Created wetlands support similar communities of low conservation value as established wetlands in Michigan

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What the statue means:

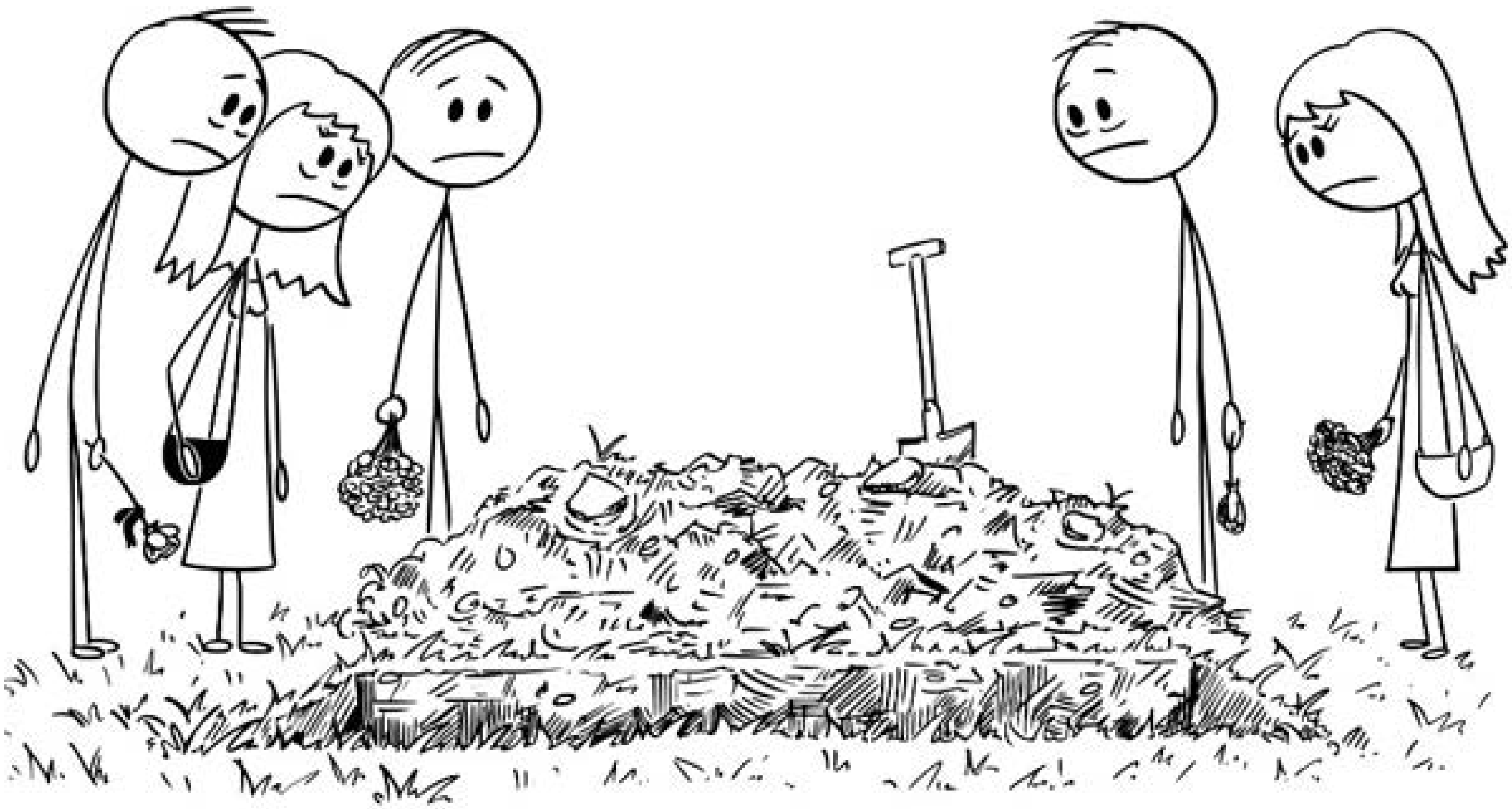
Restored – upland converted to wetland in a location where a wetland once existed in decades or centuries past

Created – upland converted to wetland in location where no evidence of prior wetland exists

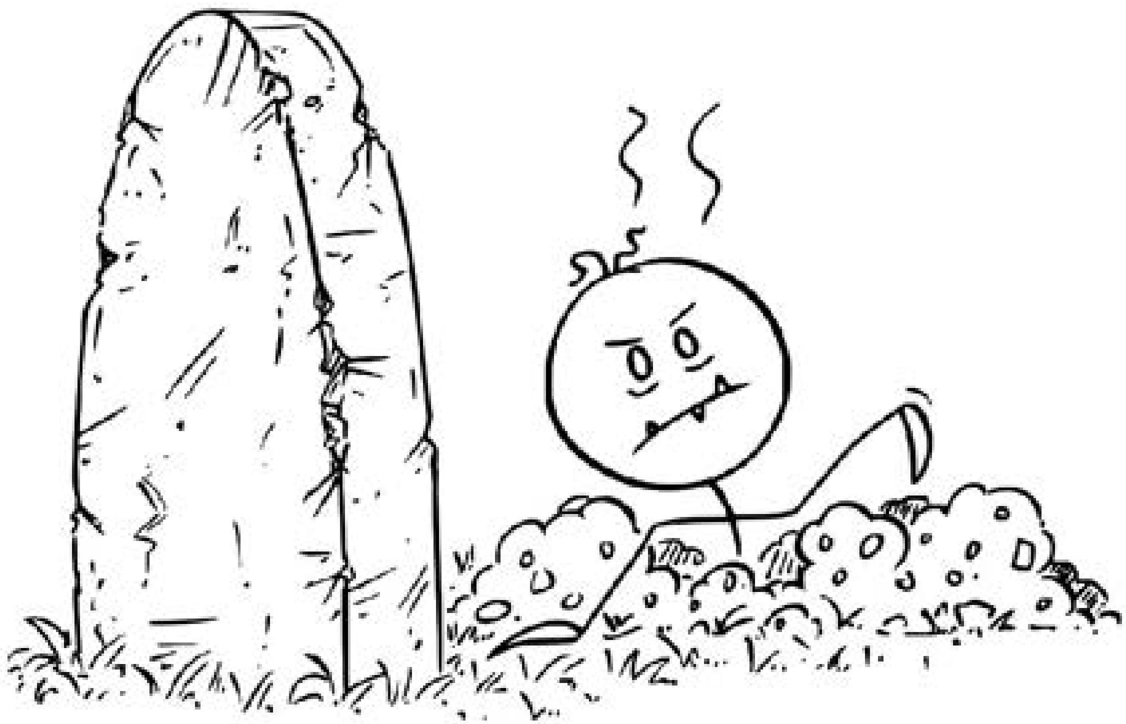
What English speakers infer:

