Development of a Preliminary Macroinvertebrate Index of Biotic Integrity for Freshwater Wetlands

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Why Wetlands?

- Diverse aquatic habitats, suffered historic declines
- National Wetland Condition Assessment (EPA)
- No established invertebrate monitoring program

Research Goals

1. Develop field sampling procedures for wetland habitats
2. Develop an index of biotic integrity (IBI) based on urban gradient

Site Selection

Targeted selection

40 ponds/wetlands

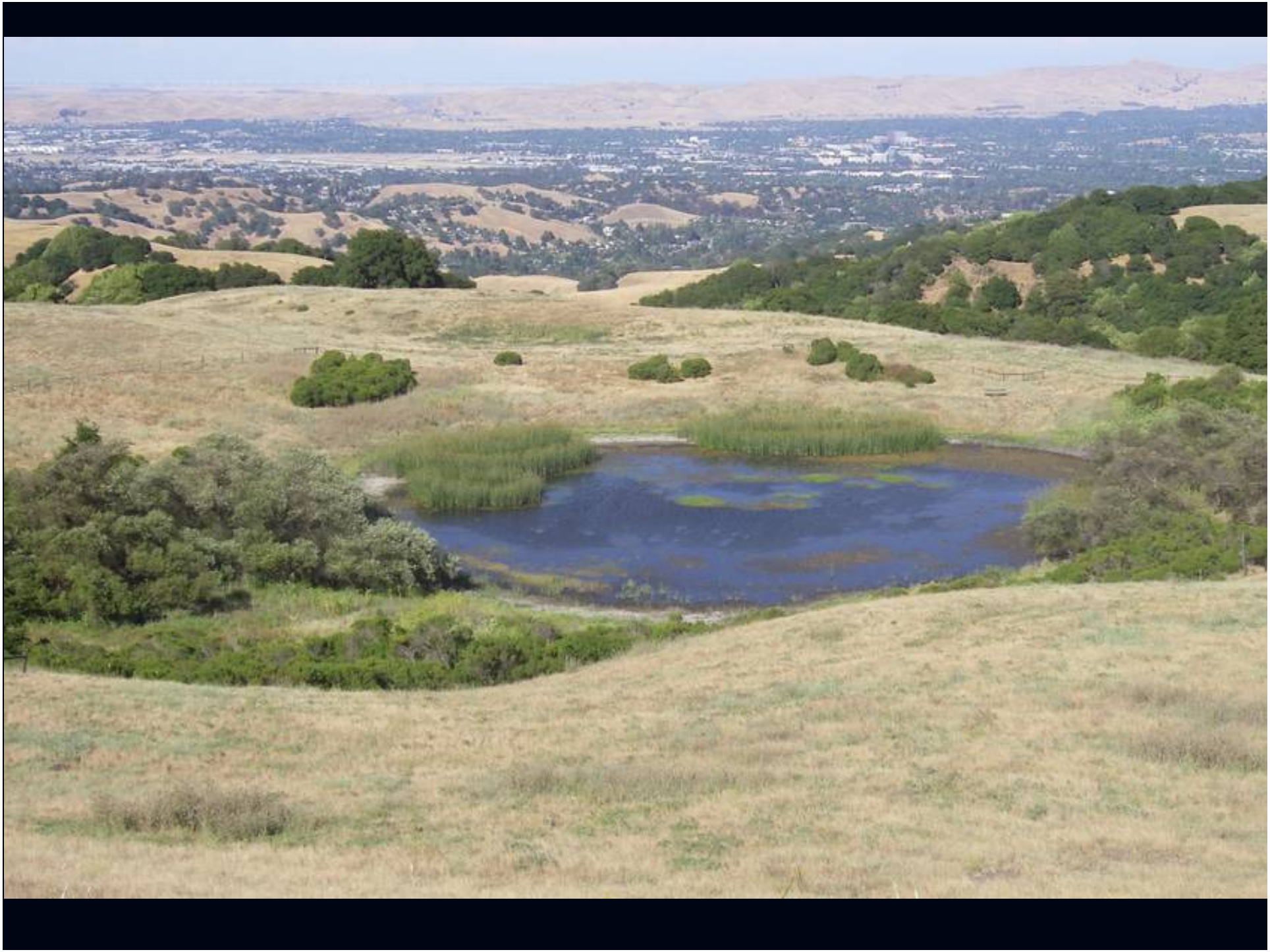
- Reference: natural, stockponds
- Urban: stormwater, flood control, natural

Size: 0.1 – 1 hectares

Index period

- May 5 – July 13

Collected 2007-2009



Field Methods

- Sample littoral zone
  (benthic, water column, surface)
- 500 µm dip net
- 20 sweep composite (6m^2)
- Habitat stratified
  - Emergent vegetation
  - Submergent vegetation
  - Floating vegetation
  - Open
- 2.5 - 5 hrs per site

Laboratory Methods

- Subsampled a fixed count of 500 aquatic organisms
- Percent subsampled 9% (range 1 - 35%)
- Identification to SAFIT Level I: Insecta to genus; Chironomidae to subfamily; include Copepoda, Cladocera & Ostracoda, Oligochaeta

Macroinvertebrate Results

- 123 unique taxa
- Non-insects prevalent and abundant
- Taxa Richness:

  Median = 19 (7 - 36)
- Extrapolated Abundance:

  3386 individuals/m^2
  (285 - 25,000/m^2)
- Mosquitoes (7/40) and biting midges were uncommon (14/40) and low-abundance (<0.4%)

		% Occurrence
Crustacea	*Simocephalus*	91%
Insecta	Chironominae	81%
Crustacea	Cyprididae	74%
Insecta	Orthocladiinae	72%
Gastropoda	*Physa*	70%
Insecta	Tanypodinae	65%
Annelida	Tubificidae	53%
Insecta	*Callibaetis*	53%

