Evaluation of the vegetation along roadways in Edwards Aquifer Recharge and Contributing Zones for Storm Water Management and Water Quality Improvement

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CITY OF SAN ANTONIO — TEXAS

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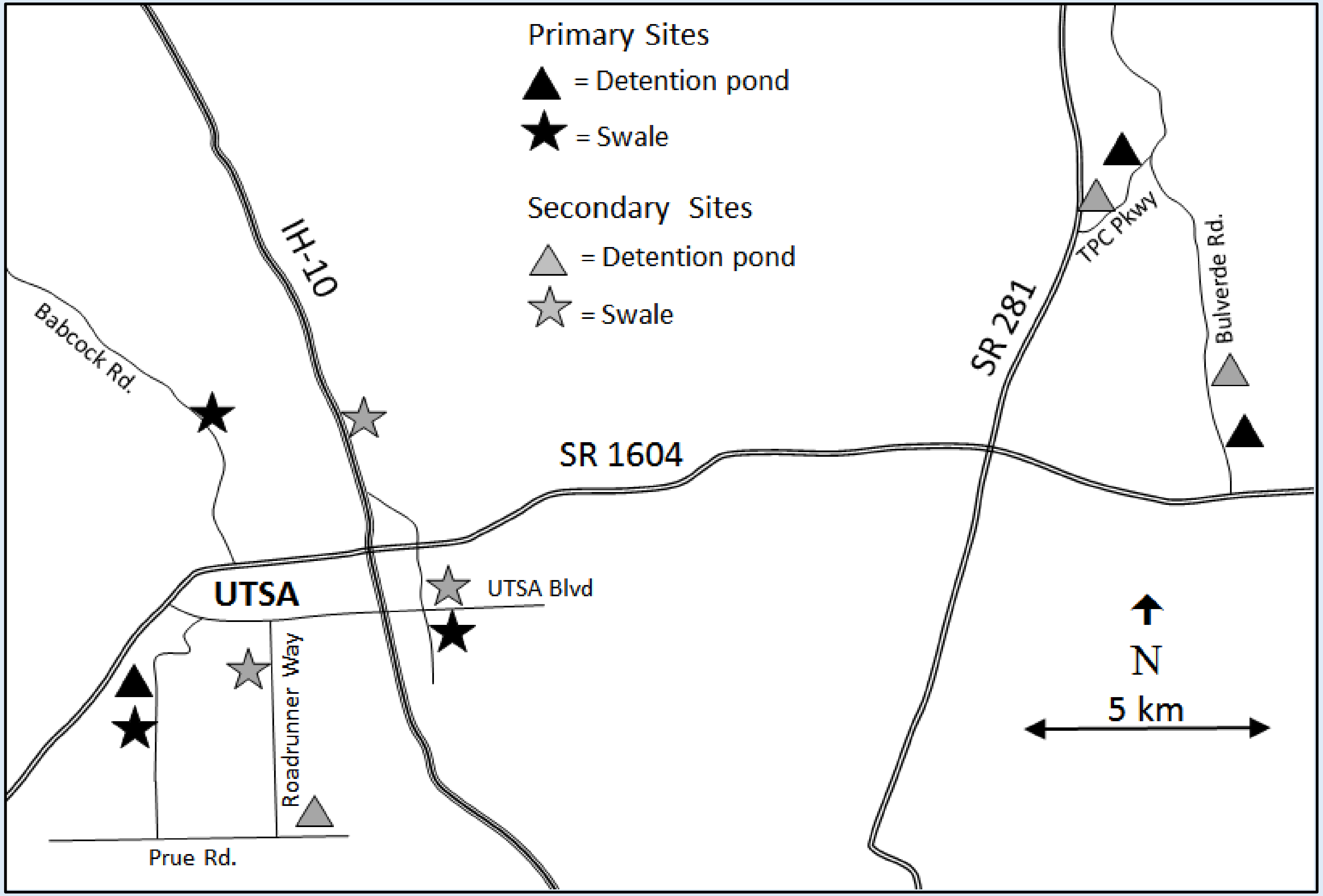
Project Overview

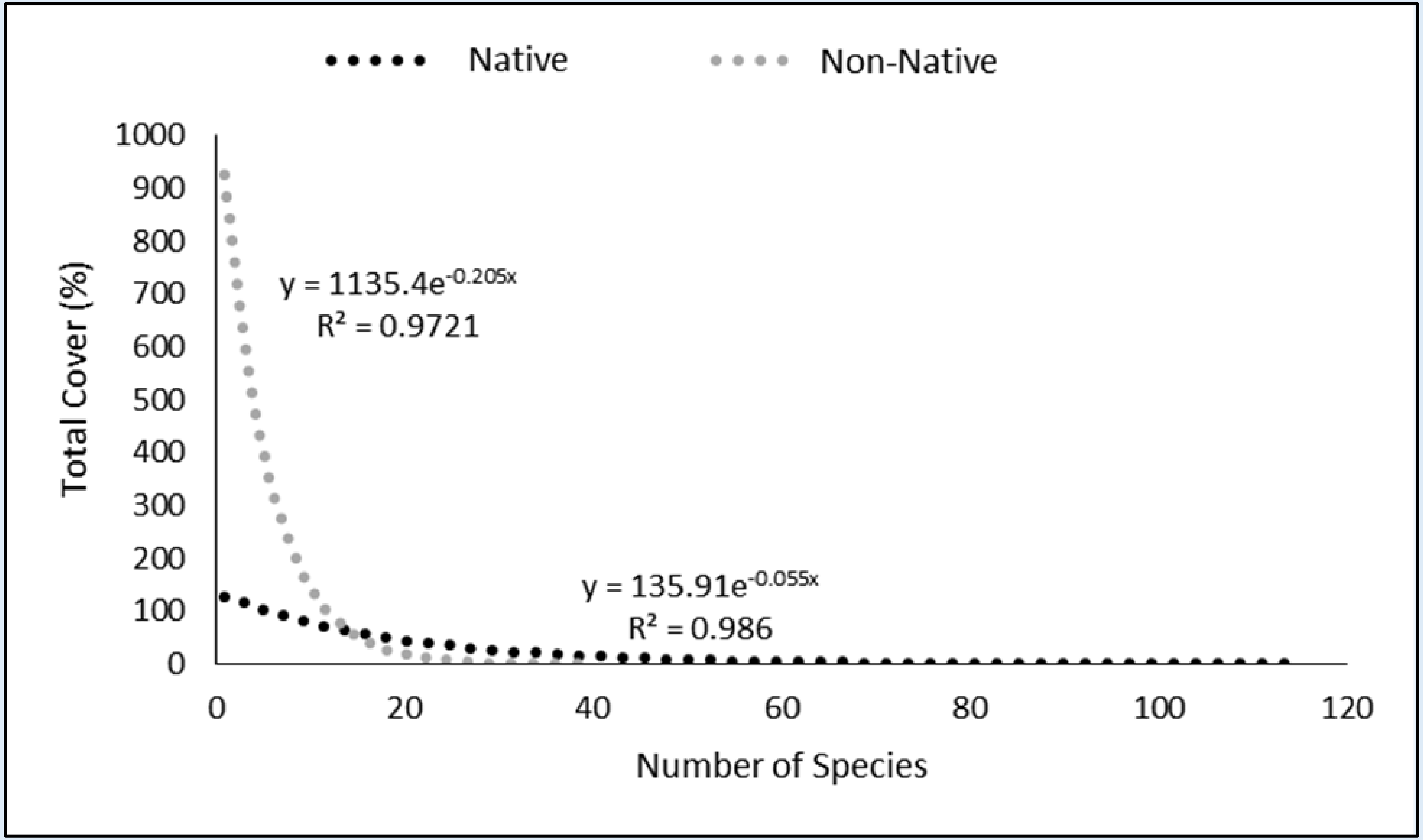
This UTSA project evaluated soil and vegetation composition and density along roadways in the Edwards Recharge and Contributing Zones of Bexar County for control of sediments, nutrients, and other pollutants and make recommendations of xeric species of vegetation most adaptable to roadway conditions.

Project Cost: $798,636	2019				2020				2021				2022				2023*	
Project Timeline	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1: Purchase initial materials and disposables			√	√														
Task 2:Initial site assessment & surveys; GIS mapping			√	√														
Task 3: Set up stormwater sampling stations				√	√													
Task 4: Vegetation surveys and analysis				√	√	√			√	√	√							
Task 5: Sediment deposition study					√	√	√	√	√	√	√	√						
Task 6: Collection of stormwater samples					√	√	√	√	√	√	√	√	√	√	√	√	√	√
Task 7: Analysis of stormwater samples					√	√	√	√	√	√	√	√	√	√	√	√	√	√
Task 8: Statistical/data analysis & results dissemination					√	√	√	√	√	√	√	√	√	√	√	√	√	√
Task 9: Public outreach											√	√	√	√	√	√	√	√
Task 10: Final report and BMP recommendations.													√	√	√	√	√	√

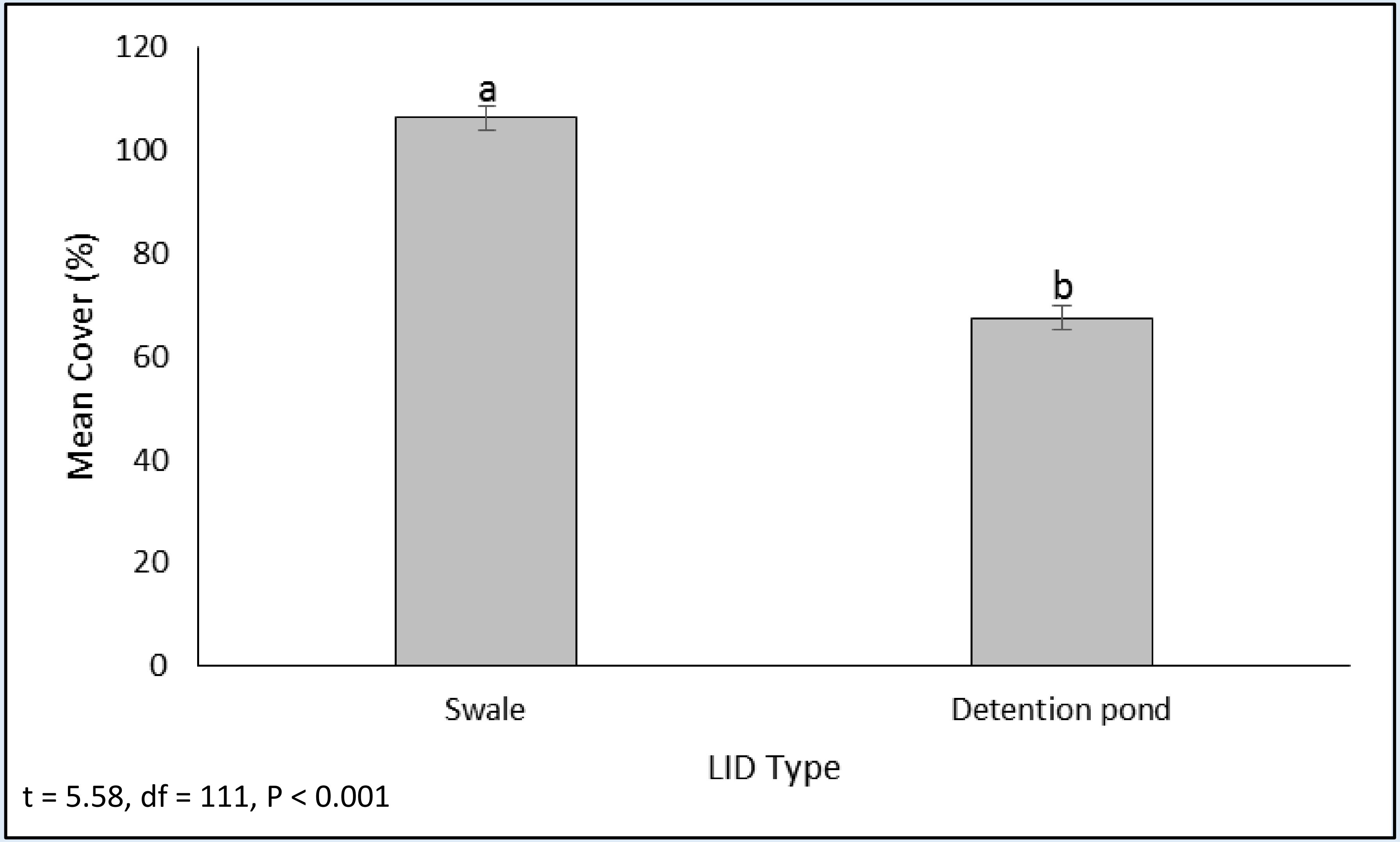
Study sites in Bexar County



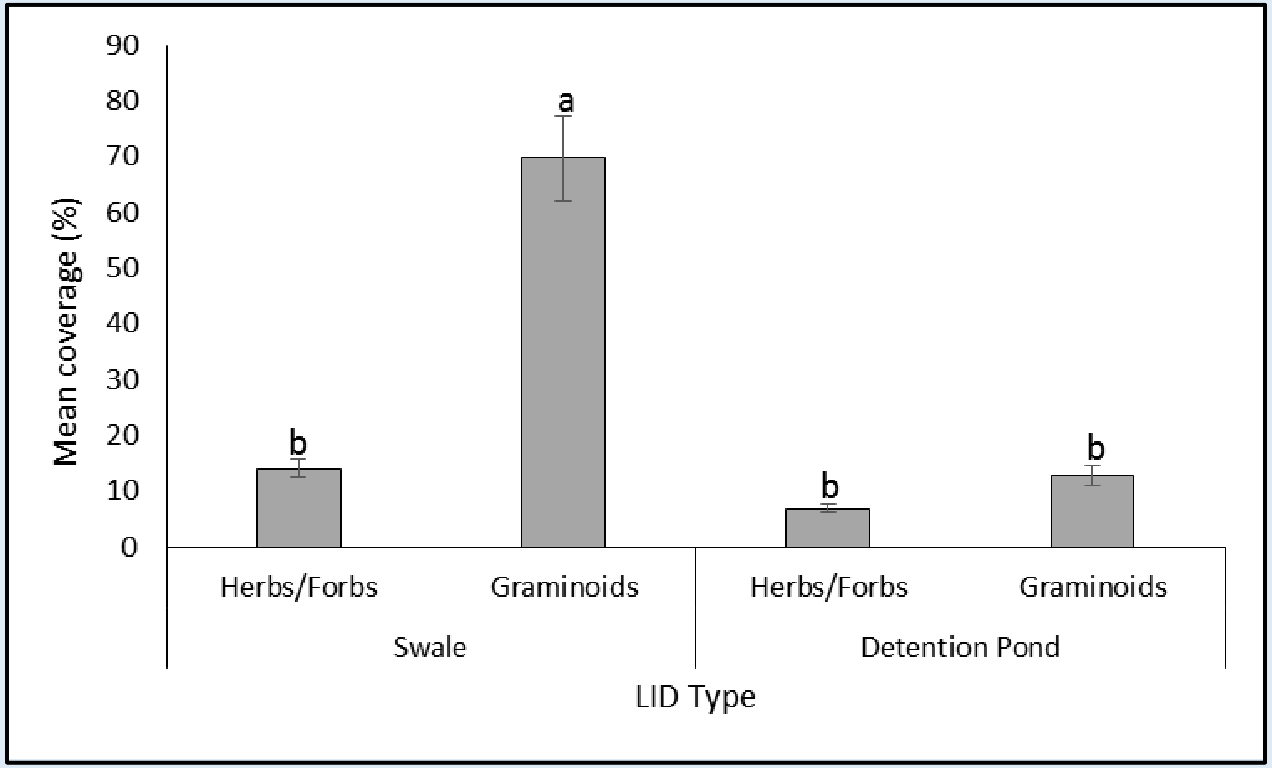
Non-linear regression analysis of the total percent coverage of each native and non-native plant species