Restored – wetland is returned to its original condition

Created – wetland is brought into existence



Thirty years later…



Best for broadest audience:

Restored – wetland is returned to its original condition

- Lack of historical data
- Few unimpacted reference wetlands

* Likely untrue for both services and biotic community*

Created – wetland is brought into existence

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Created – wetland is brought into existence

Wetland Habitat

40% of the world’s species live or breed in wetlands

Wetland Decline

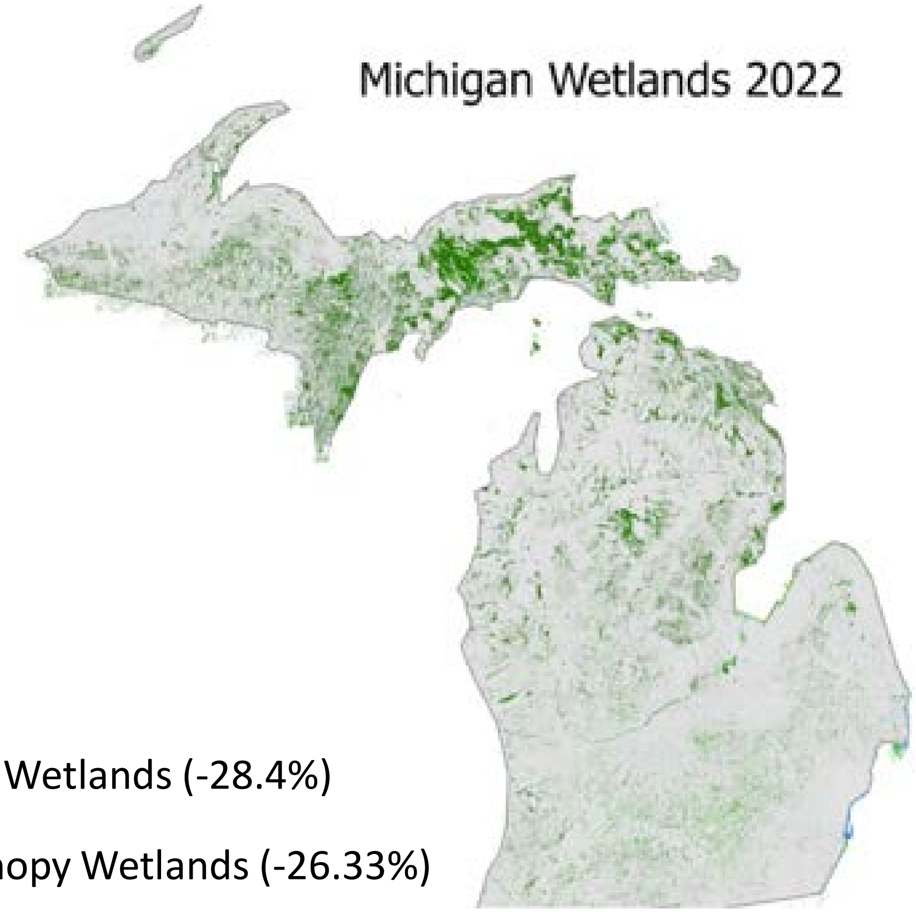
- Current extinction rate: ~1000x higher than background extinction rate
- Land use changes are the #1 driver of species declines
- Wetlands have declined globally 64-71% since 1900
- 35% since 1970

From Original 1800s Land Surveys

Forested Wetlands (-28.4%)

Open-Canopy Wetlands (-26.33%)

Overall: -54.73%



National Wetlands Inventory, 2022


Blanding’s Turtle


Eastern Massasauga


Blanchard’s Cricket Frog


Copper-bellied Watersnake


Marbled Salamander

Clean Water Act, Section 404 (1972)

- Prohibits dredging or placement of fill into ‘waters of the United States’
- Permits issued if impacts are unavoidable
- Establishes framework for compensatory wetland mitigation

Michigan is one of only two states with 404 authority over their own wetlands

Created wetlands are often relatively isolated

Questions

1. Do created wetlands support aquatic communities of similar composition or value as established wetlands in Michigan?

2. Do aquatic communities in created wetlands become more similar to those of established wetlands across space and time?

