WATER, NUTRIENT AND CARBON BALANCES ON RANCHLANDS IN THE EVERGLADES HEADWATERS

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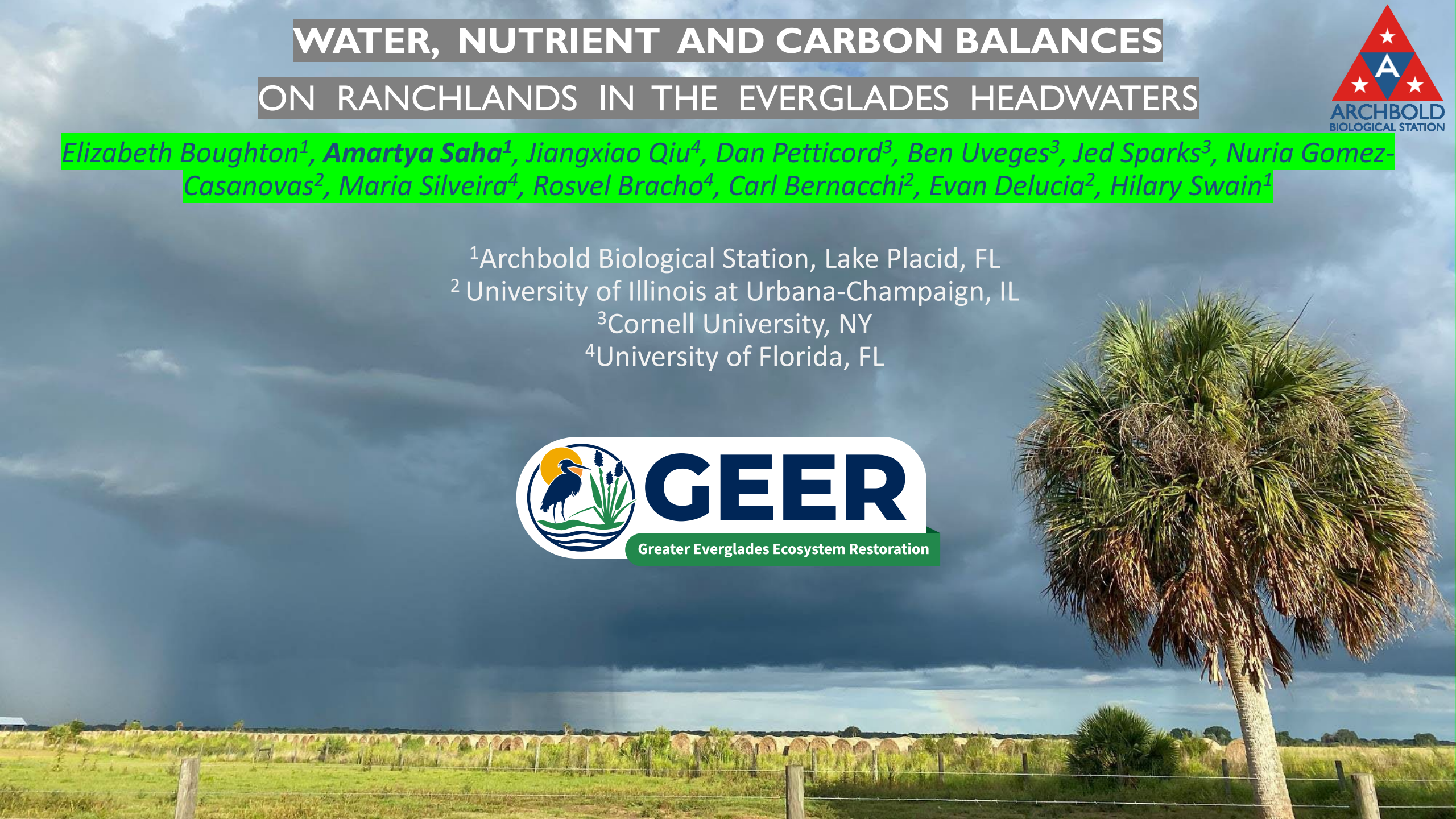
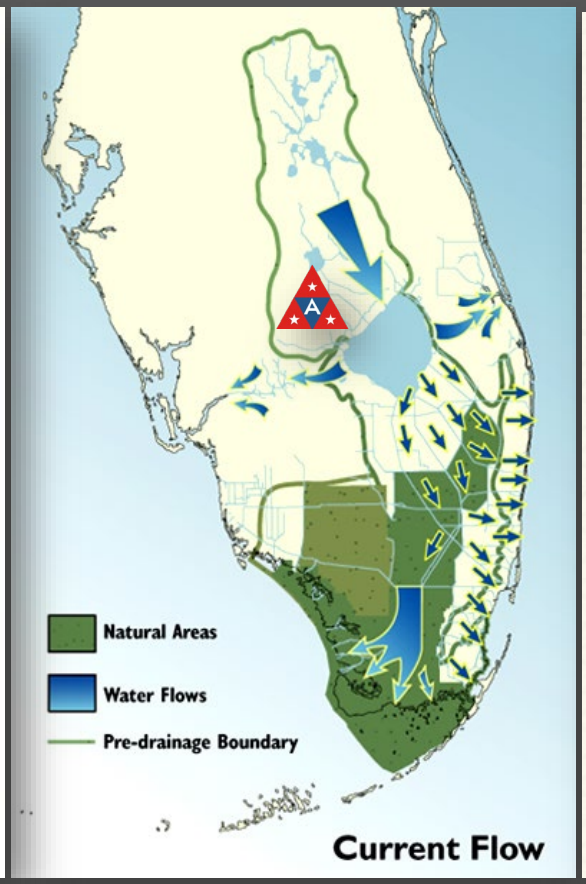
GEER
Greater Everglades Ecosystem Restoration