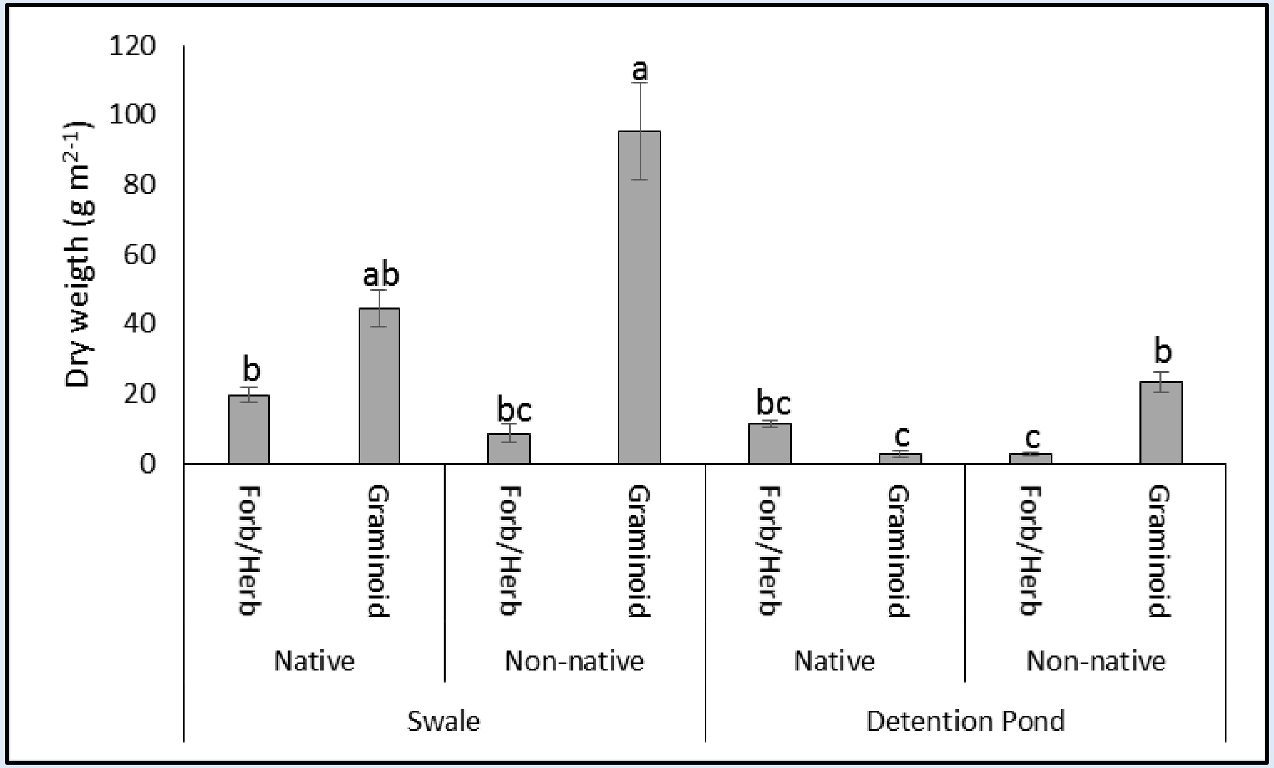
Mean percent plant cover in swales and detention ponds



Mean coverage (%) and dry weight of herbs/forbs and graminoids in swales and graminoids

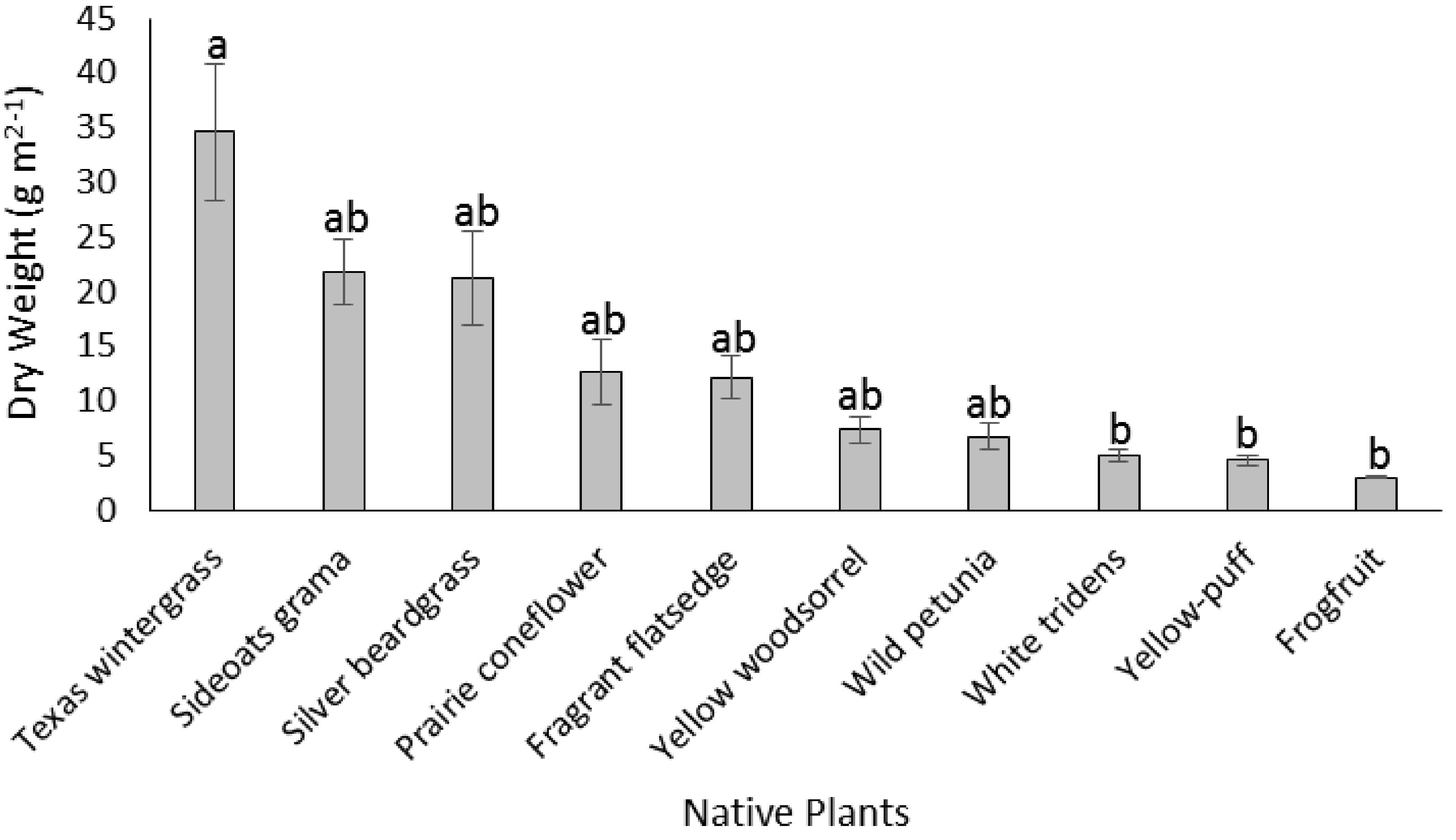


F = 6.71, df = 3, P < 0.001



F = 9.65, df = 7, P < 0.001

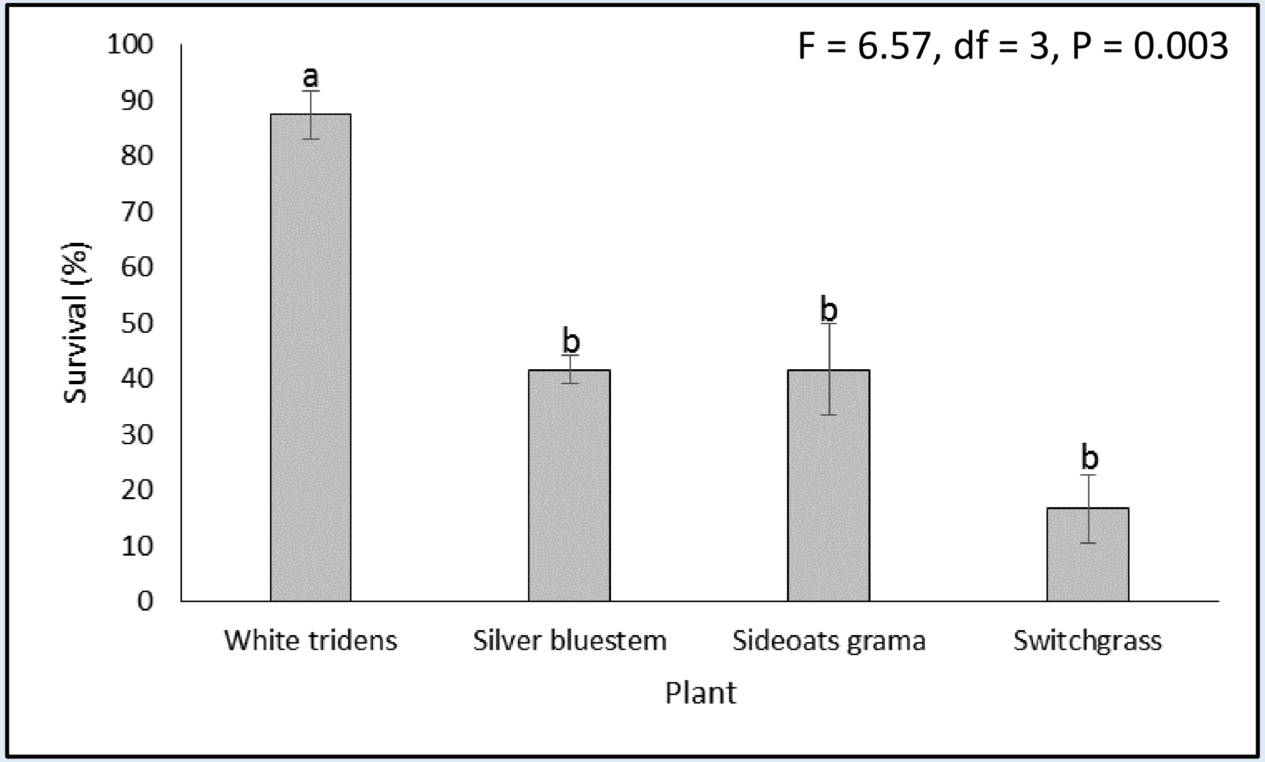
Mean dry weights (g m$^{2\ -1}$) of native species in swales and detention ponds with greater than 3 g m$^{2\ -1}$