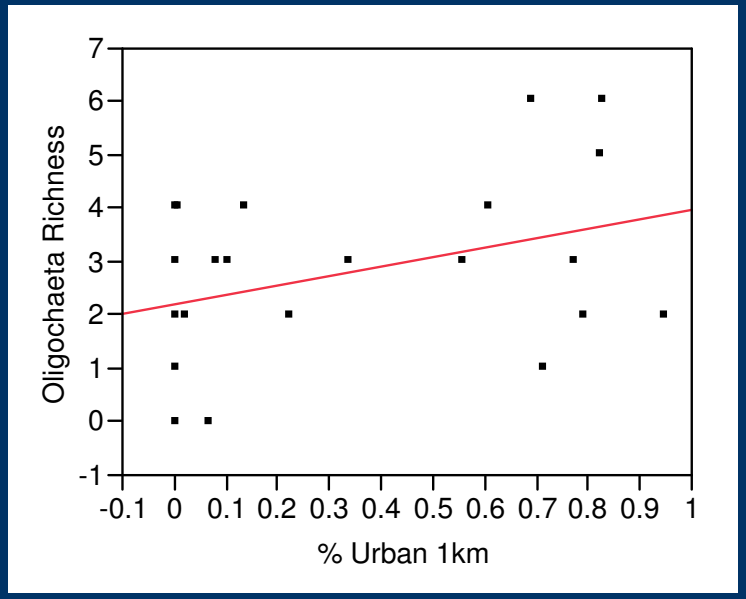
IBI Development

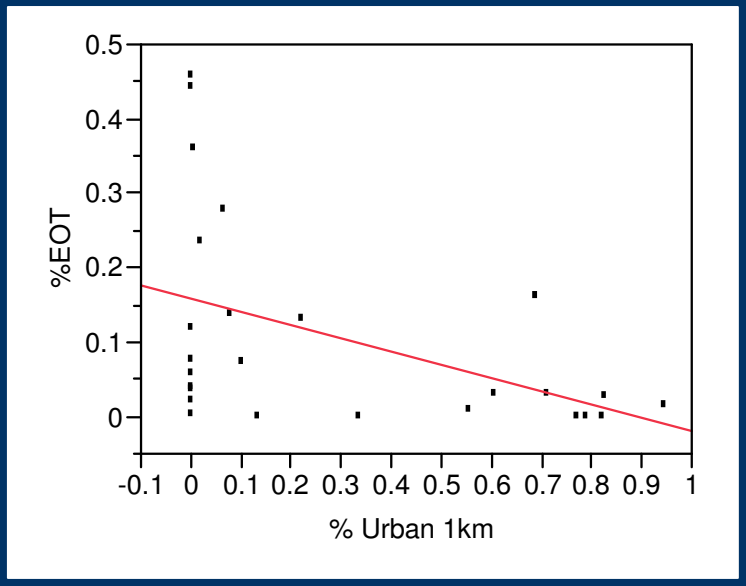
- Assigned sites to reference category (<11% urban-1km)
- Divided dataset into development (65%) and validation pools (35%) (MRPP: T = -0.91, p = 0.17)

Metric Selection and Scoring

Screened 56 metrics:

- Range
- Responsiveness to urbanization ($R^2 > 0.1$)
- Lack of redundancy ($r < 0.7$)

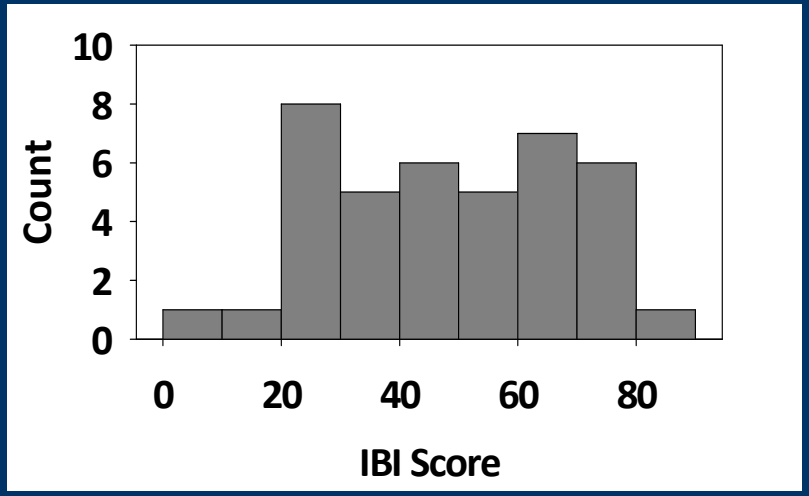




Lentic IBI Components

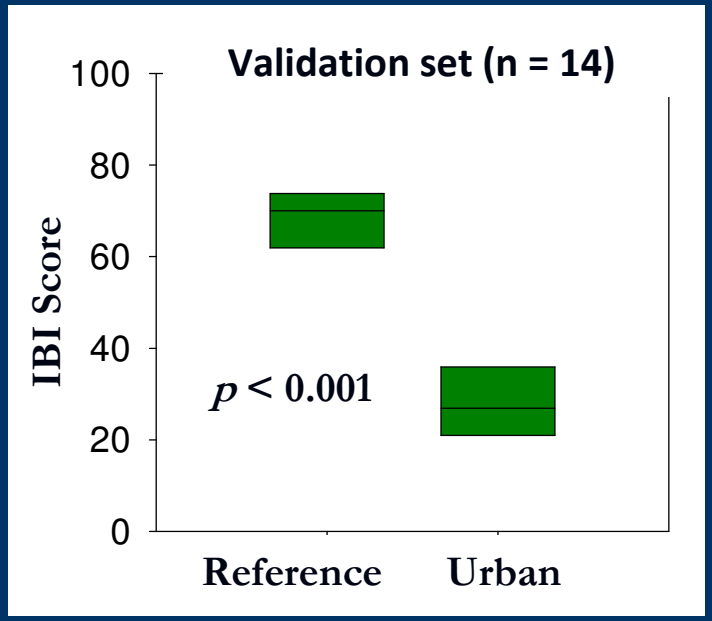
EOT richness	% EOT	Predator richness
Oligochaeta richness (pos)	% Coleoptera	Scraper richness
% 3 Dominant (pos)	% Tanypodinae/ Chironomidae	

