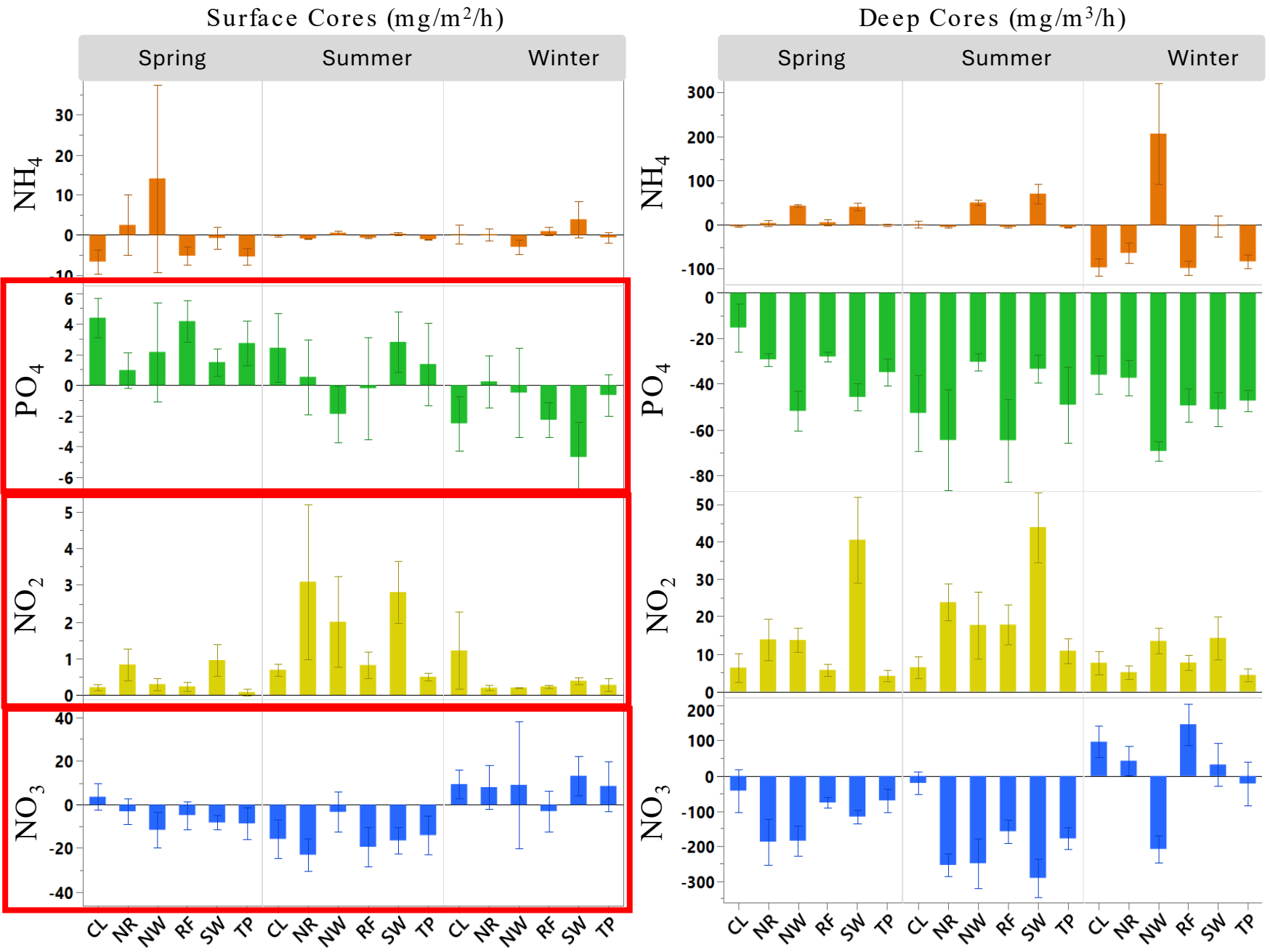

Nutrients vs. Habitat & Season

- Mean nutrient flux rates at 48h sample timepoint by habitat type & season.
- Points of Interest:
  - Mean PO_4, NO_2, & NO_3 flux rates are significantly different between seasons in surface cores ($F=7.619$, $p=.0007$; $F=5.7821$; $p=.0039$; $F=12.138$, $p<.0001$ respectively).

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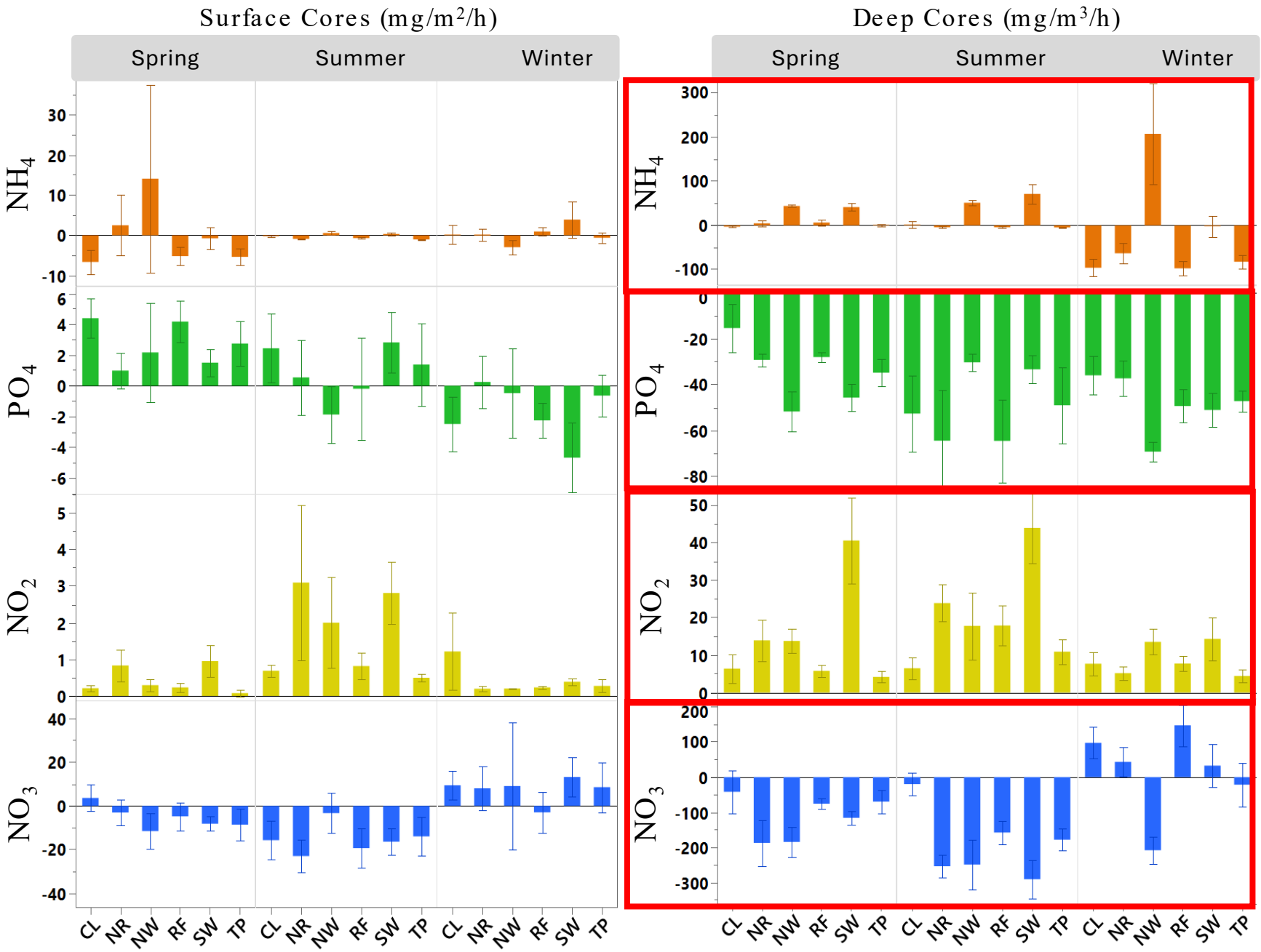