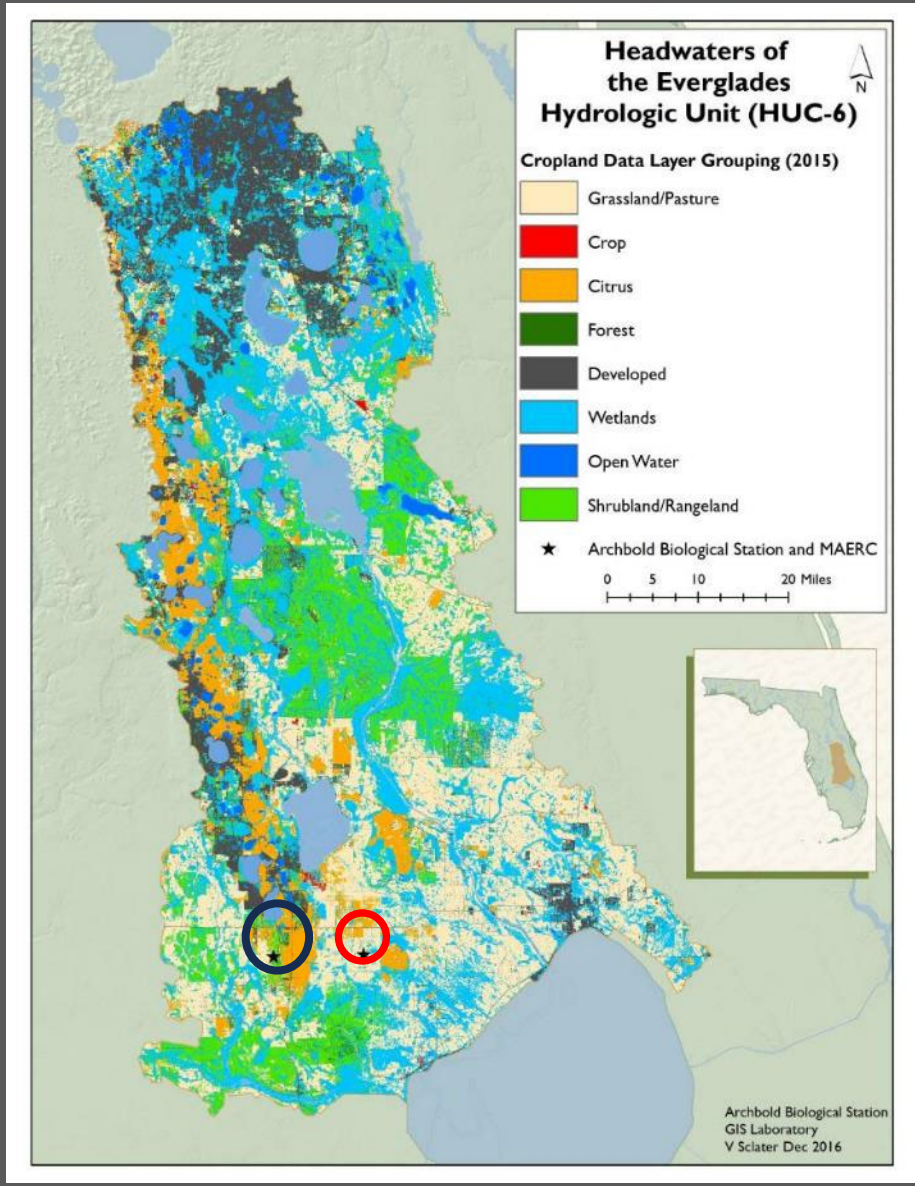


Headwaters of the Everglades

Coupling rural water quality/quantity challenges with flow to Lake Okeechobee and to the coastal estuaries



Source: SFWMD



Introduction

- **40% area of Everglades headwaters are ranchlands (1 million acres)**
- **Benefits** from ranchlands:

Food production, wildlife habitat, wetland + grassland biodiversity, carbon and water services

- **Concerns** from ranchlands:

Legacy Phosphorus -> downstream water quality (algal blooms), greenhouse gas emissions (carbon dioxide, methane).

Understanding local cycles - Important for efficient agriculture and environmental sustainability

This talk briefly synthesizes research at Archbold Biological Station on water, nutrient and carbon dynamics on ranchlands.

- Field data collection and laboratory analyses
- High resolution sensor networks
- Life Cycle analyses, nutrient budgets
- Ecosystem modeling

Water balance of a ranchland basin – slide 1

Buck Island Ranch
Agro-ecology Research Center

- Division of Archbold Biological Station
- 4,290 hectares
- Cow-calf operation, ~3,000 head of cattle
- Improved pasture and native range
- Representative of largest land use in south-central Florida

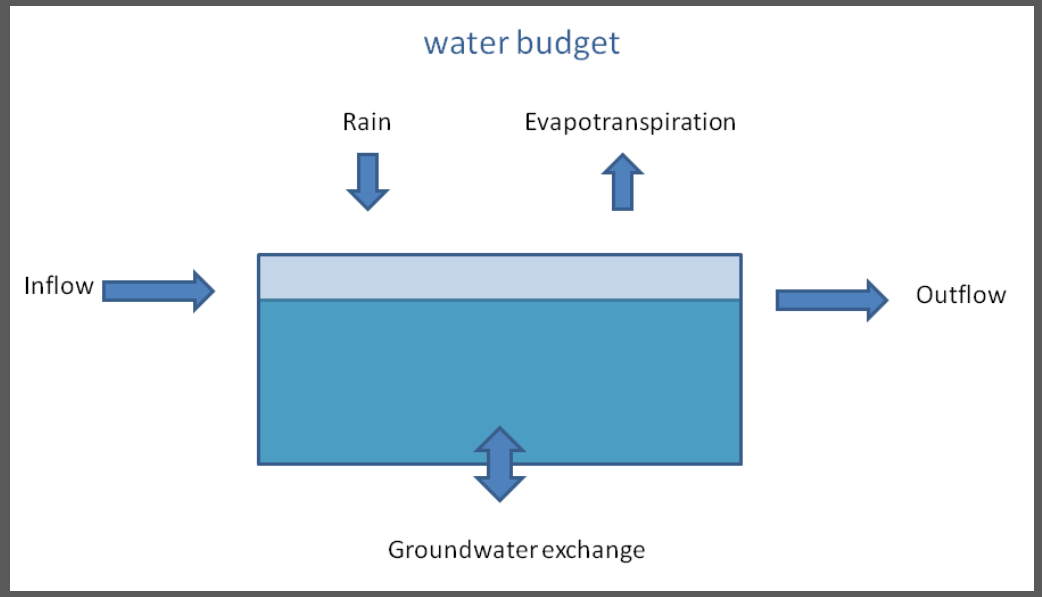
Previous MIKE-SHE modeling on water control structures and water retention in BIR35 sub-basin – Shukla et al