Paired Sample Design

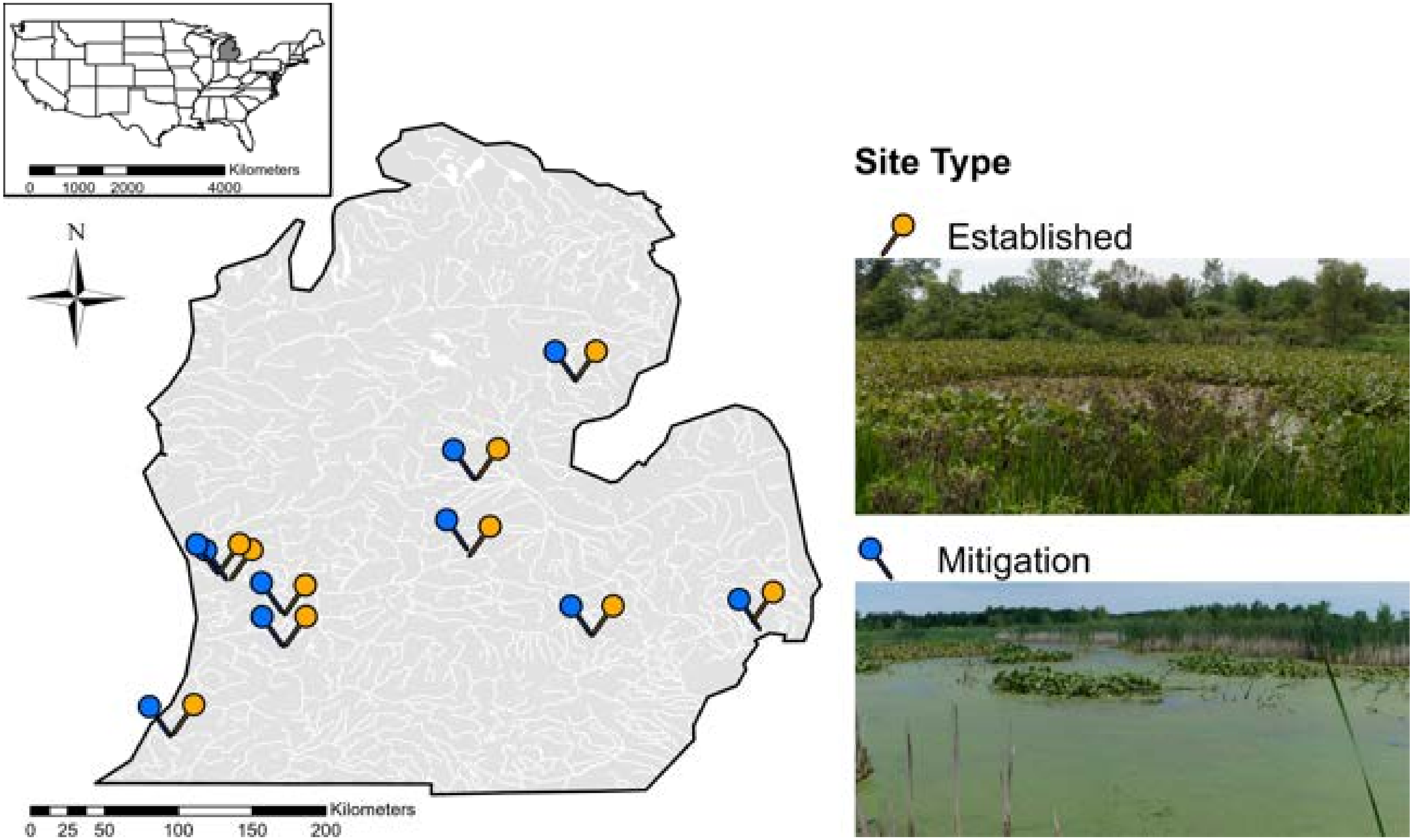
Created Wetlands

- All owned / managed by Michigan Department of Transportation (MDOT)
- 2-25 years since construction
- Native hydrophytes seeded, but no animals are deliberately introduced

Established Wetlands

- Nearest available wetland to each mitigation wetland
- No evidence of significant changes over 25 years of satellite imagery
- Not obviously artificial / disturbed

All pairs sampled on the same day from June-August, 2020


Kilometers
0 1000 2000 4000
N
Kilometers
0 25 50 100 150 200
Site Type
Established
Mitigation

Water Quality Measurements

YSI Water Probe

- Temperature
- pH
- Dissolved Oxygen (mg/L)
- Chloride (mg/L)

Fluorometry

- Chlorophyll-a (ug/L)

Vegetation

- Three Transects; up to 15 one m^2 quadrats per transect
- Transects begin 10 m upland from water's edge
- Ends at open water, or once 15 quadrats have been thrown
- Coverage estimated for all species within, above, or below quadrat
- Identified using iNaturalist and Michigan Flora Online Key
- Calculated Floristic Quality Index (FQI) (USGS/USACE)

iNaturalist

UNIVERSITY OF MICHIGAN

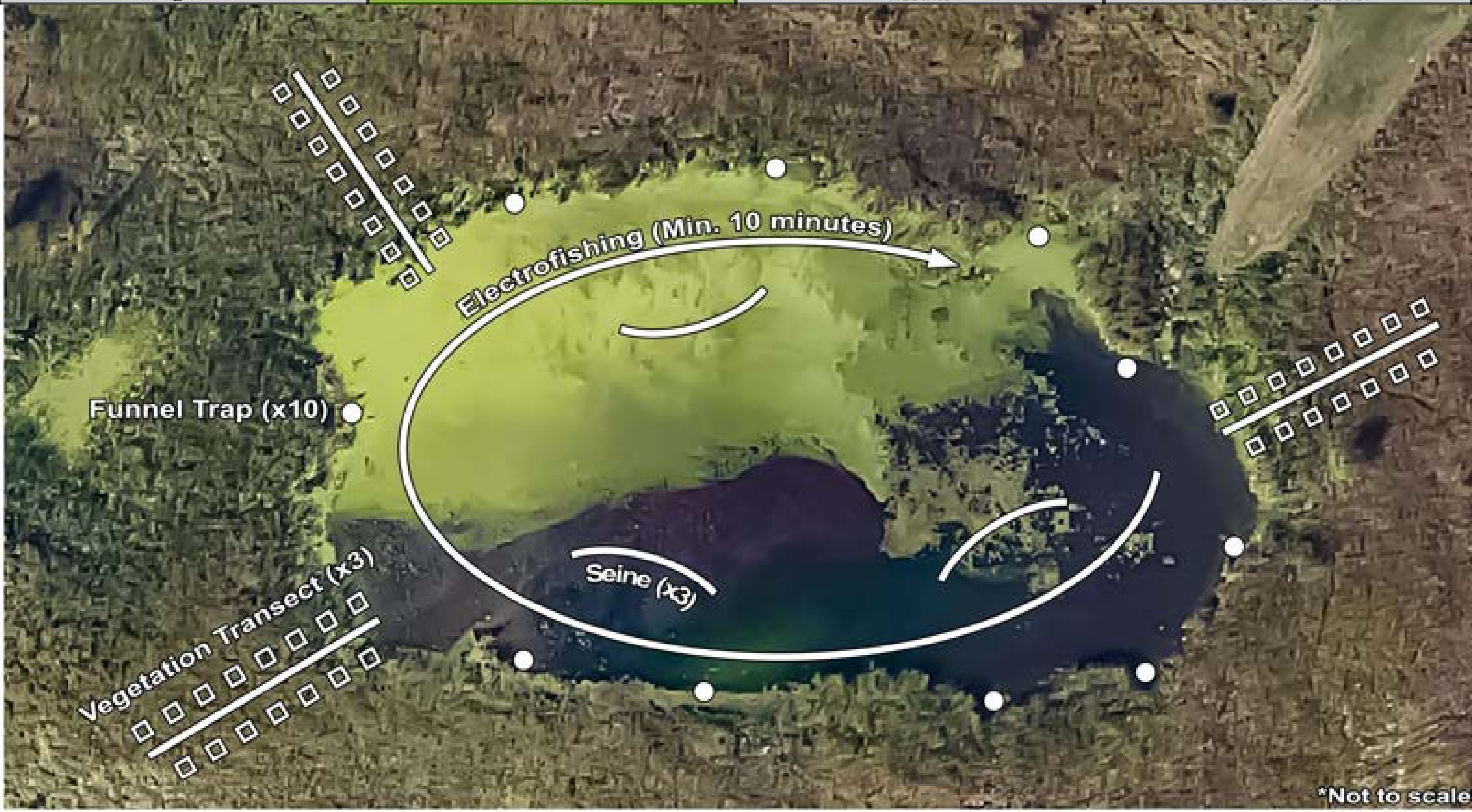
Aquatic Macroinvertebrates

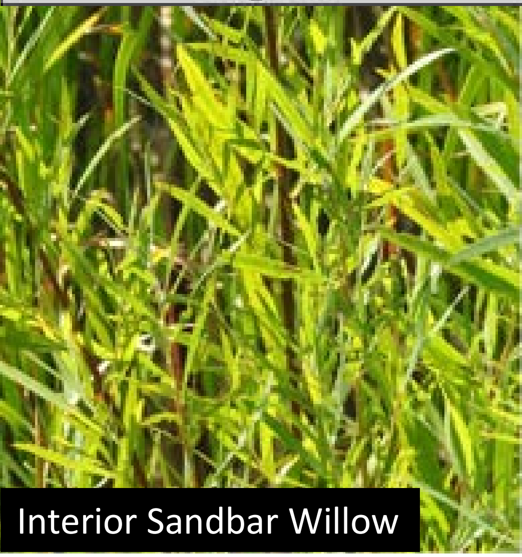
- Dip netting throughout pond (min. three sweeps) targeting different microhabitats
- Debris collected in bucket
- Sort debris for 30 person-minutes up to 150 individuals
- If 150 individuals not found, continue until next interval of 50
- Stored in ethanol, identified in the lab to genus or species with dichotomous keys
- Calculated Index of Biotic Integrity (IBI) (Burton et al. 2009)