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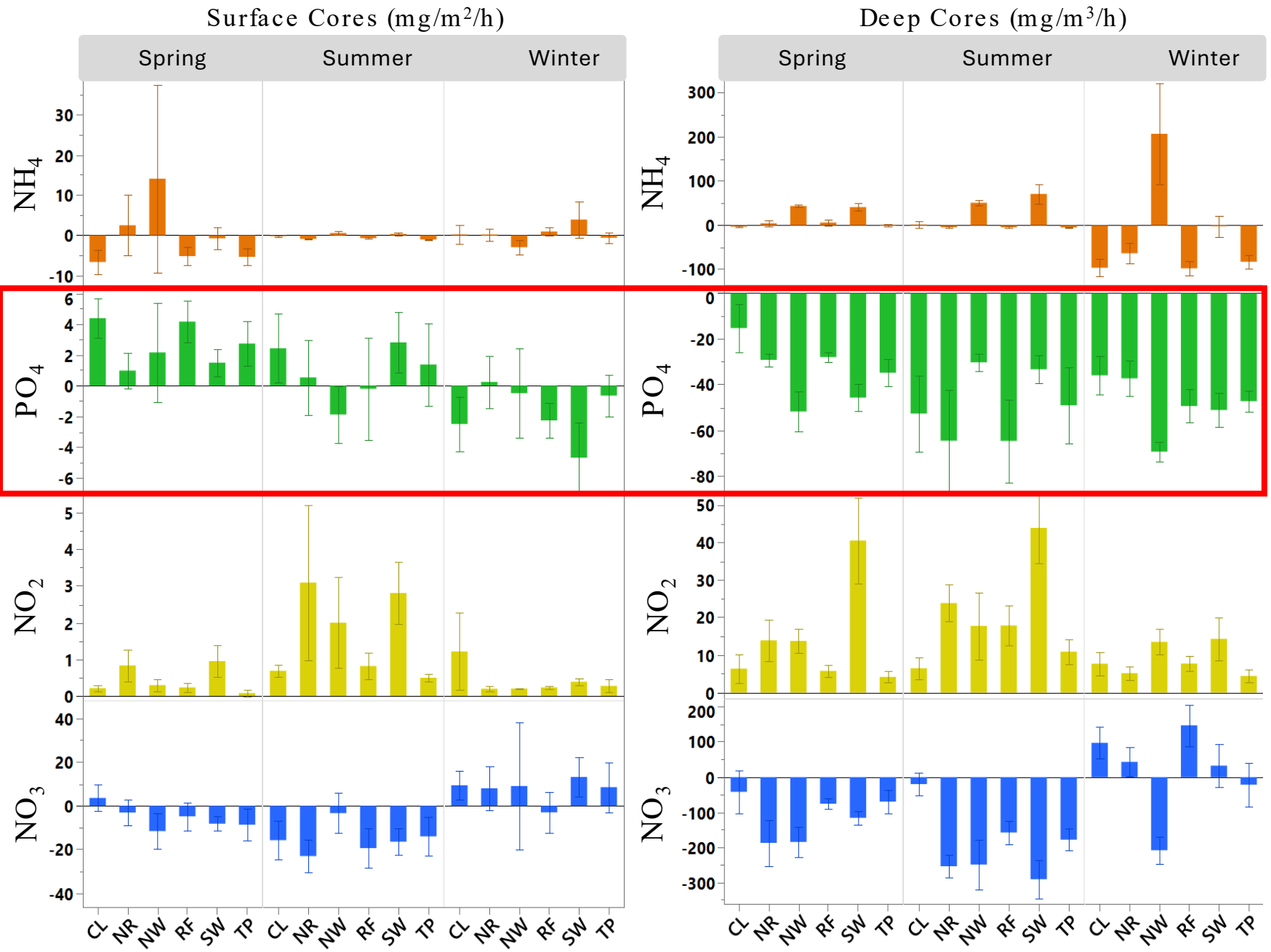
  - All mean nutrient flux rates are significantly different between seasons in deep cores ($F=13.2712$, $p<.0001$; $F=4.078$; $p=.0192$; $F=5.87$, $p<.0001$; $F=29.40$, $p<.0001$ respectively).