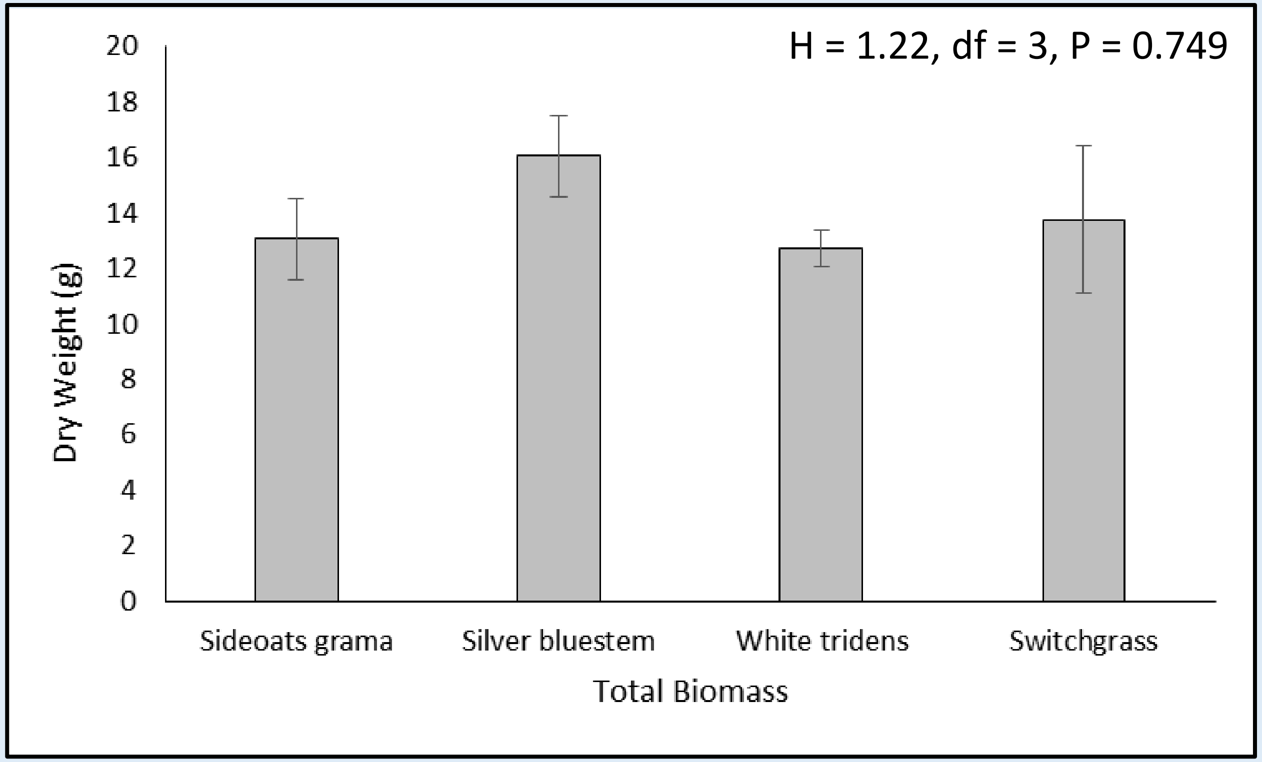


F = 2.83, df = 9, P = 0.009

54 species of native plants suggested for planting in LID structures

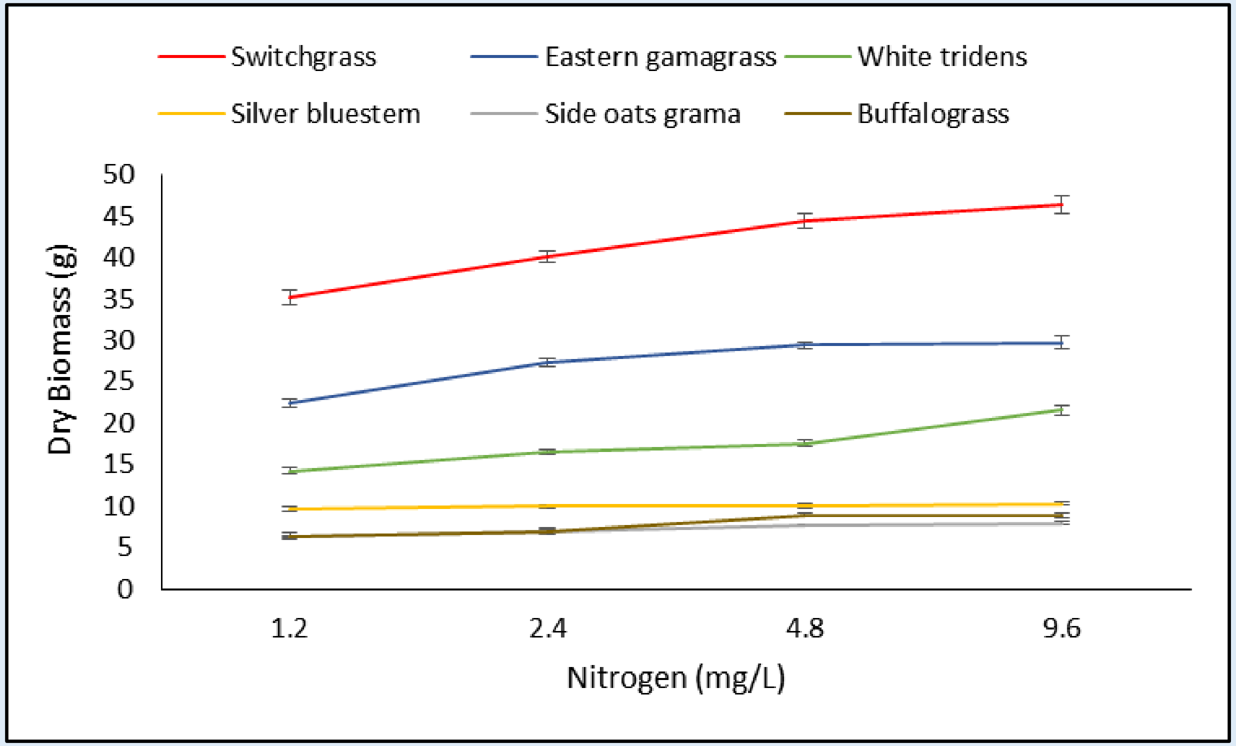
In situ swale planting of six native grass species for survival (%) and total dry weight from May 2021 to October 2022

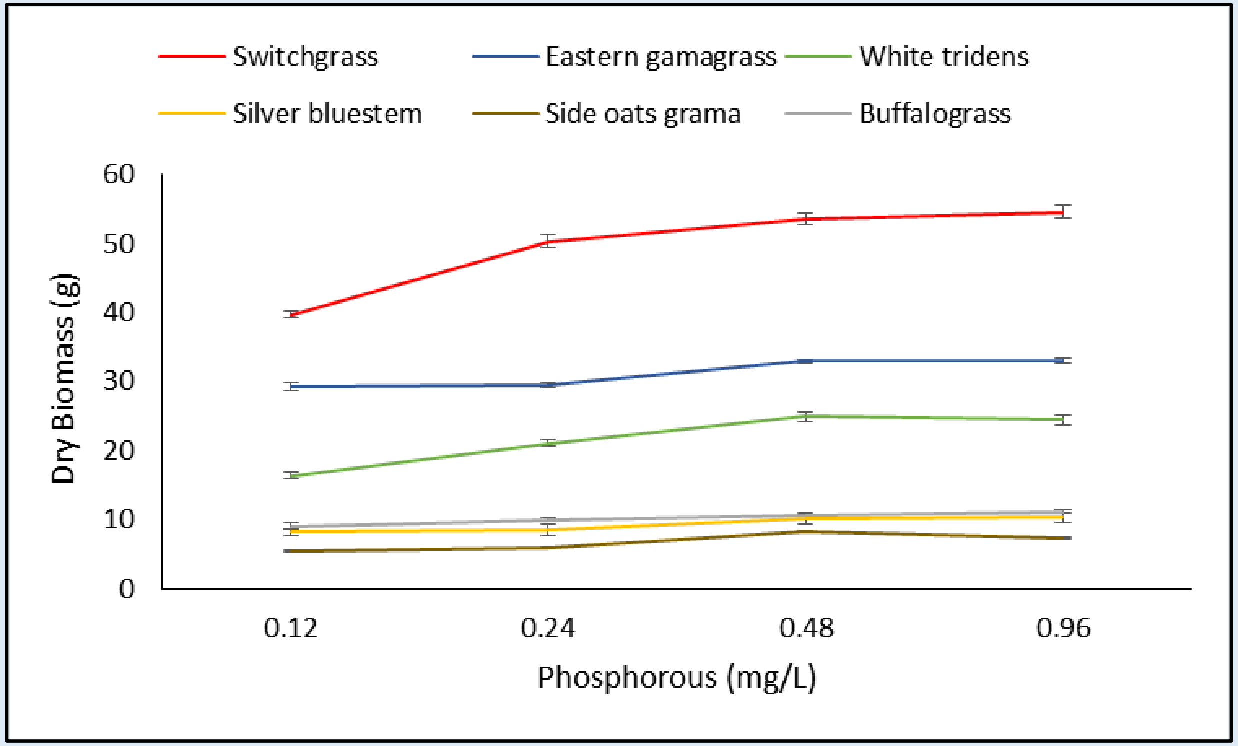




Note: no buffalograss and bushy bluestem survived

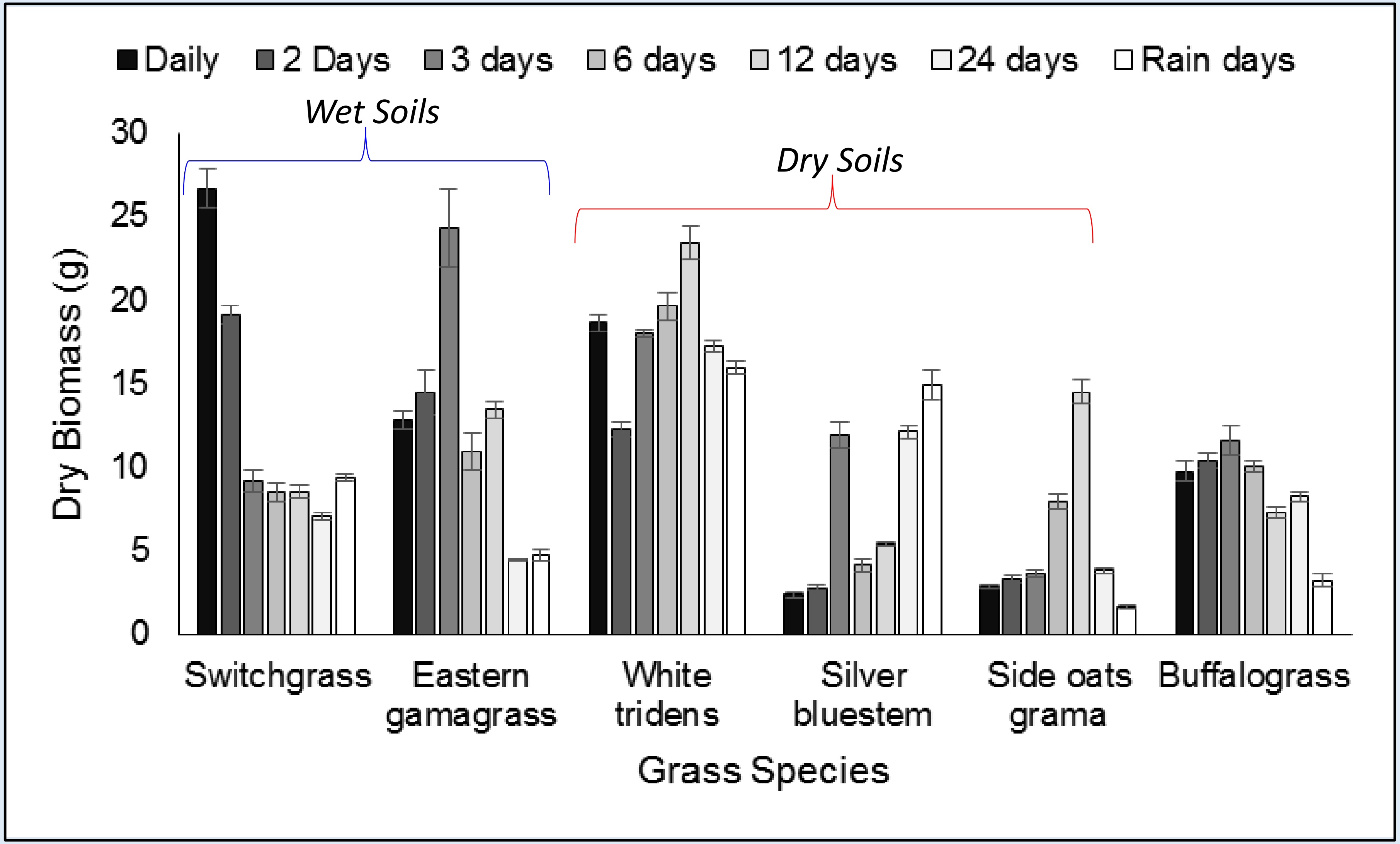
Dry biomass of six grasses grown at increasing concentrations (mg/L) of nitrogen and phosphorous



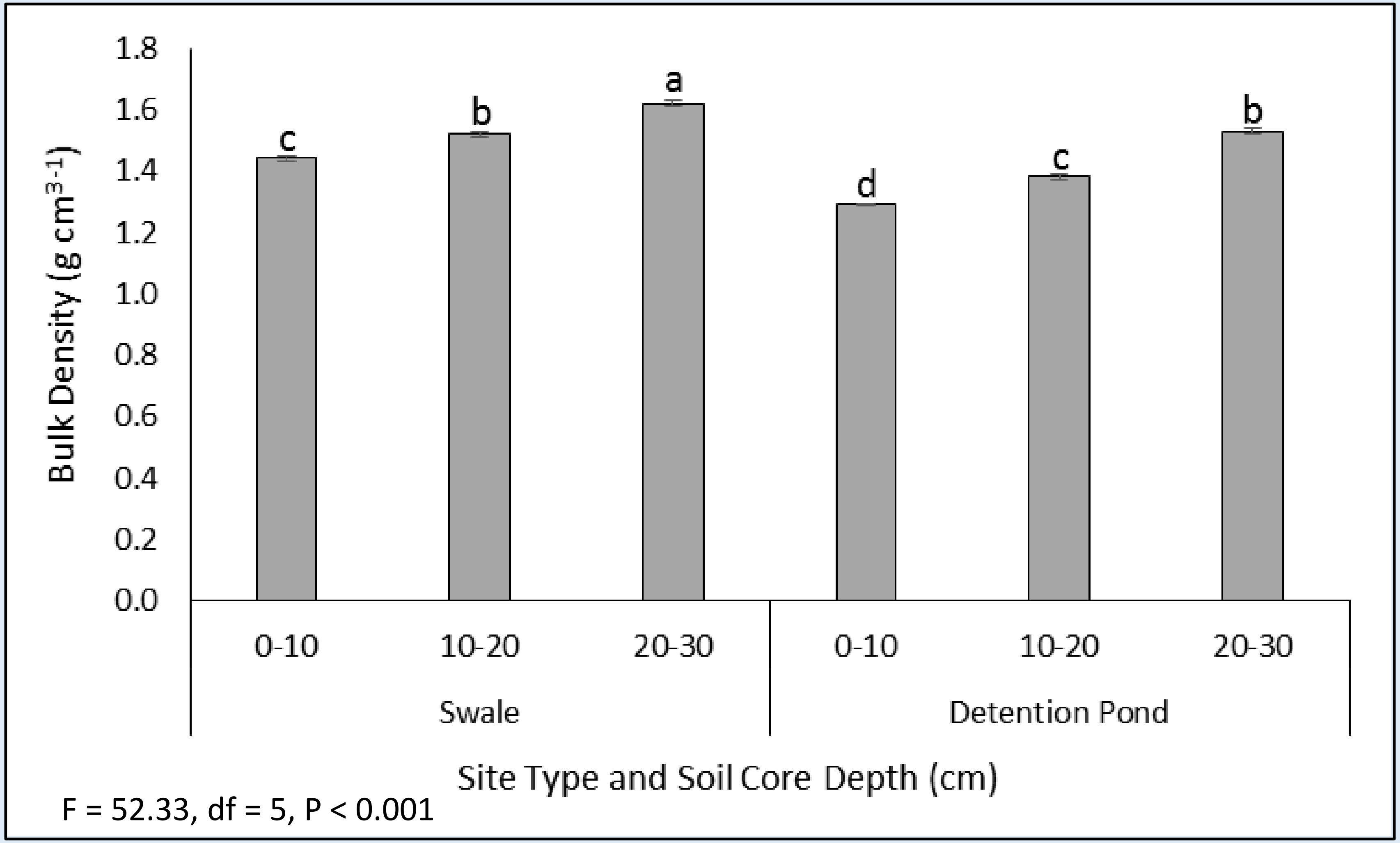


No major trends observed for increasing concentrations of nitrogen and phosphorous