Water balance of a ranchland basin – slide 2

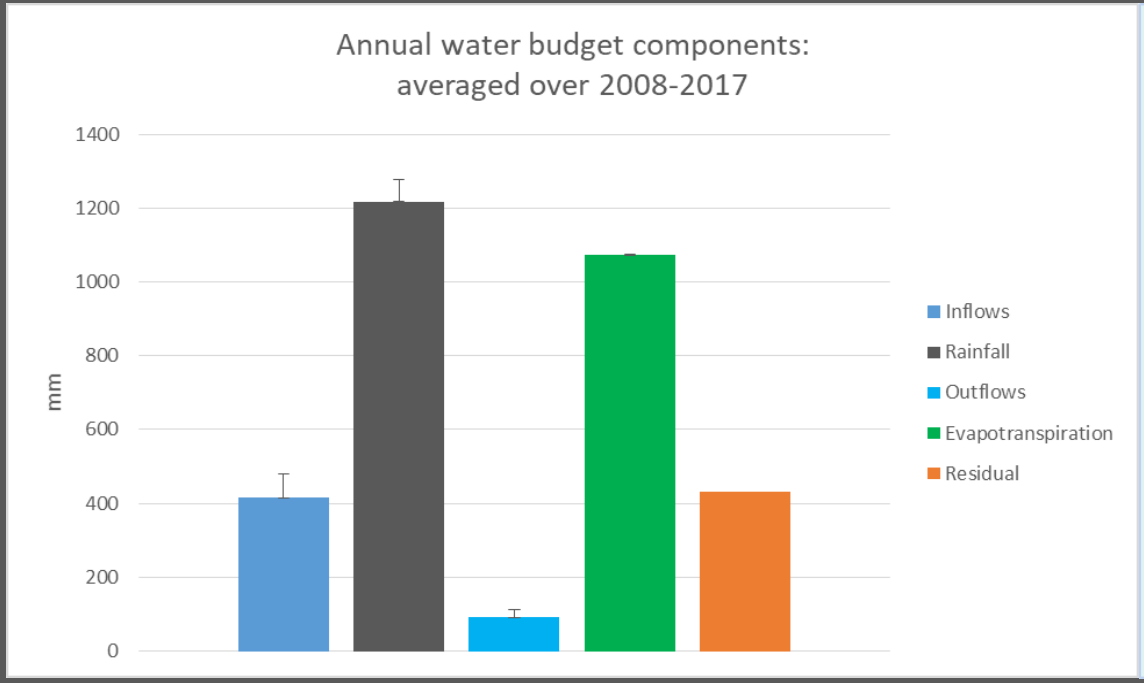
Methods

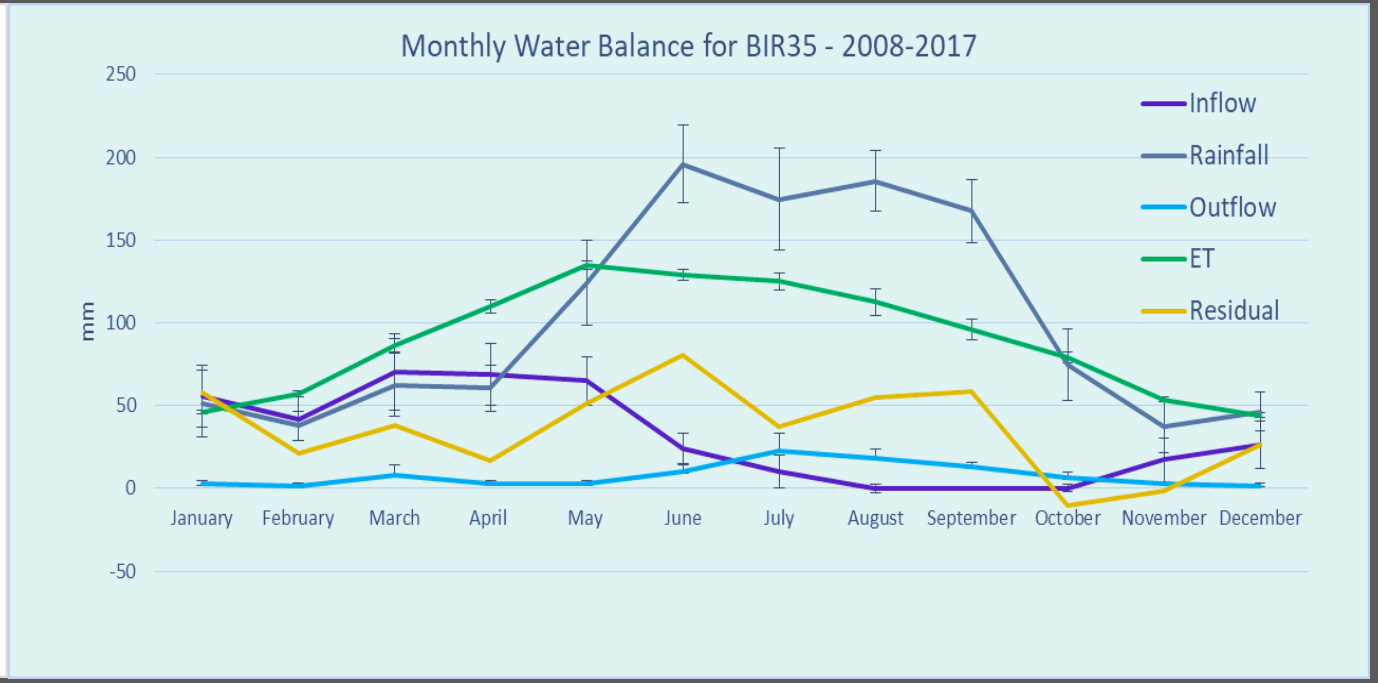
- Daily data over 2008-2017
- **Precipitation:** Rain gauges at BIR weather stations
- **Inflows**: records of pumped-in water from Harney Pond Canal
- **Outflows:** Discharge data from water level transducer and culvert flow equation at BIR35 station
- **Evapotranspiration**–Hamon(1960) and FAO Penman Monteith models, ET data from the FAWN(UF) network for Okeechobee and SFWMD ET data for Northern Everglades.
- **Residual** = Precipitation + Inflow – Outflow – ET

Residual includes soil moisture storage change, net groundwater recharge and error in each water balance term



Water balance of a ranchland basin – slide 3



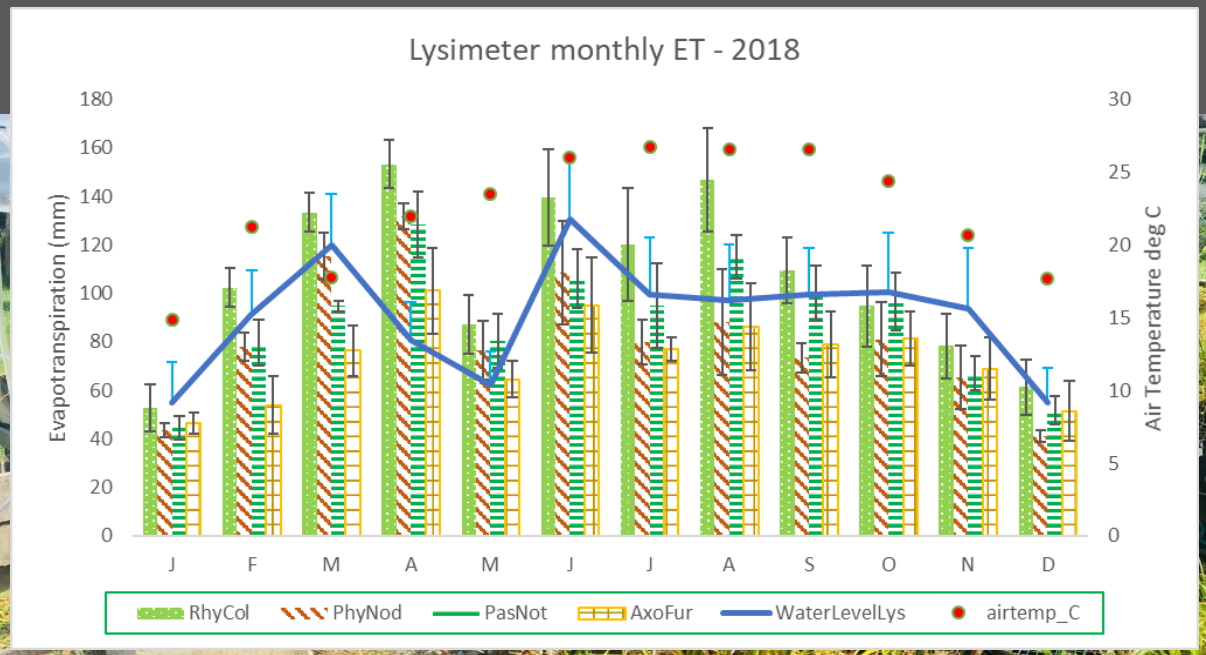


- Precipitation mainly occurs between June and September, and ~ 30% over the dry season as winter fronts.
- Evapotranspiration is related to the growing season (peaking in May and thereafter slowly declining with cloudiness and shortening daylength).
- Inflows occur in the dry season as water is pumped in for pasture irrigation.
- Outflows follow rainfall. ~90 +/- 25 mm/year
- Infiltration occurs over the year, except in late wet season (Negative values) suggesting groundwater contribution to outflows and ET over that period. ~400 +/- 350 mm/year

Water balance – uncertainties - slide 4

1. **Seepage/infiltration** – usually estimated as a residual of measured components. Using Drain Gage (METER) to quantify infiltration as well as nutrient concentration in leachate

2. **Evapotranspiration** – uncertainty in measuring. Large component of water balance – errors affect seepage estimates.