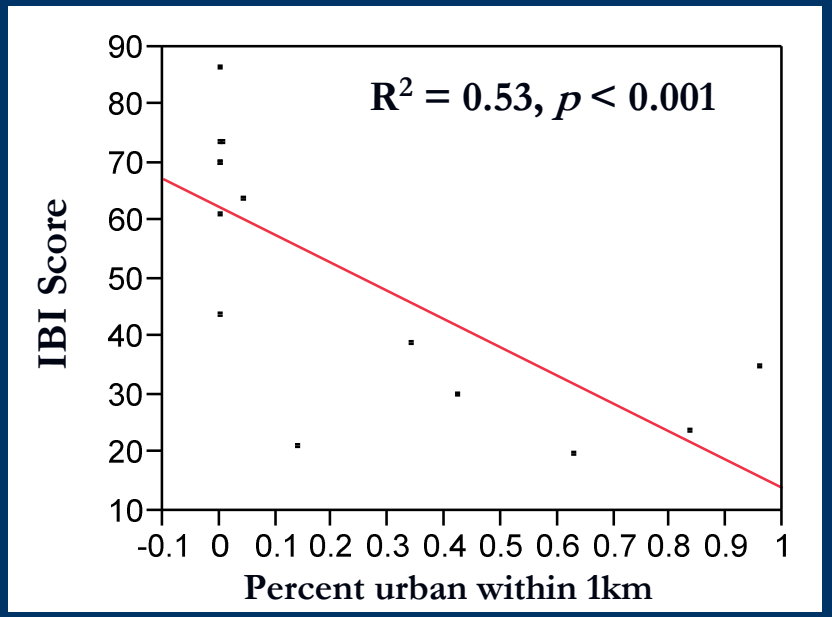
- Scaled multimetric index from 0 to 100
- IBI score range: 4 – 86, median 48



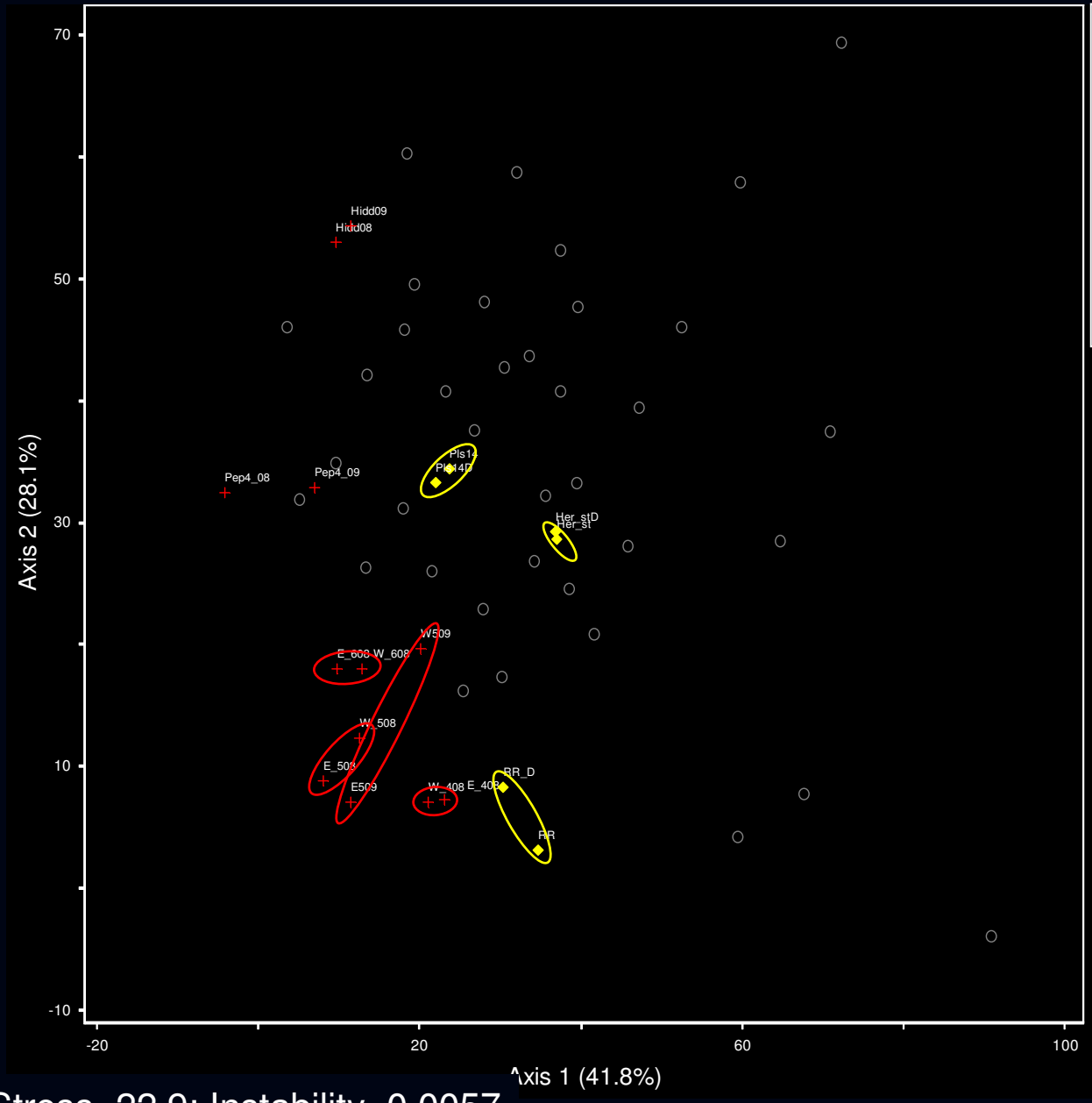
Discrimination and Responsiveness

- Discrimination: Reference (68) vs Urban (30)
- Significant negative relationship with urbanization





Measurement Precision



Stress=22.9; Instability=0.0057

IBI Variability:

