

# **Development and Application of a Benthic Macroinvertebrate Index for Pinelands Rivers and Streams**

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# Overview

- Biomonitoring using benthic macroinvertebrates
- NJDEP's Ambient Biomonitoring Network (AMNET)
- Results of initial sampling in Pinelands waters
- Development of the Pinelands Macroinvertebrate Index (PMI)
- Application of the PMI in the Pinelands
- Stewardship-level Index

# Biomonitoring using Benthic Macroinvertebrates

- Methods based on USEPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (1989, revised in 1999)
- Monitor in-stream populations of benthic macroinvertebrates as indicators of water quality
- Benthic (bottom-dwelling ) macroinvertebrates (organisms without backbones visible to the naked eye) inhabit all types of aquatic habitats
- Common forms- aquatic insects, crustaceans, aquatic worms, and mollusks.

# Examples of Common Types of Benthic Macroinvertebrates



# Rationale for Biomonitoring

- Presence and relative abundance of organisms in a stream is governed by environmental conditions and by the pollution tolerances of the respective taxa
- Overall community is reflective of conditions in its environment
- Therefore, changes in water quality and/or instream habitat are evident by changes in the macroinvertebrate community structure

# Some Advantages of using Benthic Macroinvertebrates

- Good indicators of localized conditions
- Sampling relatively easy and inexpensive
- Integrate cumulative effects of different stressors such as excess nutrients, toxins, and sedimentation
- Assess non-chemical impacts to streams such as habitat effects, or altered flow regimes
- Sensitive to short-term, episodic events, such as spills or intermittent discharges

# Background of the AMNET Program

- Network began in 1990
- Statewide network currently with 760 active sites in freshwater (non-tidal) rivers and streams throughout New Jersey
- Sites sampled once every 5 years by Water Region on a rotational basis
- Initially, all sites were assessed using a multimetric index called the New Jersey Impairment Score (NJIS)
- Index comprised of 5 metrics, family-level taxonomy, 0-30 scoring scale, and 3 ratings- Non-impaired, Moderately Impaired, and Severely Impaired

# Data Usage

- Evaluating attainment of aquatic life use for the state's biennial "Integrated Water Quality Monitoring and Assessment Report" (includes 303(d)&305(b) lists)
- NJDEP's Environmental Trends report
- Designation of special protection waters (Category one or C1 waters) based on "exceptional ecological significance."





Sampling is performed using a D-framed net (800x900 micron) using the “jab and sweep” method, focused on the most productive habitats in Coastal Plain streams- submerged banks, macrophytes, and snags (woody debris).