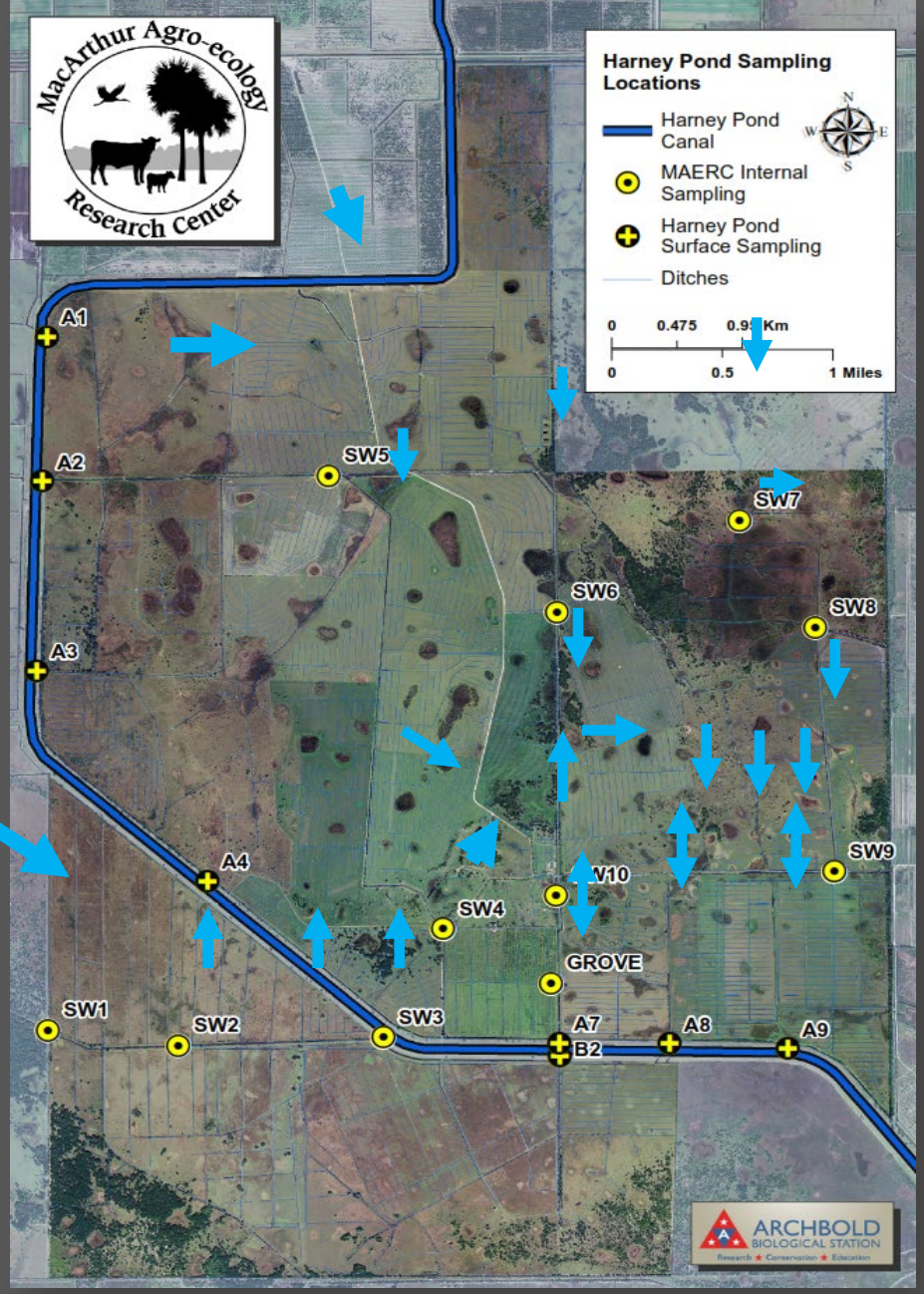


Lysimeters measure ET – ET varies by species and community types – *Saha et al 2023 Ecohydrology*

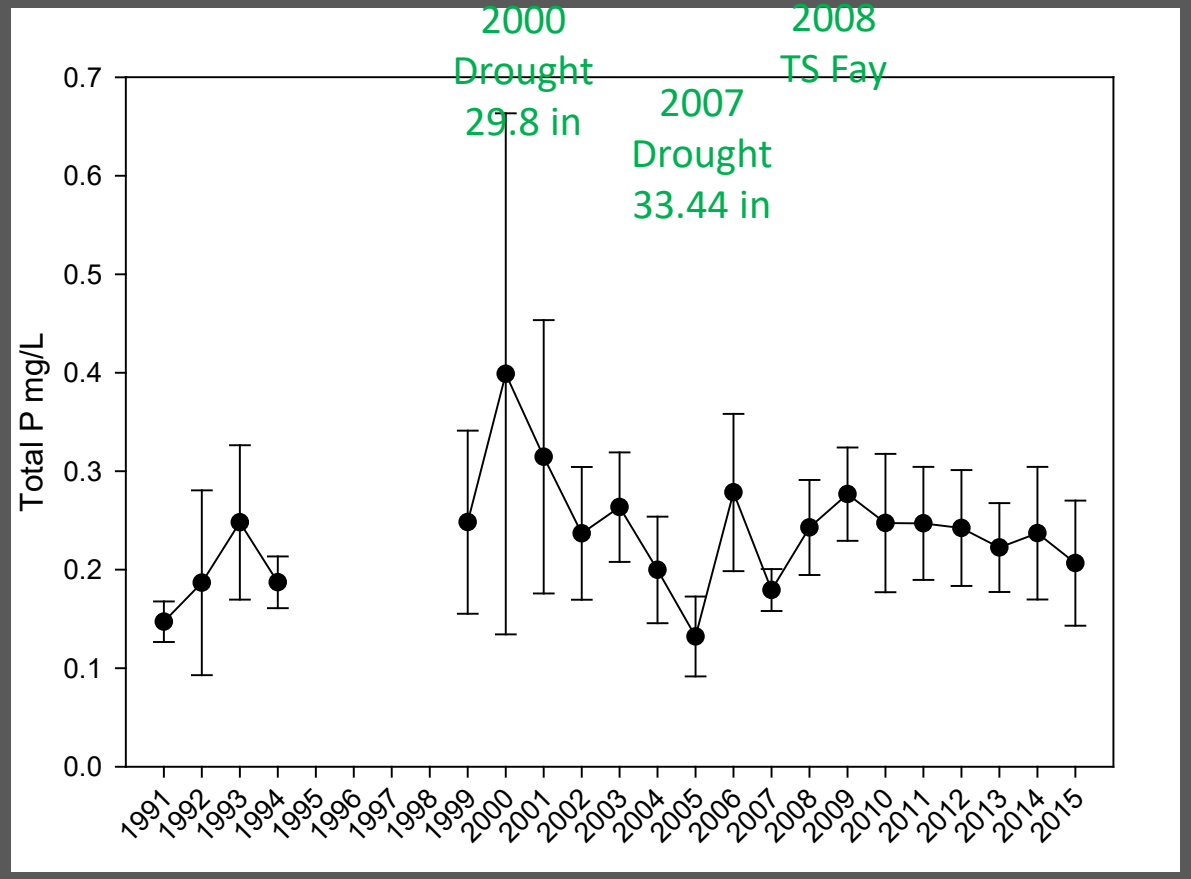
Buck Island Ranch
Long-term Water Quality Sampling

Long-term sampling locations show almost no change in phosphorus concentrations since ~1991, although within permit levels

