Perceptions of greenness: Wetland assessments through field measurements, remote sensing, and citizen engagement

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It's Not Easy Being Green

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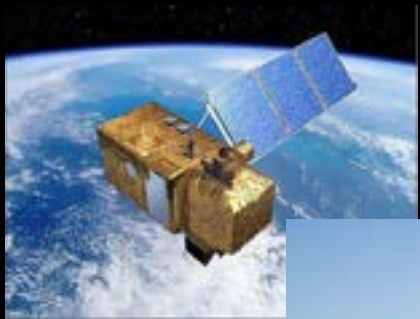
Sam Hutchins

Kassidy Haynes
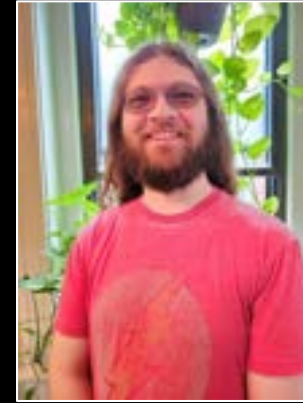
Madison Cicha

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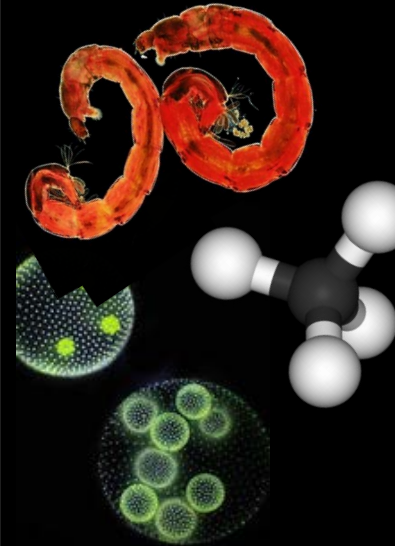
Dr. Andrea Gaughan

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McKenzie Goodwyn

Mark Tierney

Jacob Webb
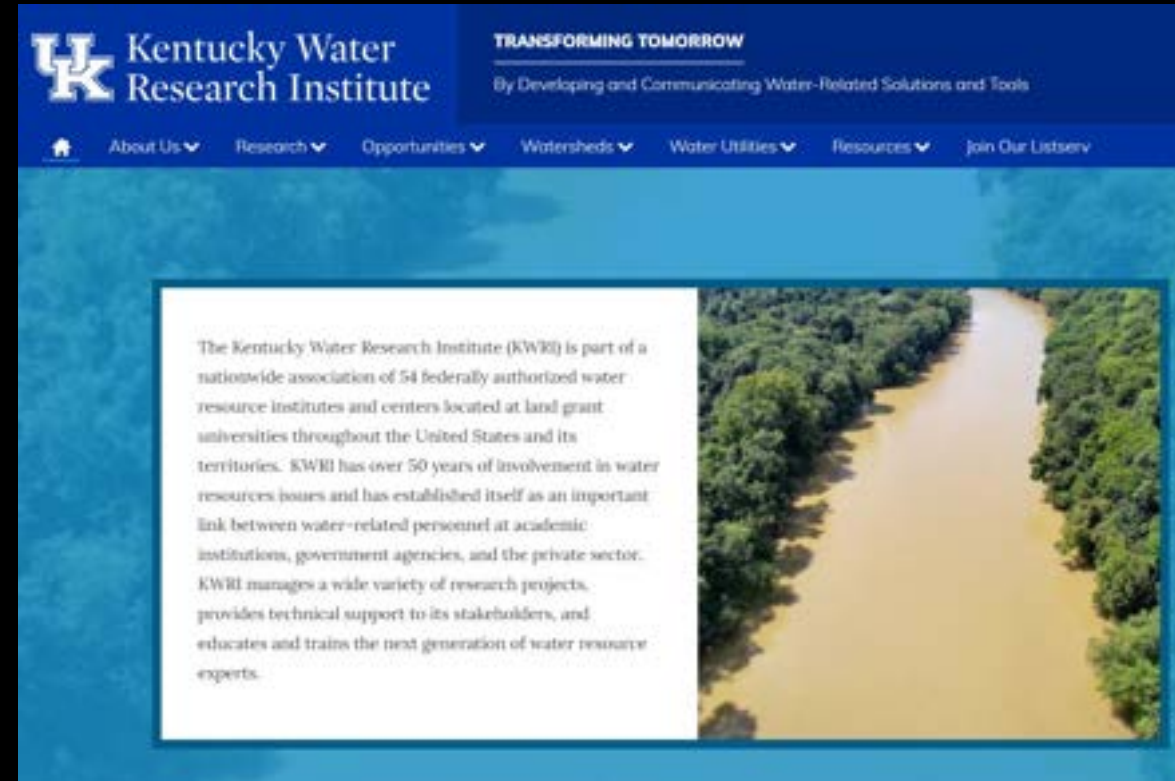
Taylor Cowles

Dr. Andrew Mehring

It's Not Easy Being Green

Ecological Component

Remote Sensing Application

Citizen/Community Engagement

Wetlands

Areas of land that are inundated for at least part of the year, leading to physico-chemical and biological conditions characteristic of shallowly flooded systems (IPCC, 1996b)

Wetlands

Areas of land that are inundated for at least part of the year, leading to physico-chemical and biological conditions characteristic of shallowly flooded systems (IPCC, 1996b)

- Wetlands are one of the most ecologically productive types of ecosystems on the planet, producing high amounts of plant material and storing energy.

- Wetlands are also among the Earth's most biodiverse ecosystems, with ~40% of all species living or breeding in wetland landscapes.

- They protect human welfare physically and economically through disaster mitigation.

Nature-based solutions

0.3°C of cooling by 2100

Girardin et al 2021 – *Nature*

reforestation and avoided forest conversion

wetland restoration and protection

over 1/3 of the cost-effective mitigation needed to limit warming below 2°C

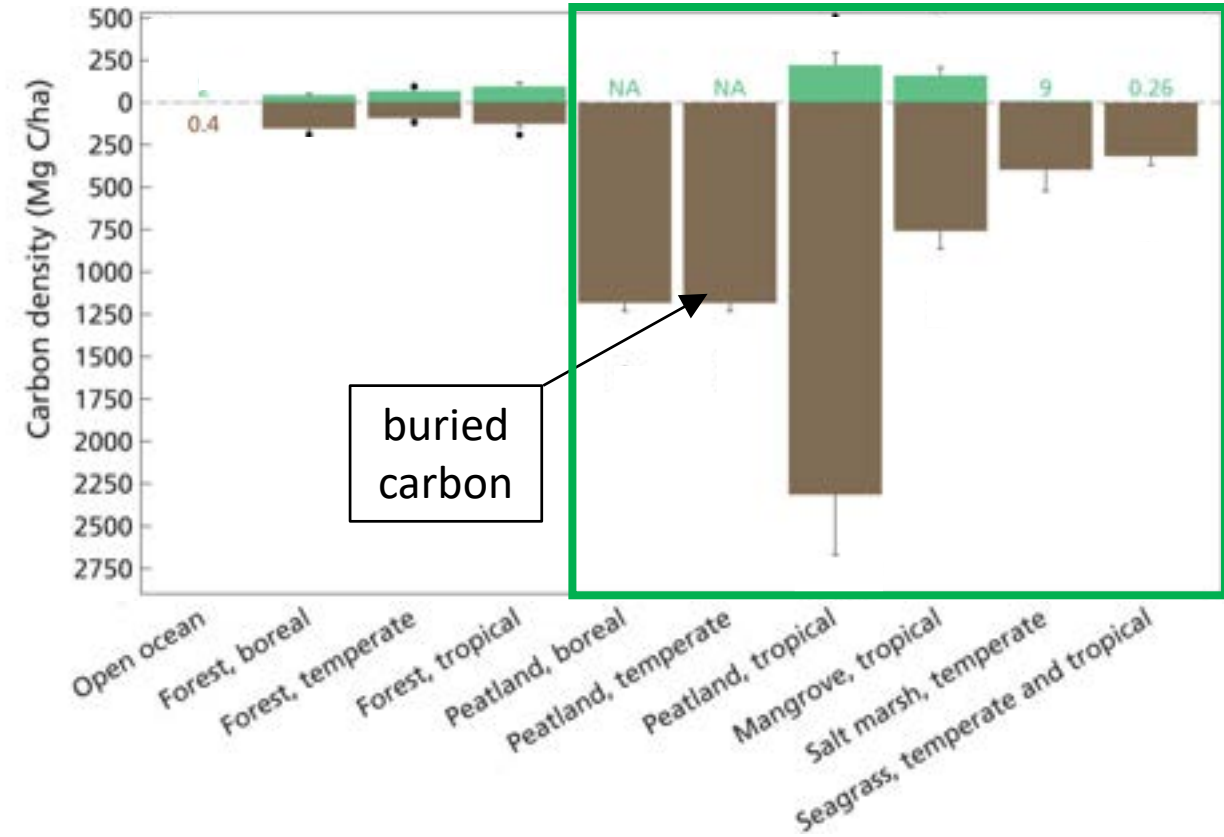Griscom et al 2017 – *PNAS*

Nature-based solutions

Wetlands *can* store more carbon than forests

FRONTIERS IN ECOLOGY and the ENVIRONMENT

Research Communication | 🔓 Free Access

High carbon burial rates by small ponds in the landscape

Scott Taylor, Peter J Gilbert, David A Cooke, Michael E Deary, Michael J Jeffries ✉
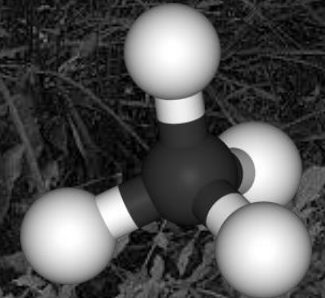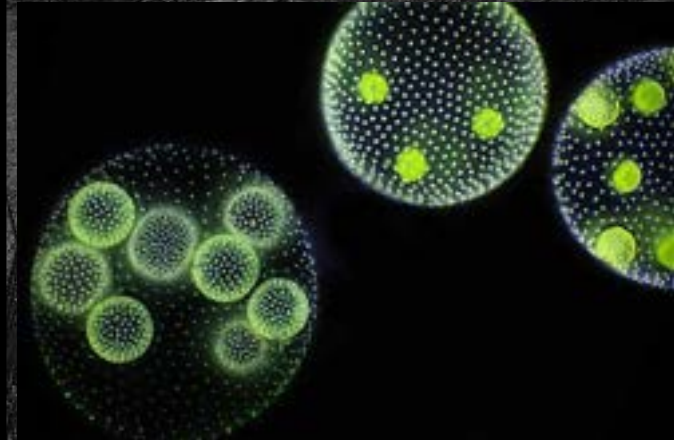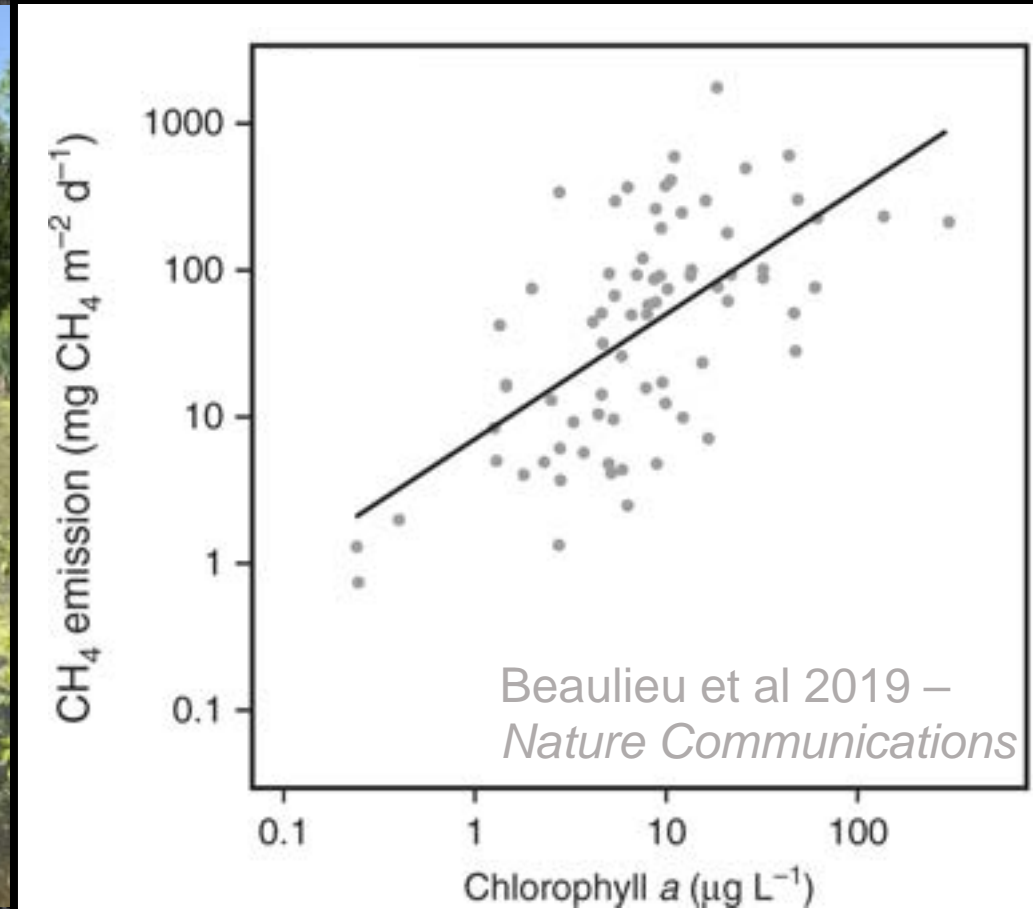

buried carbon

Temmink et al 2022 - *Science*

Source or sink?