Field duplicates: SD 6.2

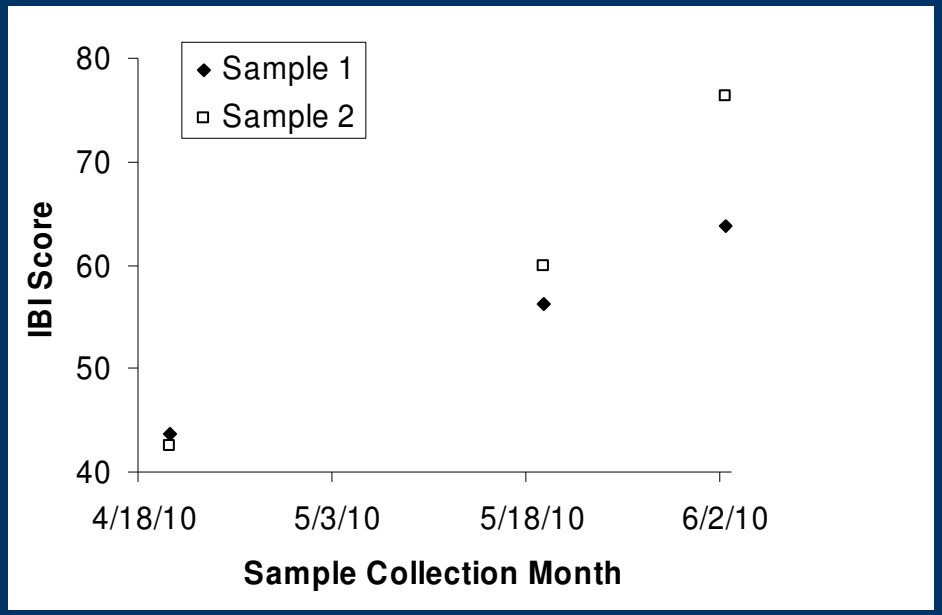
Lab replicates: SD 3.2

MDD: 27.2 IBI points

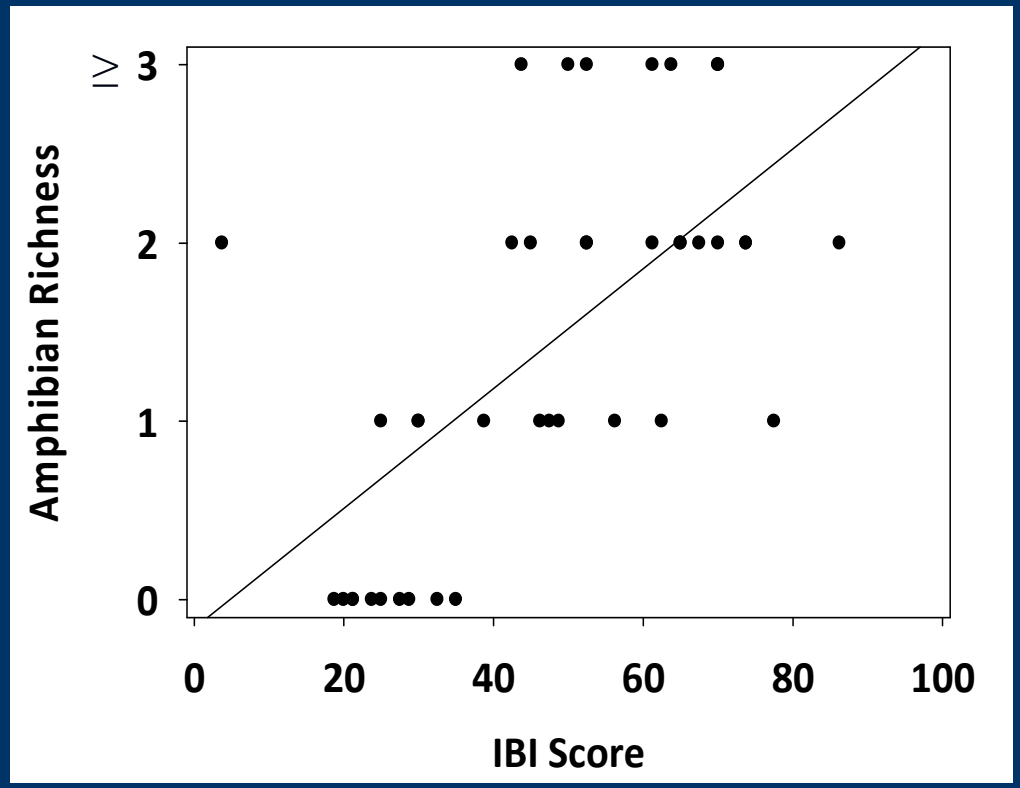
Robustness and Bias

- No effect of environmental gradients on IBI: pond area, ecoregion, precipitation, elevation, pond size, hydroperiod, artificial vs. natural, or sample date

- Seasonal effects observed at a non-perennial pond



Indicator for Vertebrates?



$R^2=0.34,\ p < 0.001$

Conclusions

1. Field methods reliably surveyed the invertebrate population
2. IBI validated and robust
3. Applications: ambient assessments, compensatory mitigation, restoration

Future Steps

- Identify additional anthropogenic stressors
- Metric improvement:
  - Tolerance data, FFG for wetland species lacking
- Index period
- Compare with other wetland indicators (e.g. CRAM)