LEGACY PHOSPHORUS



1991-2015Total P Average =0.24 mg L-1



Water/Nutrient Management on ranches

Buck Island Ranch – 10,500 Acres

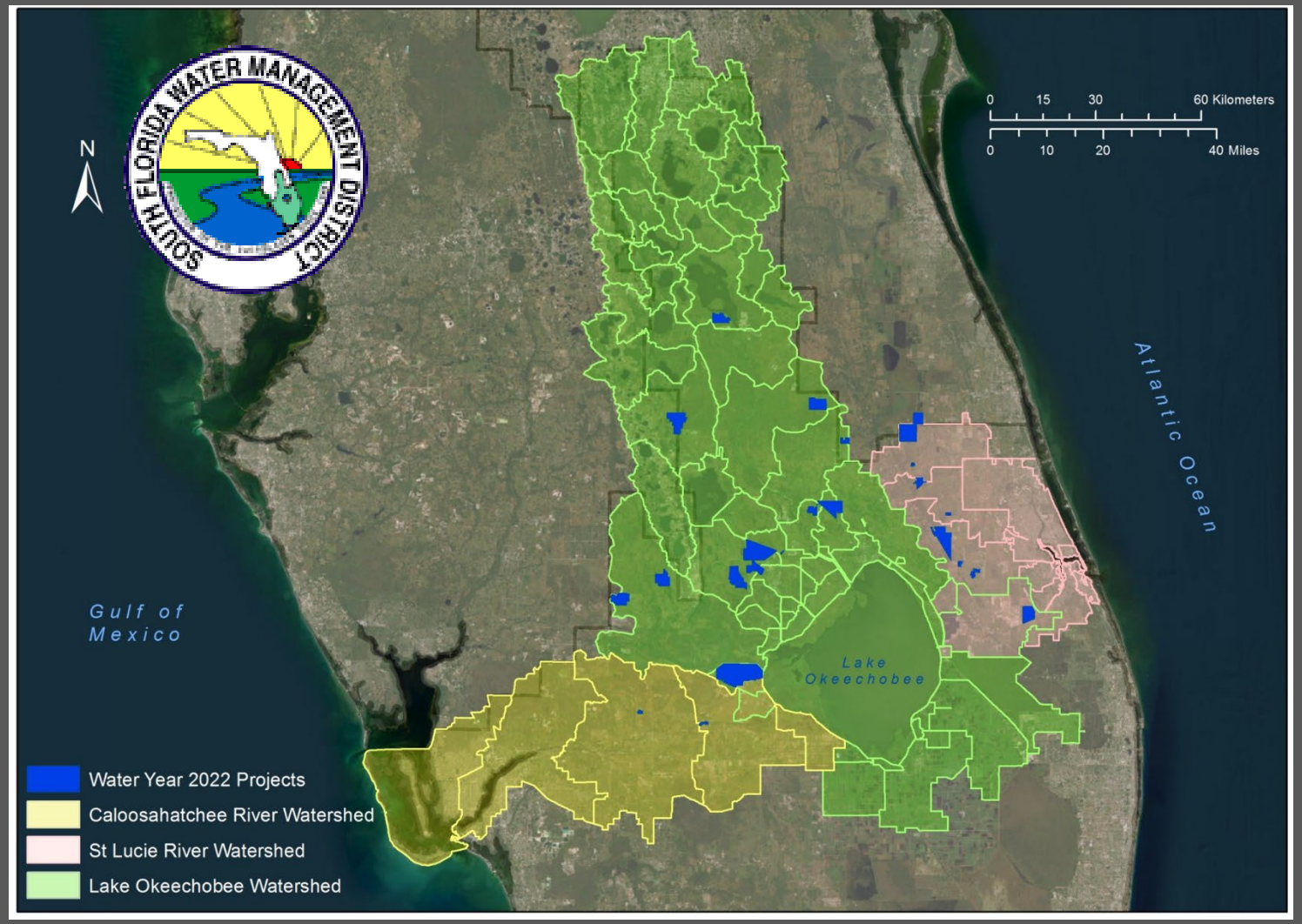
- 629 wetlands
- ~500 miles of ditches
- Regional canal to Lake Okeechobee is C41, the Harney Pond Canal
- Legacy P in the interior improved pastures

More than 100 water control structures on Buck Island Ranch

Ranches can provide water + nutrient retention

Payment for Water Services (SFWMD)

Dispersed Water Management (DWM) in the Everglades Headwaters



Need ~1M acre-feet of water north of Lake O to reduce excessive discharges

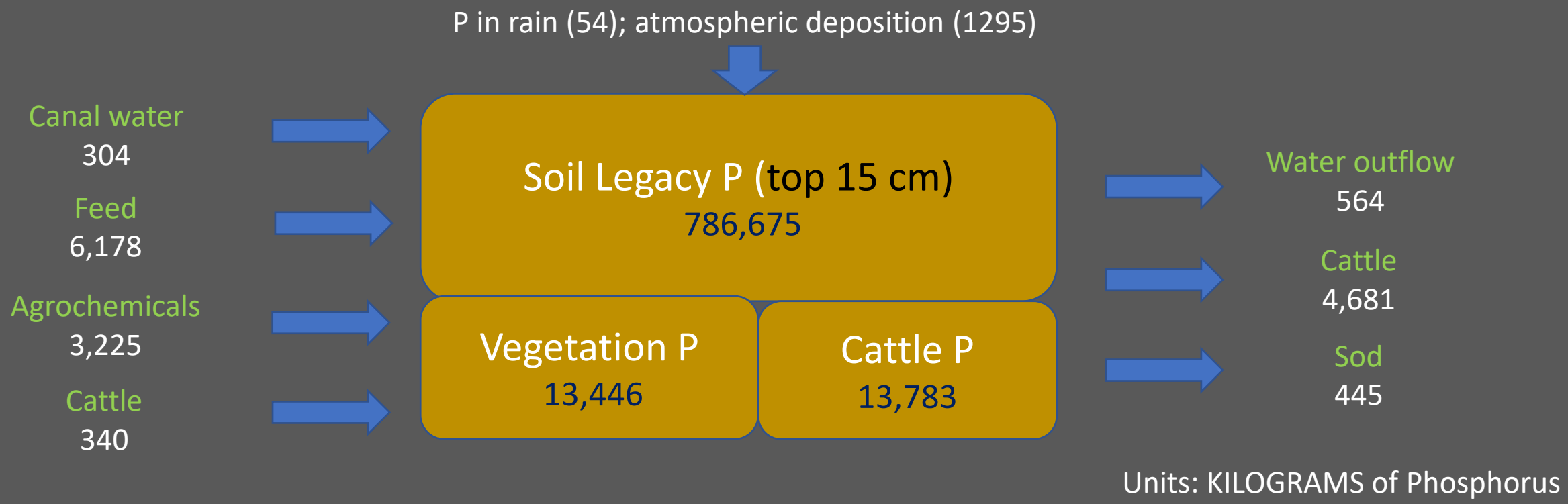
PES solutions complement other initiatives

DWM projects also provide multiple co-benefits:

- Wetland hydroperiod enhancement
- Benefits to aquatic organisms
- May reduce undesirable land use change

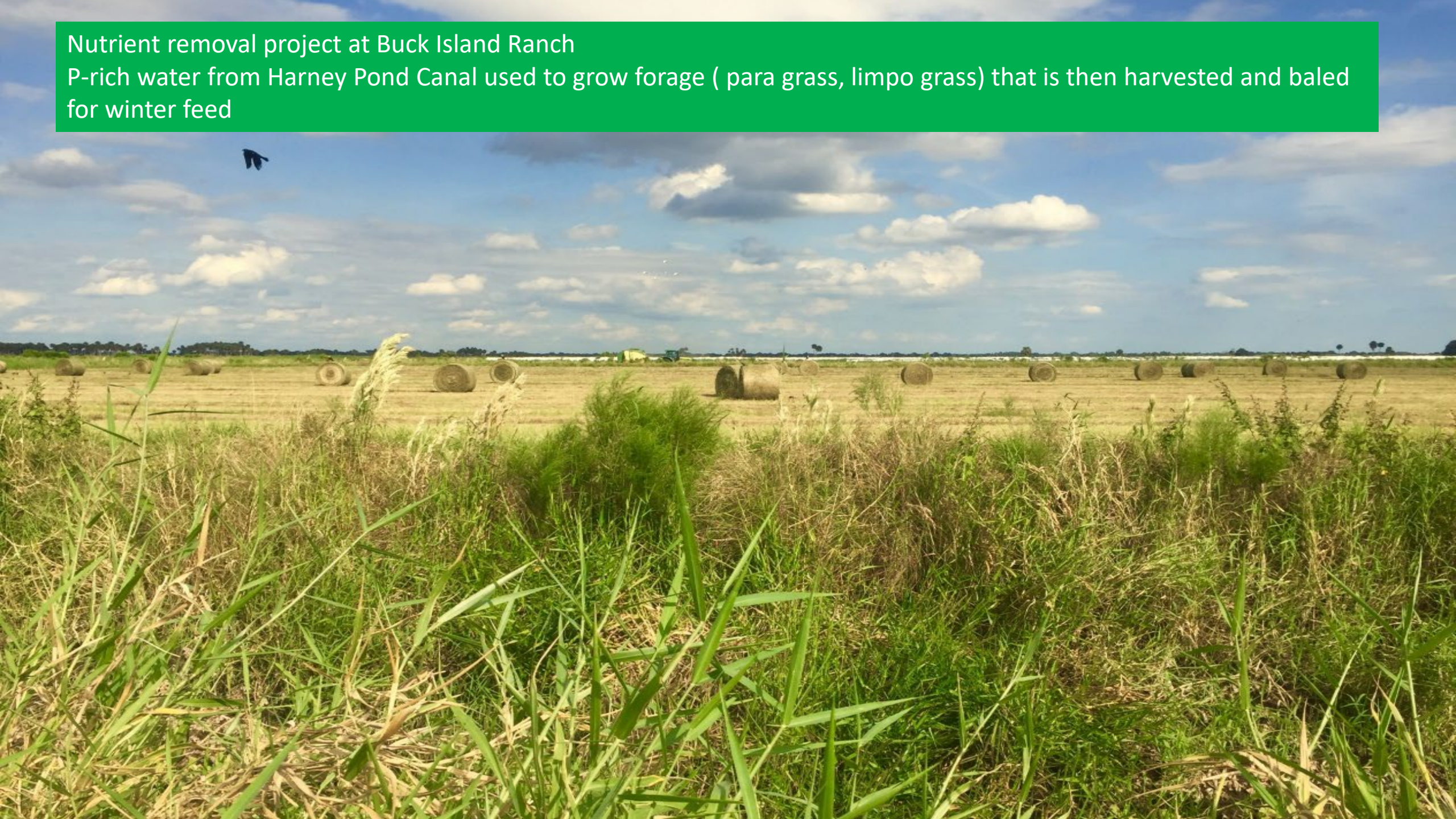
Annual Farm-to-Gate Phosphorus Budget (2008-2018) for Buck Island Ranch