- Most **vegetated** wetlands are CO_2 sinks
- Plants grow faster than they decompose, bury C in sediments
- Wetlands largest natural emitters of methane (CH_4)
(Kirschke et al 2013 – *Nat. Geoscience*)

Beaulieu et al 2019 –
Nature Communications

"Little things mean a lot"

- Small ponds (area <1,000 m^2) make up ~9% of global standing water
- Wetlands impacted by fertilizer runoff emit more greenhouse gas
- May account for 15% and 41% of global standing water CO_2 and CH_4 emissions
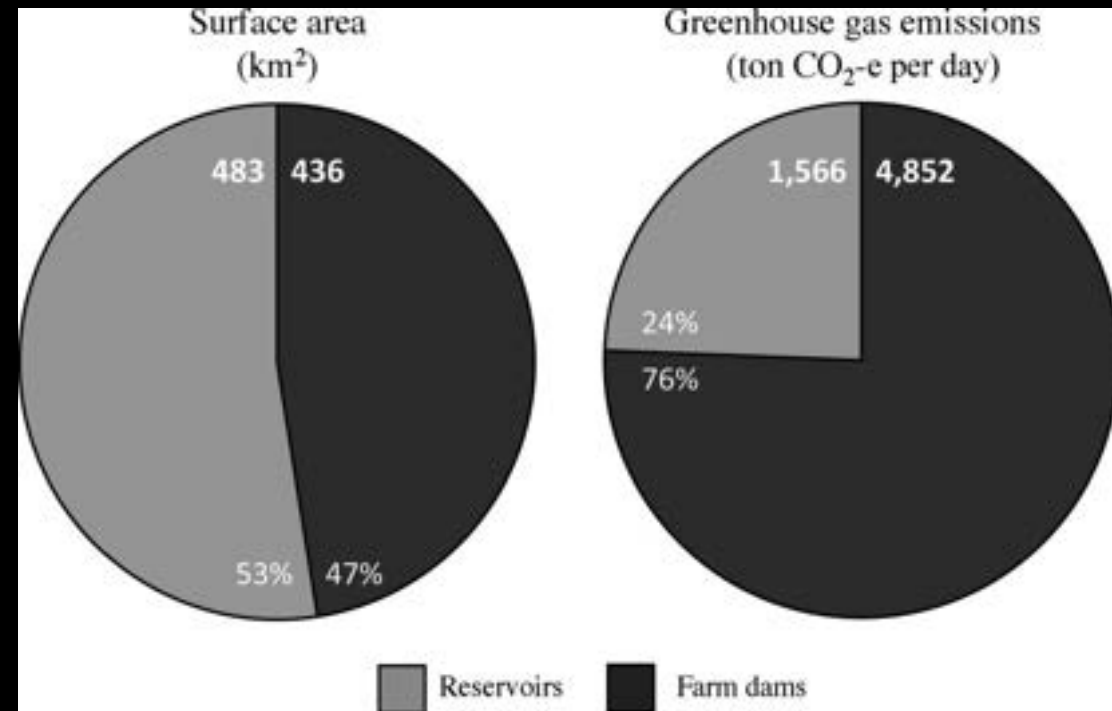
(Holgerson 2016 *Nature Geoscience*; Smith et al. 2002 *STOTEN*; Renwick et al. 2005 *Geomorphology*; Downing 2010 *Limnetica*)

Ollivier et al 2019 – *Global Change Biology*

Wetlands - small ponds, disproportionate impacts

Can we improve the ability to rapidly detect healthy ponds and wetlands vs GHG-emissions hotspots?

One Component:
How can we leverage remote sensing data to assist us in measuring and monitoring pond dynamics over space and time?

Another Component:
How to public perceptions of wetlands match against expert opinion?

Chickasaw Park
Olmsted Parks Conservancy
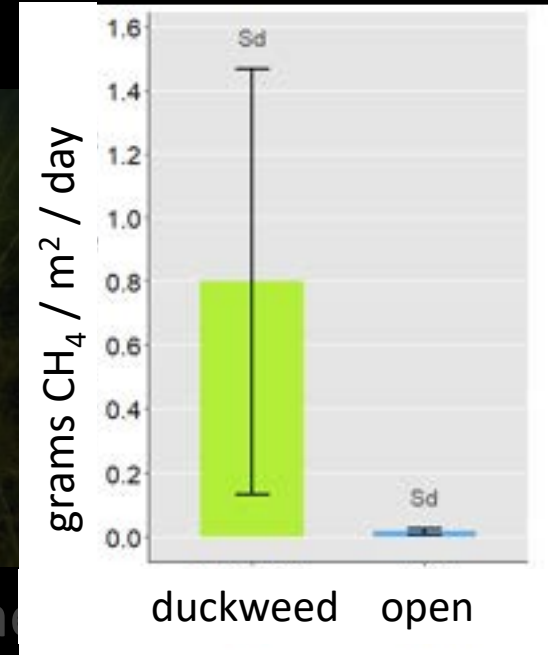Louisville, KY

Alternate states of "greenness"

methane emissions

emergent veg-dominated

subme...

duckweed   open
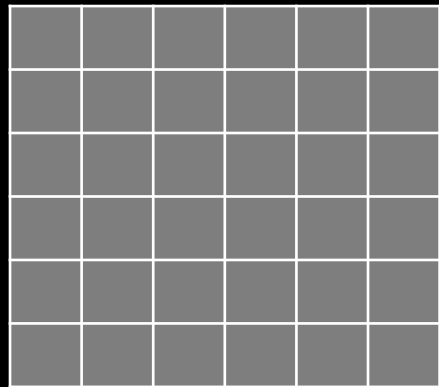
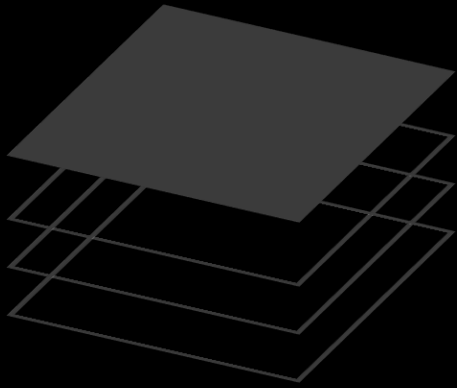algae-dominated
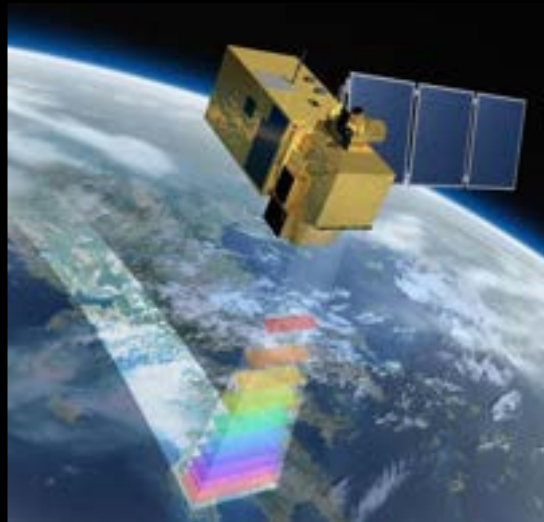
floating veg-dominated

Remote Sensing Data

Biophysical/Remote Sensing Protocol

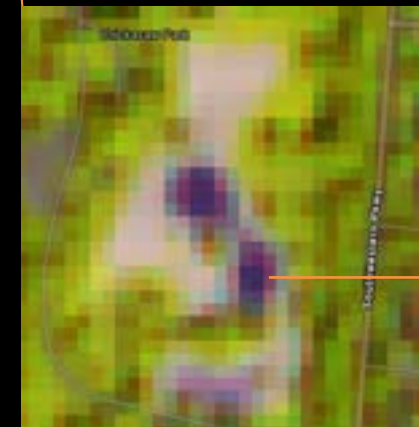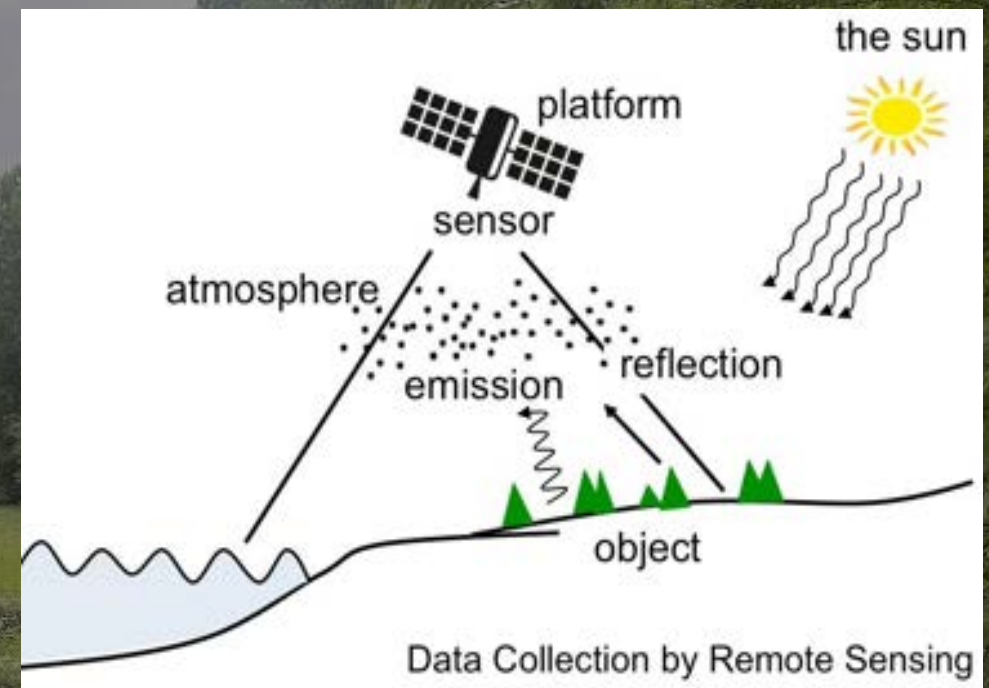Electromagnetic
Spectrum