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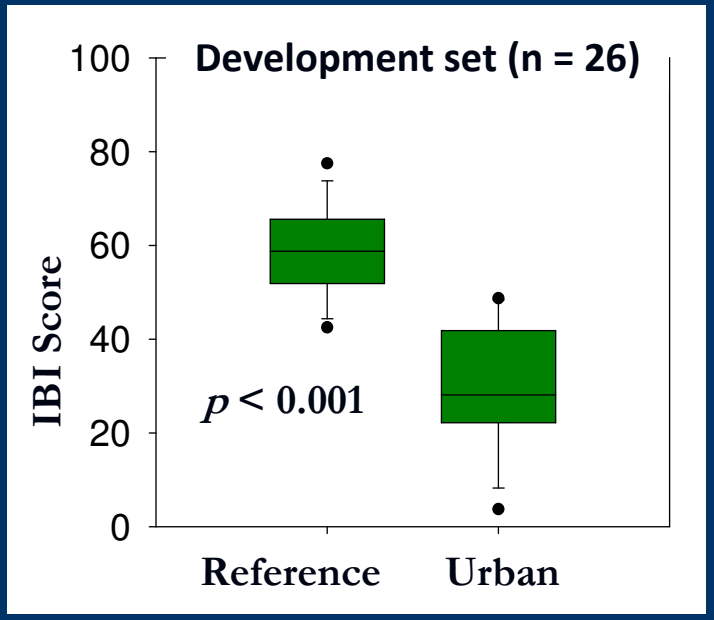
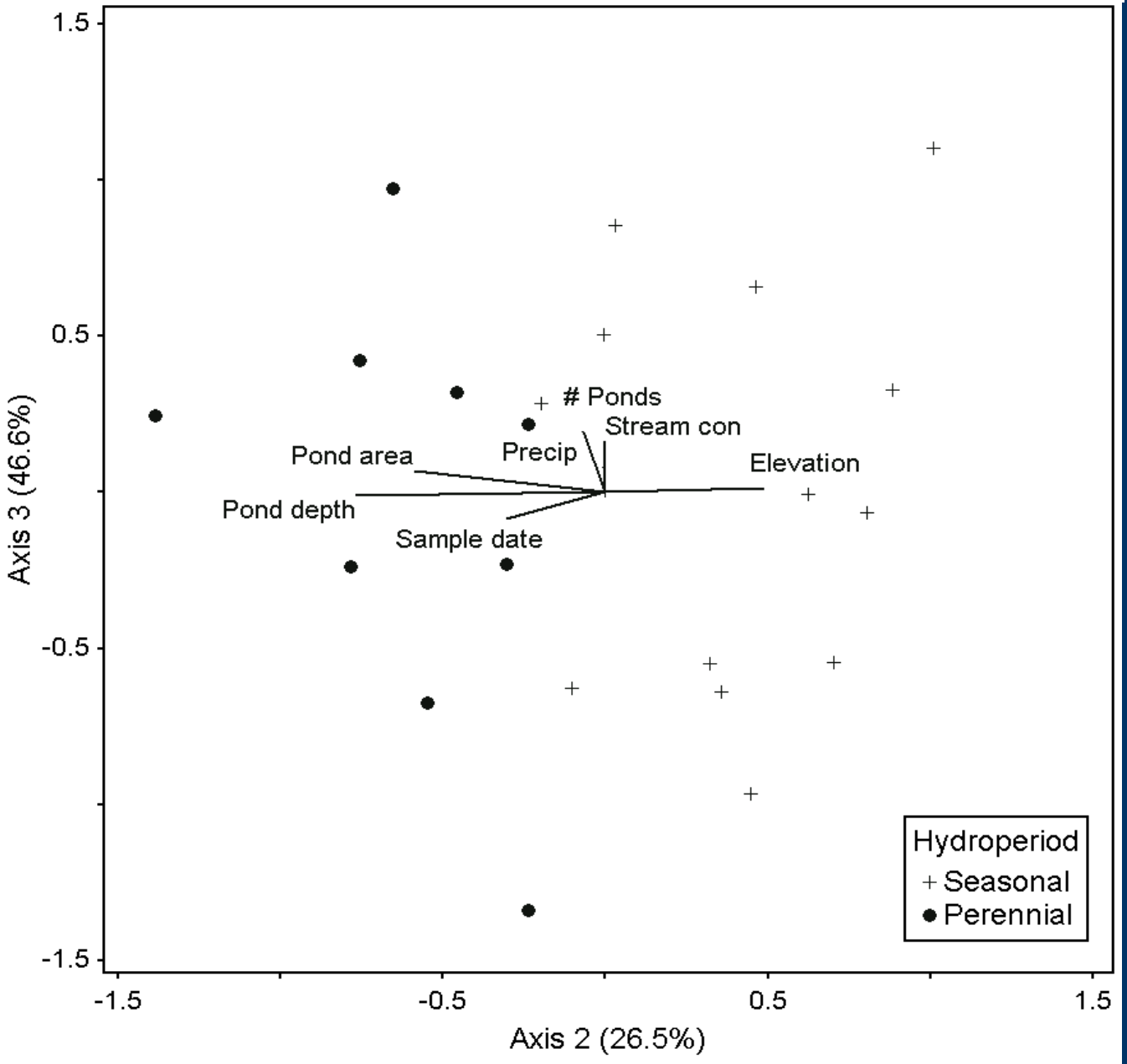
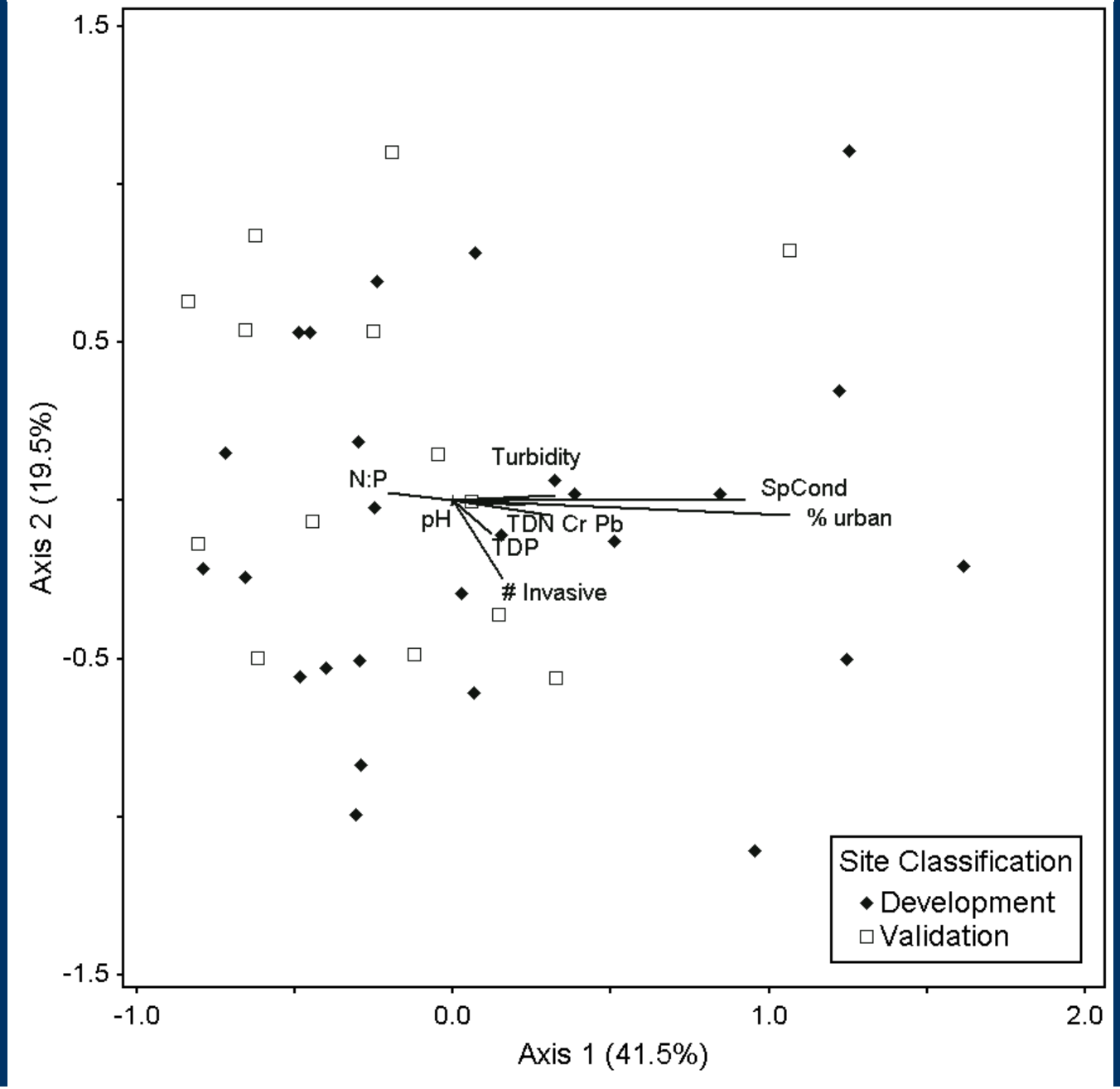