Mean Nutrient Flux Rates - 48h



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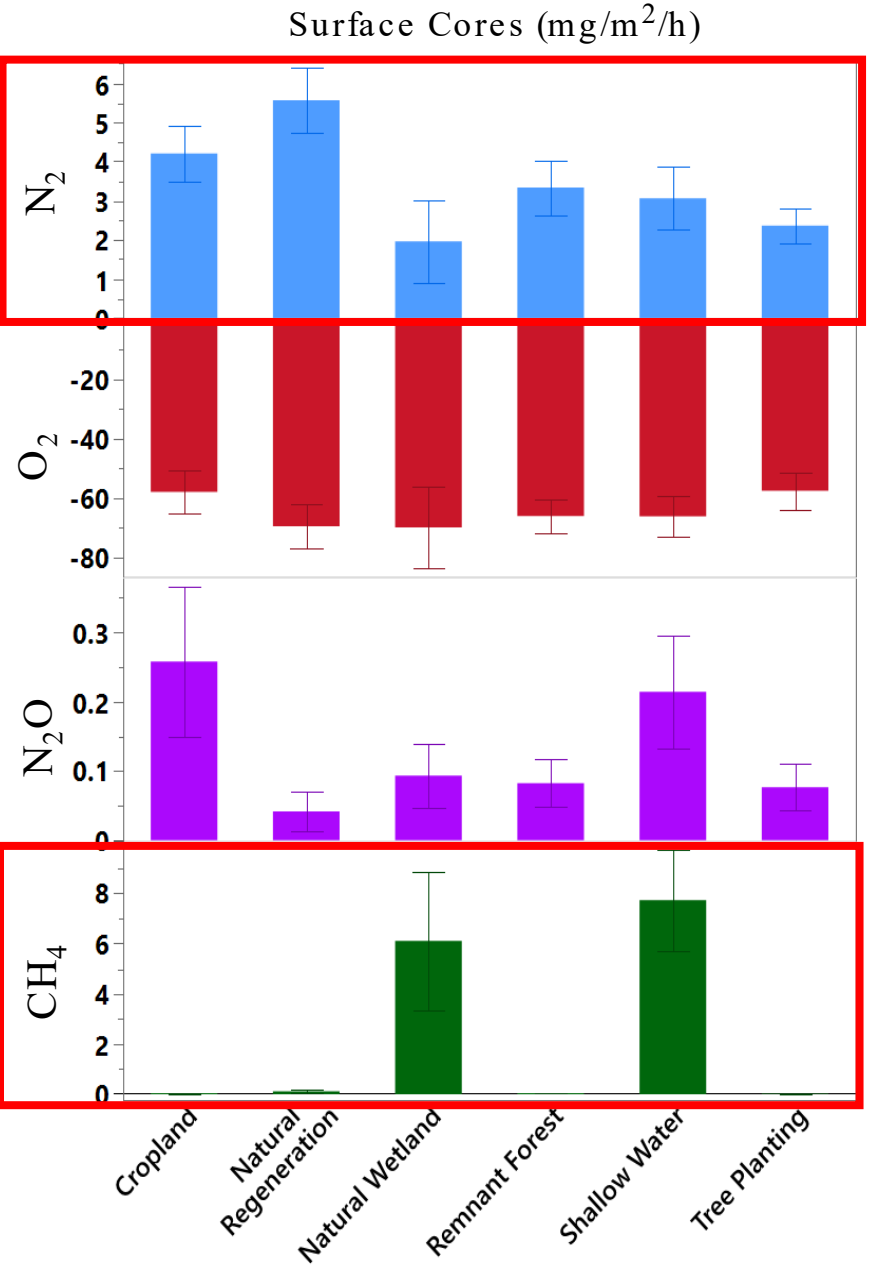
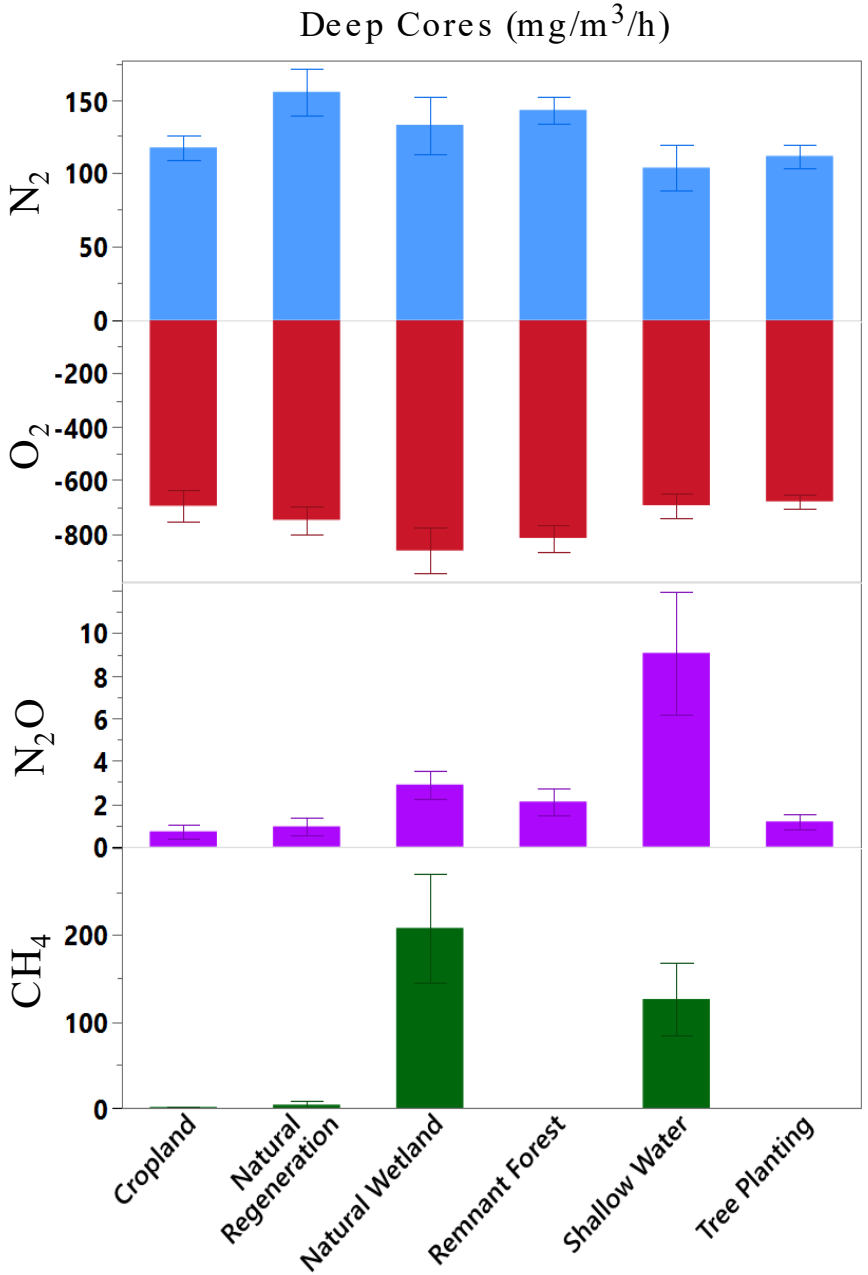
  - PO_4 flux in surface (+/-) vs. deep (-) cores