Columns
and Rows

Pixel

Sentinel 2
January 2023
Louisville, KY

Water – From Above

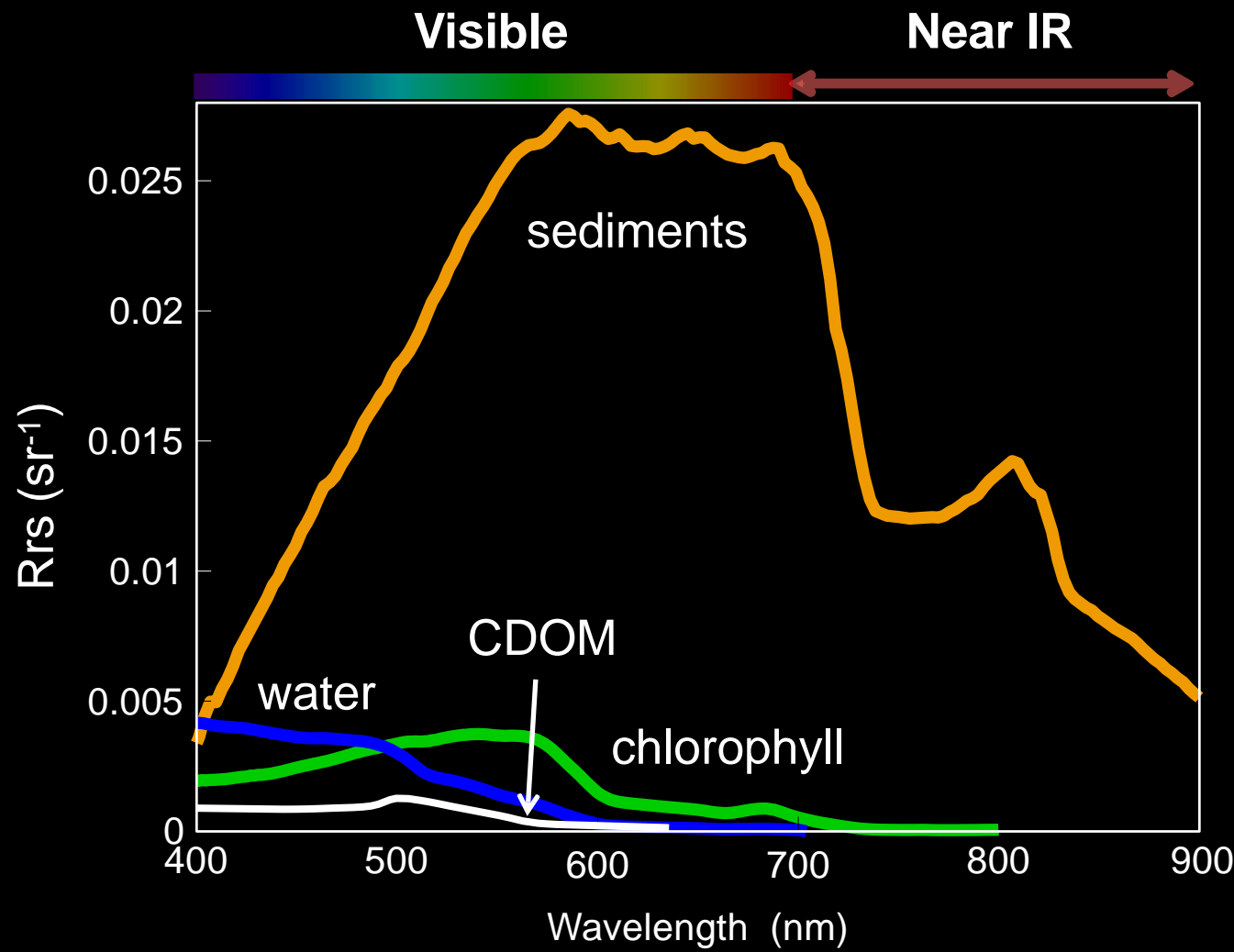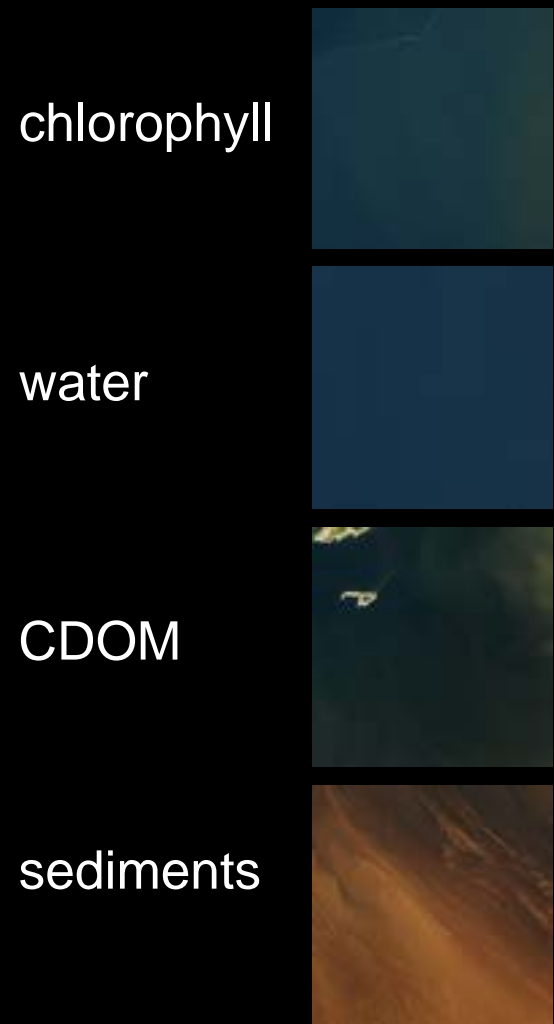Data Collection by Remote Sensing

Reflected Solar Radiation (~color of water)

- Measured by satellite sensors
- Used to derive the properties of optically-active water constituents
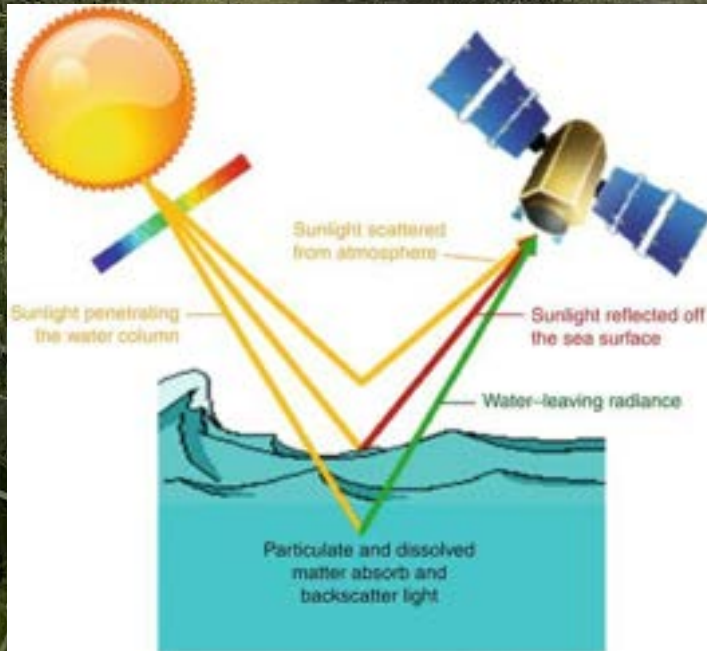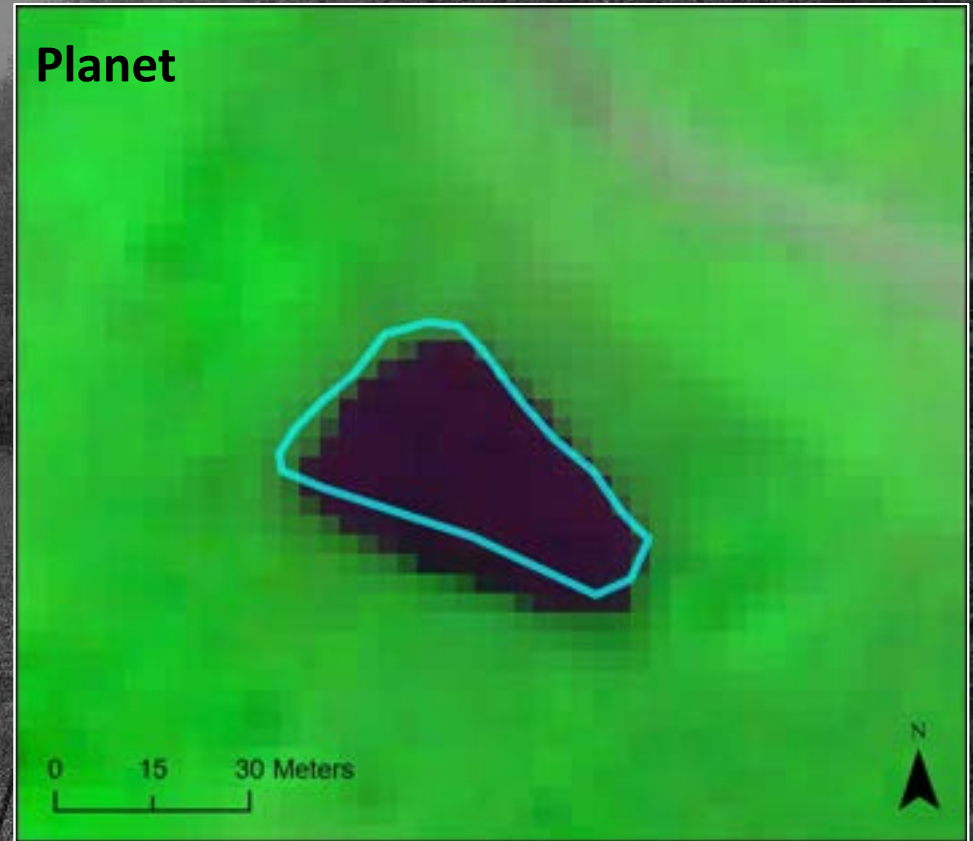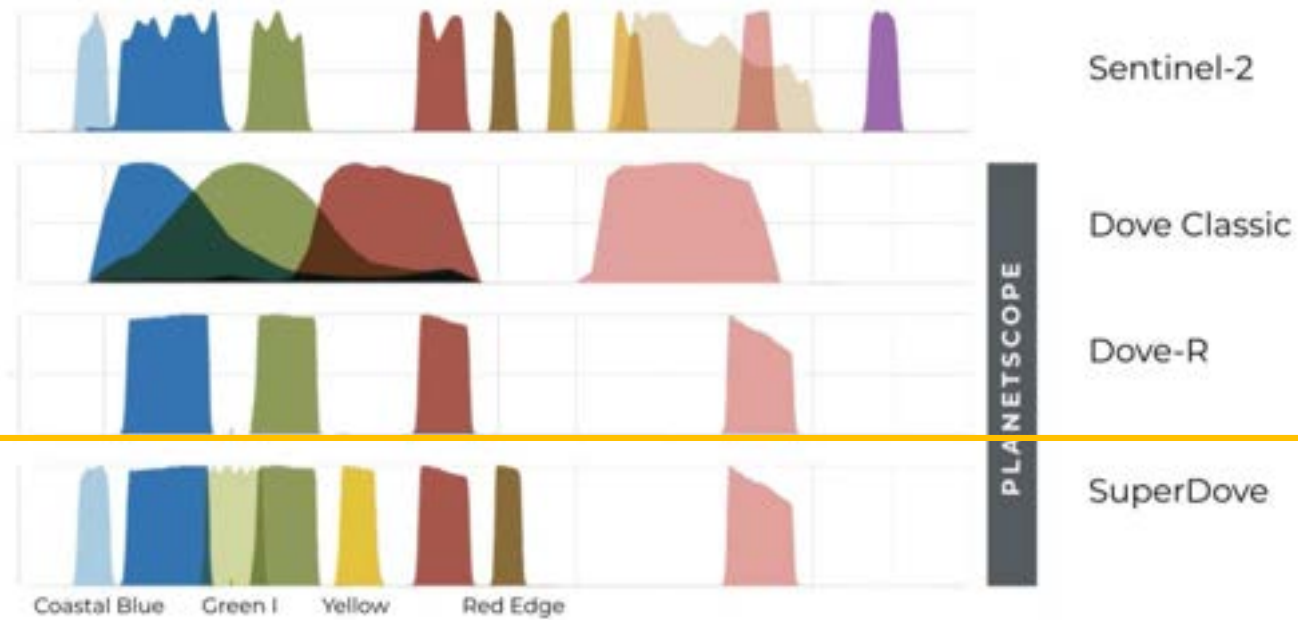