Vertebrates

- Fish and herpetofauna
- Electrofishing until 10 minutes elapse without finding a new species (~45 minutes)
- Three seine net sweeps
- Light-baited funnel traps left overnight for >12 hours
- Random encounters (herpetofauna only)
- Identified to species and released


Electrofishing (Min. 10 minutes)
Funnel Trap (x10)
Seine (x3)
Vegetation Transect (x3)
*Not to scale

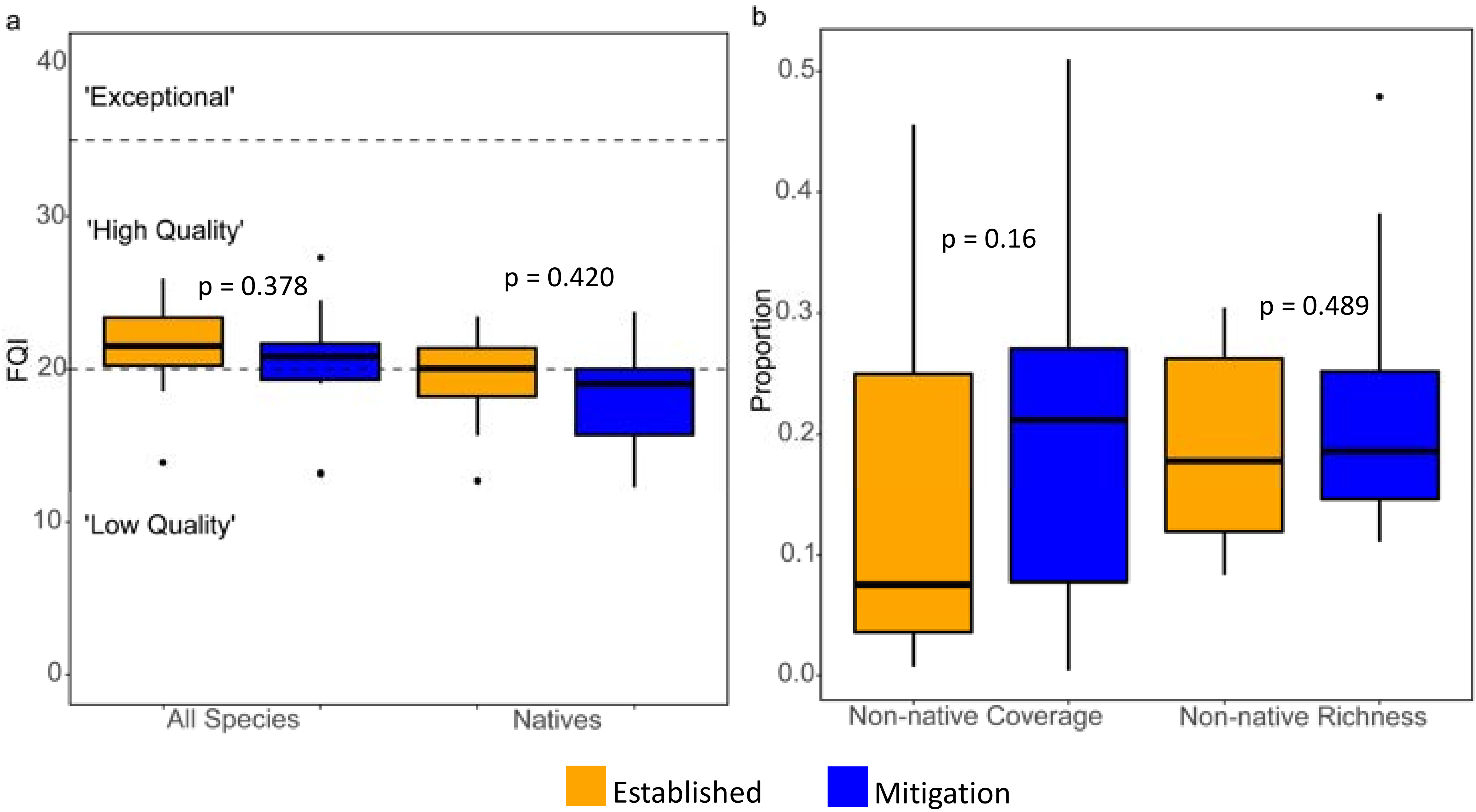

Interior Sandbar Willow


Reed Canary Grass (Invasive)


Narrow-leaved Cattail (Invasive)

Vegetation Results

- 174 plant taxa (range:7-48, SD: 10.76)
- Most Common: Reed Canary Grass, Narrow-leaved Cattail, Willows
- Indicator Analysis
  - Rushes (*Juncus spp.*) associated with mitigation wetlands
  - False nettle (*Boehmeria cylindrica*), Riverbank Grape (*Vitis riparia*), and Virginia Creeper (*Parthenocissus cinquefolia*) associated with established wetlands



a
40
30
20
10
0
FQI
'Exceptional'
'High Quality'
'Low Quality'
p = 0.378
p = 0.420
All Species
Natives
b
0.5
0.4
0.3
0.2
0.1
0.0
Proportion
p = 0.16
p = 0.489
Non-native Coverage
Non-native Richness
Established
Mitigation

Metric		Test	V/T-Stat	**p-Value**
Vegetation				
	Observed Richness	Paired t-test	0.556	**0.592**
	Estimated Richness (Chao1)	Paired t-test	0.168	**0.870**
	Evenness (Pielou)	Wilcoxon	40	**0.232**
	Diversity (Shannon)	Paired t-test	1.607	**0.143**
	Non-Native Coverage	Wilcoxon	13	**0.160**
	Non-Native Richness	Paired t-test	-0.722	**0.489**
	Native FQI	Paired t-test	0.928	**0.378**
	Non-Native FQI	Paired t-test	0.717	**0.492**