Mean Gas Flux Rates - 48h

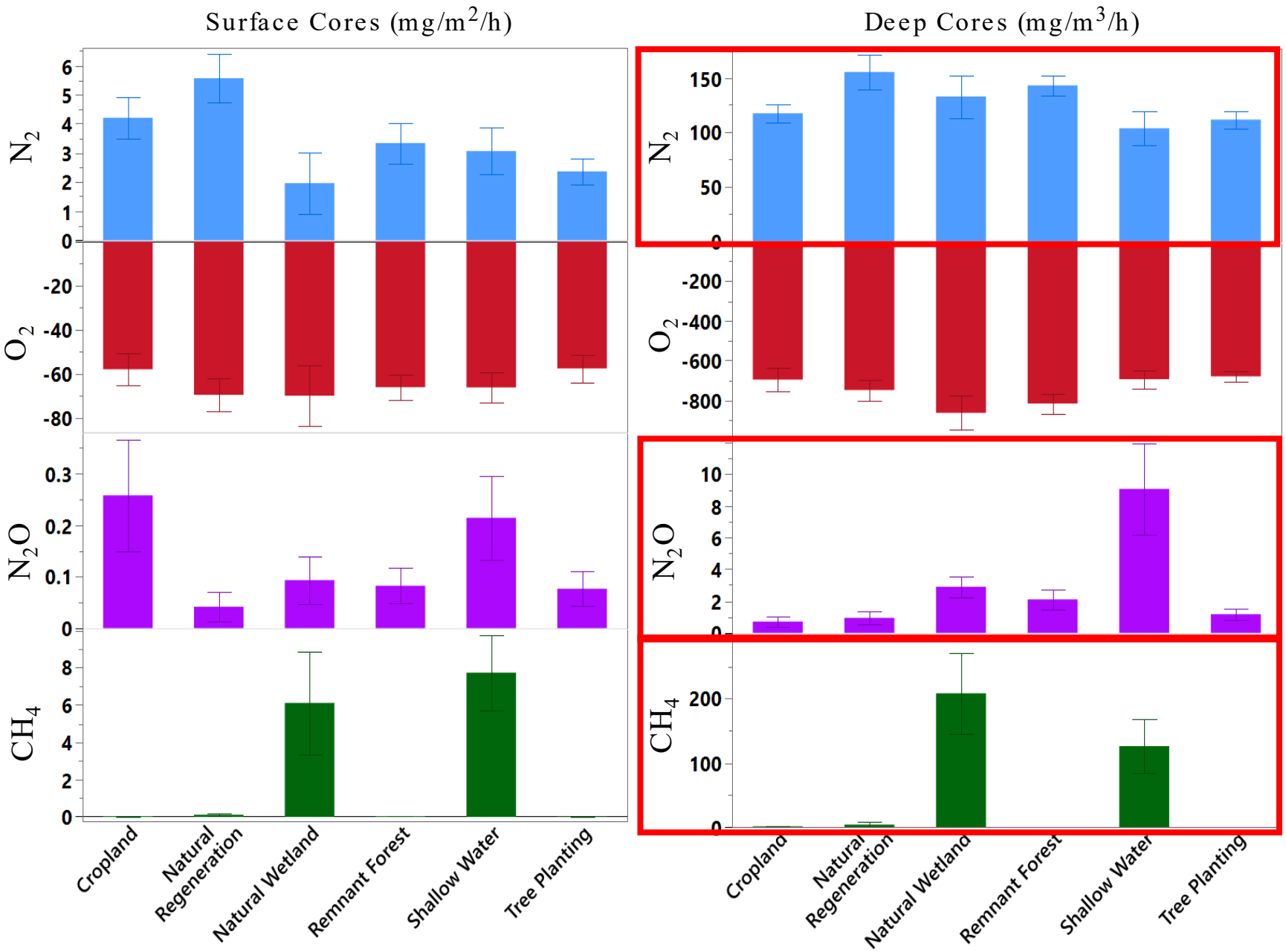




Gases vs. Habitat

- Mean gas flux rates at 48h sample timepoint by habitat type.
- Points of Interest:
  - Mean N_2 & CH_4 flux rates are significantly different between habitat types in surface cores ($F=2.91$, $p=.0161$; $F=10.76$, $p<.0001$ respectively).

Mean Gas Flux Rates - 48h



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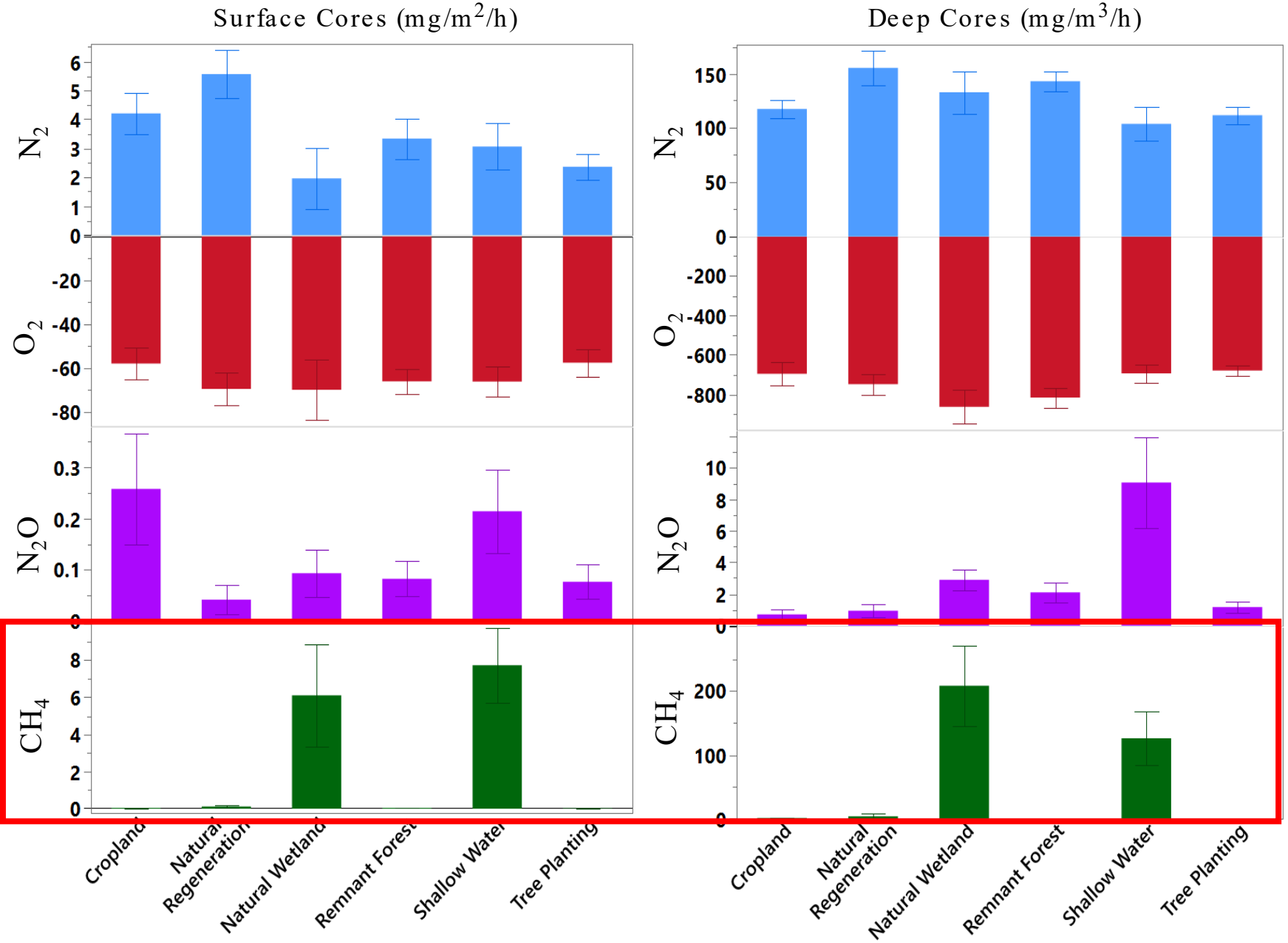
  - Mean N_2, N_2O, & CH_4 flux rates are significantly different between habitat types in deep cores ($F=2.61$, $p=.0278$; $F=5.29$, $p=.0002$; $F=10.05$, $p<.0001$ respectively).