- Suspended Sediments
- Algae
- Colored Dissolved Organic Matter
- Detrital Organic Matter
- Submerged or floating vegetation

Inherent Optical Properties (IOPs) and the 'Color' of Water

Source: NASA ARSET

Big Picture – From Above

Alignment with Sentinel-2

Sentinel-2
Dove Classic
Dove-R
SuperDove

PLANETSCOPE

Coastal Blue   Green I   Yellow   Red Edge

Planet

0   15   30 Meters

N

Satellite (Sensor)	Spatial Resolution	Temporal Resolution	Spectral Bands
Sentinel 2	10 m, 20 m, 60 m	5 day revisit	13 bands
PlanetScope	3 m	2 times per day	8 bands

Methods

Pond sample total: n=35

Field Data:
Water sample
Reference data
Turbidity estimate

Created At	Open Water % Cover	Emergent Vegetation % Cover	Floating Algae % Cover	General Notes	Photo 1
30th Aug, 2023	0%	25-50%	0%	Load of Typha / cattails No wat...	
30th Aug, 2023	0%	0-25%	0%	Bottle is FP-1, nothing on cap	
30th Aug, 2023	0%	0%	0%	Duckweed city Bottle is PJ-02...	
30th Aug, 2023	75-100%	0-25%	0%	Emergent veg is a super narro...	
30th Aug, 2023	75-100%	0-25%	0-25%	Duckweed is here but barely - ...	
30th Aug, 2023	75-100%	0-25%	0-25%	Very little floating algae just ne...	
30th Aug, 2023	75-100%	0-25%	0-25%	Small Amt of floating algae. So...	
30th Aug, 2023	75-100%	0-25%	0%	Creeping primrose willow pres...	
	0%	0-25%		Algae floating with the wind ne...	

epicollect5

Field Site Example

Lemma/Wolffia Cover
75-100%

TR-5, 12 Apr 2023

TR-6, 12 Apr 2023

TR-5, 30 Aug 2023

TR-6, 30 Aug 2023

Field Site Example

Lemma/Wolffia Cover
25-75%

FP-4 30 Aug 2023

FP-3, 30 Aug 2023

Field Site Example

Lemma/Wolffia Cover
0-25%

MC-1 30 Aug 2023

CP=1, 30 Aug 2023

Field Site Example
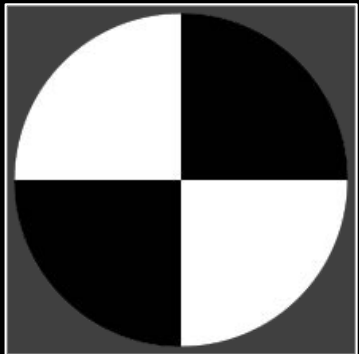
Algae

TH-1 30 Aug 2023

IP-1, 30 Aug 2023

Methods

Turbidity Estimates

Turbidity might block light so we want to try and control for that in the modeling

Low tech [turbidity tube](#)!

Secchi disk

Methods

Pond sample total:
n=35

Team divides and
conquers

Field Data:
Water sample
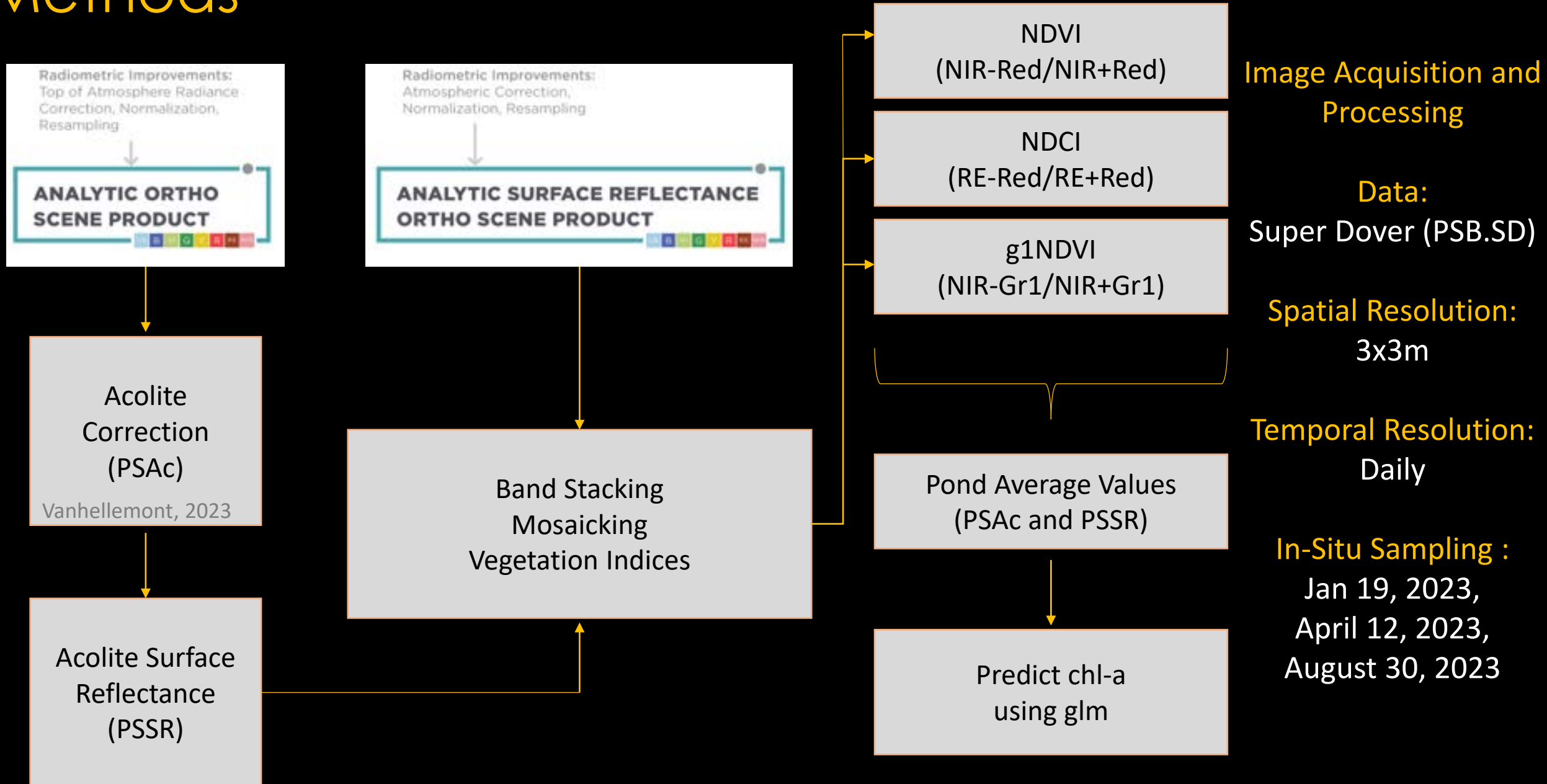Turbidity estimate
Reference data

January 2023:
n=24

April 2023:
n=34

August 2023:
n= ~35

Methods

Radiometric Improvements:
Top of Atmosphere Radiance Correction, Normalization, Resampling

ANALYTIC ORTHO SCENE PRODUCT

Radiometric Improvements:
Atmospheric Correction, Normalization, Resampling

ANALYTIC SURFACE REFLECTANCE ORTHO SCENE PRODUCT

Acolite Correction (PSAc)

Vanhellemont, 2023

Acolite Surface Reflectance (PSSR)

Band Stacking
Mosaicking
Vegetation Indices

NDVI
(NIR-Red/NIR+Red)

NDCI
(RE-Red/RE+Red)

g1NDVI
(NIR-Gr1/NIR+Gr1)

Pond Average Values
(PSAc and PSSR)

Predict chl-a
using glm

Image Acquisition and Processing

Data:
Super Dover (PSB.SD)

Spatial Resolution:
3x3m

Temporal Resolution:
Daily

In-Situ Sampling :
Jan 19, 2023,
April 12, 2023,
August 30, 2023

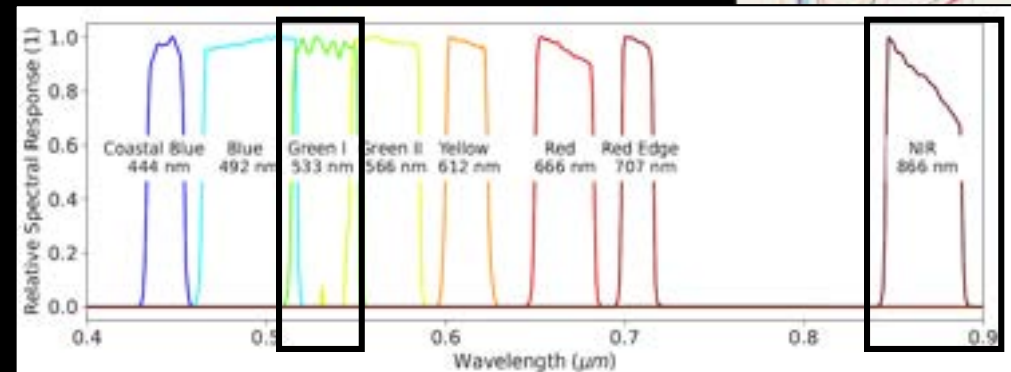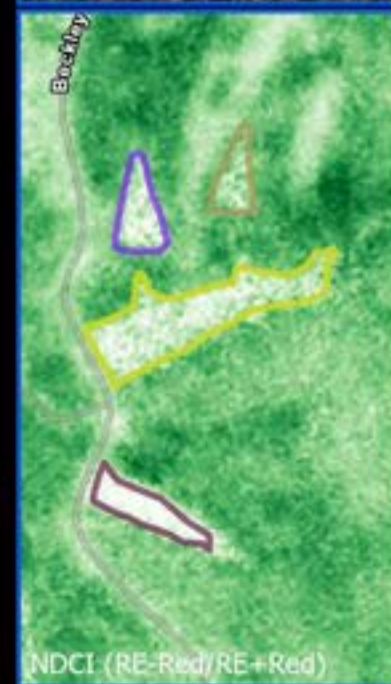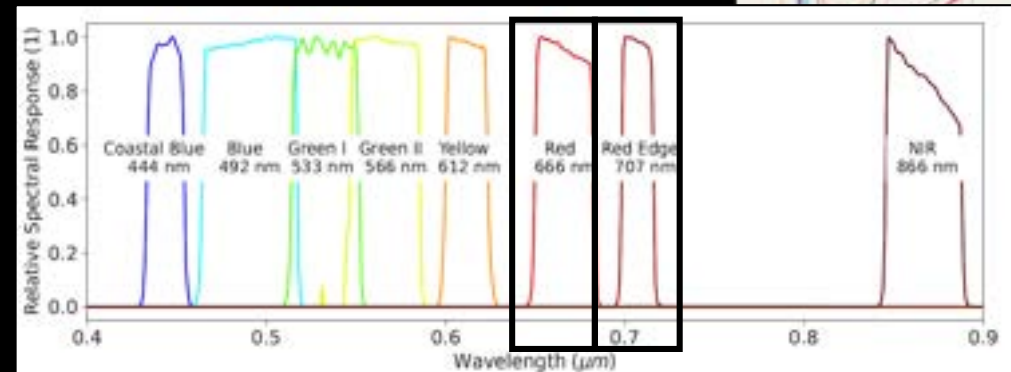# Study Area