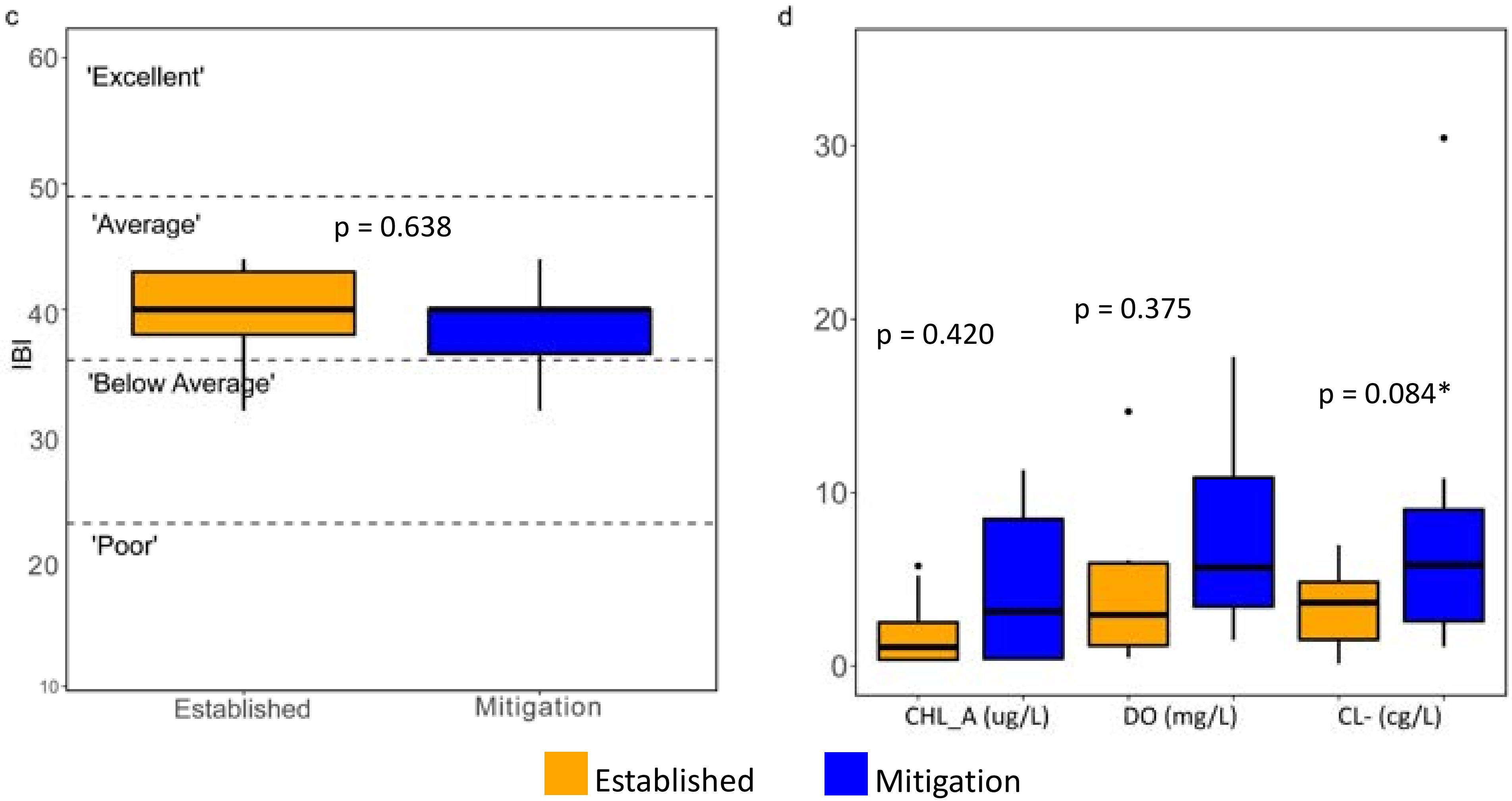

Quillwort


Pickerel Weed


Bullrush (*Scirpus spp.*)

Aquatic Macroinvertebrate Results

- 103 Aquatic Macroinvertebrate Taxa (range 6-25, SD: 5.63)
- Most common: Midges (Chironomidae), Bladder Snails (Physidae), and Ramshorn Snails (Planorbidae)
- Indicator Analysis
  - Pea clams (Sphaeriidae) associated with established wetlands
  - No indicators for mitigation wetlands


c
60
'Excellent'
50
'Average'
p = 0.638
40
IBI
'Below Average'
30
'Poor'
20
10
Established
Mitigation
d
30
20
p = 0.420
p = 0.375
p = 0.084*
10
0
CHL_A (ug/L)
DO (mg/L)
CL- (cg/L)
Established
Mitigation

Metric	Test	V/T-Stat	**p-Value**
Aquatic Macroinvertebrates			
Observed Richness	Wilcoxon	31	**0.759**
Estimated Richness (Chao1)	Paired t-test	-0.635	**0.541**
Evenness (Pielou)	Paired t-test	-0.628	**0.546**
Diversity (Shannon)	Paired t-test	-0.709	**0.496**
IBI	Paired t-test	-0.487	**0.638**


Northern Clearwater Crayfish


Predaceous Diving Beetle


Green Sunfish


Black Bullhead

Central Mudminnow

Fish Results

- 20 Fish Taxa (range: 0-8, SD: 2.39)
- Most Common: Central Mudminnow (*Umbra limi*), Green Sunfish (*Lepomis cyanellus*), and Black Bullhead (*Ameiurus melas*)
- No indicator species

Metric		Test	V/T-Stat	**p-Value**
Fish				
	Observed Fish Richness	Wilcoxon	11	**0.188**
	Estimated Fish Richness (Chao1)	Wilcoxon	12	**0.232**
	Fish Evenness (Pielou)	Wilcoxon	27	**0.652**
	Fish Diversity (Shannon)	Paired t-test	-0.681	**0.515**