Mean Gas Flux Rates - 48h



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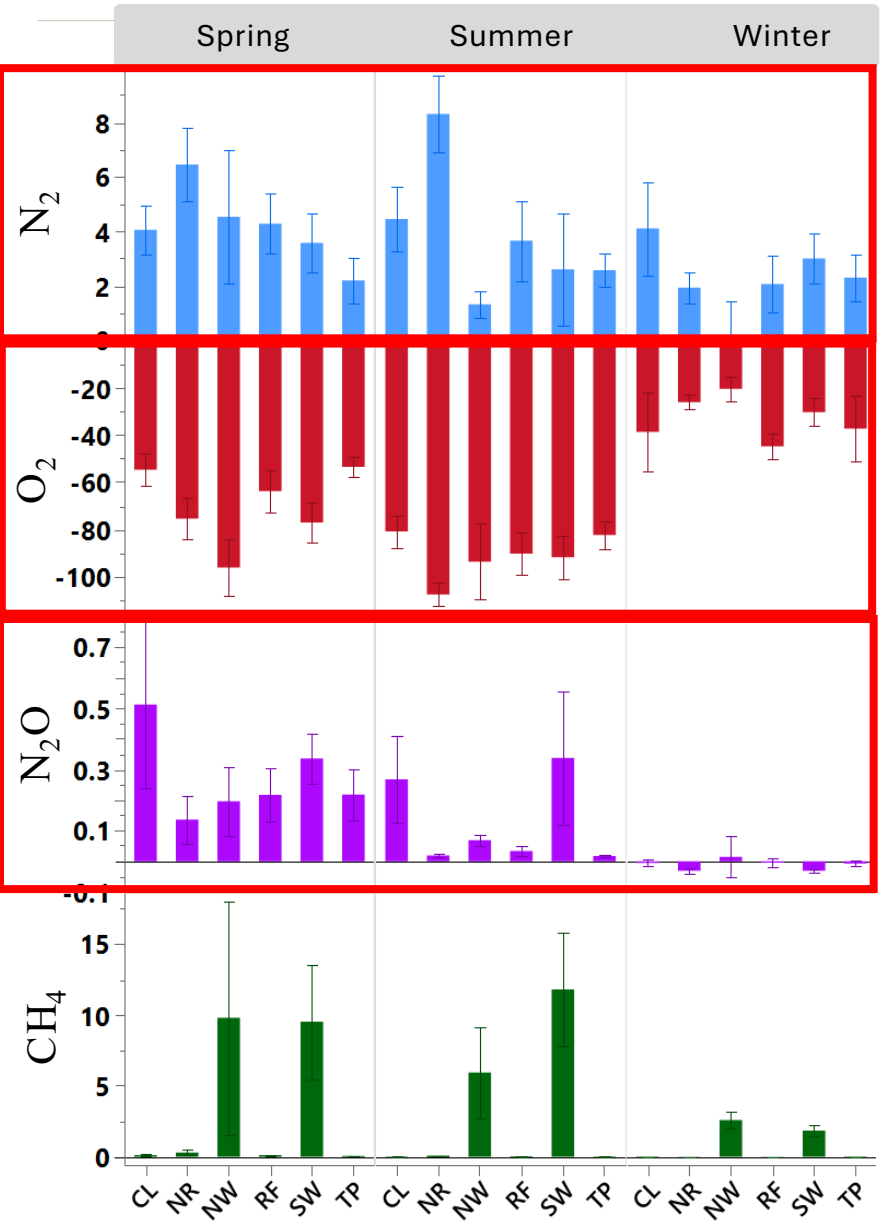
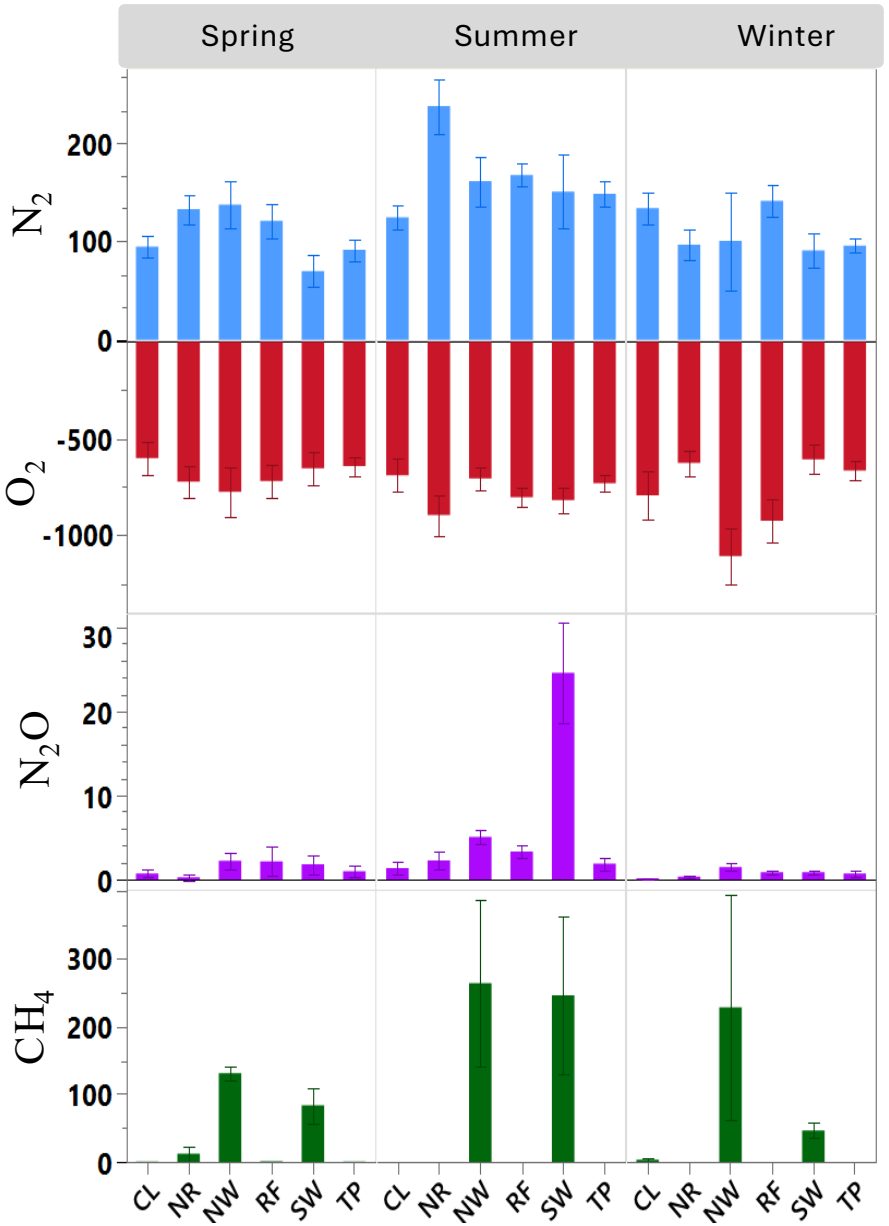
  - CH_4 flux in inundated sites