Table 1. SuperDove band names, centre wavelengths and full width at half maximum in nm as derived from the RSR in Fig. 3.
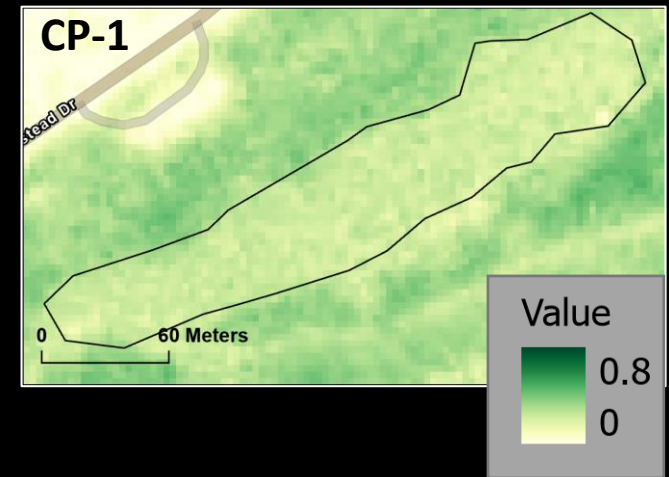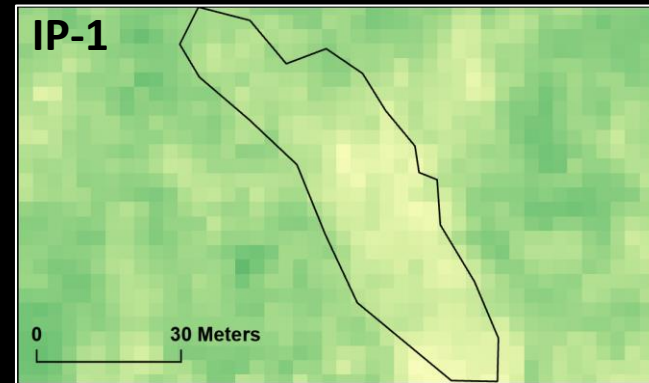
Band Name	Wavelength (nm)	FWHM (nm)
Coastal Blue	444	20
Blue	492	52
Green I	533	37
Green II	566	38
Yellow	612	23
Red	666	32
Red Edge	707	16
NIR	866	41

Louisville, KY, Jefferson County

**The Parklands
Beckley Creek Park**

NDVI (NIR-Red/NIR+Red)

Study Area

Table 1. SuperDove band names, centre wavelengths and full width at half maximum in nm as derived from the RSR in Fig. 3.
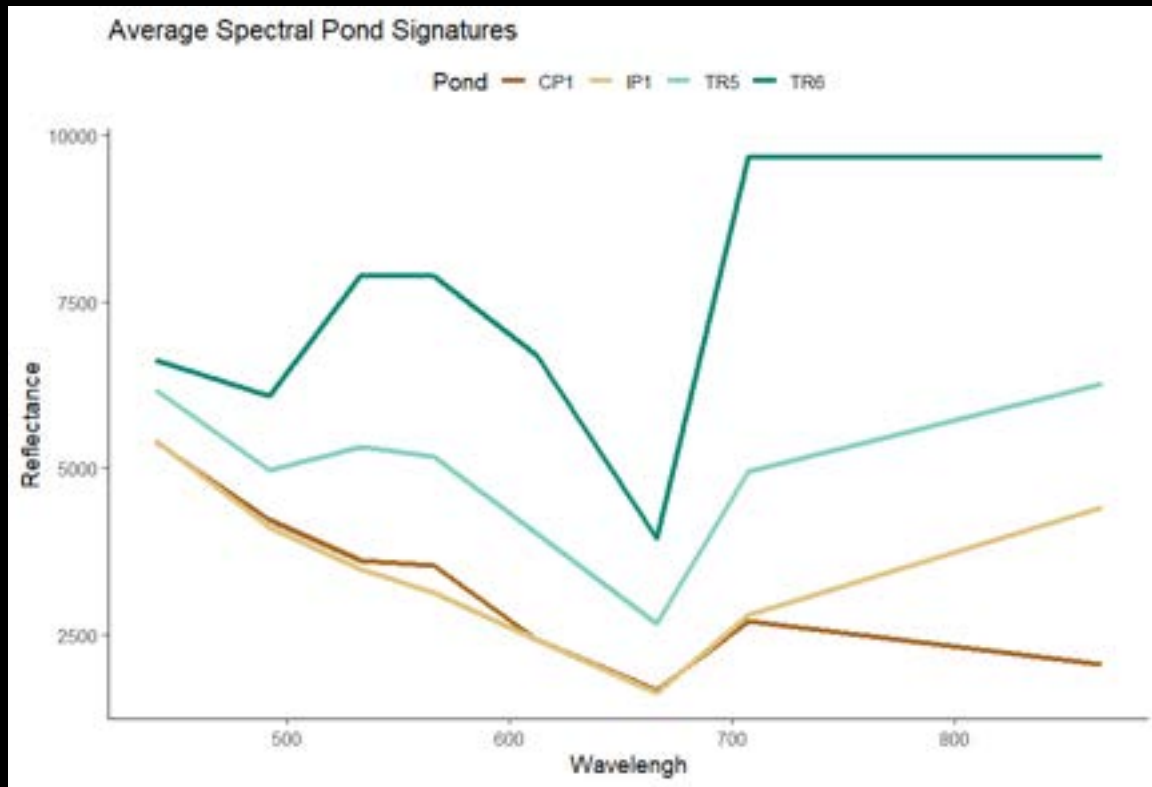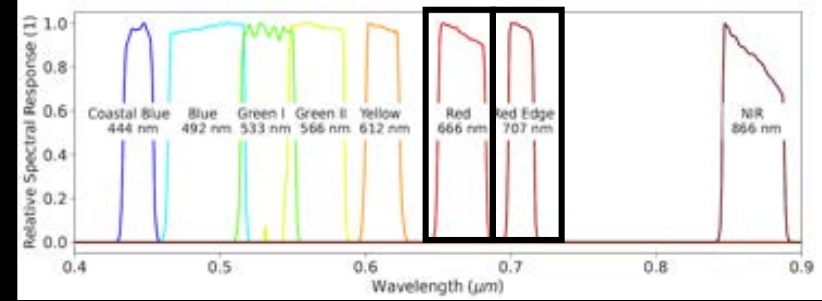
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Coastal Blue	444	20
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Red	666	32
Red Edge	707	16
NIR	866	41

Louisville, KY, Jefferson County

The Parklands
Beckley Creek Park

gNDVI (NIR-Gr/NIR+Gr)

Study Area

Table 1. SuperDove band names, centre wavelengths and full width at half maximum in nm as derived from the RSR in Fig. 3.

Band Name	Wavelength (nm)	FWHM (nm)
Coastal Blue	444	20
Blue	492	52
Green I	533	37
Green II	566	38
Yellow	612	23
Red	666	32
Red Edge	707	16
NIR	866	41

Louisville, KY, Jefferson County

The Parklands
Beckley Creek Park

NDCI (RE-Red/RE+Red)

Results

AUG NDCI (RE-Red/RE+Red)

TR-6, 30 Aug 2023

TR-5, 30 Aug 2023

IP-1

CP-1

Value

0.8

0

Model Results

VI	model	AICc	deltaAICc	R2	MSE	RMSE
NDCI_PSAc	glm(NDCI_PSAc~chla_ugl+Duckweed_cat+turb_NTU)	-156.0	0	0.43	0.101994	0.319364
NDCI_PSSR	glm(NDCI_PSSR~chla_ugl+Duckweed_cat+chla_ugl*turb_NTU)	-142.2	13.8	0.35	0.132209	0.363605
g1NDVI_PSAc	glm(g1NDVI_PSAc~chla_ugl+Duckweed_cat+turb_NTU)	-62.7	93.3	0.24	0.170444	0.412849
NDVI_PSAc	glm(NDVI_PSAc~chla_ugl+Duckweed_cat+turb_NTU)	-36.5	119.5	0.28	0.195373	0.44201
NDVI_PSSR	glm(NDVI_PSSR~Duckweed_cat+turb_NTU+Duckweed_cat*turb_NTU)	19.7	175.7	0.26	0.319727	0.565444
g1NDVI_PSSR	glm(g1NDVI_PSSR~chla_ugl+Duckweed_cat+turb_NTU)	77.7	233.7	0.08	0.36457	0.603797

VI	model	AICc	deltaAICc	R2	MSE	RMSE
NDCI_PSAc	glm(NDCI_PSAc~chla_ugl+turb_NTU)	-135	0	0.27	0.103449	0.321635
NDCI_PSSR	glm(NDCI_PSSR~chla_ugl+turb_NTU+chla_ugl*turb_NTU)	-125.5	9.5	0.08	0.132501	0.364007
g1NDVI_PSAc	glm(g1NDVI_PSAc~chla_ugl+turb_NTU+chla_ugl*turb_NTU)	-52.6	82.4	0.15	0.182439	0.427129
NDVI_PSAc	glm(NDVI_PSAc~chla_ugl+turb_NTU+chla_ugl*turb_NTU)	-27.0	108.0	0.20	0.221722	0.470874
NDVI_PSSR	glm(NDVI_PSSR~chla_ugl+turb_NTU+chla_ugl*turb_NTU)	17.6	152.6	0.14	0.323828	0.569059
g1NDVI_PSSR	glm(g1NDVI_PSSR~chla_ugl+turb_NTU+chla_ugl*turb_NTU)	63.9	198.9	0.10	0.381731	0.617844

Model Results

Best model

glm(NDCI_PSAc~chla_ugl+Duckweed_cat+turb_NTU

R-sq of 0.44
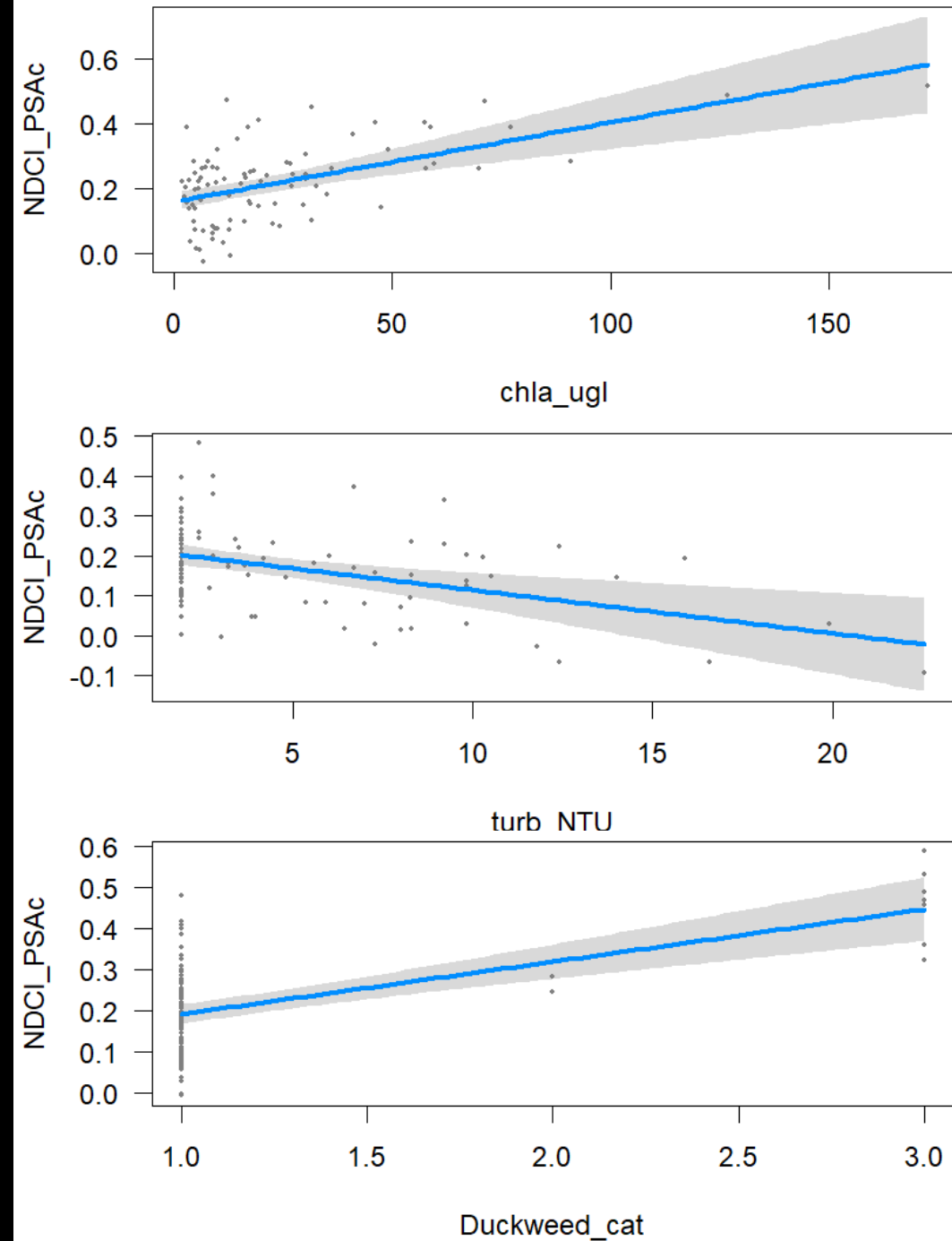
Citizen/Community Engagement