Bullheads and Shiners


Brook Stickleback


American Bullfrog


Spring Peeper


Green Frog

Herpetofauna Results

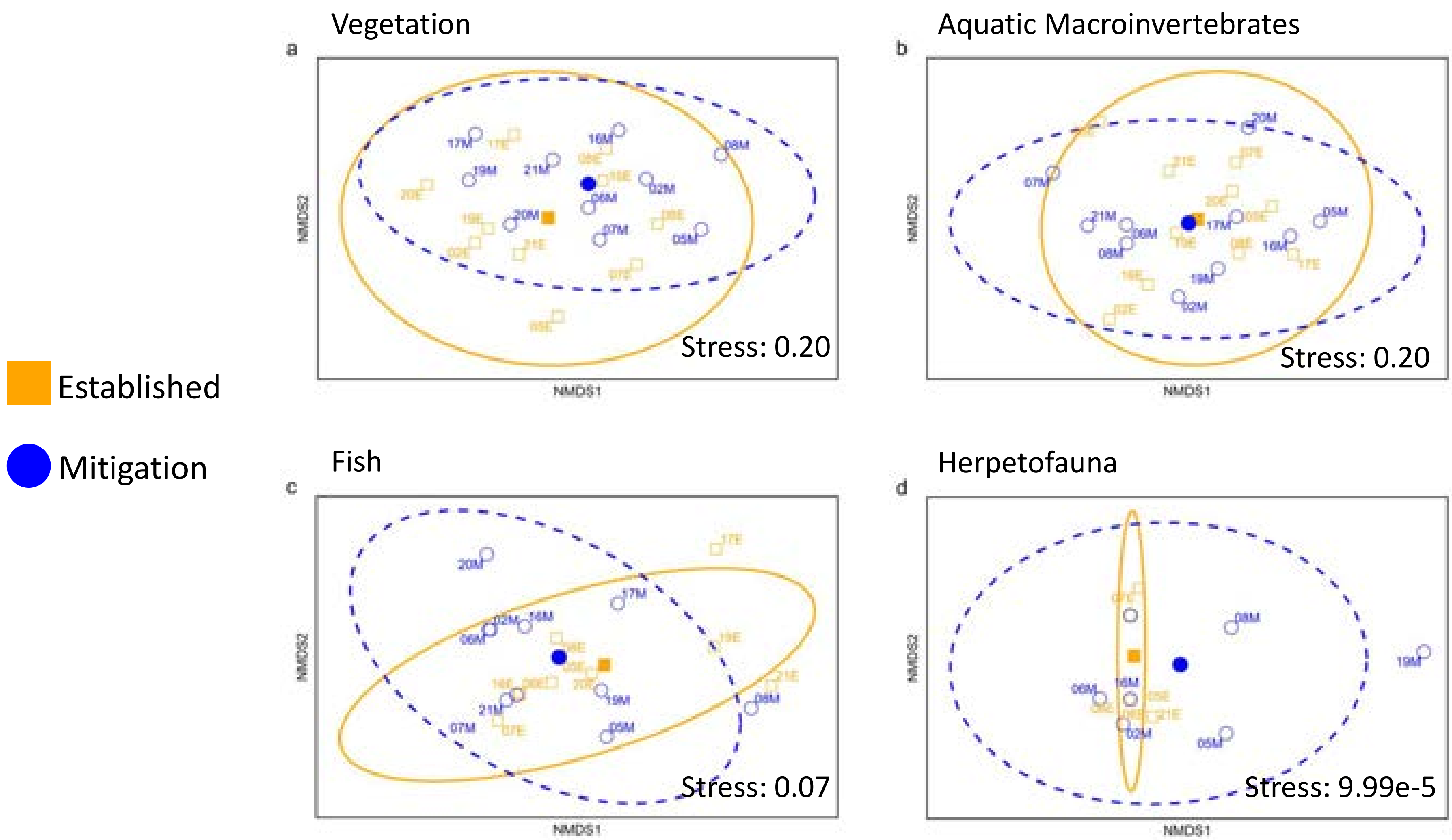
- Nine herpetofauna taxa (range: 0-6, SD: 1.38)
- Most Common: Green Frogs (*Lithobates clamitans*), Bullfrogs (*Lithobates catesbaeianus*), and spring peepers (*Pseudacris crucifer*)
- No indicator species

Metric	Test	V/T-Stat	**p-Value**
Herpetofauna			
Observed Richness	Wilcoxon	11	**0.354**
Estimated Richness (Chao1)	Wilcoxon	13	**0.521**


Northern Water Snake


Northern Leopard Frog


Common Snapping Turtle


Vegetation
a
Stress: 0.20
Aquatic Macroinvertebrates
b
Stress: 0.20
Fish
c
Stress: 0.07
Herpetofauna
d
Stress: 9.99e-5
NMDS1
NMDS2
Established
Mitigation

Conclusions

1. Do created wetlands support aquatic communities of similar composition or value as established wetlands in Michigan?

2. Do aquatic communities in created wetlands become more similar to those of established wetlands across space and time?