Dry biomass (mg L^{-1}) of six grasses grown at decreasing water regimes

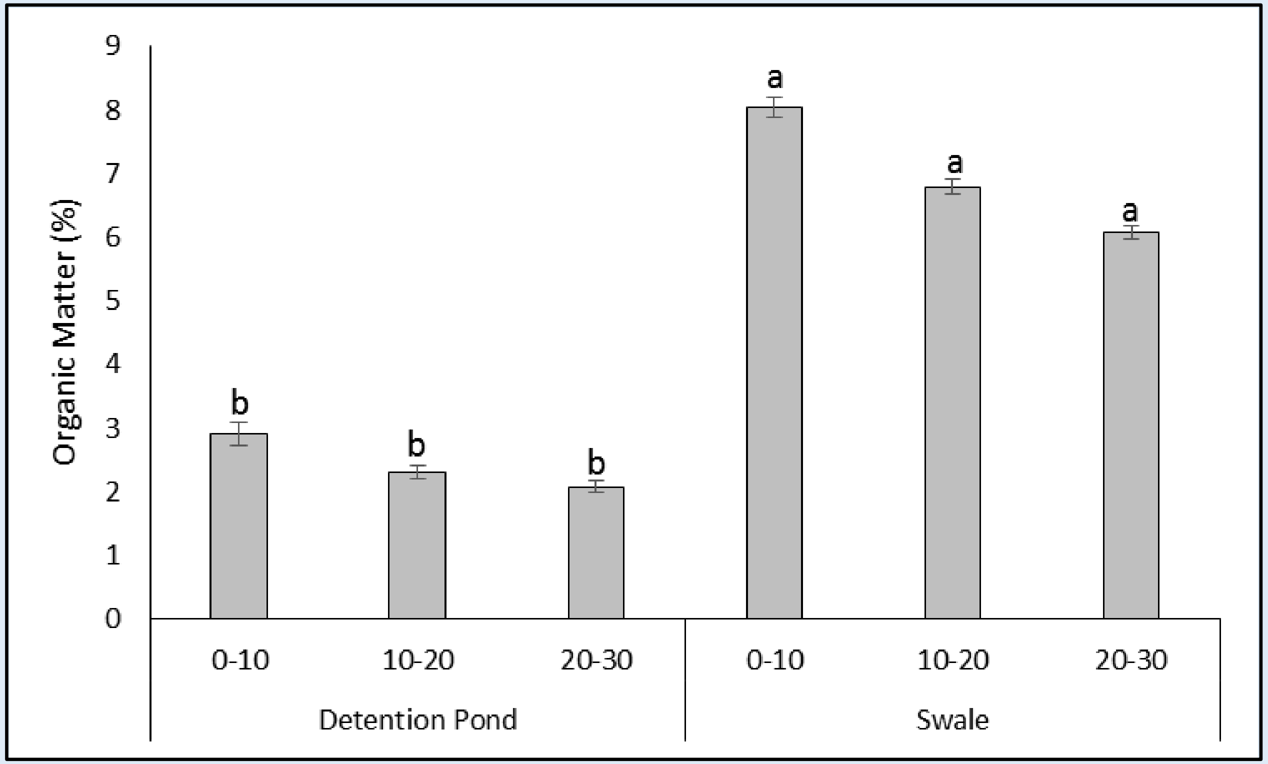


Bulk density in sediment at 3 depths in swales and retention ponds

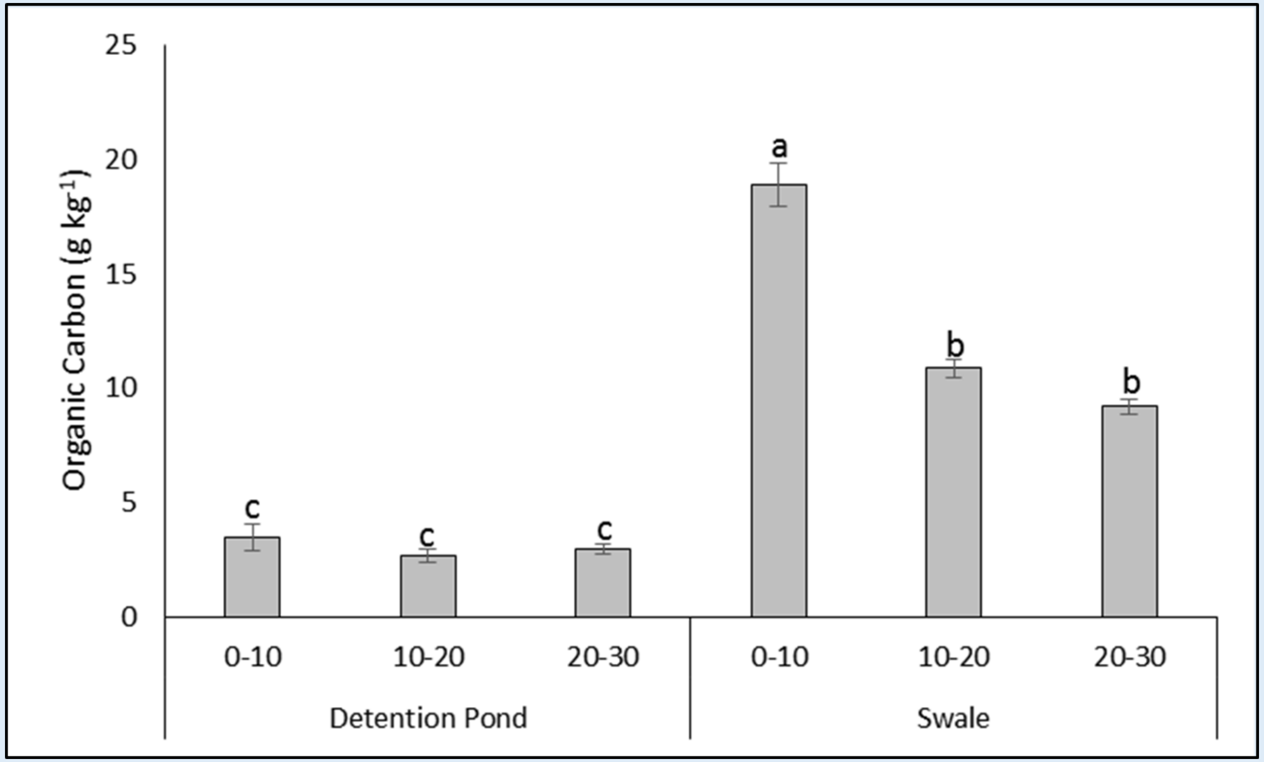


Compacted soils > 10 cm may have prevented the establishment of some native grasses