Main Objective:

Develop a user perceptions survey of wetland health in urban park systems

Goal:

Identify similarities and differences of citizen's knowledge versus expert opinions of wetland health

Intended Outcome:

Enhance public involvement and provide a sense of ownership for natural resources in our public parks

Citizen Engagement – Survey

Citizen Engagement – Signage

Citizen Engagement

Main Objective:
Develop a user perceptions survey to determine similarities and differences of citizen's knowledge versus expert opinions of wetland health in urban park systems
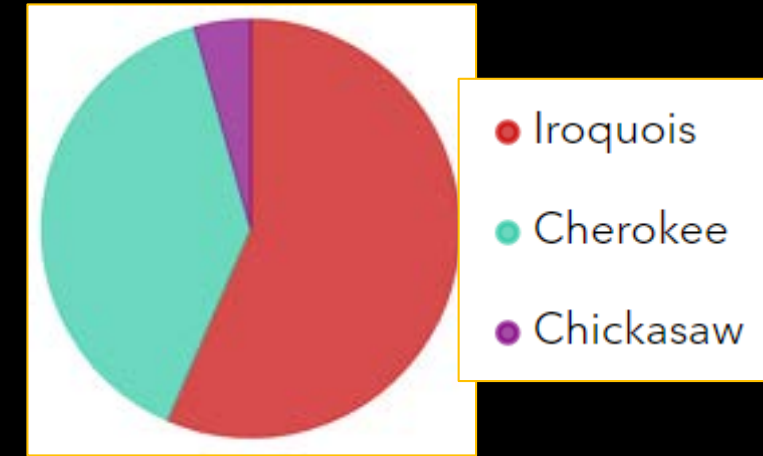

Chickasaw

Cherokee

Iroquois

Citizen Engagement

Main Objective:
Develop a user perceptions survey to determine similarities and differences of citizen's knowledge versus expert opinions of wetland health in urban park systems
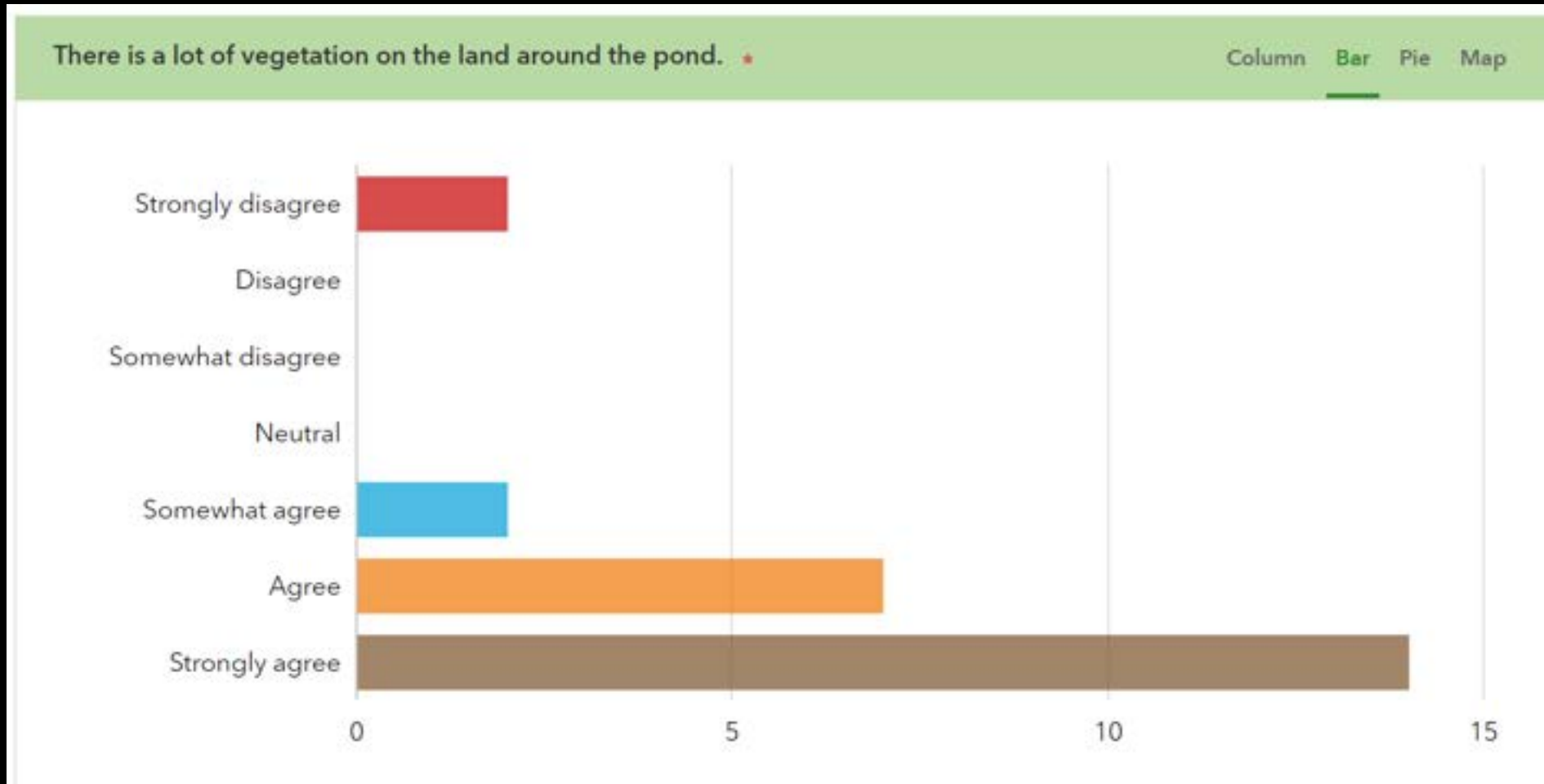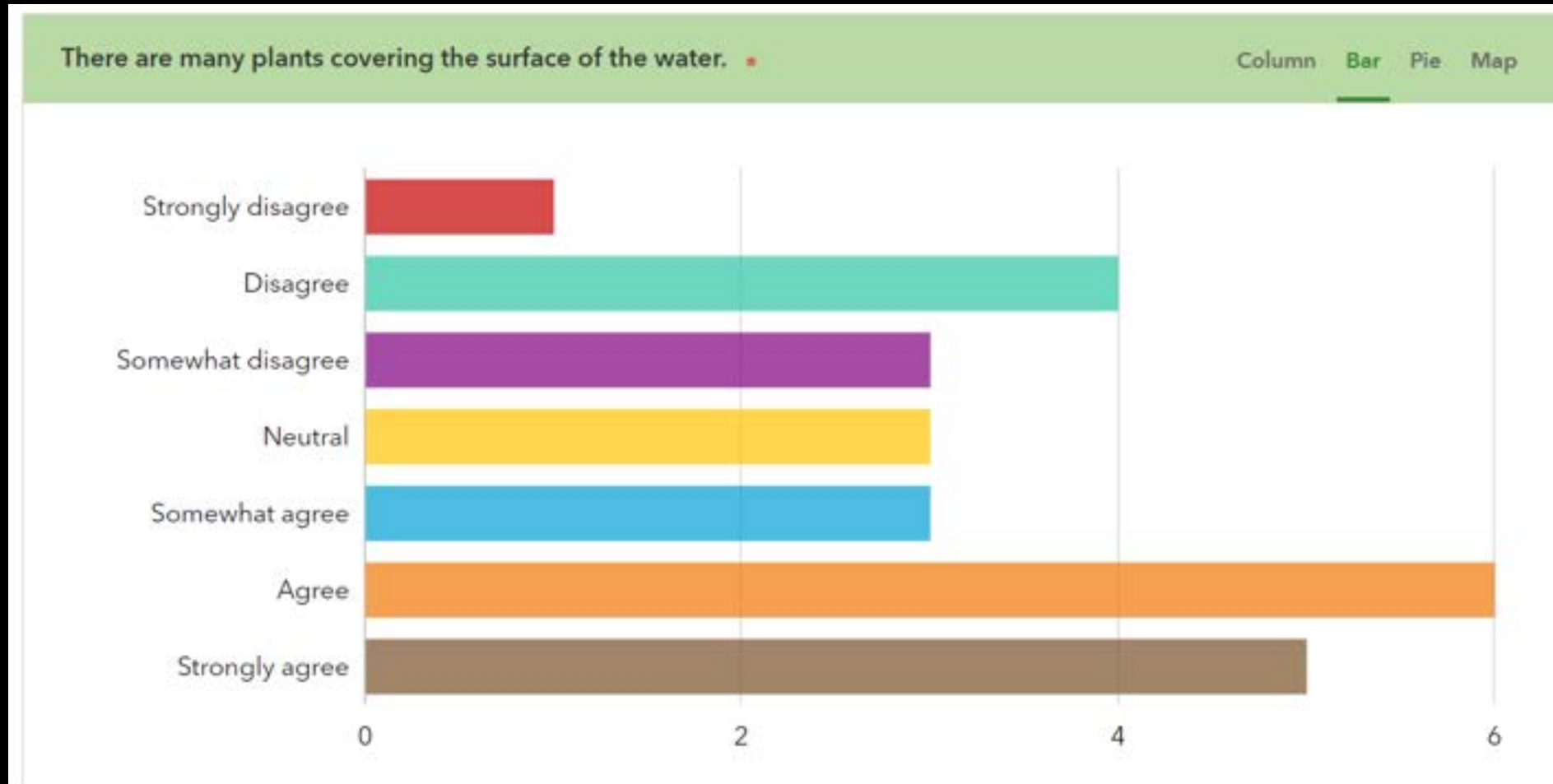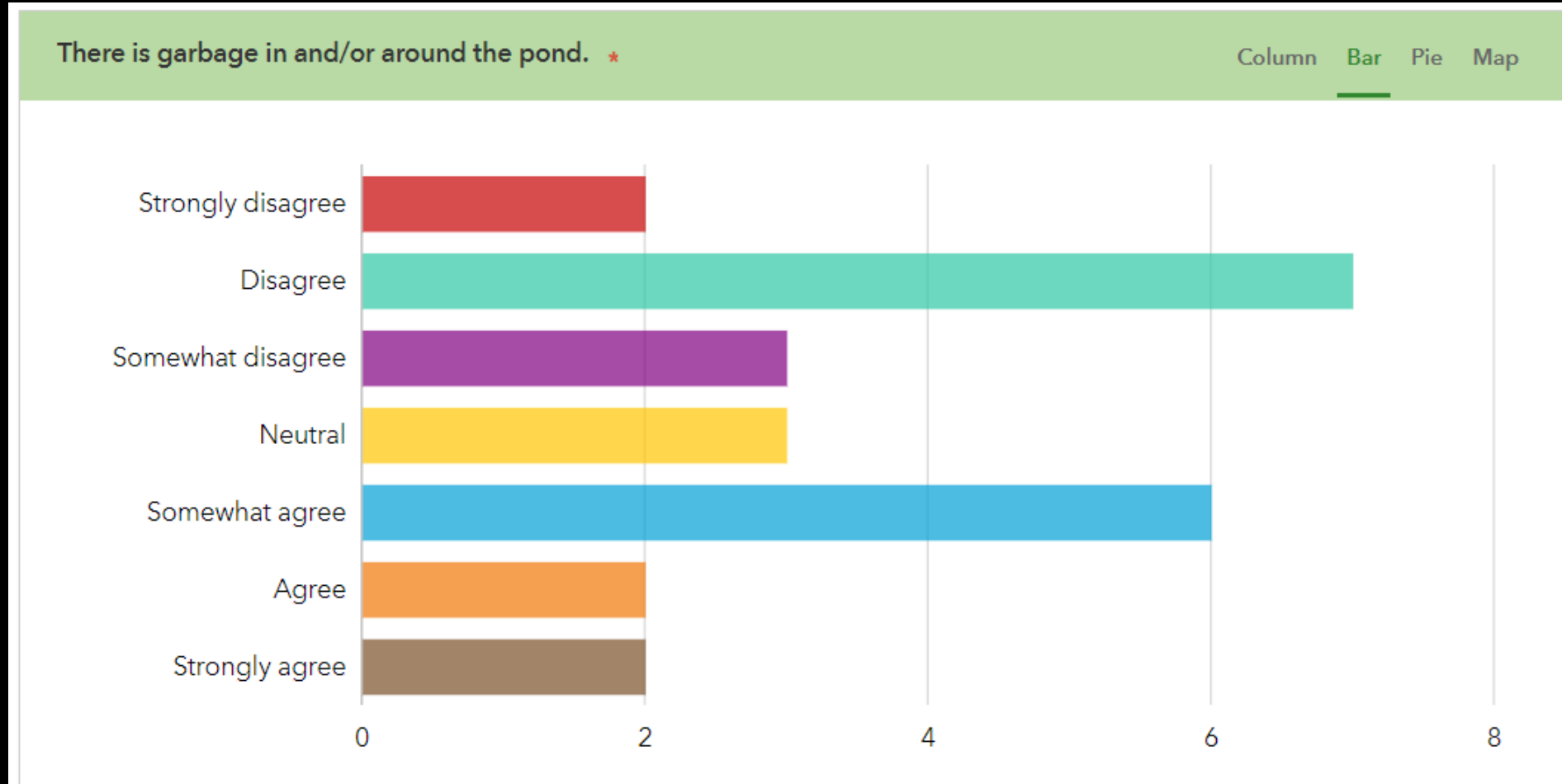