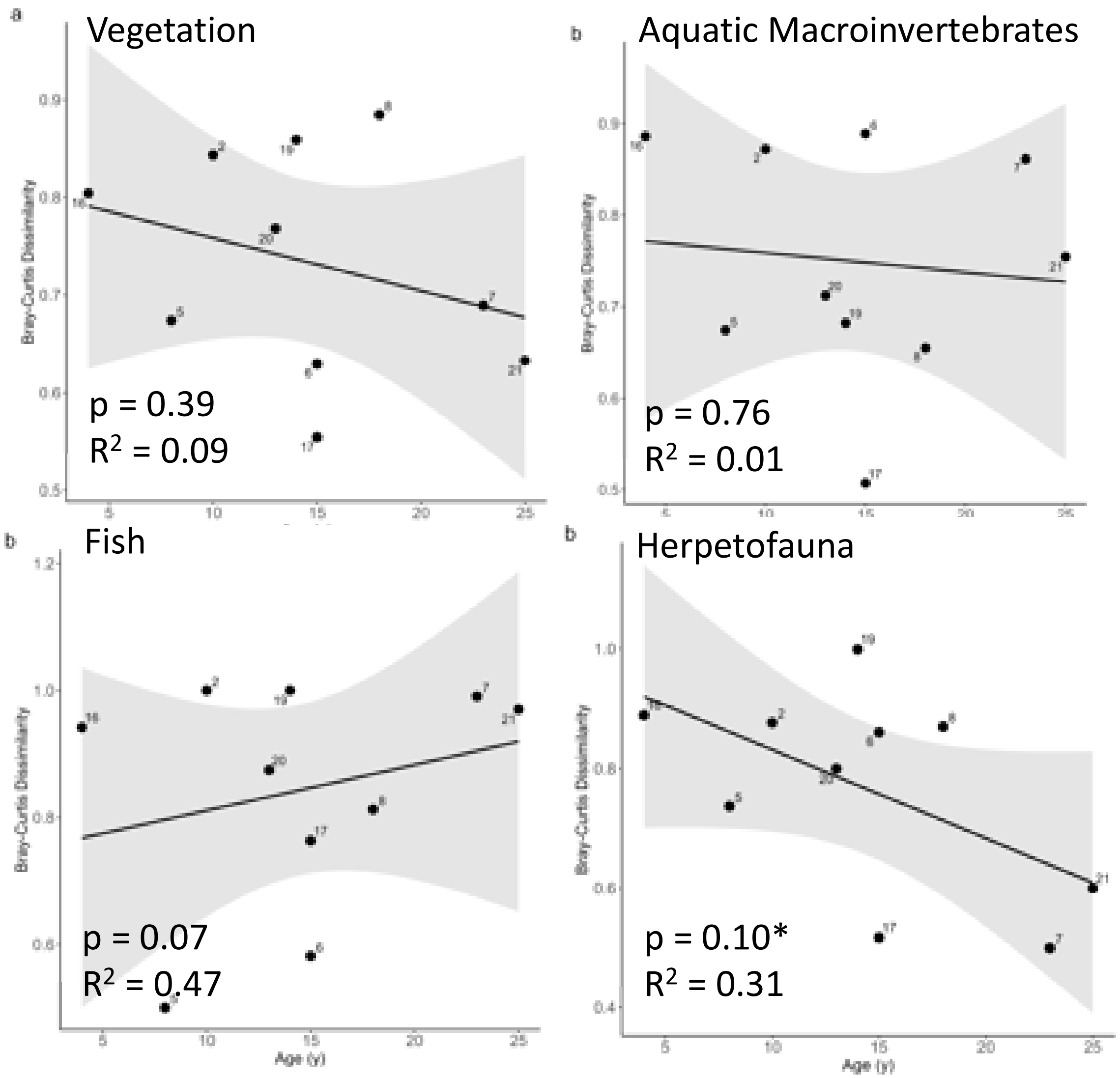
Conclusions

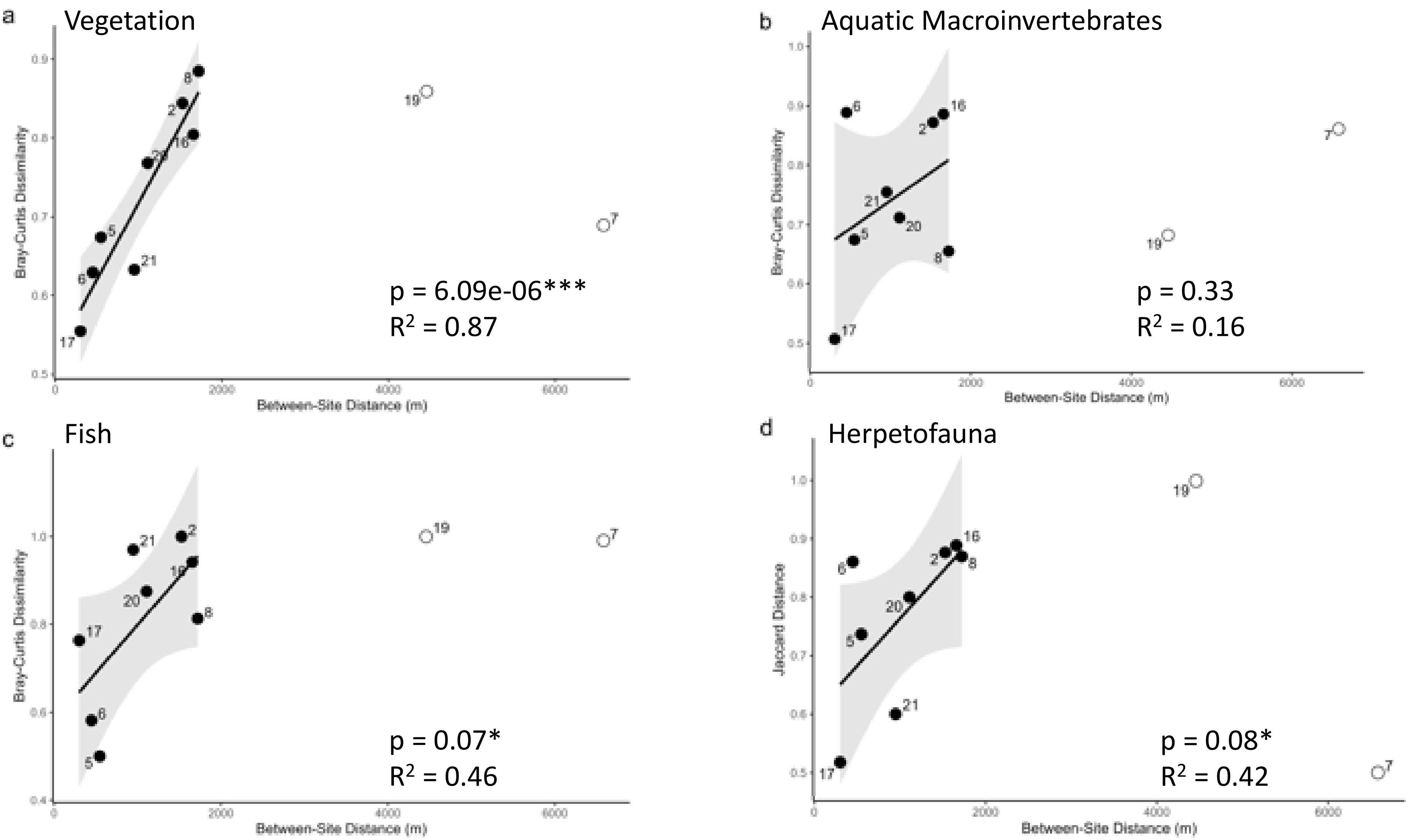
1. Do created wetlands support aquatic communities of similar composition or value as established wetlands in Michigan?

   -**Yes, although both are of low to moderate conservation value**

2. Do aquatic communities in created wetlands become more similar to those of established wetlands across space and time?

*Age was not a significant predictor of similarity for any taxa except herpetofauna, which showed a weak relationship.




a
Vegetation
Bray-Curtis Dissimilarity
Between-Site Distance (m)
p = 6.09e-06***
R² = 0.87
b
Aquatic Macroinvertebrates
Bray-Curtis Dissimilarity
Between-Site Distance (m)
p = 0.33
R² = 0.16
c
Fish
Bray-Curtis Dissimilarity
Between-Site Distance (m)
p = 0.07*
R² = 0.46
d
Herpetofauna
Jaccard Distance
Between-Site Distance (m)
p = 0.08*
R² = 0.42

Conclusions

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   -Yes, although both are of low to moderate conservation value

2. Do aquatic communities in created wetlands become more similar to those of established wetlands across space and time?