Organic matter and carbon in sediment at 3 depths in swales and retention ponds

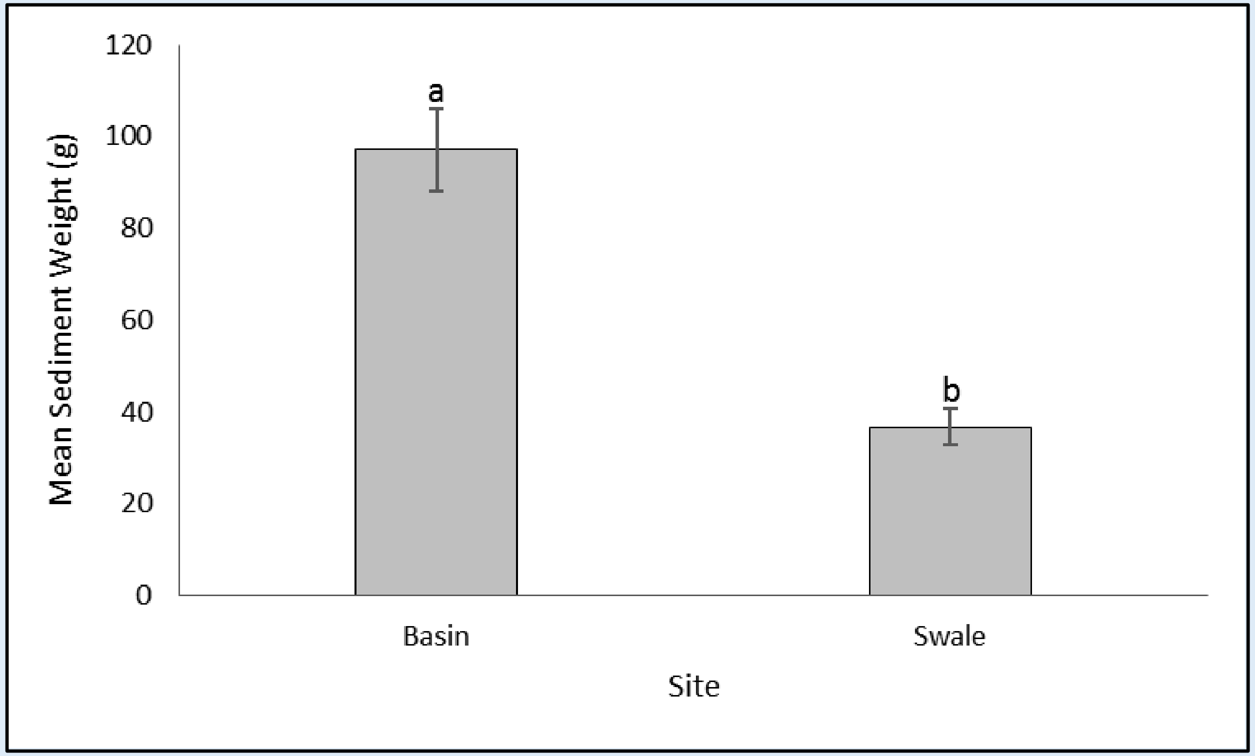


H = 312.58, df = 5, P < 0.001

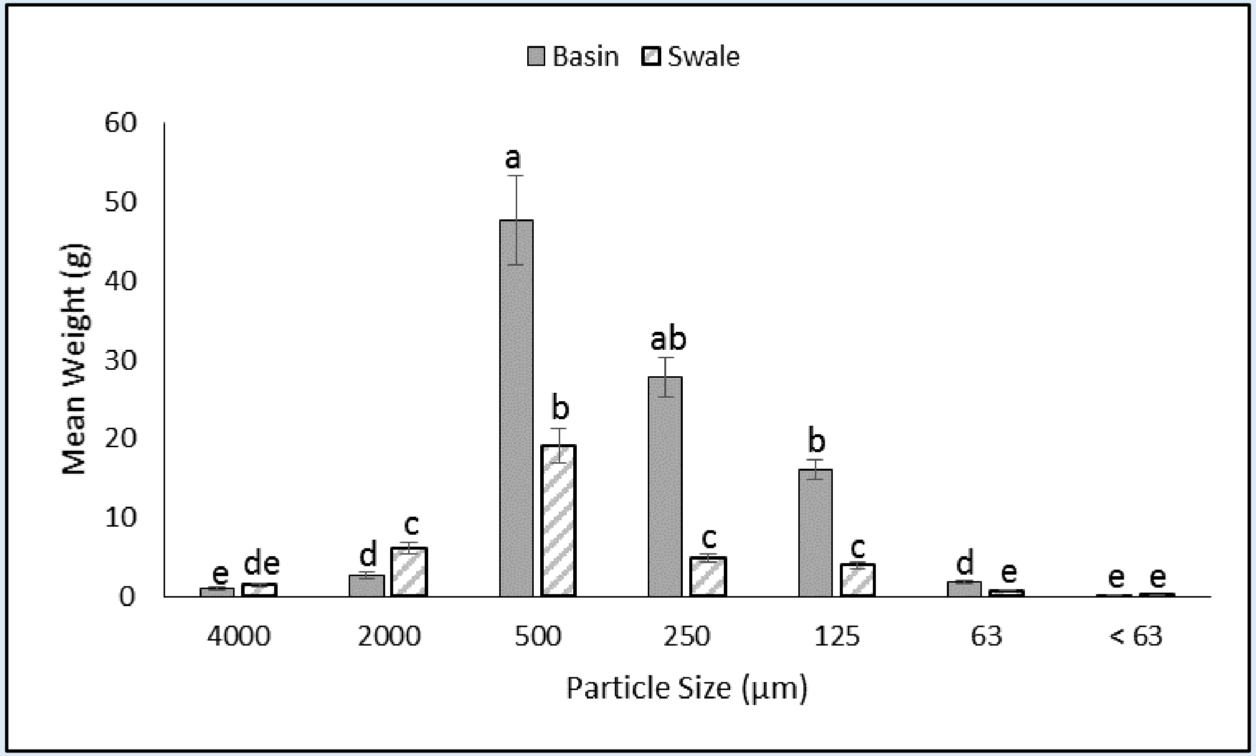


F = 49.62, df = 5, P < 0.001

Mean sediment weight by site and particle size

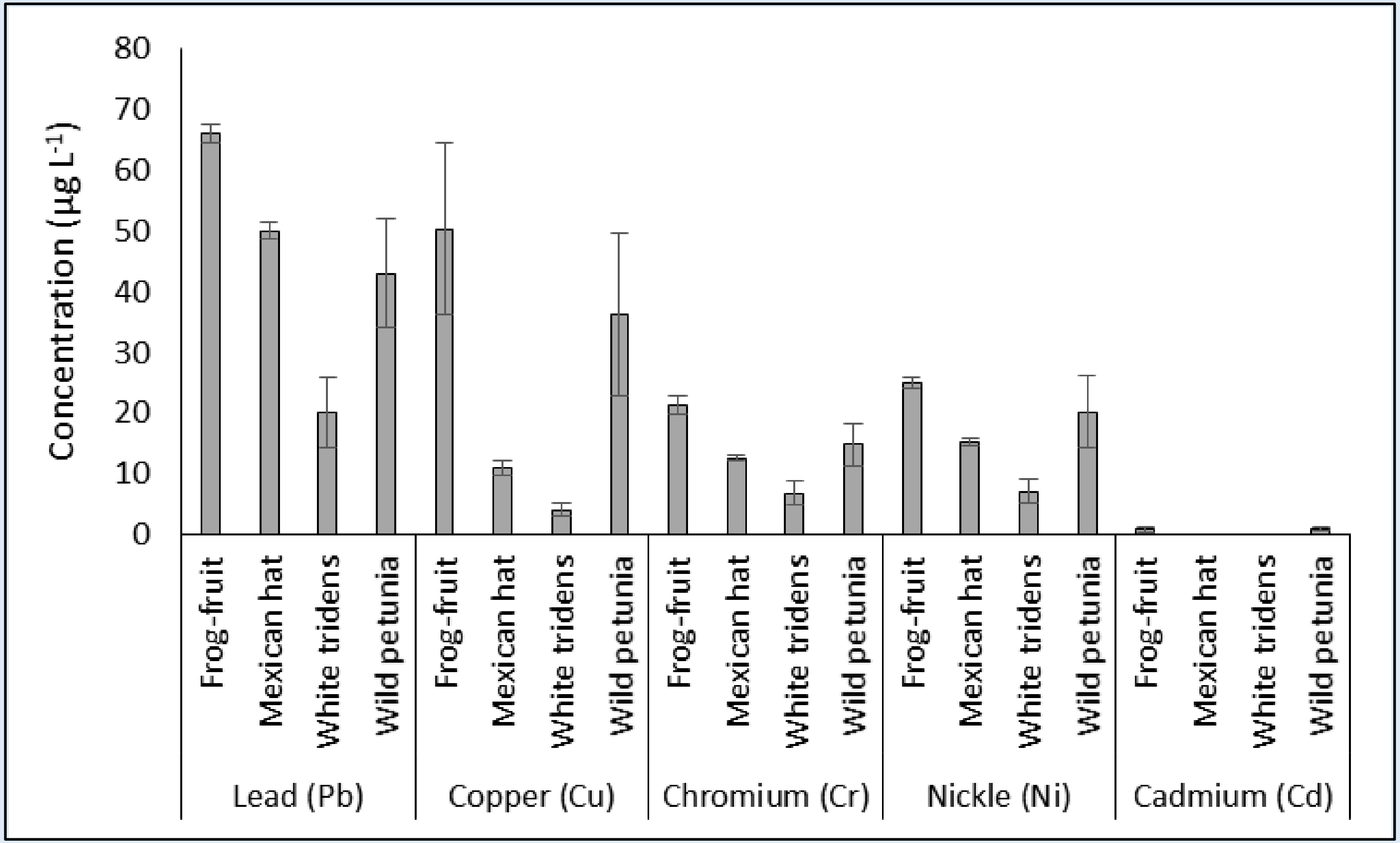


t = 1.97, df = 142, P = 0.002

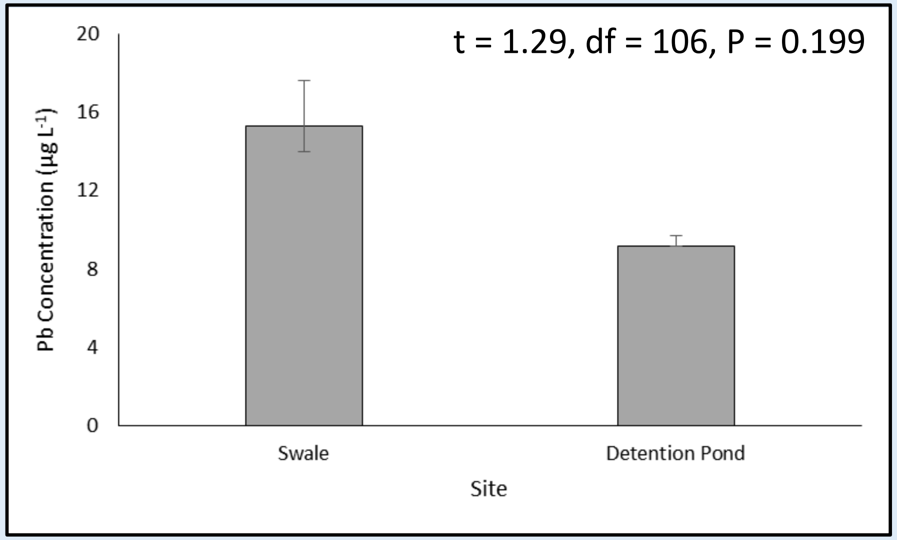


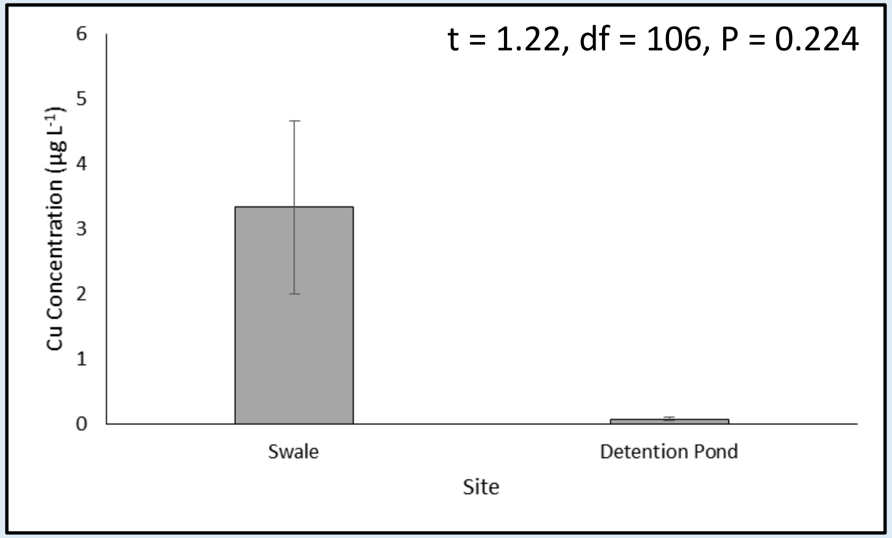
H = 586.94, df = 13, P < 0.001

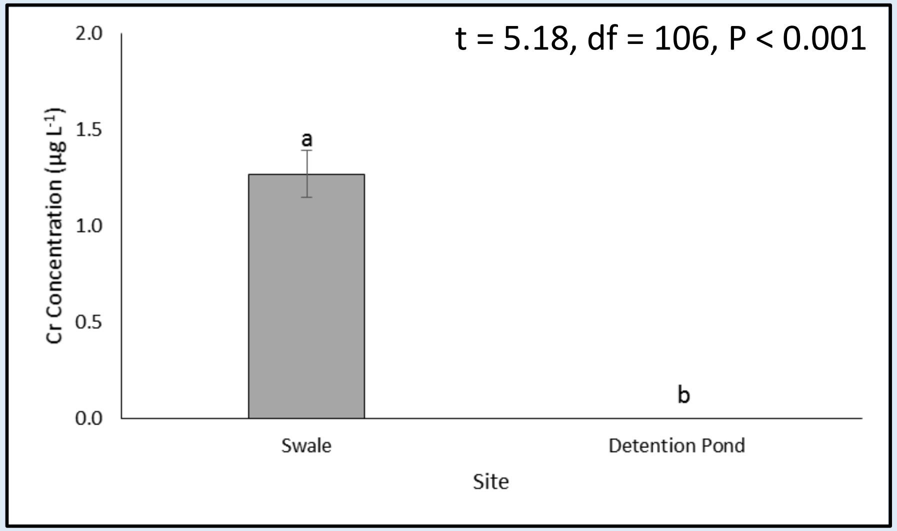
Concentrations of metal uptake by four common native plant species found in swales and detention ponds

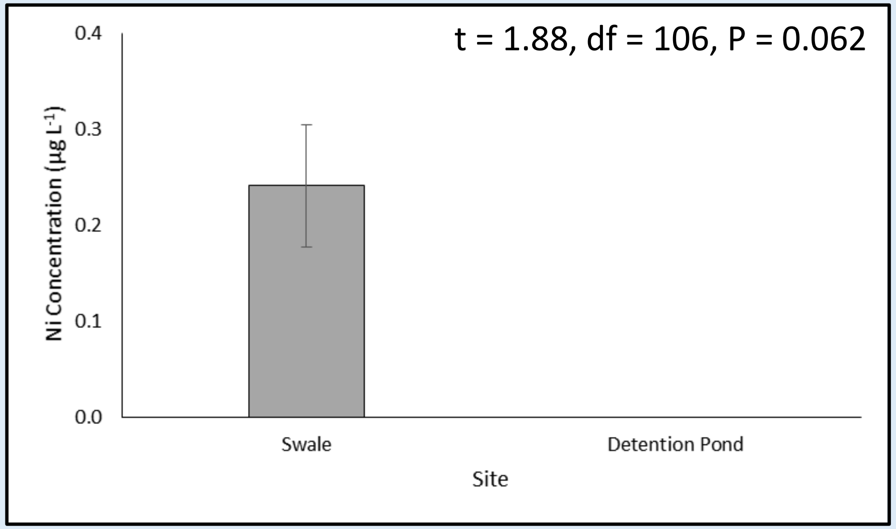


Lead (Pb), copper (Cu), chromium (Cr), and Nickel (Ni) concentrations in sediment from swales and detention ponds