- Iroquois
- Cherokee
- Chickasaw

Chickasaw

Cherokee

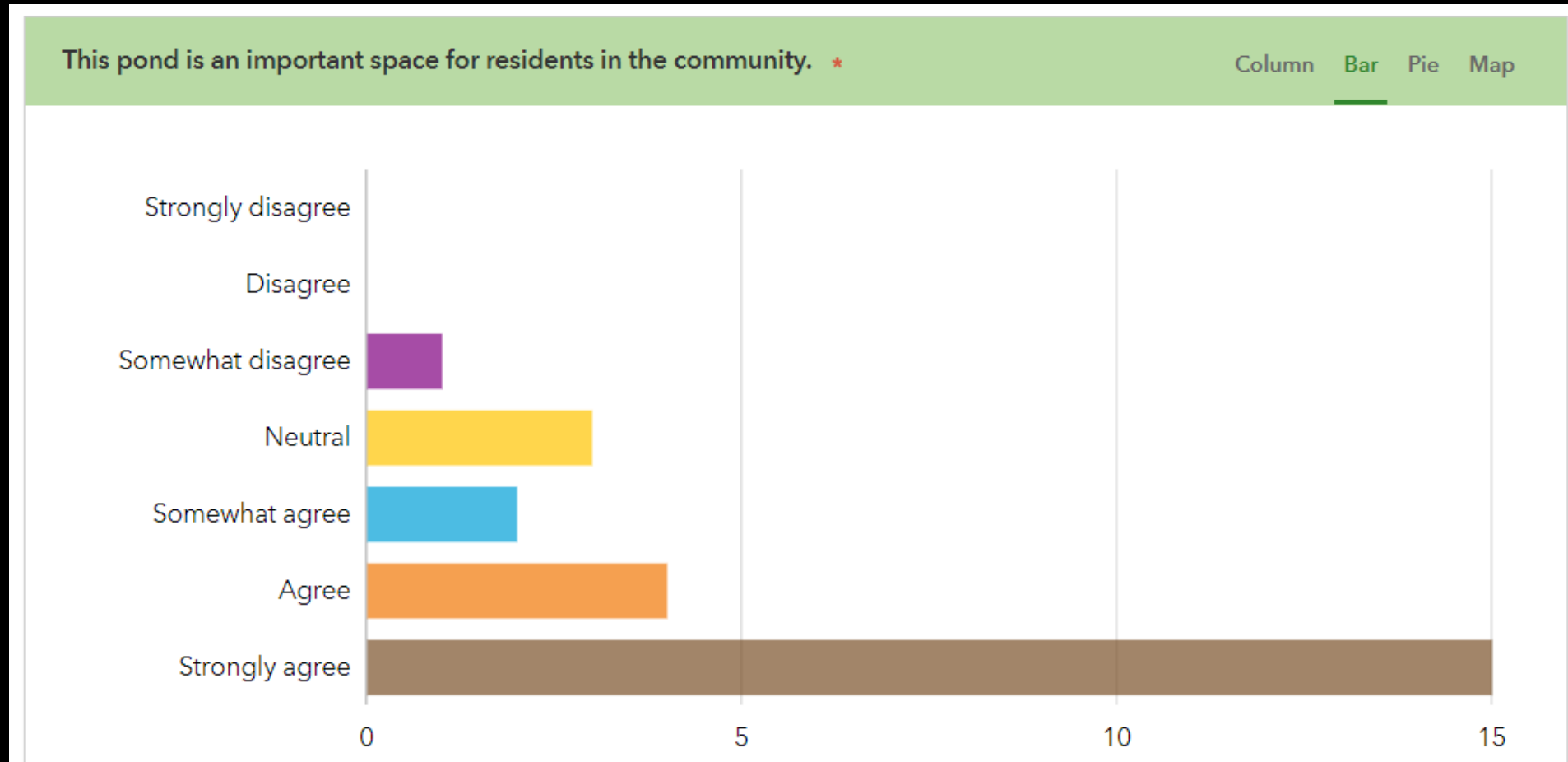Iroquois

# Citizen Engagement
n=25

Citizen Engagement
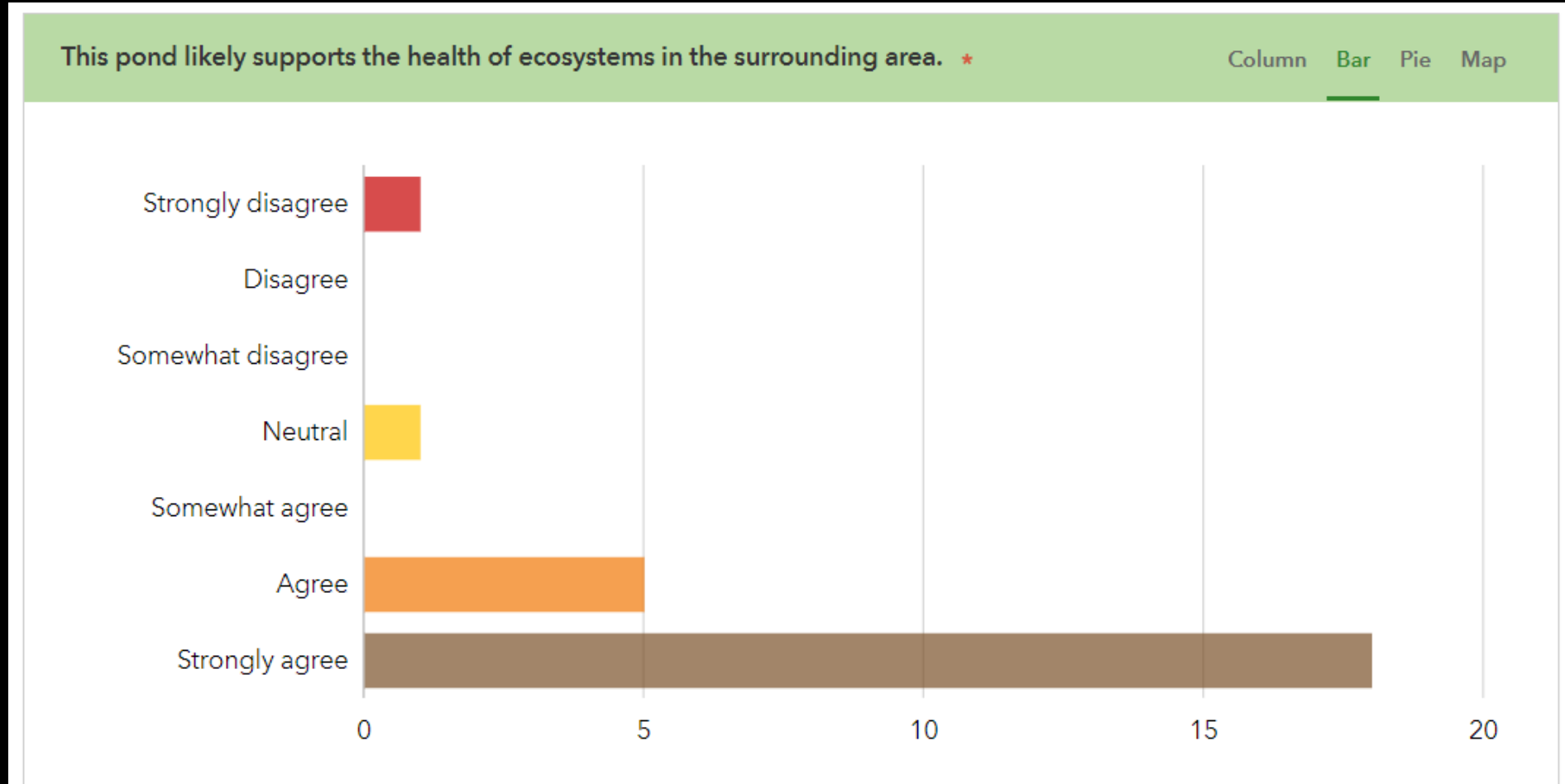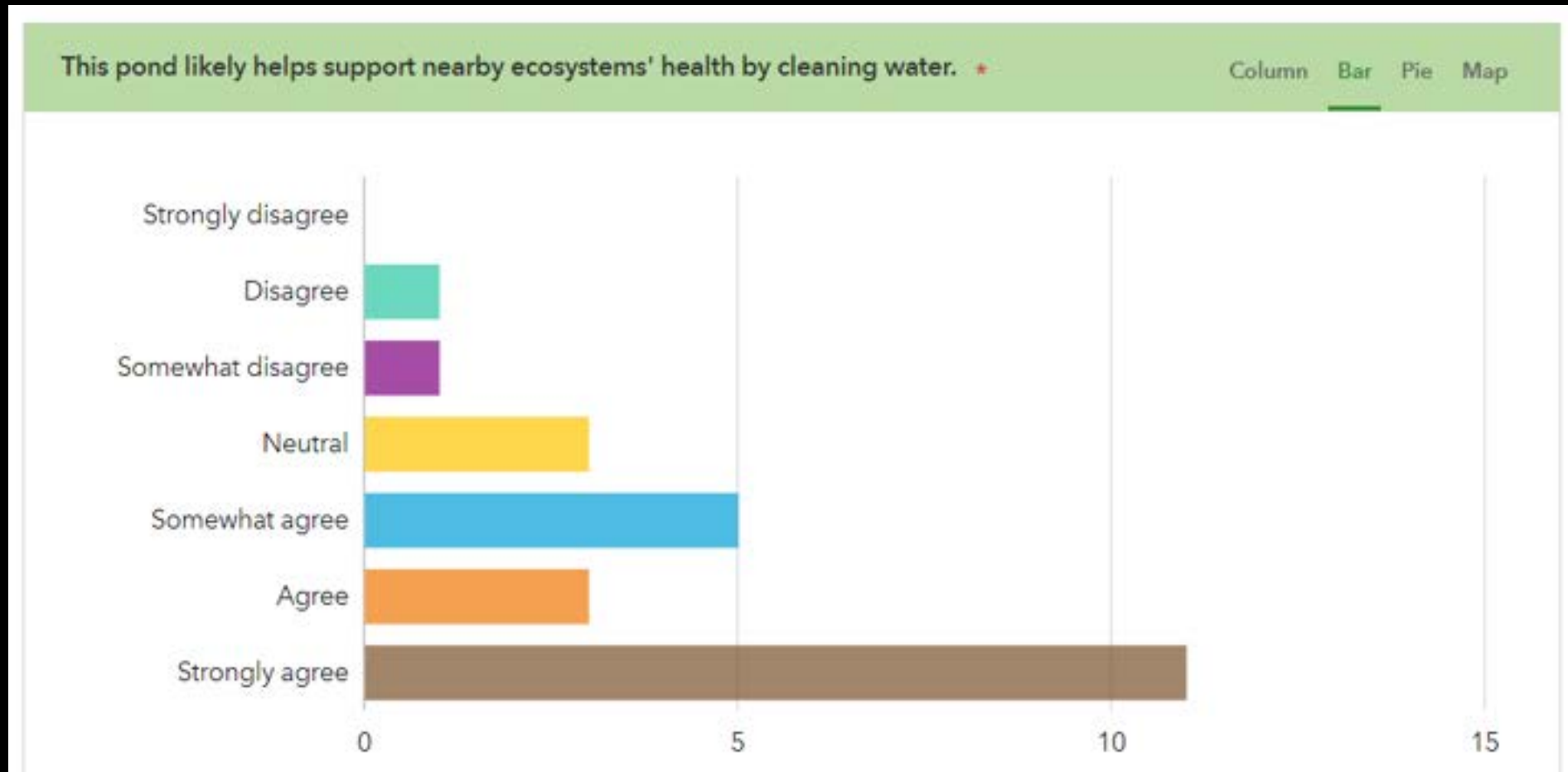n=25