Development set (n = 26)
IBI Score
100
80
60
40
20
0
p < 0.001
Reference
Urban

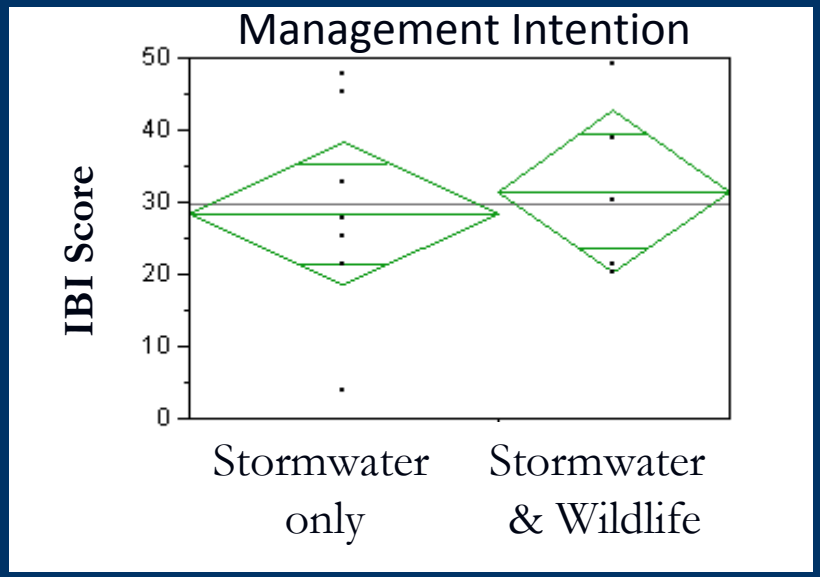
Reference Condition



Stressor Comparison



Maximizing Conservation Value



-No effect of managing for wildlife (p = 0.66)

-Best scoring stormwater ponds:

Local buffer, low conductivity, near rural

Effects of Grazing

- NMS community shift
- Increased mayflies, dragonflies, damselflies
- n.s.: % snails or total density
- IBI scores no different: Grazed (63) Ungrazed (63)
- Increase amphibian richness