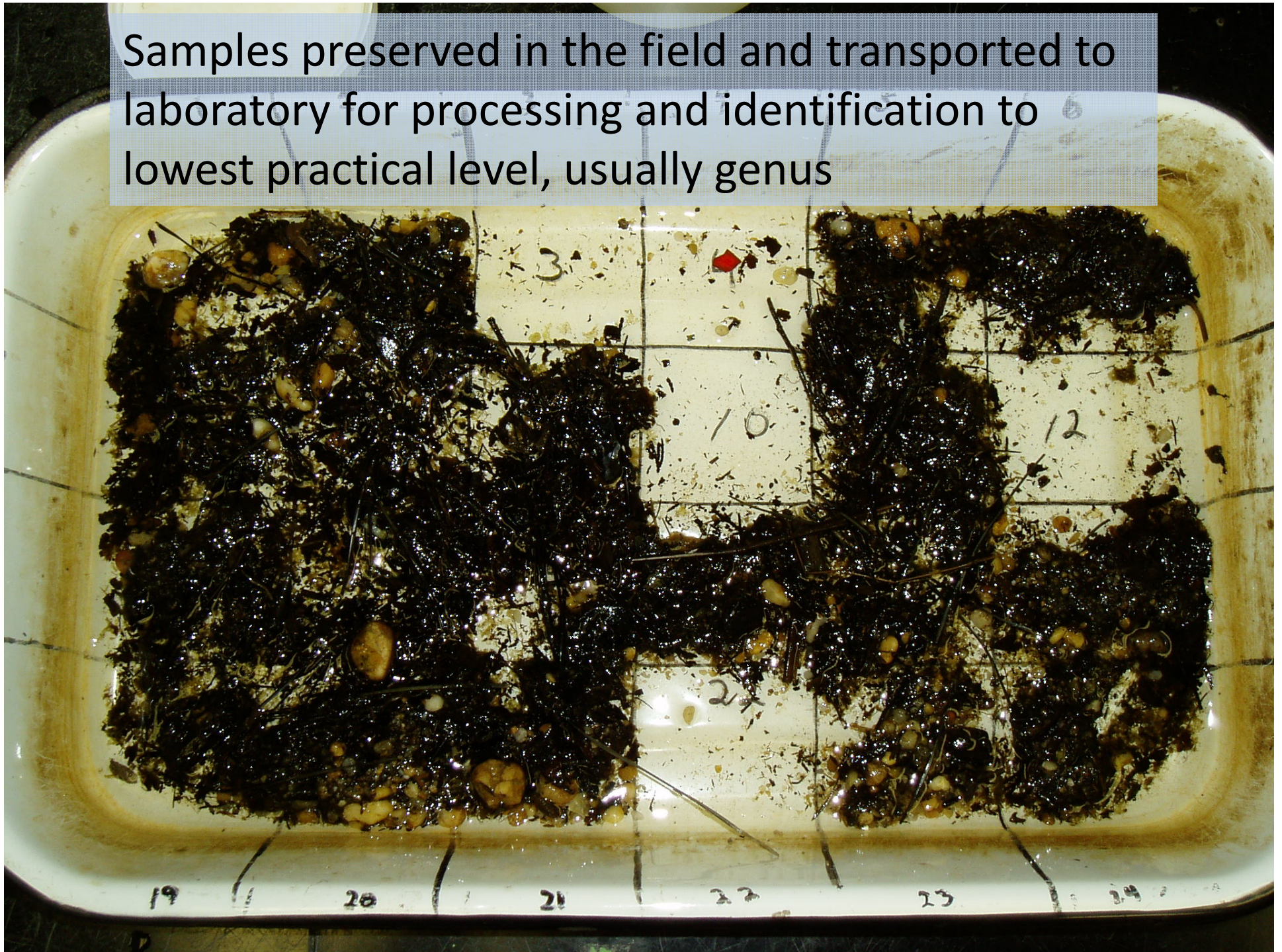
# Visual-based Habitat Assessment

- Method from Rapid Bioassessment Protocols, 2nd. Ed.
- Evaluations of instream habitat quality, sediment deposition, channel alteration and sinuosity, bank vegetation and stability, and riparian vegetative zone.
- Ten parameters scored on 0-20 scale.
- From total score, rating of optimal, suboptimal, marginal, or poor is assigned.

# Other Data Collected

- Digital photographs taken
- Basic water chemistries (pH, water temperature, dissolved oxygen, and specific conductance)
- Stream observations and measurements
  - stream width and depth
  - water clarity
  - flow
  - presence of stormwater outfalls
  - surrounding land use
  - canopy
  - Any potential local sources of pollution

Samples preserved in the field and transported to laboratory for processing and identification to lowest practical level, usually genus



# Pinelands Stressors

- As elsewhere in NJ, aquatic resources in Pinelands are threatened by numerous anthropogenic stressors related to urbanization and agriculture.
- In the Pinelands, development and associated pollution change the character of streams by raising both pH and specific conductance.
- Associated changes in other analytes are also observed such as increases in calcium, magnesium, ammonia, nitrate, and phosphorus.

# Altered Watersheds

- Physical and chemical changes in the watershed and water column affect the resident biota and alter instream community structure
- Pinelands Commission have observed and documented that disturbed watersheds support a greater number of exotic species which can replace native Pinelands species (fish, plants, and frogs)
- A benthic macroinvertebrate index used in the Pinelands must be sensitive to the changes and responsive to the various stressors affecting Pinelands streams

**AN0584 Springers Bk @ Rt. 206  
Shamong Twp., Burlington Co.**

**LU/LC: 26% urban, 33% Forest, 23% Ag,  
17% wetlands**

**2005: pH- 6.0 SC-188 $\mu$ S/cm  
NJIS- 24, Non-impaired**



# In Need of a Better Method

- Funding secured from USEPA Region 2 with the assistance of Jim Kurtenbach
- Contracted Tetra Tech Inc., Owings Mill, MD, with Benjamin Jessup as Project Lead.
- Task:
  - To identify metrics of the macroinvertebrate community that are responsive to stressors in the Pinelands (discriminate degraded sites from least impacted sites) and integrate the most responsive metrics into an index of biological integrity for Pinelands macroinvertebrates.