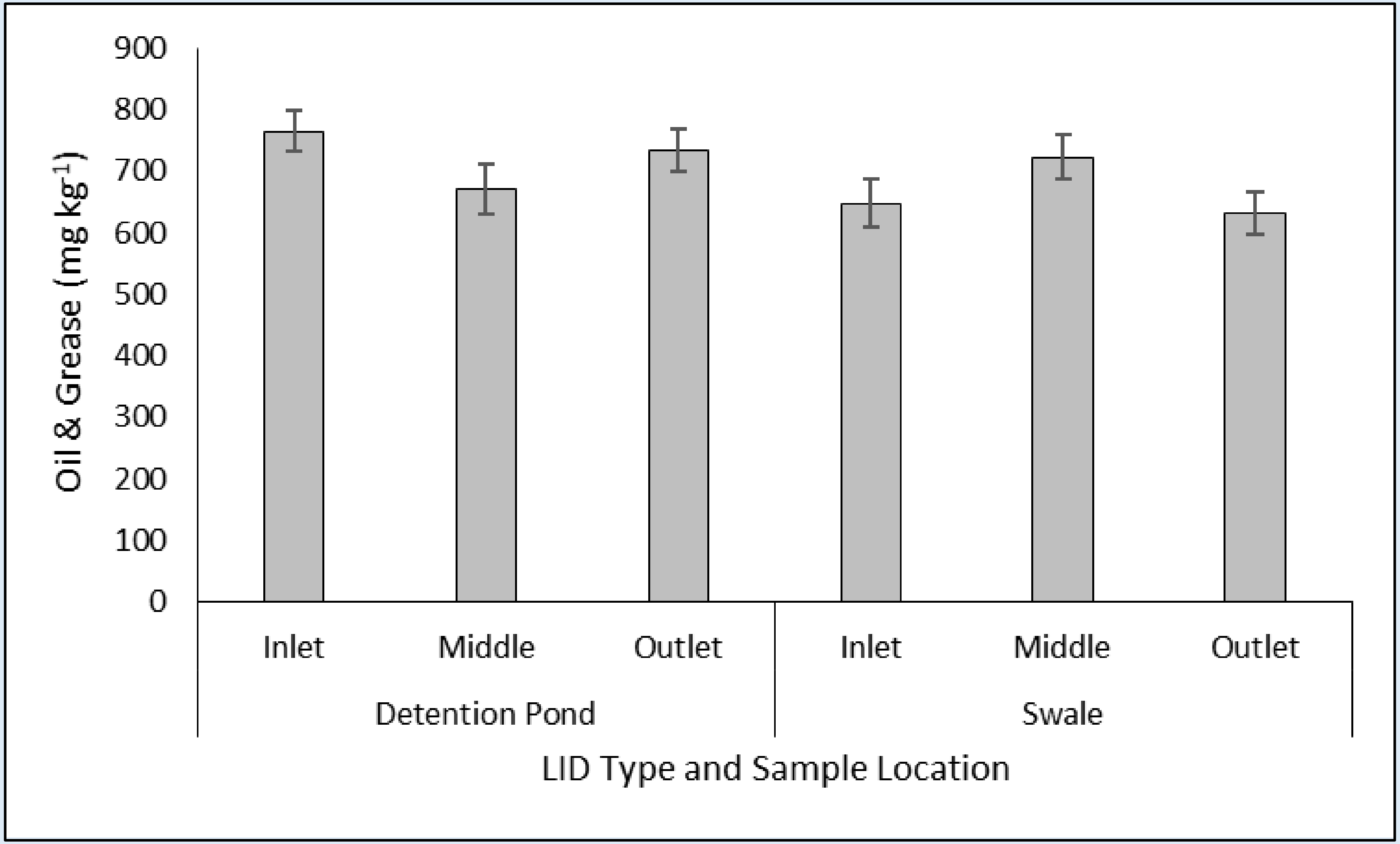




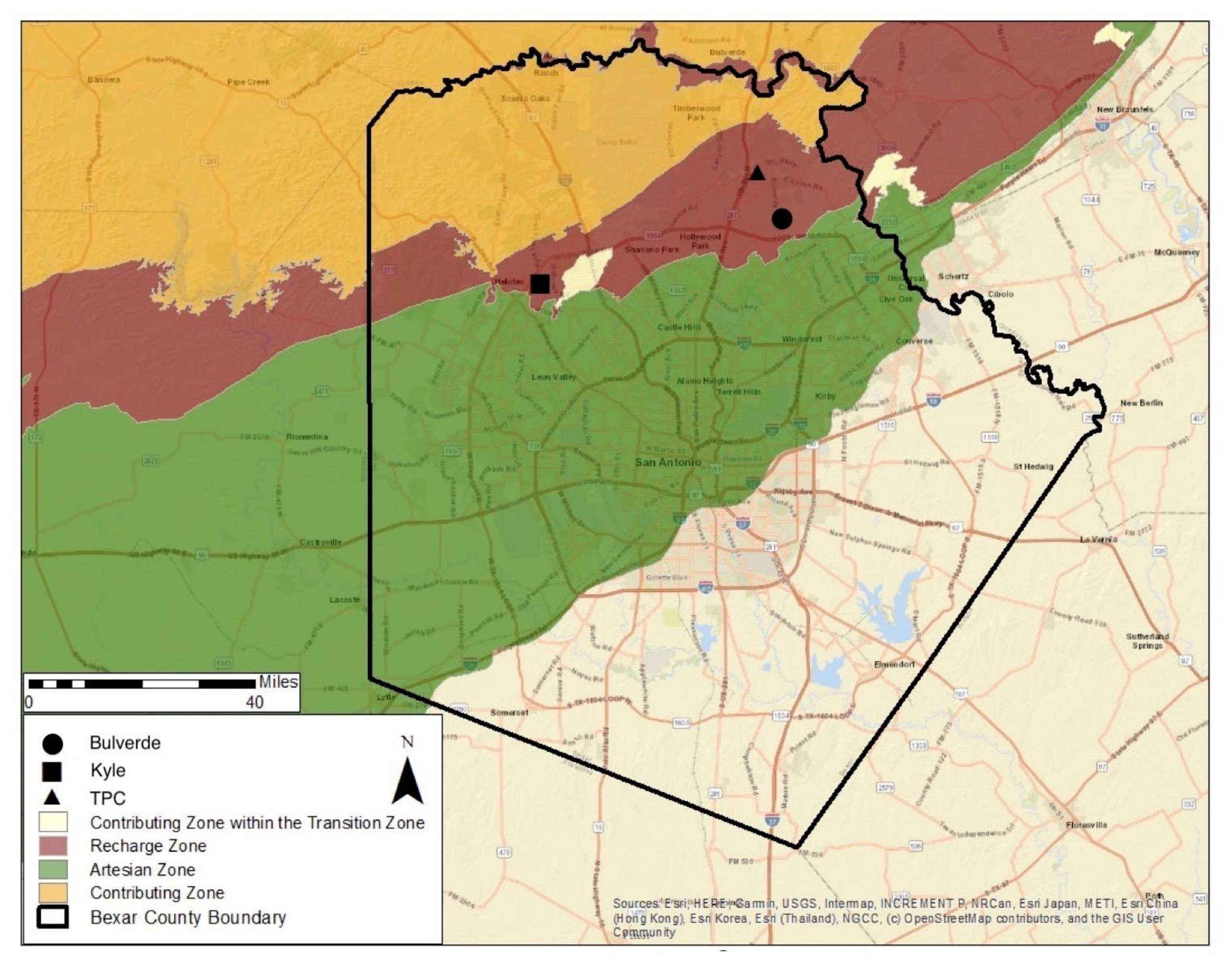


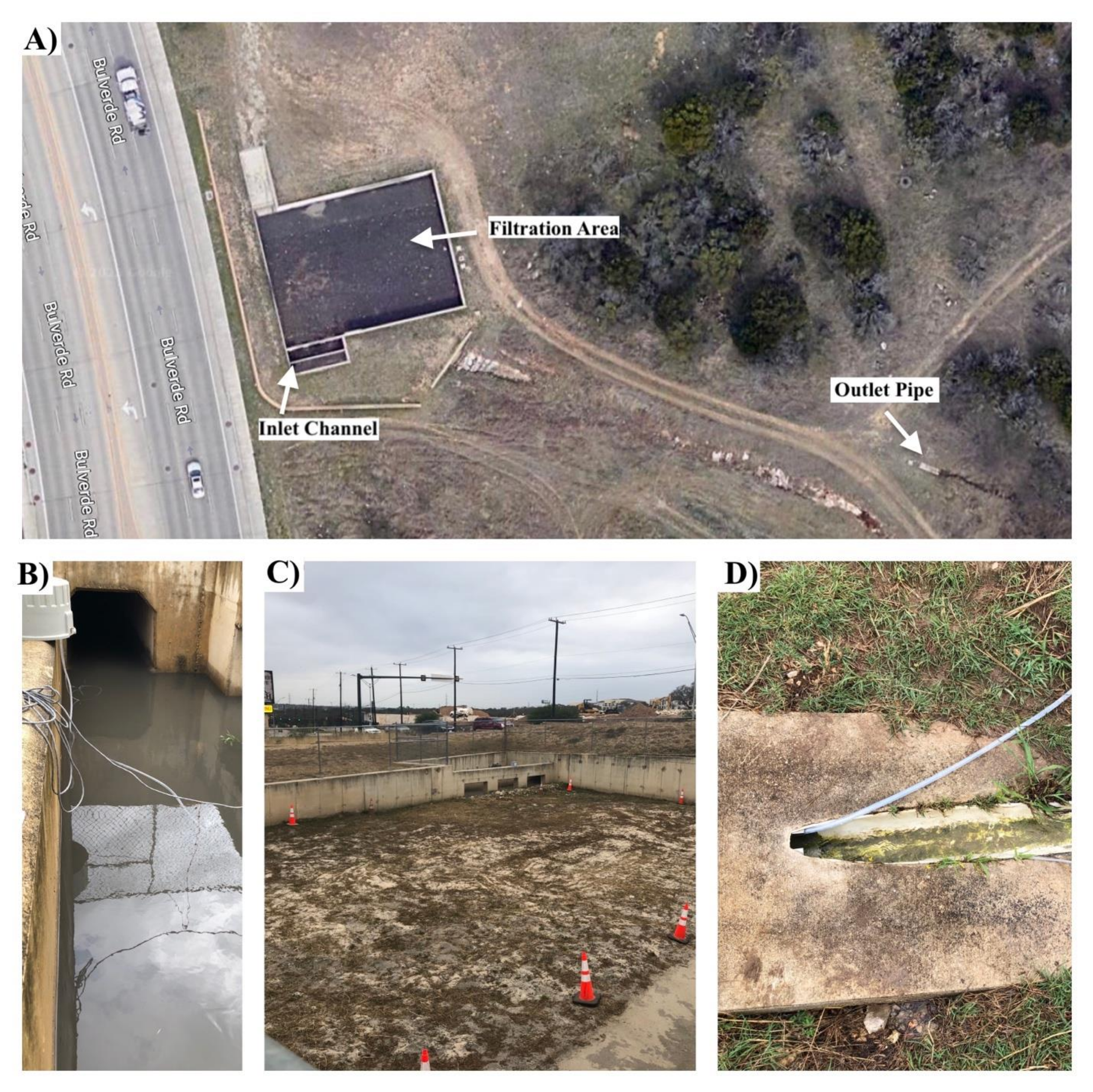
Metal concentrations were higher in plants compared to concentrations in soils

Oil and grease concentrations at three depths in detention ponds and swales



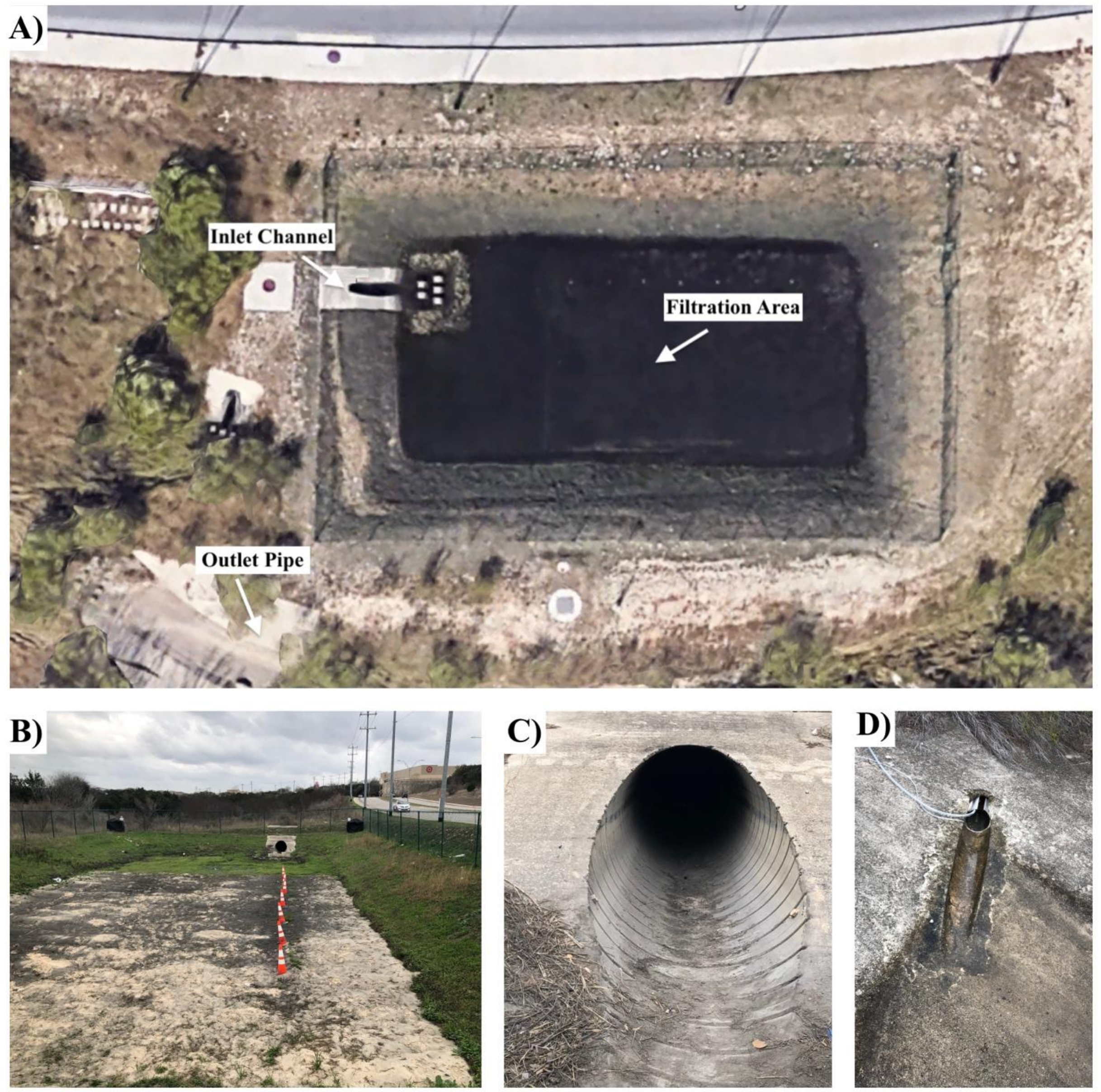
Water quality monitoring- Detention basins





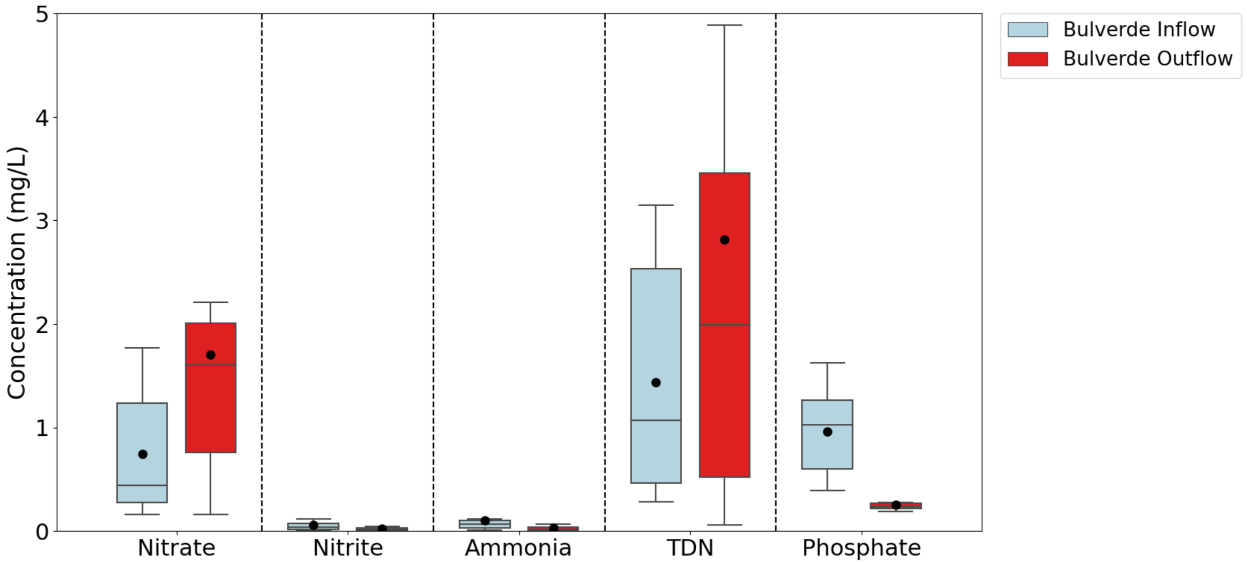
Bulverde Basin A) plan view image of Bulverde site with the inlet channel, filtration area and outlet pipe B) inlet channel C) basin filtration area D) Outlet pipe

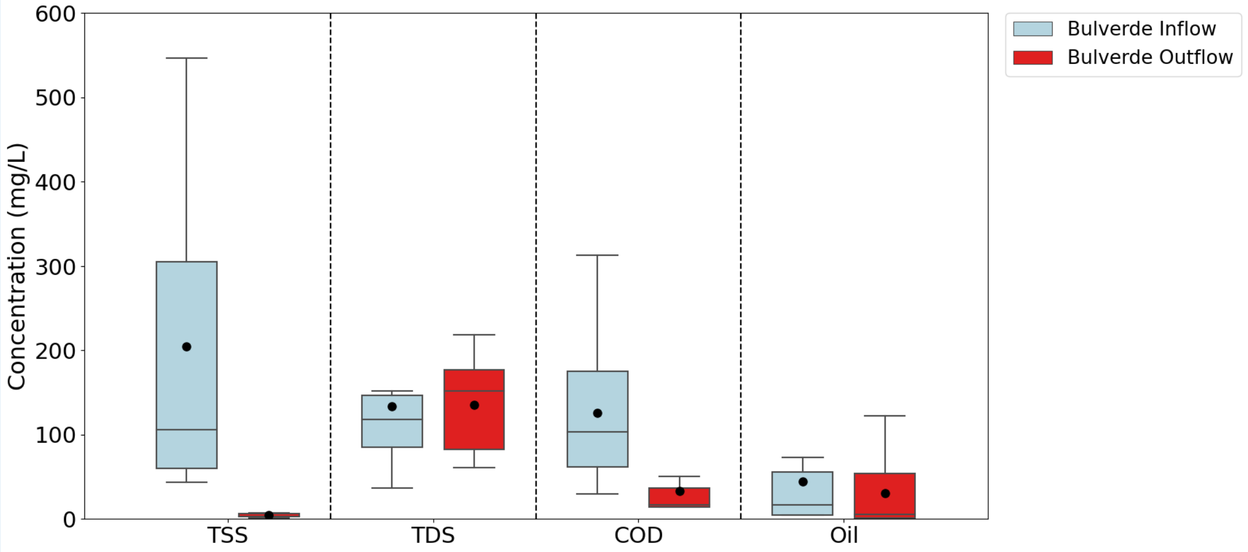
Kyle Basin A) plan view image of Kyle site with the inlet channel, sedimentation area, filtration area, rock gabion and outlet pipe B) sedimentation area and inlet channel C) filtration area and rock gabion D) Outlet pipe