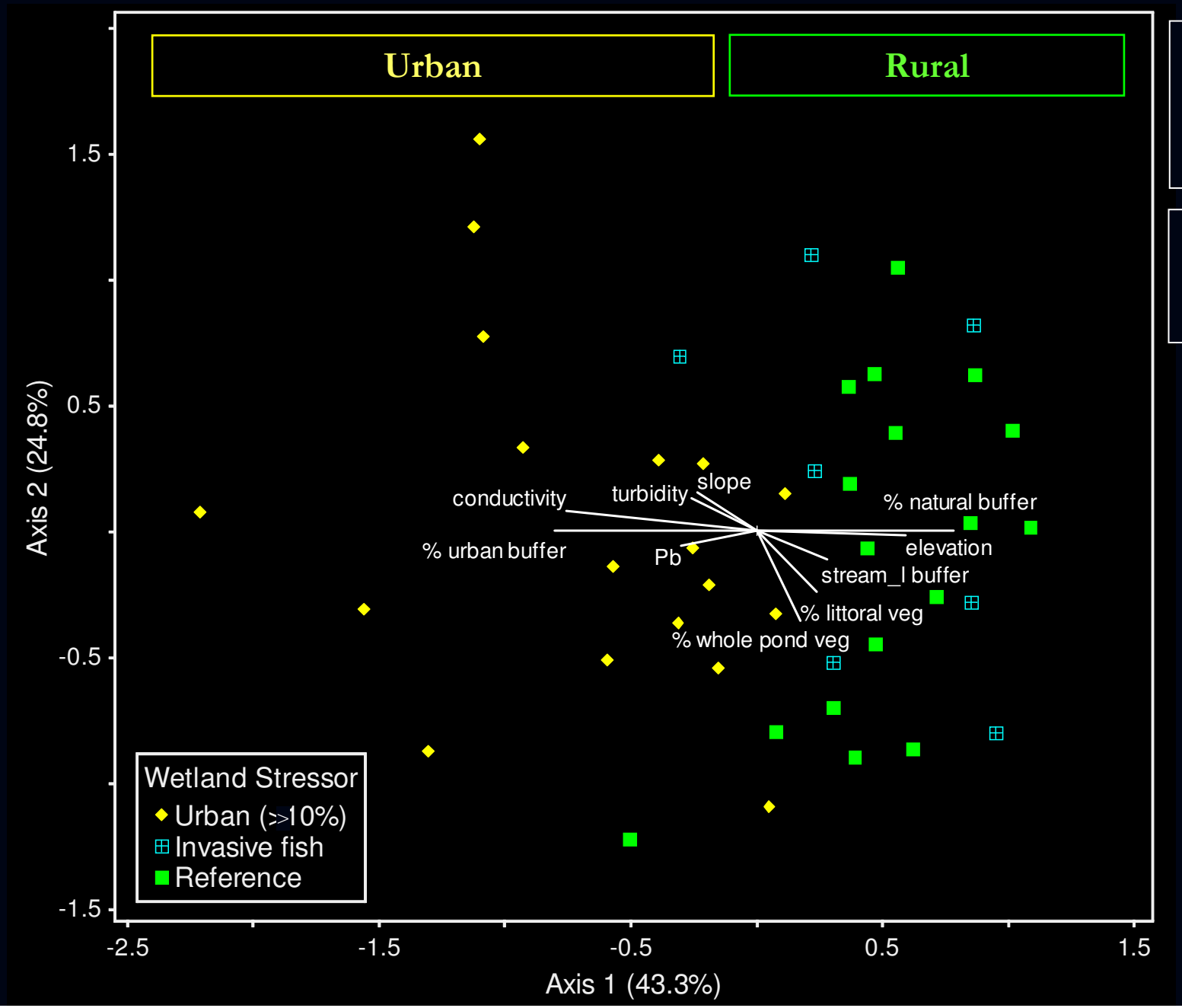
Effects of Introduced Fish

Sport fishing & Recreation

- Possible shift in community
- No change in density
- Slight but NS decrease amphibian richness

Mosquito/vector control

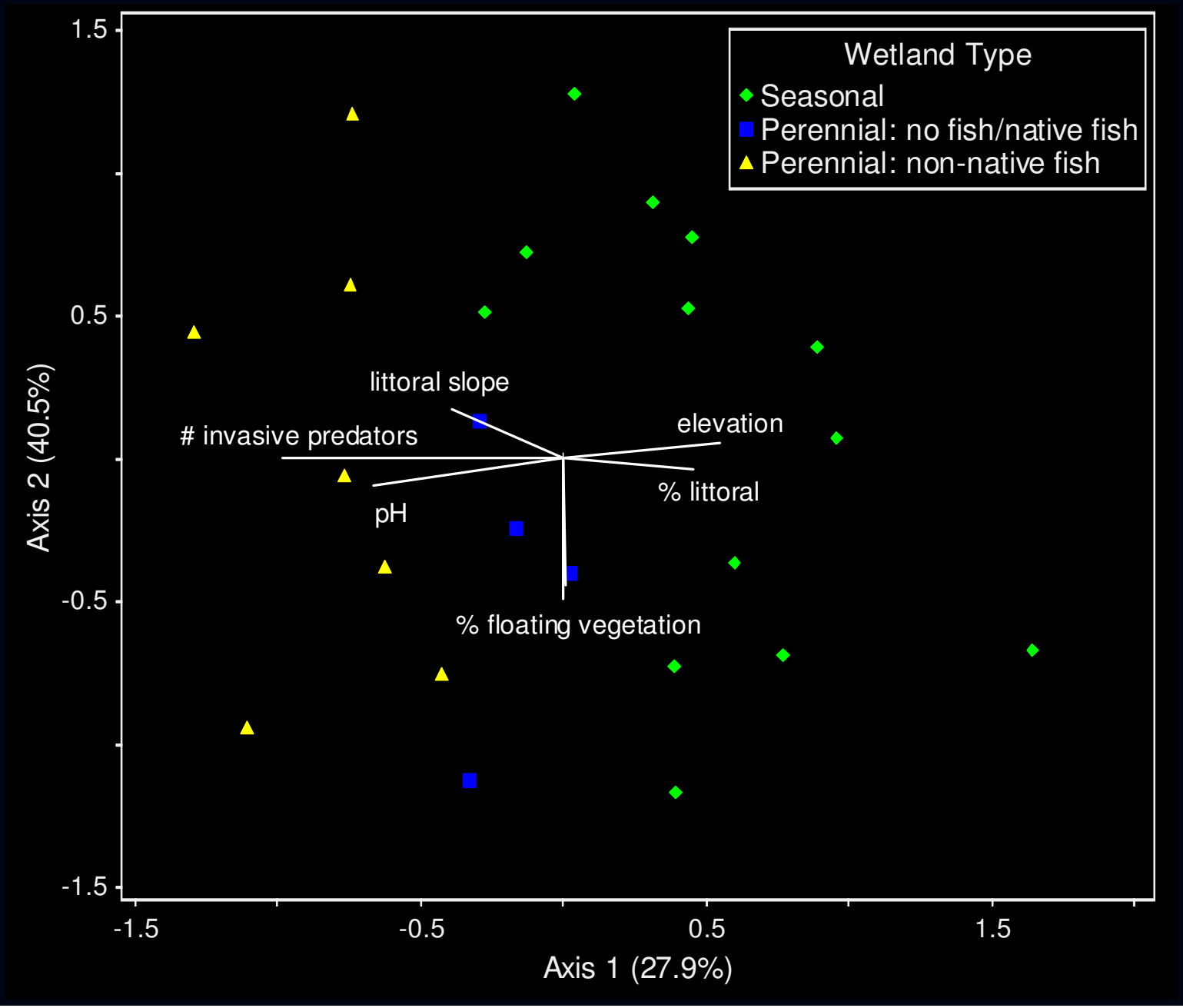
Key Environmental Variables at all Ponds