# Study Area

- Pinelands National Reserve boundary; plus
- 5 km buffer surrounding the Pinelands political boundary, to encompass streams which may flow into or out of the Reserve and also exhibit the characteristics of the unique Pinelands ecosystem (low pH and low specific conductance)
- For index development, sites in the “Pineland Buffer” could be considered “reference”, if the specific criteria are met

# Index Development Steps

- Collect and organize the data, separating calibration and verification data;
- Define reference and degraded sites;
- Stratify natural biological conditions;
- Calculate biological metrics and determine sensitivity of each metric;
- Combine appropriate metrics into index alternatives;
- Select the most appropriate index for application in the Pinelands based on sensitivity and variability, and;
- Assess performance of the index.

# Reference and Degraded Site Criteria

Environmental Parameter	Reference Criterion	Degraded Criterion
Predicted intensive land use (PLU%)	< 10%	>25%
Percent agricultural land cover	< 10%	>25%
Percent urban land cover	< 10%	>50%
Below Dam	No	No criterion

$$PLU \% = 12 pH + 61 \log(spec.cond.) - 148$$

Dow and Zampella (2000):

# Calibration Sites

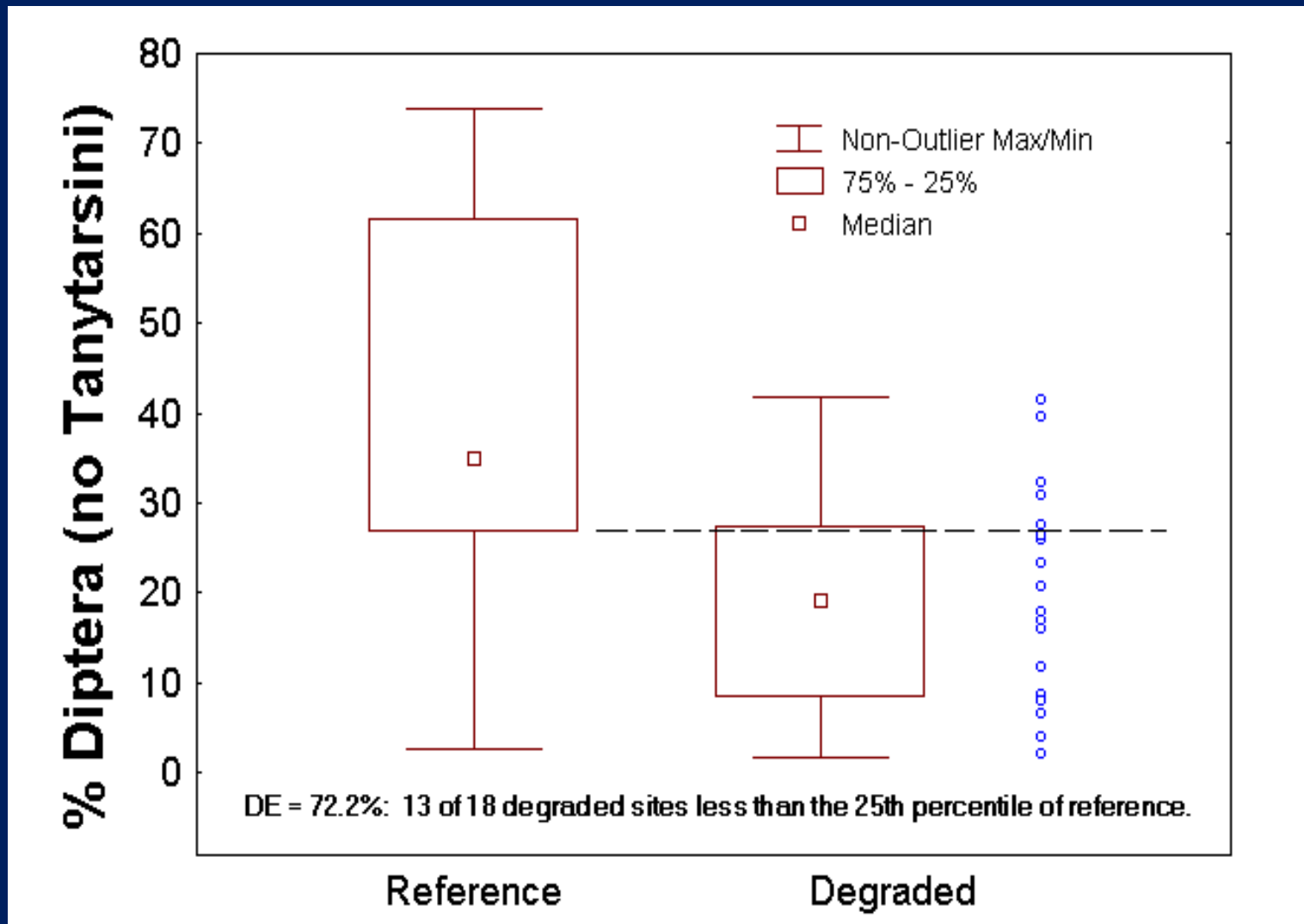
## Reference

- Mt Misery Bk
- Black Run
- UNT to Black Run
- Blacks Br
- Old Hurricane Br
- Wrangle Bk
- Jakes Br
- Cedar Ck
- N Br Forked River
- Skit Br
- Penn Swamp Br
- Tulpehocken Ck
- Papoose Br
- E Br Bass River
- Mare Run
- Gibson Ck
- McNeals Br
- Manumuskin River

## Degraded

- Barton Run
- Kettle Run
- Haynes Ck
- UNT to Ridgeway Br
- Hays Mill Ck
- Albertson Bk
- Great Swamp Bk
- Cedar Bk
- Hammonton Ck
- Springers Bk
- S Br Absecon Ck
- Great Egg Harbor River (2 sites)
- Penny Pot Stream
- Hospitality Br (2 sites)
- Marsh Lake Br
- Collings Br