Mean Gas Flux Rates - 48h

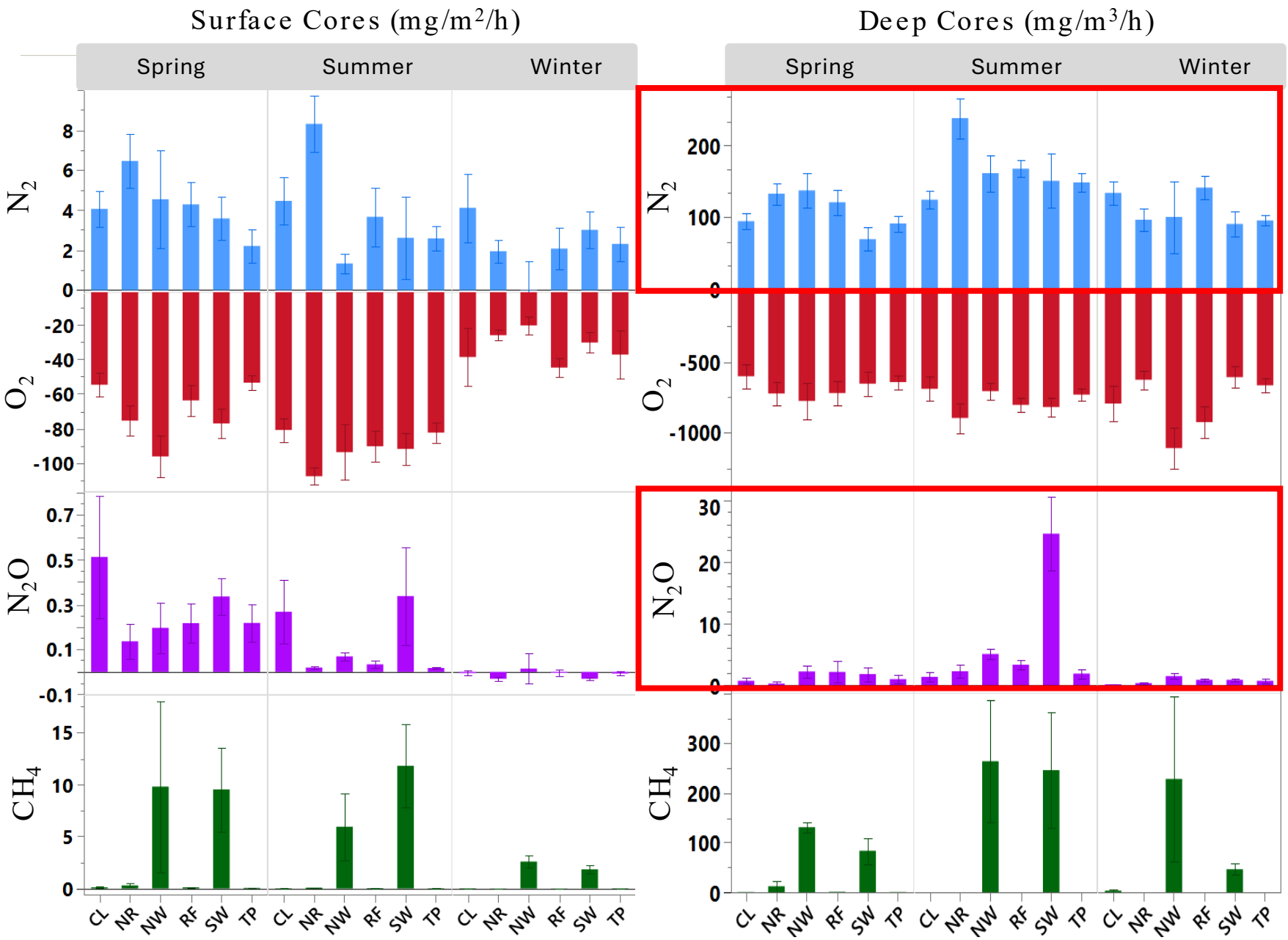




Gases vs. Habitat & Season

- Mean gas flux rates at 48h sample timepoint by habitat type and season.
- Points of Interest:
  - Mean N_2, O_2, & N_2O flux rates are significantly different between seasons in surface cores ($F=3.35$, $p=.039$; $F=61.60$, $p<.0001$; $F=11.62$, $p<.0001$ respectively).