NMS
Stress=23.8
Instability=0.0059
R^2 = 68.1%

MRPP
T = -6.97
p < 0.0001

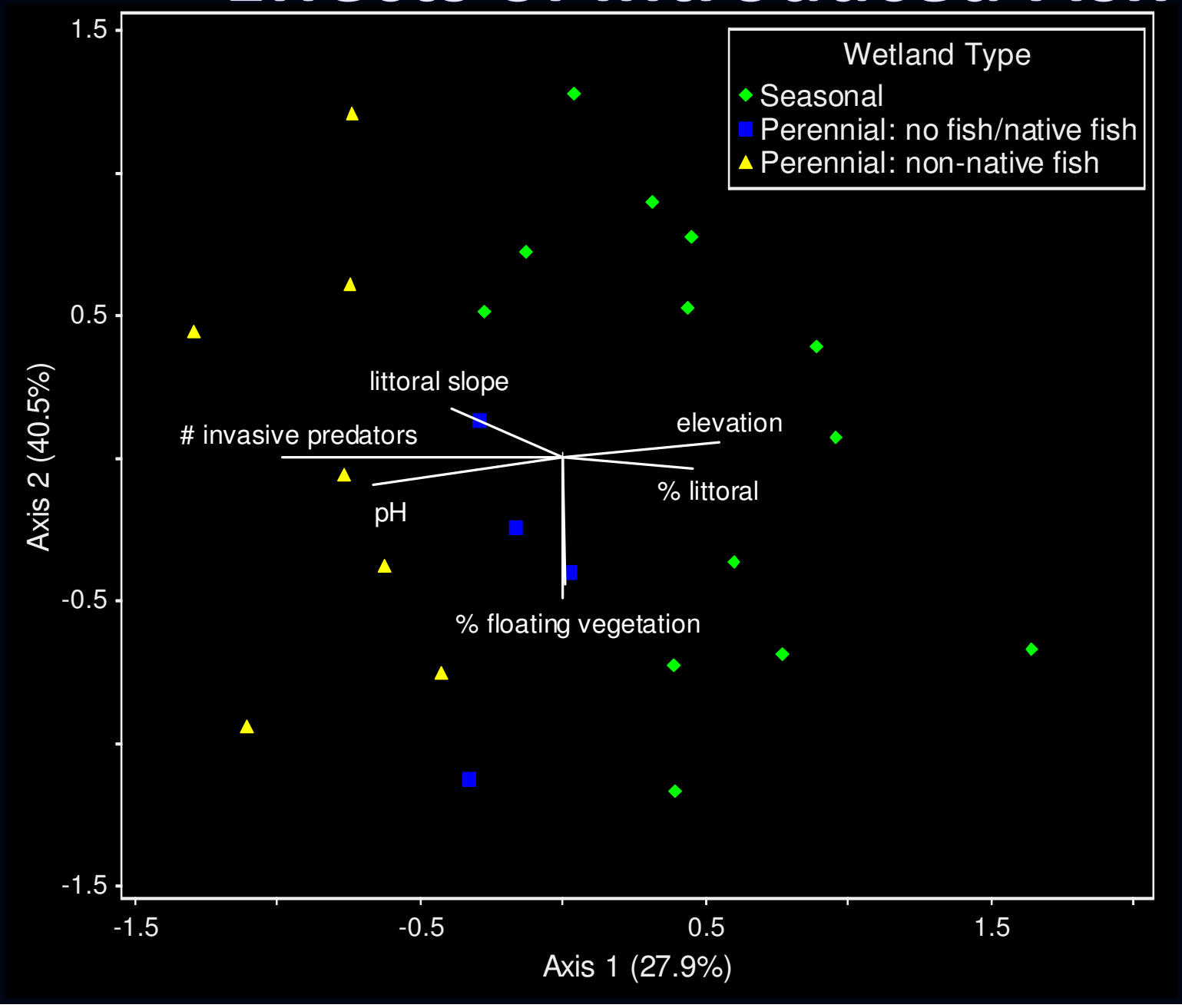
Key Environmental Variables at Rural Ponds



NMS
Stress=20.63
Instability=0.0059
R2 = 68.4%

MRPP
T = -5.0
p = 0.0001

Effects of Introduced Fish



NMS
Stress=20.63
Instability=0.0059
R2 = 68.4%

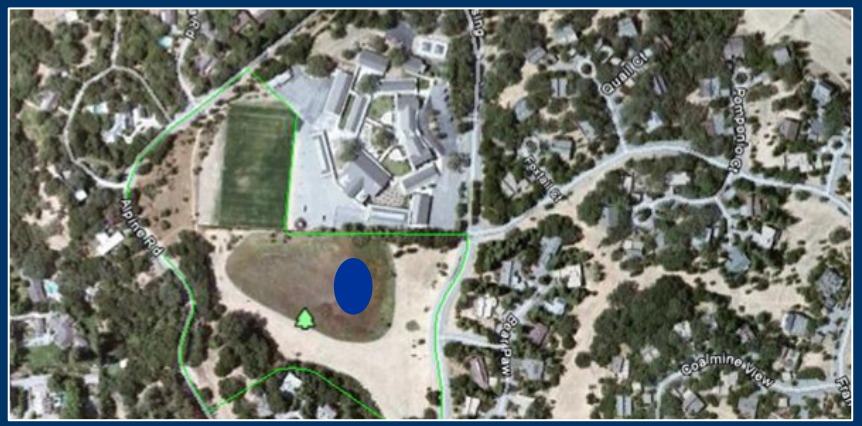
MRPP
T = -5.0
p = 0.0001

Maximizing Conservation Value

Artificial ponds are slightly different:

MRPP T=-2.9, p=0.011, n=22

IBI: Nat. 61 vs. Art. 64 *n.s*



Urban natural ponds

Rural-residential, buffer

Potential Factors

	Abiotic	Biotic
In-pond	Size, depth, slope, % littoral pH, conductivity, turbidity, nutrients (TP, TN), heavy metals (Cr, Pb)	Fish (presence) Vegetation (% cover)
Landscape	% urban (1k, 50m) Stream length (1k, 50m); # ponds (1k), upland slope	Upland vegetation quality

Effects of Grazing at Rural Ponds