Kohmann et al 2021 'Farm-scale phosphorus budgets of beef cow-calf operations



Net import of ~5500 kg P / 10500 acres

Opportunities to decrease feed and water outflows


Nutrient removal project at Buck Island Ranch
P-rich water from Harney Pond Canal used to grow forage (para grass, limpo grass) that is then harvested and baled for winter feed

Phosphorus Budget (2018-2022)

Buck Island Ranch Nutrient Removal Project

P_rain: 20 lbs
OR
Wet+Dry Deposition:
206 lb

P in forage harvest:
12769 lbs

P inflow
Canal water:
814 lbs

Soil Legacy P (2017)
115826 lbs in
188 acres, top 75 cm

P outflow:
897 lbs

P removal by forage harvest: 18 lbs P / acre per year

The Carbon Story on Florida ranchlands

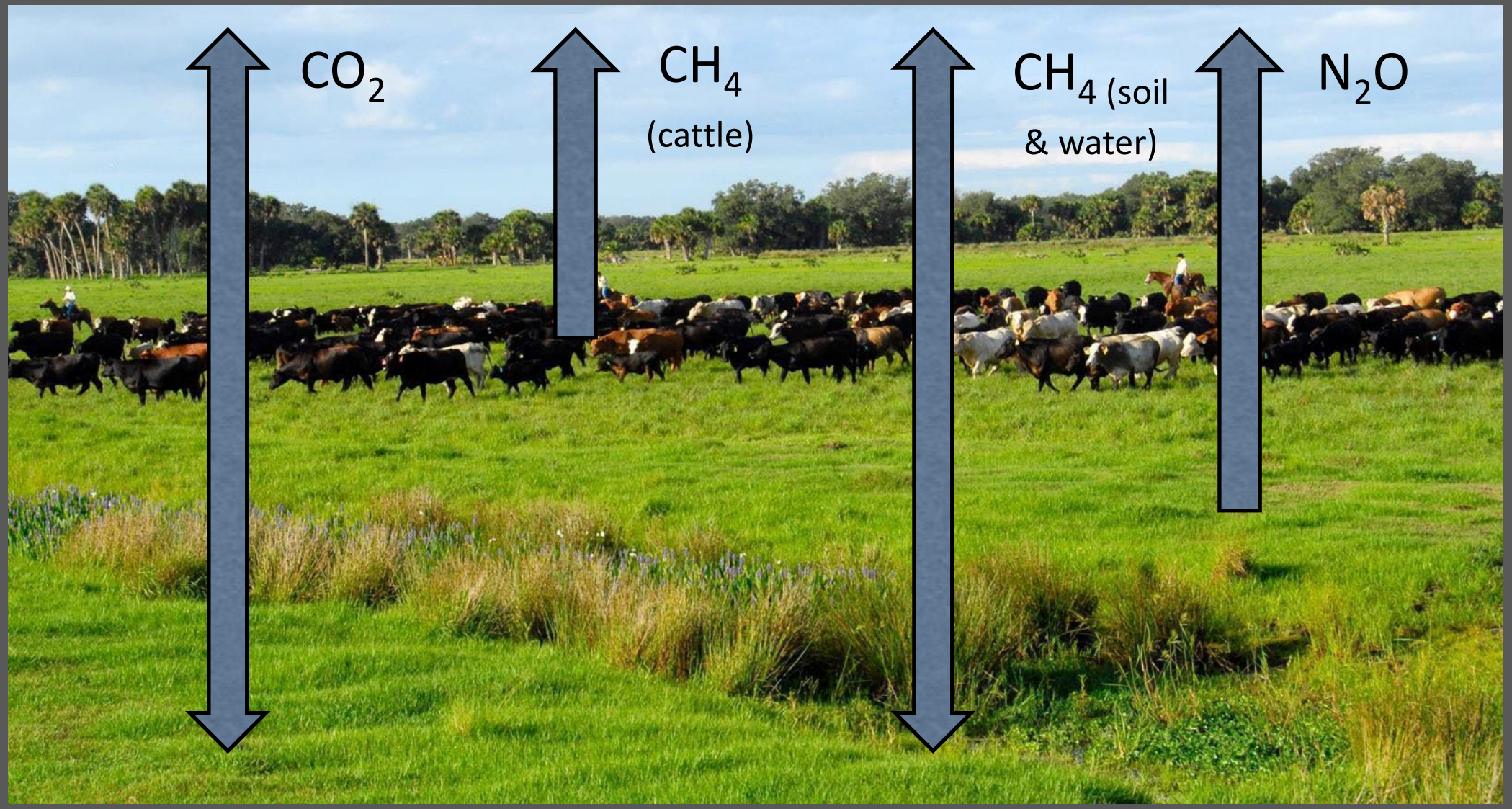
Understanding our carbon cycle to inform climate mitigation -