Mean Gas Flux Rates - 48h



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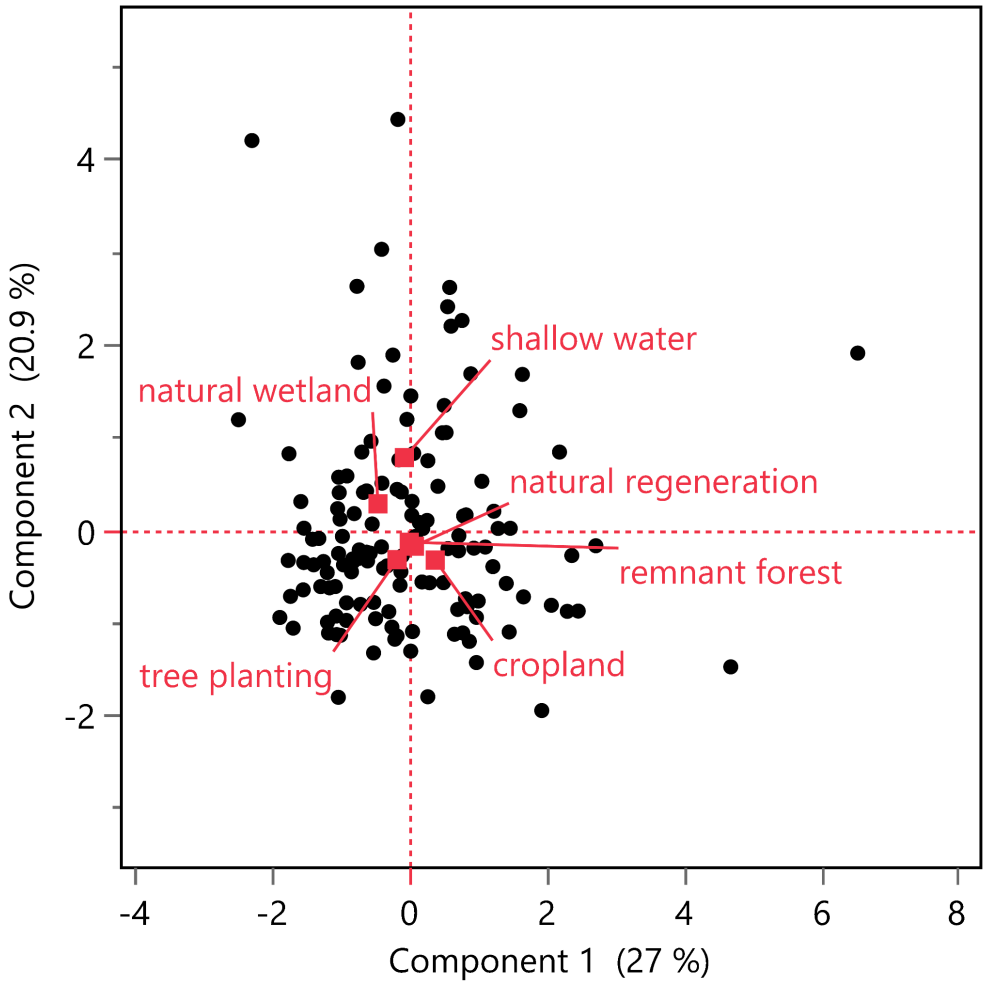
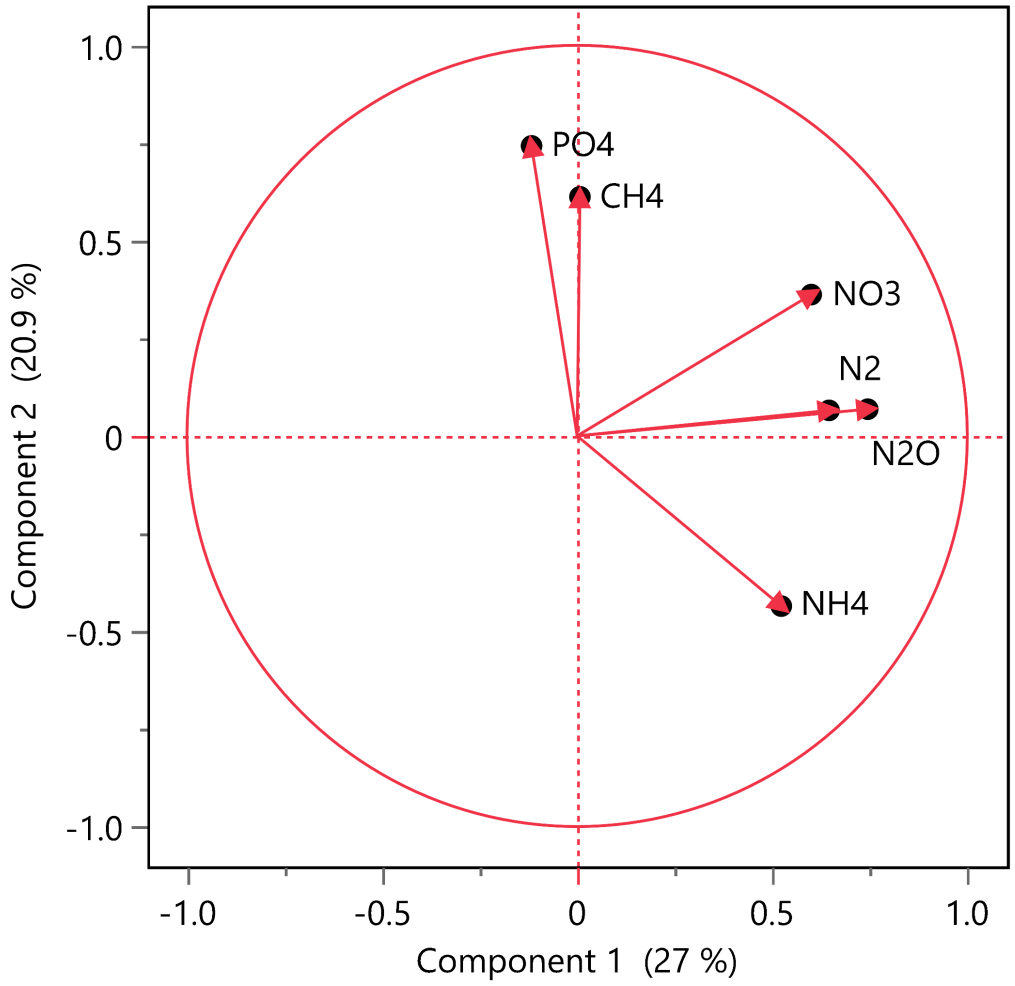
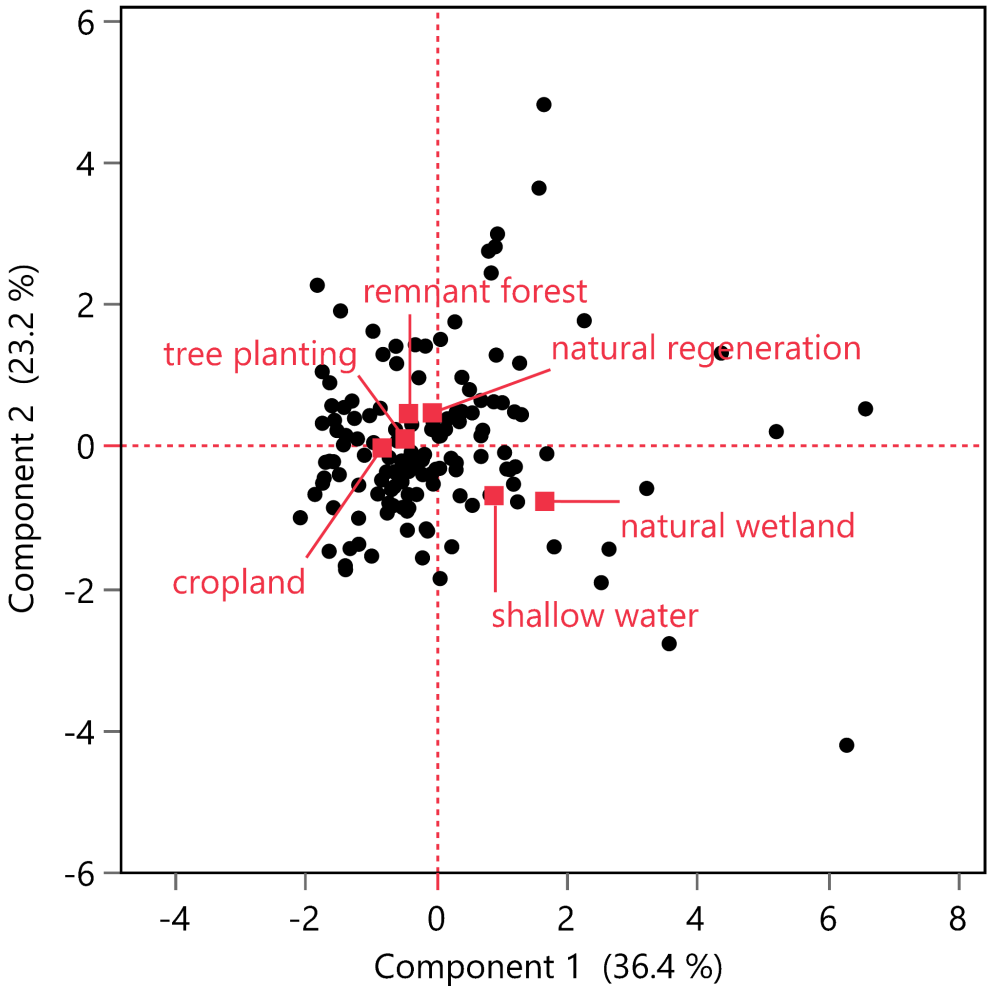
  - Mean N_2 & N_2O flux rates are significantly different between seasons in <u>deep</u> cores ($F=16.46$, $p<.0001$; $F=10.58$, $p<.0001$; $F=10.05$, $p<.0001$ respectively).