Citizen Engagement
n=25

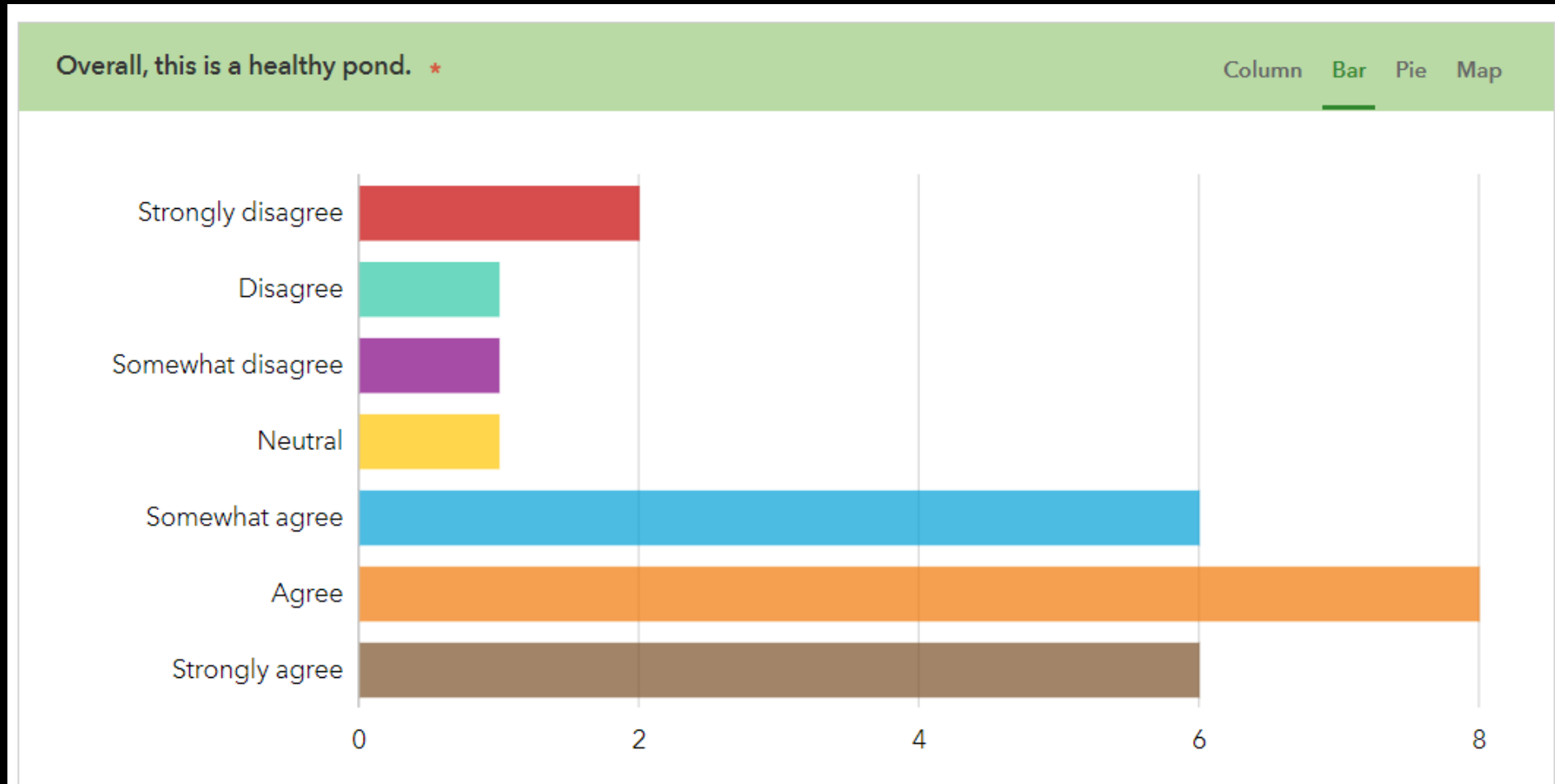# Citizen Engagement
n=25
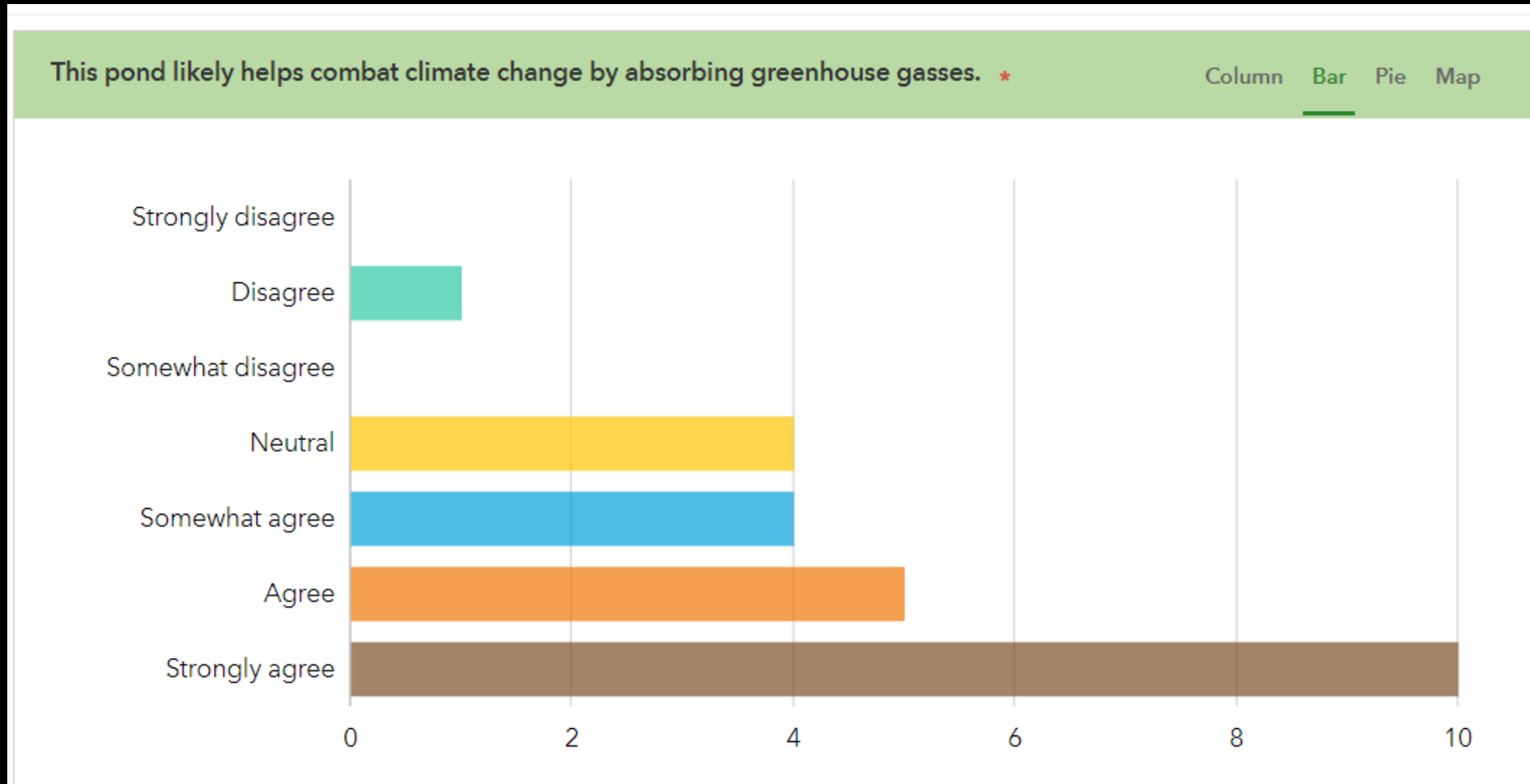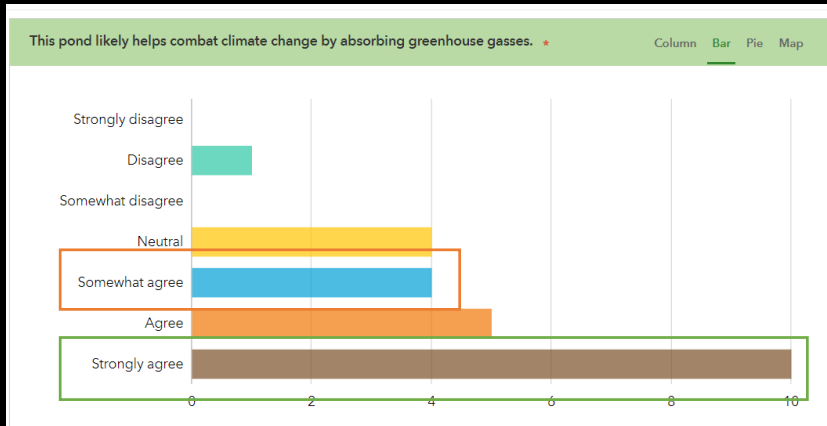
# Citizen Engagement
n=25

Citizen Engagement
n=25

# Citizen Engagement
n=25

# Citizen Engagement
n=25

Citizen Engagement
n=25

This pond likely helps combat climate change by absorbing greenhouse gasses. ·   Column Bar Pie Map

- Strongly disagree
- Disagree
- Somewhat disagree
- Neutral
- Somewhat agree
- Agree
- Strongly agree

0 2 4 6 8 10

Expert Opinion
This pond likely helps combat climate change by absorbing greenhouse gases

More likely to be a net sink for carbon

Aug 23, 2023 - Cherokee

Sep 3, 2023 - Iroquois

Project – Next Steps

- Ecological Monitoring

- Ramp up the number of ponds with signage

- Remote sensing data analysis

- Model assessment and variable inclusion

- Student Research projects

Thank you

E-mail: ae.gaughan@louisville.edu

It's not east being green Story Map

UNIVERSITY OF
LOUISVILLE.

FY2022 USGS 104b grant