   -There is a significant relationship when sites are within ~2 km of each other, but we found little evidence that age is a factor

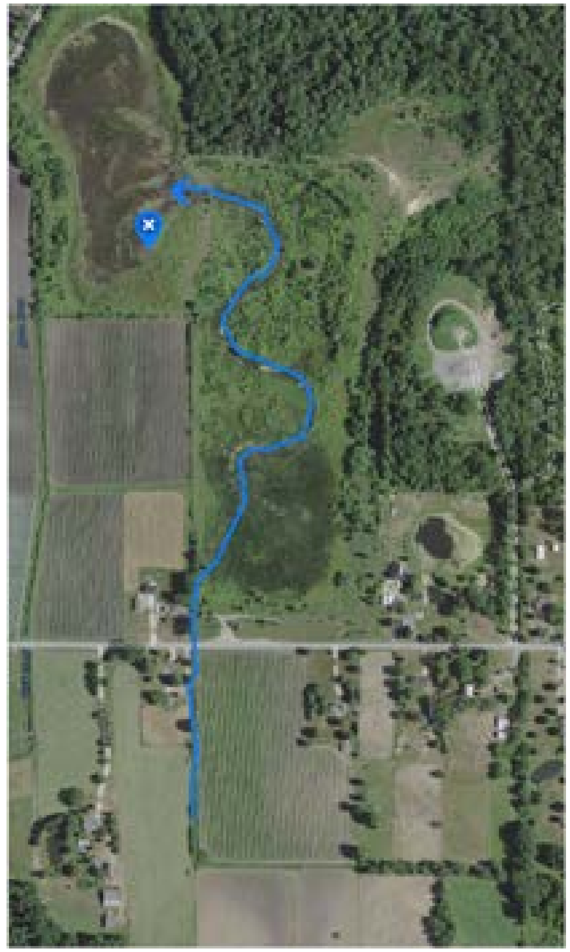
Other Observations

Created wetlands fed by surface connections

+ Rapid biodiversification (age not a factor)

+ Drains greater area = more nutrients, chloride, oxygen

- Allows colonization by predatory fish and non-native species



Non-native cattails and carp

Other Observations

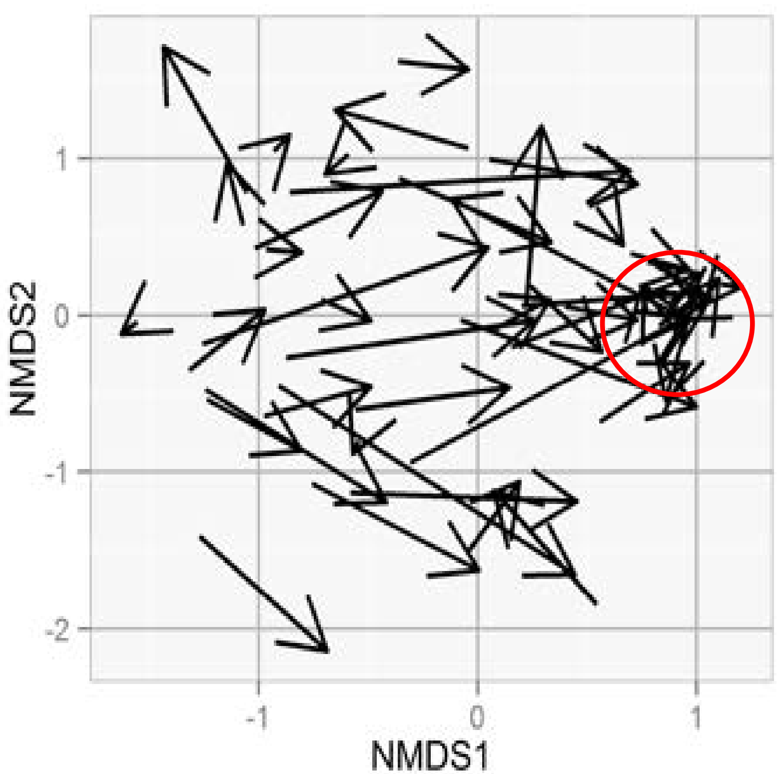
- Homogenous communities of generalist or non-native species (i.e. ‘The Homogenocene’)
- No Species of Greatest Conservation Need
- Many fish-tolerant, once-common species missing (e.g. eastern newts, tiger salamanders)
- Evidence of disturbances in both groups
  - Mowing
  - Fish Stocking
  - Pesticide Use
  - Road salts


Largemouth Bass


Mowing

Naturally occurring wetlands are undergoing homogenization, 1997-2015

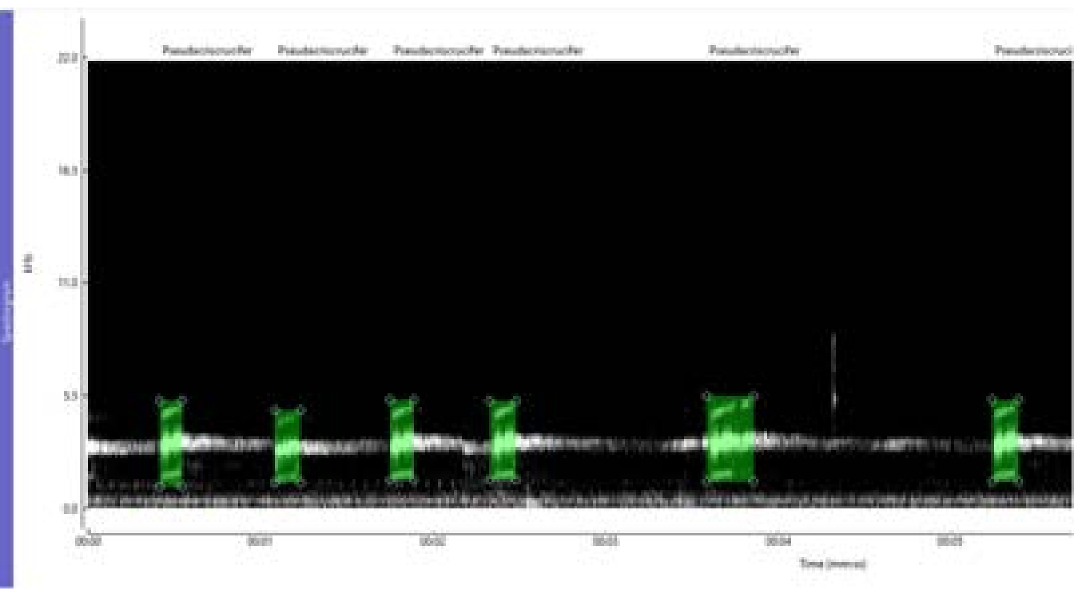
(Price, Spyreas, Matthews. 2018. *J. Ecology*)



Ongoing Research

1. Is biotic homogenization affecting Michigan's wetlands? Other taxonomic groups than plants?

2. If so, what are the causes?
   - Vegetation Structure
   - Community Interactions
   - Landscape Context
   - Within-wetland Conditions



Ongoing Research

1. How can wetland design be improved to support declining herpetofauna?

2. Should soundscapes be considered in wetland design?

Acknowledgements

<u>Mentoring and Support</u>

- Dr. Tiffany Schriever (WMU)
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Questions?