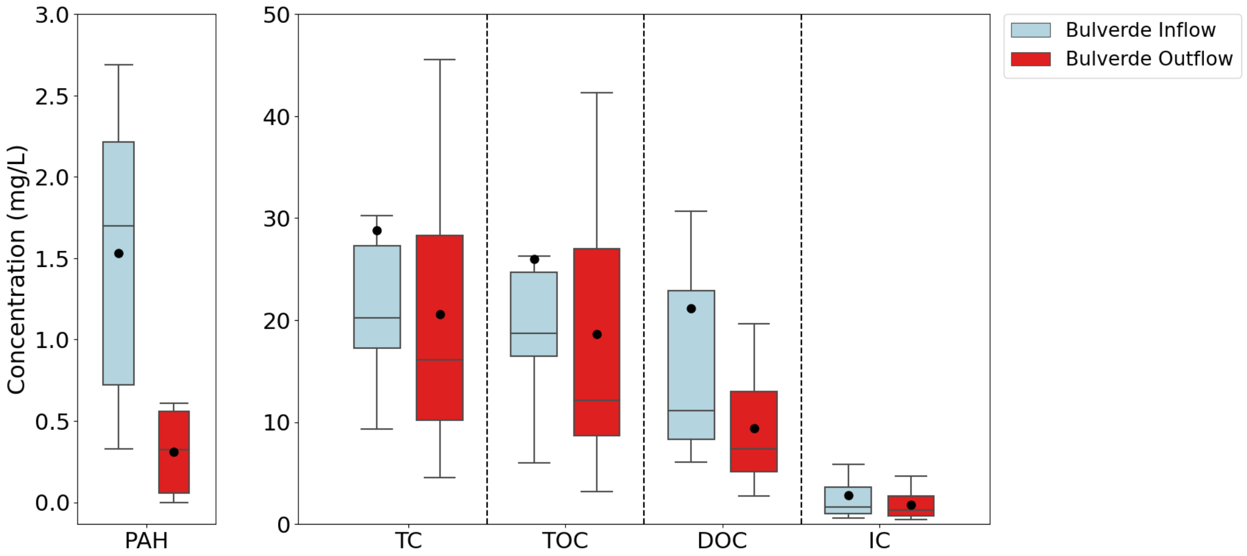


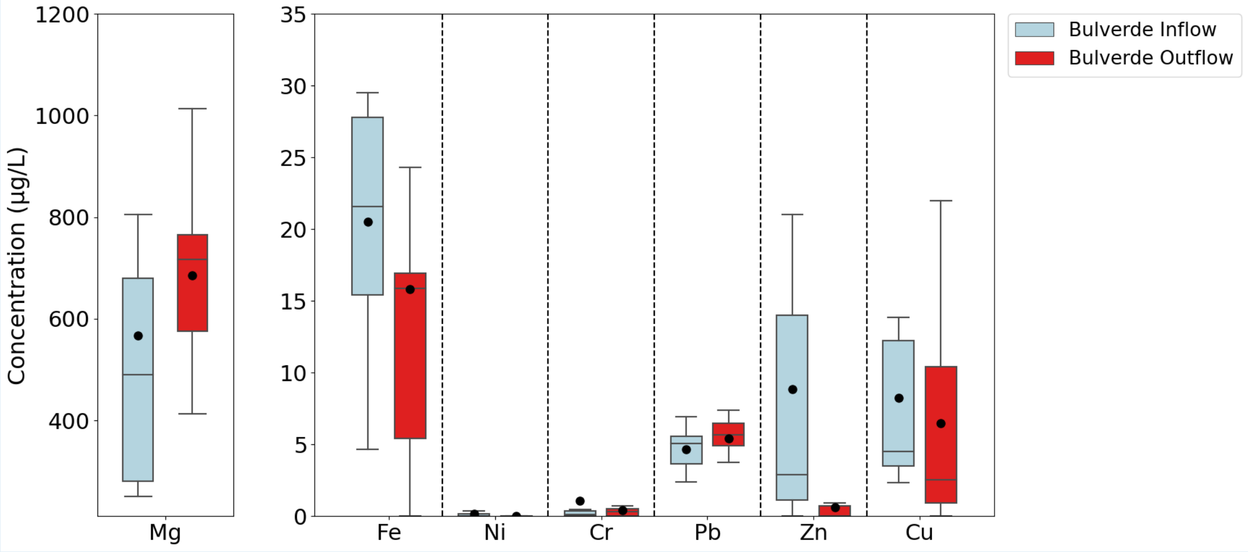
TPC Basin A) plan view image of TPC site with the inlet channel, filtration area and outlet pipe B) the view from the inside of the basin C) inlet channel D) Outlet pipe