# Metric Performance



DE= Discriminatory Efficiency

# Metric Responses to > Stress

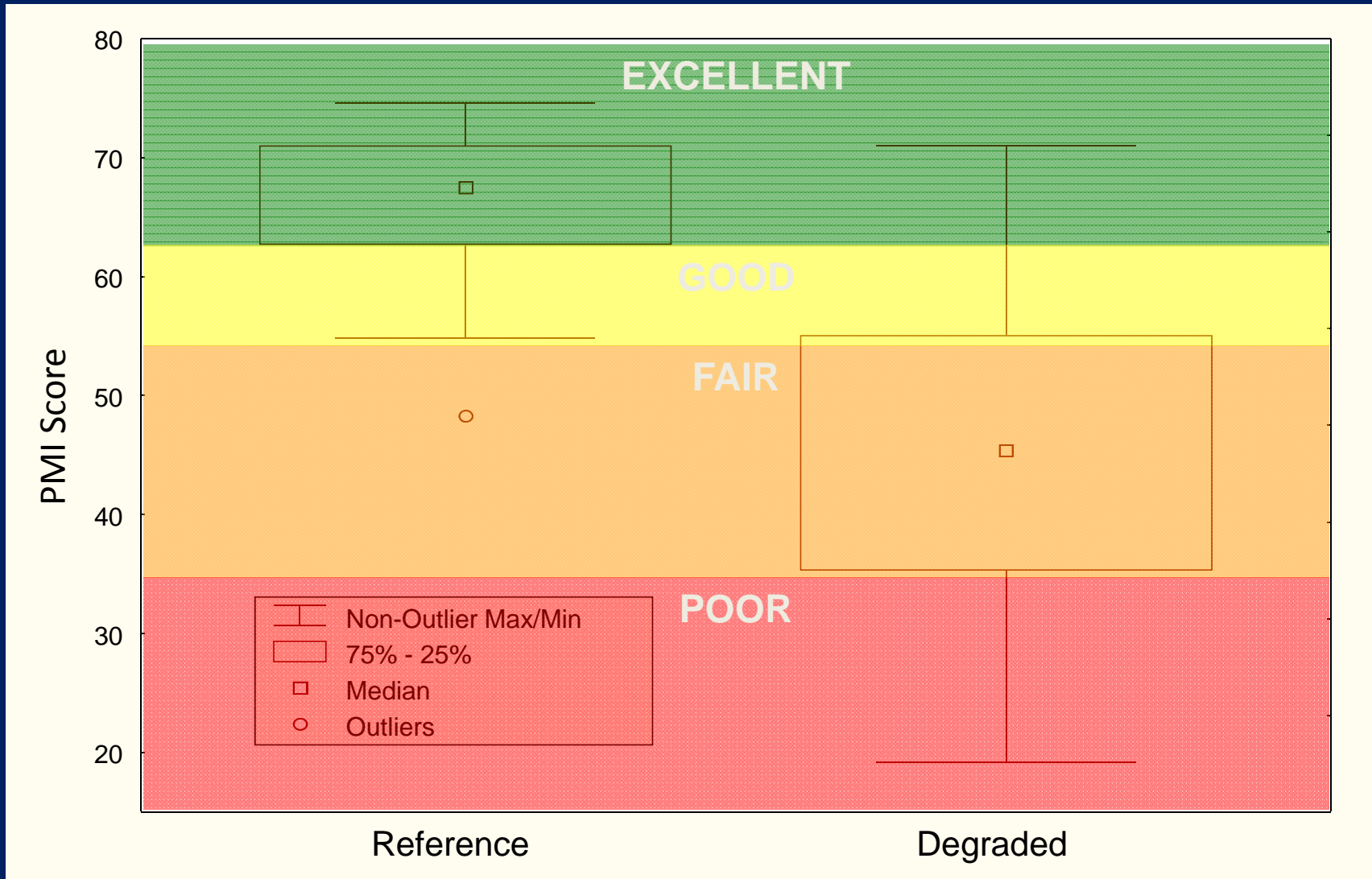
Metric	DE	Expected	Observed
Insect taxa	66.7	-	-
Non-insect taxa	83.3	+	+
EPT taxa	61.1	-	-
Diptera taxa	33.3	-	-
Chironomidae taxa	<25	-	NR
Orthoclaadiinae taxa	38.9	-	-
Tanytarsini taxa	44.4	-	+
Tanypodinae taxa	<25	-	NR
<b>%Diptera</b>	<b>61.1</b>	<b>+</b>	<b>-</b>
<b>%Diptera w/o Tanytarsini</b>	<b>72.2</b>	<b>+</b>	<b>-</b>
<b>%Orthoclaadiinae</b>	<b>38.9</b>	<b>+</b>	<b>-</b>
<b>%Tanytarsini</b>	<b>55.6</b>	<b>-</b>	<b>+</b>
%Crustacea & Mollusca	77.8	+	+
%Mollusca & Amphipoda	77.8	+	+
%Plecoptera & Trichoptera	66.7	+	+
Beck's Biotic Index	55.6	+	+

# Pinelands Macroinvertebrate Index (PMI)

1. # of Insect Taxa (-)
2. # of Non-insect Taxa (+)
3. % Plecoptera and Trichoptera (-)
4. % Diptera excluding Tanytarsini (-)
5. % Mollusca and Amphipoda (+)
6. Beck's Biotic Index (-)
7. % Filterers (+)



# Index Thresholds





# Index Performance

- Using calibration data set, PMI's DE was 94.4%
- With same data set, NJIS had a DE of 44.4%
- Mean separation of index scores between reference and degraded was 22.4 points