1. Are Ranches Carbon sinks or sources?

2. How does seasonality and ranch management – grazing, fire and irrigation affect this ?

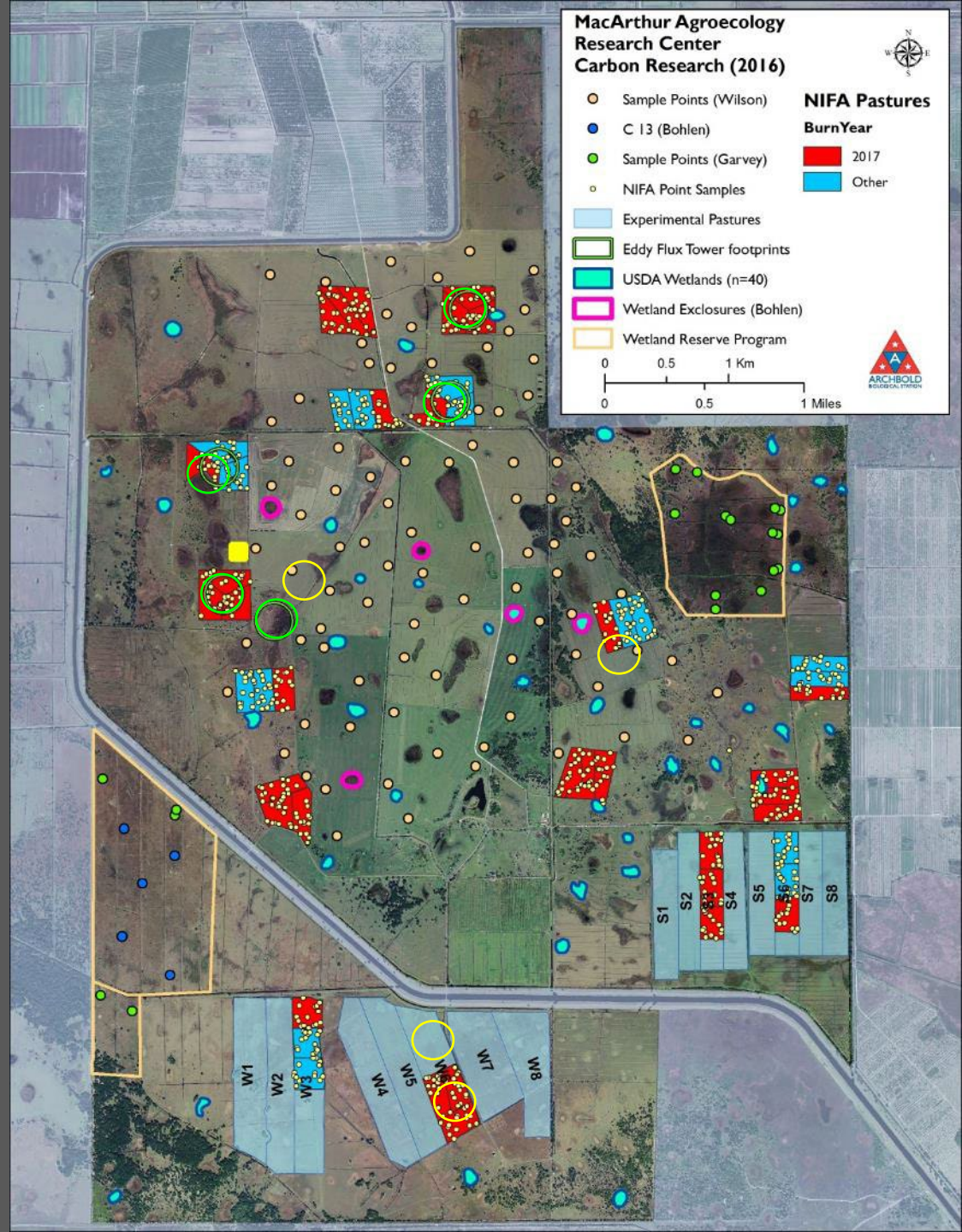
3. Methane from wetlands and cows

Pasture Greenhouse Gas Exchange

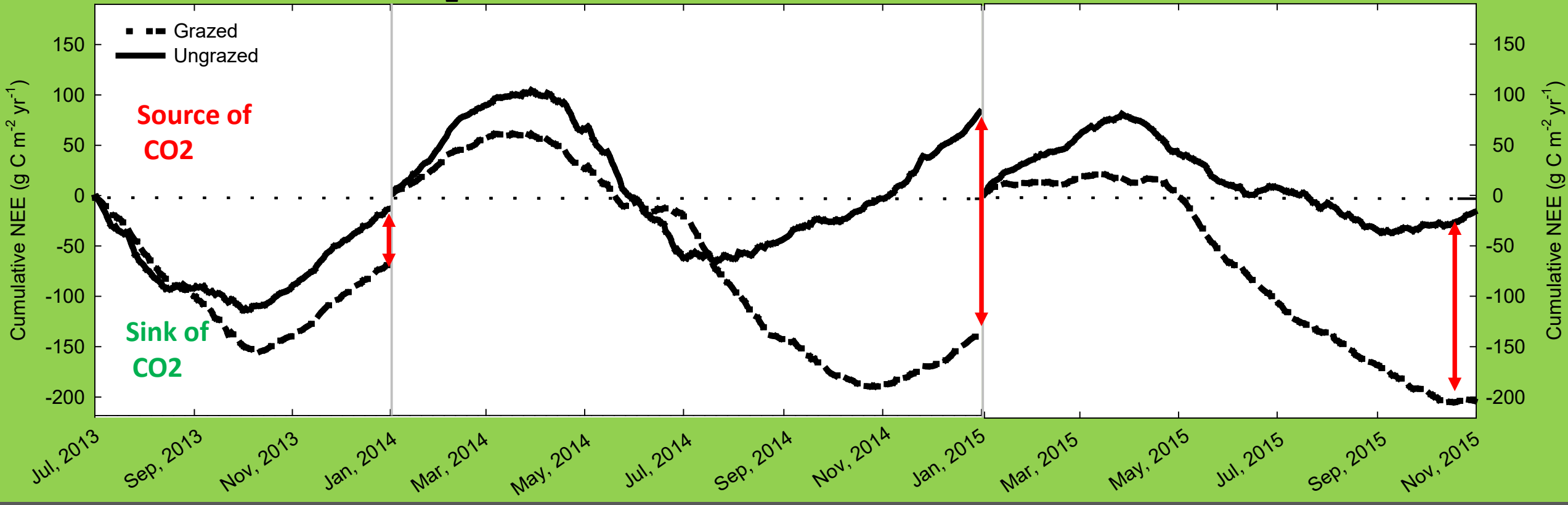


Carbon budget of ranchlands

What is the magnitude and direction of GHG entering or leaving the ranch?