Water quality monitoring at Bulverde Basin

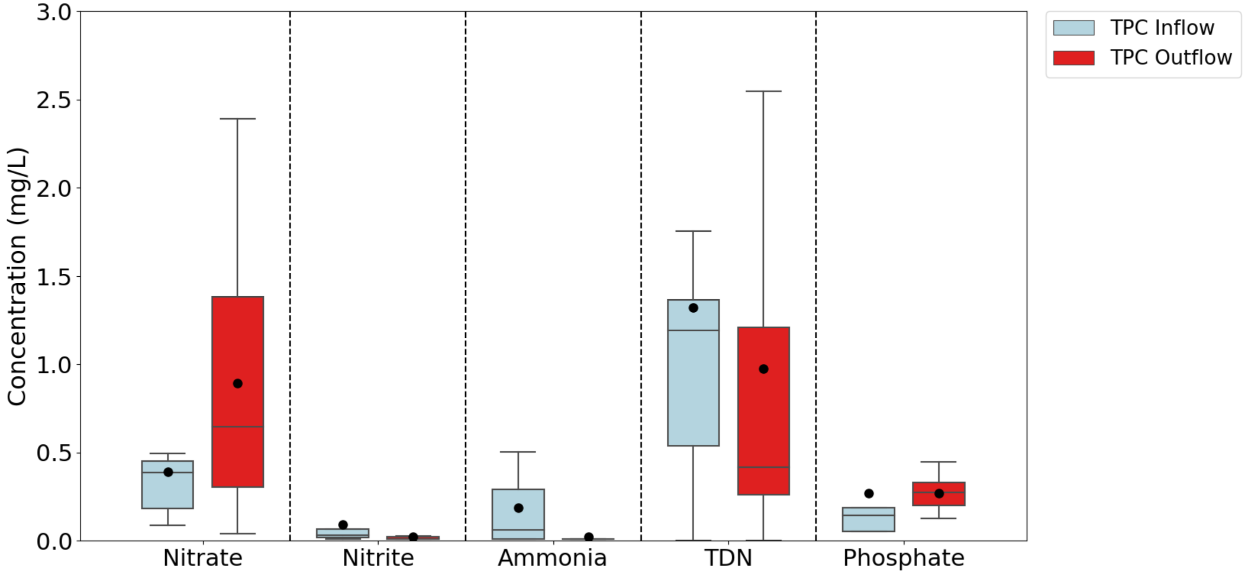


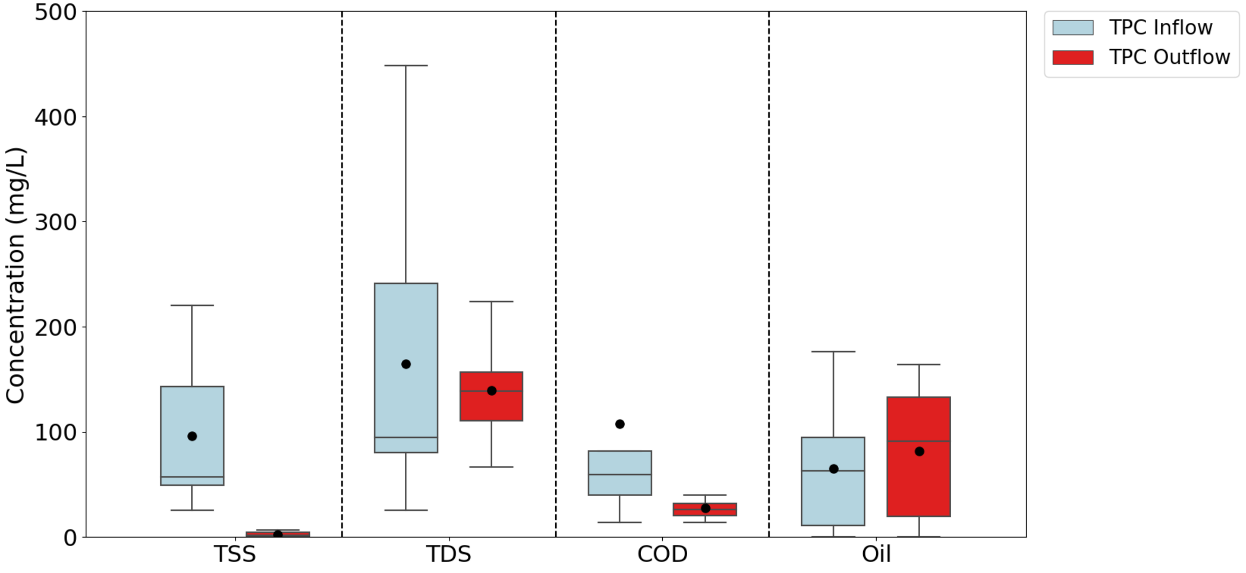


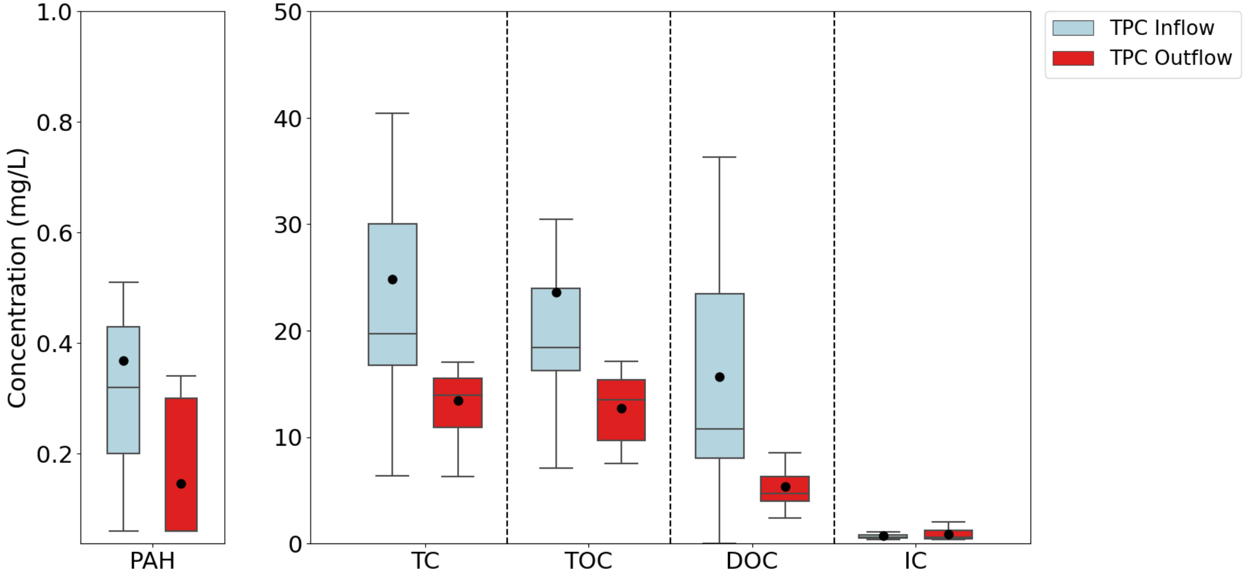


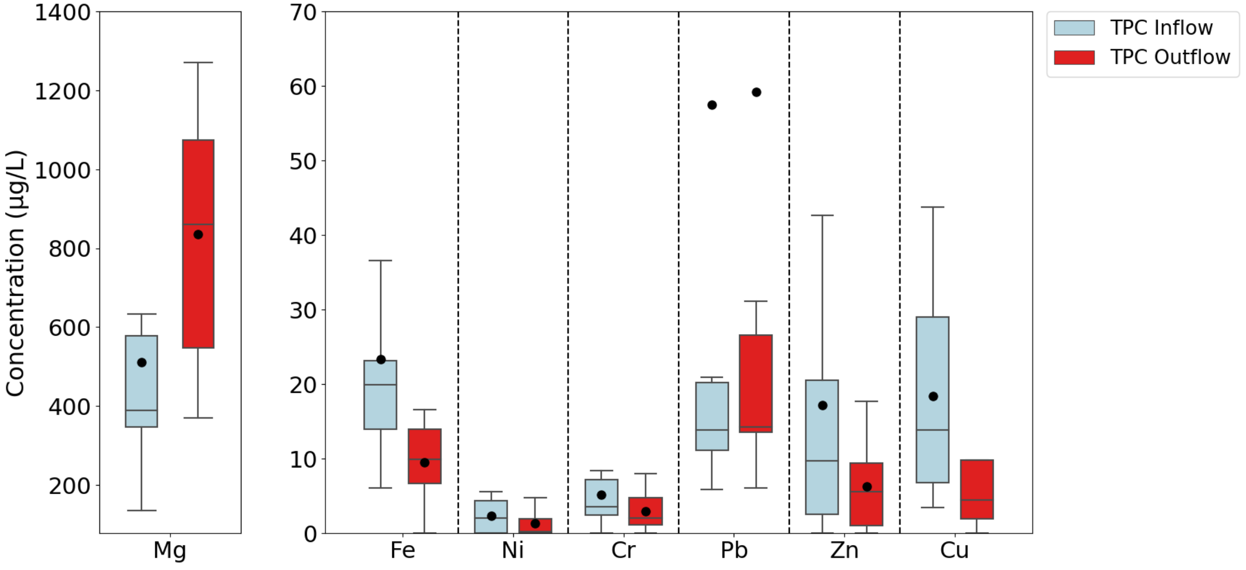


Water quality monitoring at TPC Basin

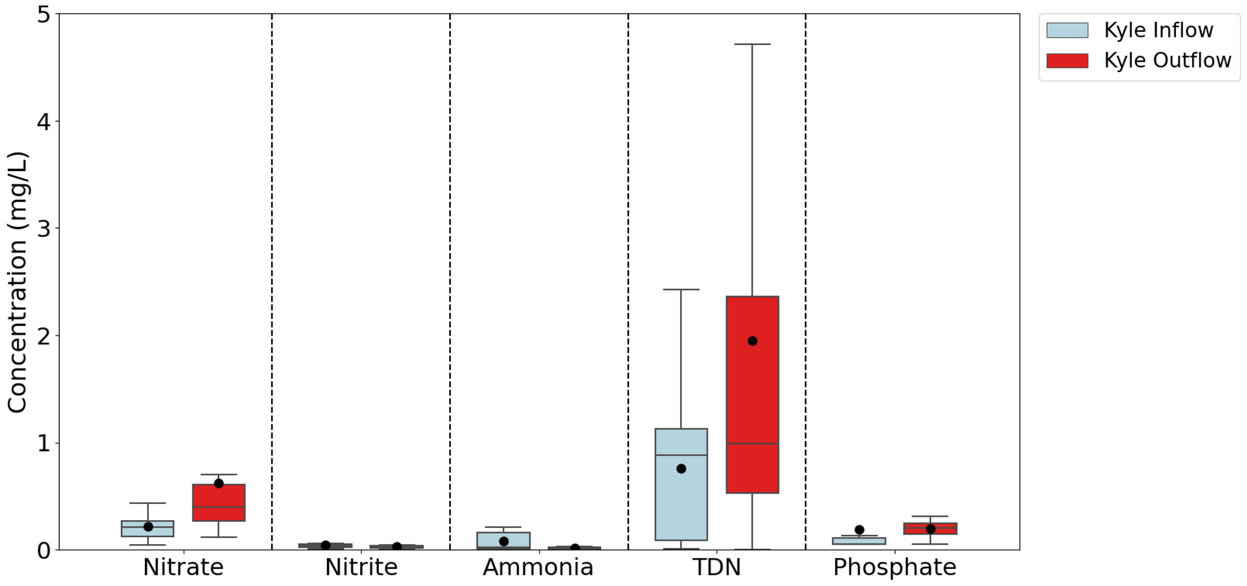


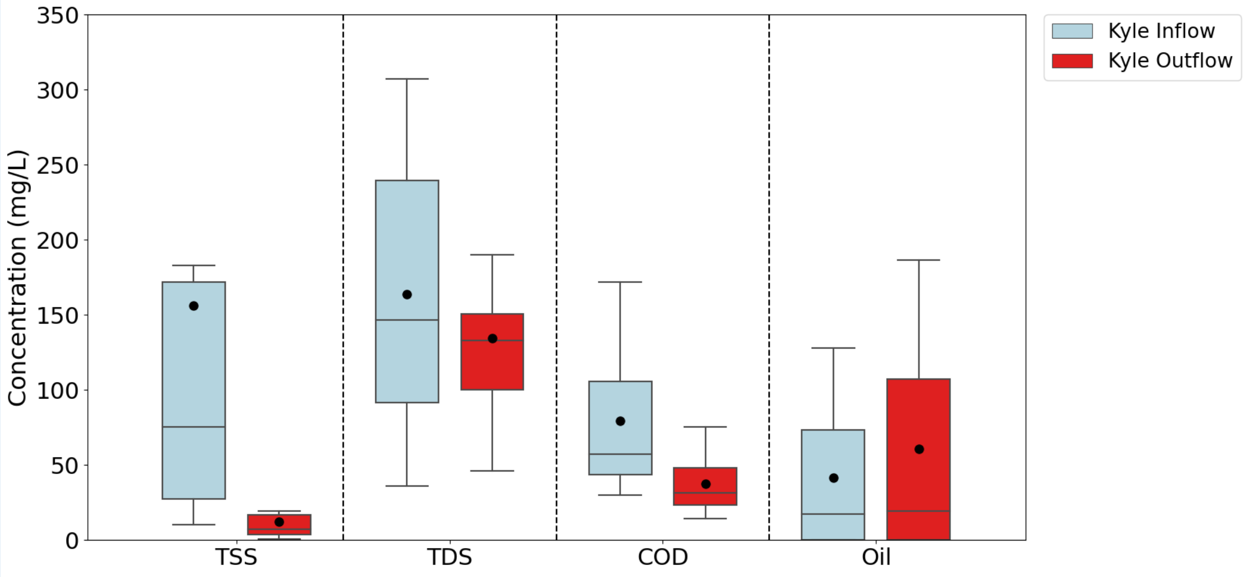


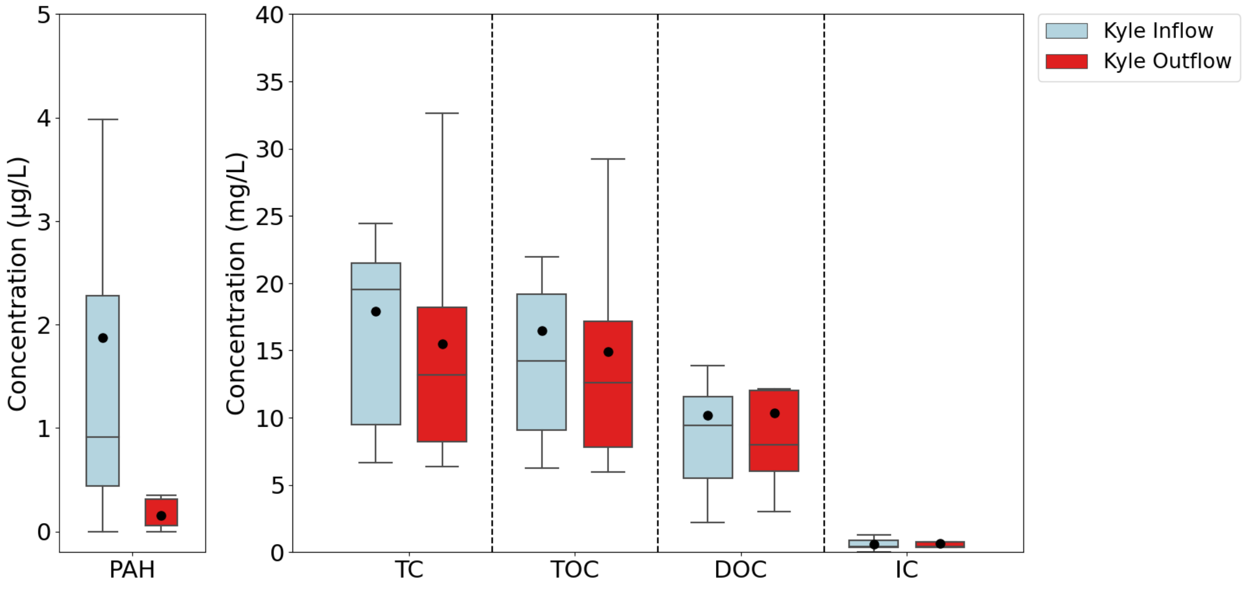


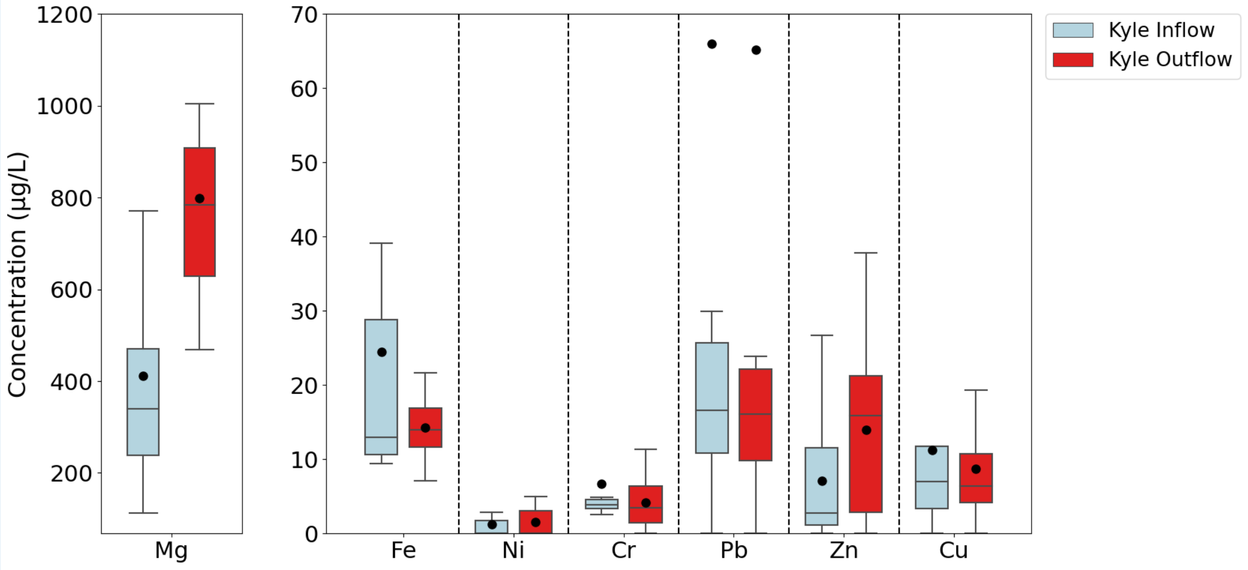


Water quality monitoring at Kyle Basin

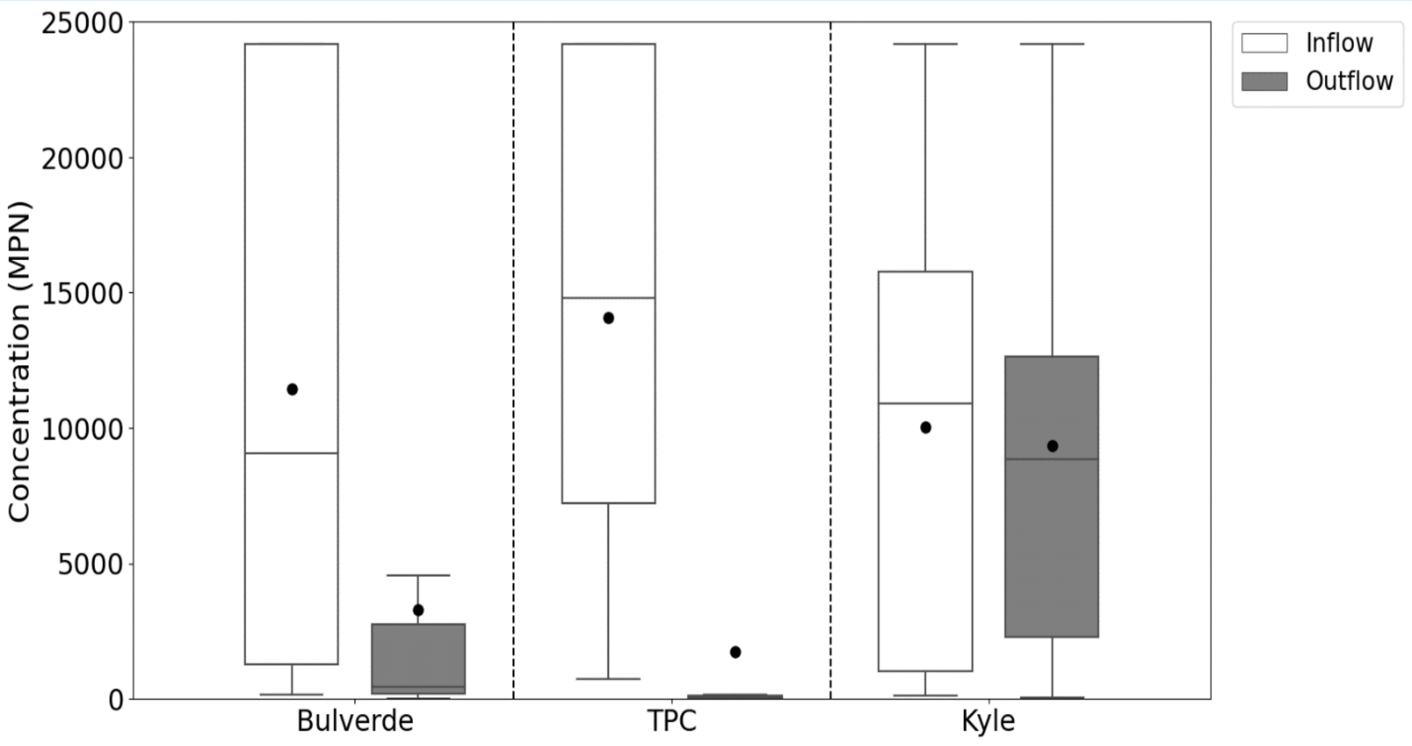








Fecal coliform removal



Water quality results

	Kyle			TPC			TCEQ acceptable concentration
Constituent	Inlet	Outlet	p-value	Inlet	Outlet	p-value	
NO_3-N	0.92	1.62	0.018*	0.39	0.64	0.04*	0.68
NO_2-N	0.12	0.07	0.22	0.03	0.01	0.003*	_
NH_3-N	0.05	0.01	0.02*	0.06	0.01	0.007*	1.7
TDN	0.88	0.99	0.054	1.19	0.92	0.39	_
PO_4^{3-}	0.05	0.22	0.03*	0.14	0.27	0.03*	1.25
TSS	72.0	13.4	0.01*	57.0	1.2	<0.001*	100
TDS	146	132	0.56	94	139	0.6	_
TOC	18.6	14.1	0.36	18.4	13.5	<0.001*	_
TC	19.4	15.5	0.45	19.7	13.9	0.02*	_
COD	56	31	0.02*	59	26	0.003*	60

Conclusions

- Non-native plants were significantly greater in coverage in swales and detention ponds
- Native plant species richness was high in swales and detention ponds but mean coverage was low
  - 54 native plant species are recommended for planting in LID structures
- Higher vegetation cover reduced total sediment in swales compared to detention ponds
- Common native plants were accumulators of metals with greater concentrations in their roots and shoot compared to soil
- Oil and grease concentration were high in swales and detention ponds indicating that these LIDs may serve as sinks for oil and grease

Conclusions

- Detention basins effectively reduced TSS and COD concentrations
- Detention basins exhibited higher nitrate concentrations in outflow
- Efficient removal of heavy metals except for Pb and Mg
  - Kyle exhibited higher concentrations of Zn and Cu in outflow
- Significant reduction in concentration of PAHs
- Bulverde and TPC effectively reduced fecal coliform bacteria

Public Outreach

- Incorporated lectures on LID technology into courses at UTSA:
  - Water Pollution Control (2020 and 2022) - ES 4173 and ES 5493
  - Aquatic Ecology (2020, 2021, & 2022) - ES 4023 and ES 6973
  - Natural Resource Policy and Administration (2021 & 2022) - ES 4133
  - Trained UTSA students in analyzing water, soil, and plant samples
- Presented talks at the EWRI National Stormwater Conference, AEESP conference, and ACS Meeting
- Peer-reviewed publications
- We are available to provide the information to any group or NGO upon request

Acknowledgements

- City of San Antonio and associated partners for providing funding
- Karen Bishop for her support, suggestions, and comments throughout the study
- City of San Antonio's Transportation and Capital Improvements (Martin Hernandez, Les Sabernik, Eric Meyer, and Michael Dicolla)
- Department of Integrated Biology and School of Civil & Environmental Engineering, and Construction Management at UTSA
- Multiple graduate and undergraduate students who assisted with lab, greenhouse, and field studies