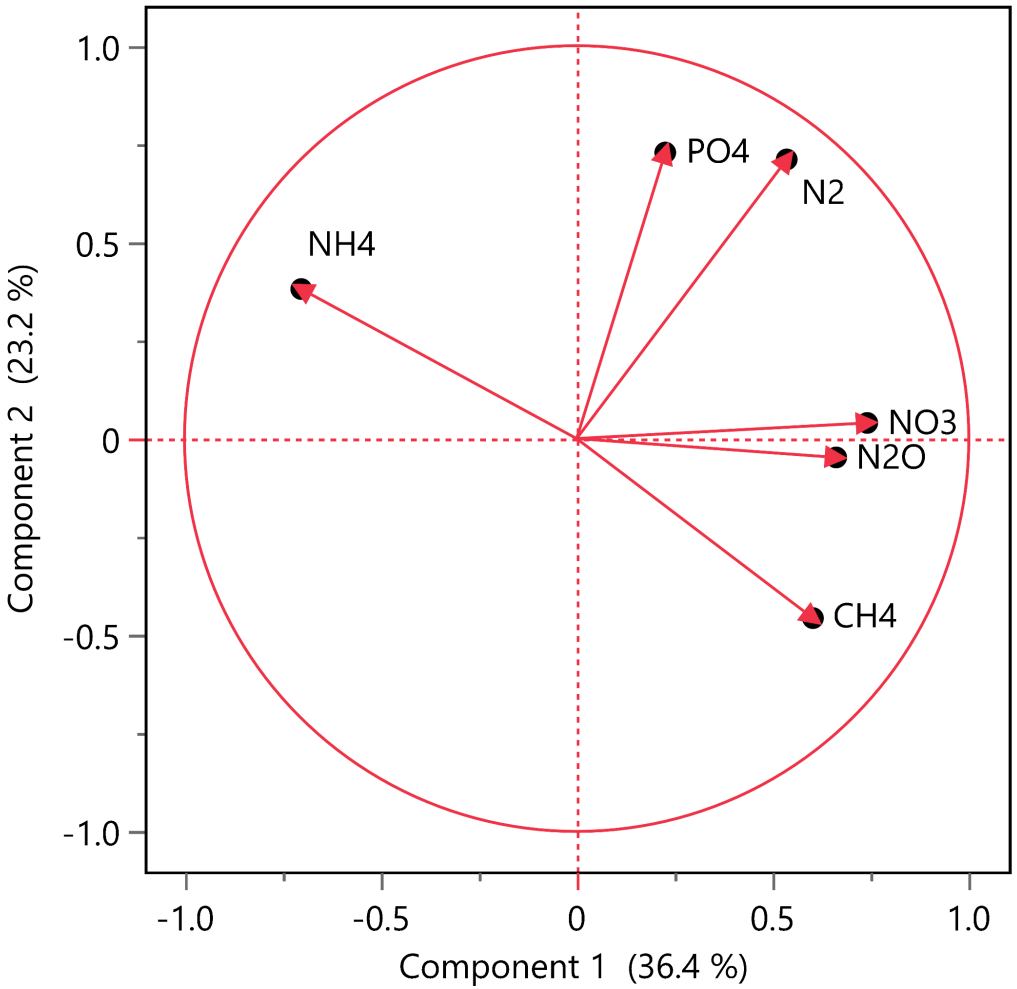
Surface Water Tradeoffs





Shallow Groundwater Tradeoffs



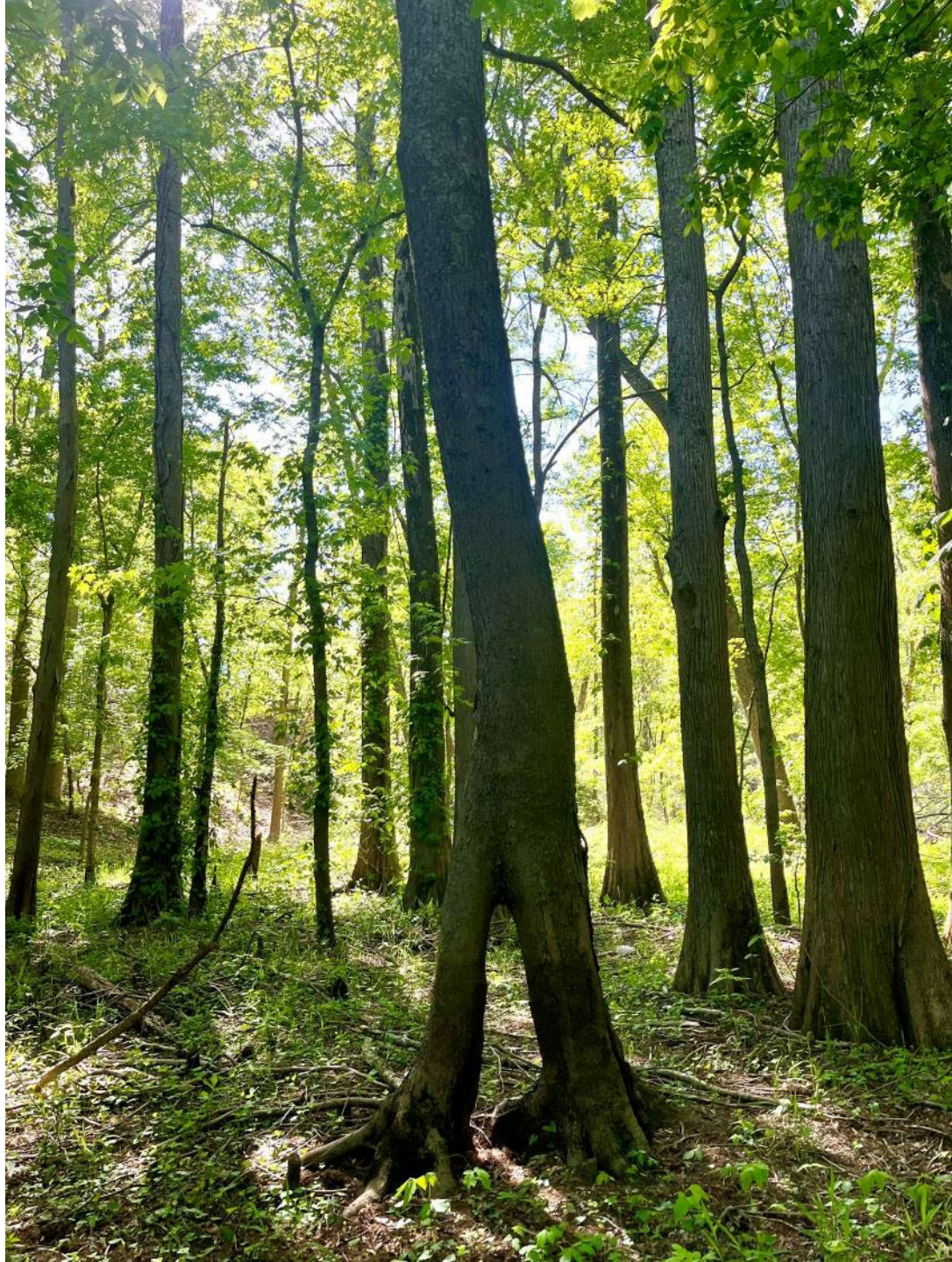


Insights for Restoration Planning

- Inundated areas generally had different rates that dry areas.
  - Higher N and P retention
  - Highest CH_4 and N_2O release

- Dry areas were similar in flux rates
  - Nat Regen had high N_2 release
  - Croplands had high N_2O release

- Nutrient/GHG tradeoffs occurred
  - Surface Waters
    - Locations with highest NO_3 retention and N_2 release had highest N_2O release
    - Locations with the highest PO_4 retention had the highest CH_4 release
  - Shallow Groundwater
    - High NO_3 retention coincides with high N_2O and CH_4 release
- Season variation >> habitat variation
- Groundwater has more consistent nutrient retention than surface water; Keep water on wetlands after a flood



USDA CEAP Wetlands

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