Grazing increases net CO_2 sink strength

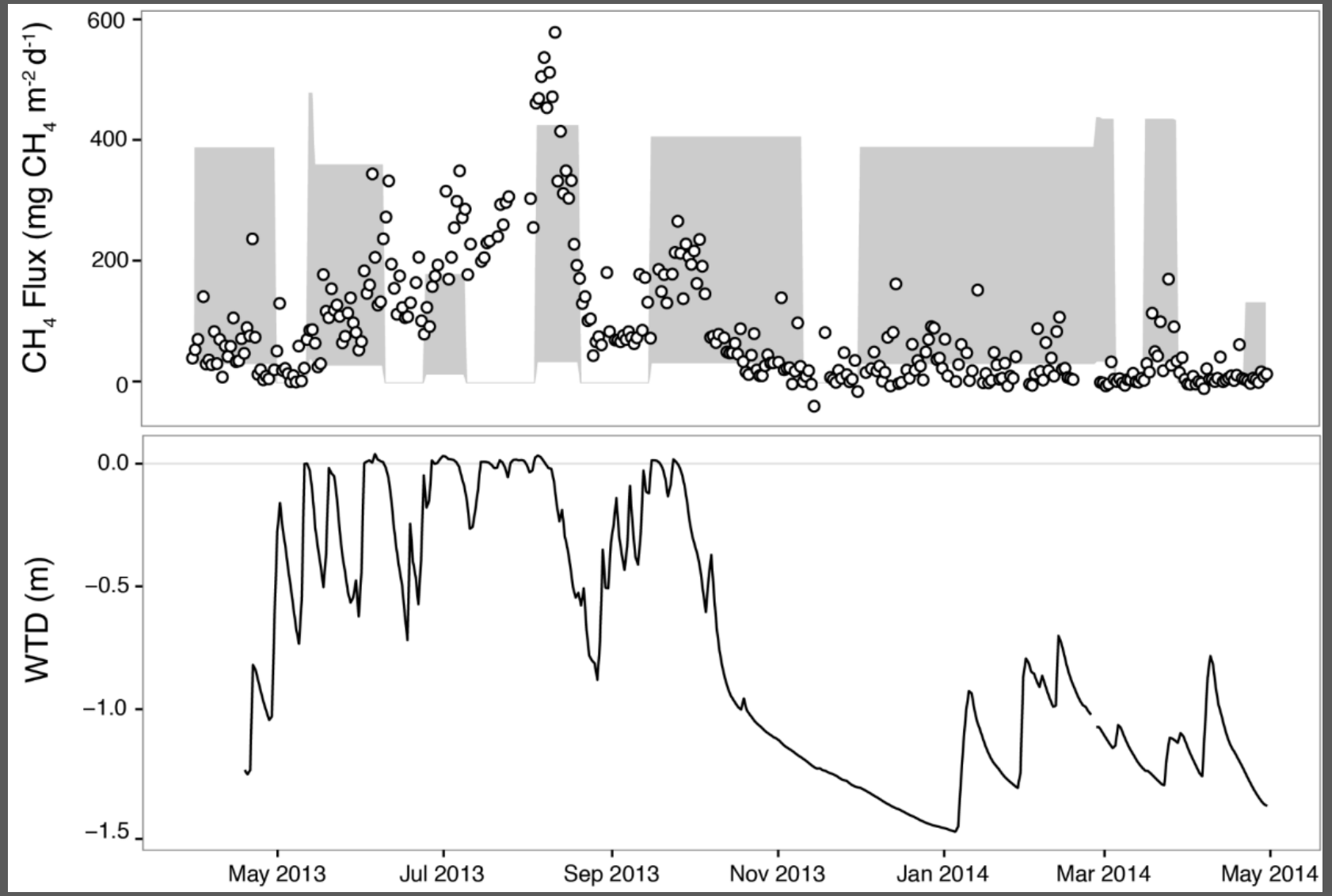


Gomez-Casanovas et al. 2018

Grazing:

- Reduces litter, less decomposition
- Lowers ET, increased soil wetness, possibly lowers Oxygen for decomposition
- Still a sink after accounting for CH4 release from cattle

Ecosystem CH_4 Flux and depth to water table



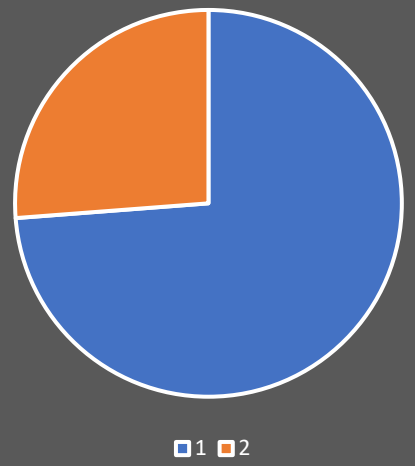
Chamberlain et al. 2015 *Ecosystems*

CH_4 Budget

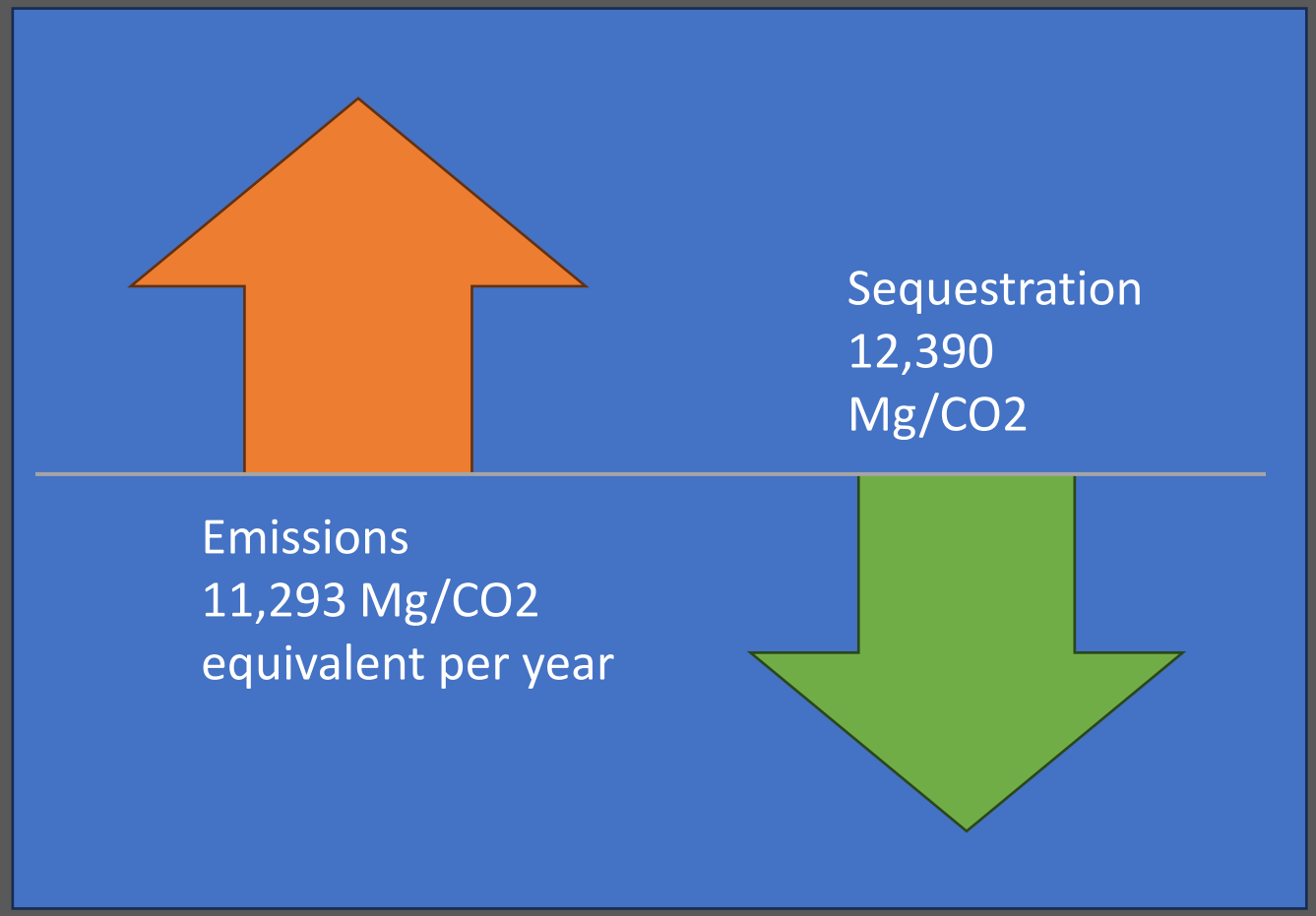
Ecosystem Estimates	Net CH_4 (g CH_4 m^{-2} yr^{-1})
Eddy Covariance	23.36 ± 1.48
Cattle Flux (IPCC per cow emission factor)	8.3 ± 1.3

Cattle emit ~28-44% of annual pasture CH4 budget in improved pastures at MAERC.

Annual Methane emissions at BIR 2013-2015



Buck Island Ranch is a net Carbon sink: ~1097 metric tons CO2 equivalent per year



In summary

Understanding water, nutrient and carbon cycles on ranchlands, as a function of management and climate, is essential for sustainable watershed management.

MANAGEMENT INTERVENTIONS FOR WATER QUALITY:
Water retention on ranchlands, hay harvest for nutrients and overseeding legumes in pastures.

Ongoing research:

- how fluctuating water table interacts with spodic soils to affect surface water quality and nutrient loss from ranchlands
- Leachate nutrient concentrations and groundwater transport modeling
- Rainfall variability on ecosystem processes – forage productivity, decomposition and gas emissions, biodiversity
- Ecosystem methane - Research on Dominant grasses, cattle feed enzymes that reduce methane emissions, soil types and soil amendments.
- Carbon markets for ranchlands

Partnerships and Collaborations: open to opportunities