ALK7



AN0584 Springers Bk

PMI: 43.83, Fair

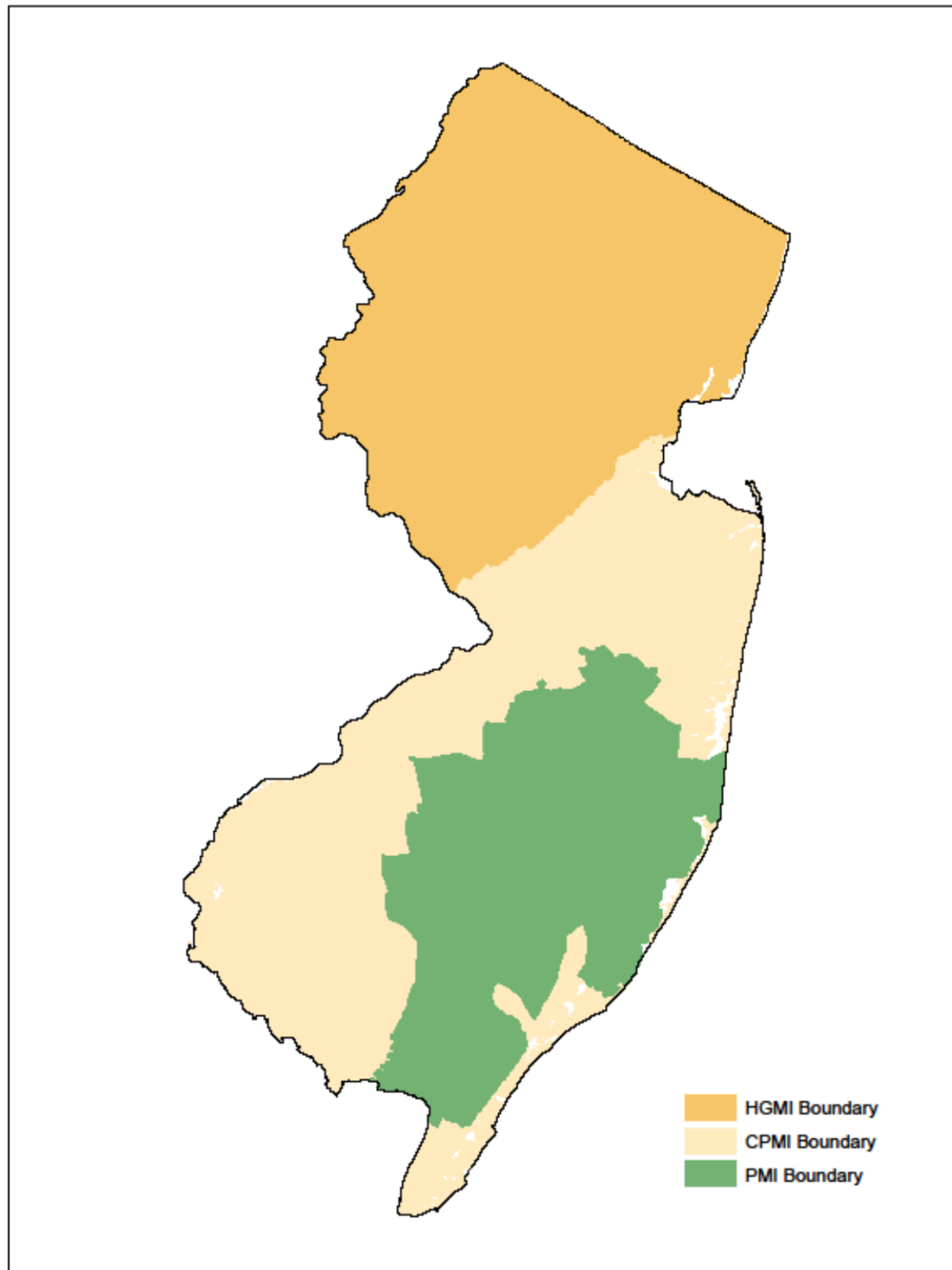


# Conclusions

- PMI is efficient at distinguishing reference from degraded conditions, but may be more sensitive to severe stresses than moderate stresses. Future refinements may be necessary to better assess slight to moderately enriched conditions.
- PMI cannot determine the stressor or stressors causing degradation without further study.
- The mechanism by which stresses in the Pinelands cause changes in the benthic macroinvertebrate community are poorly understood partly because of the nature of the stresses is unusual.

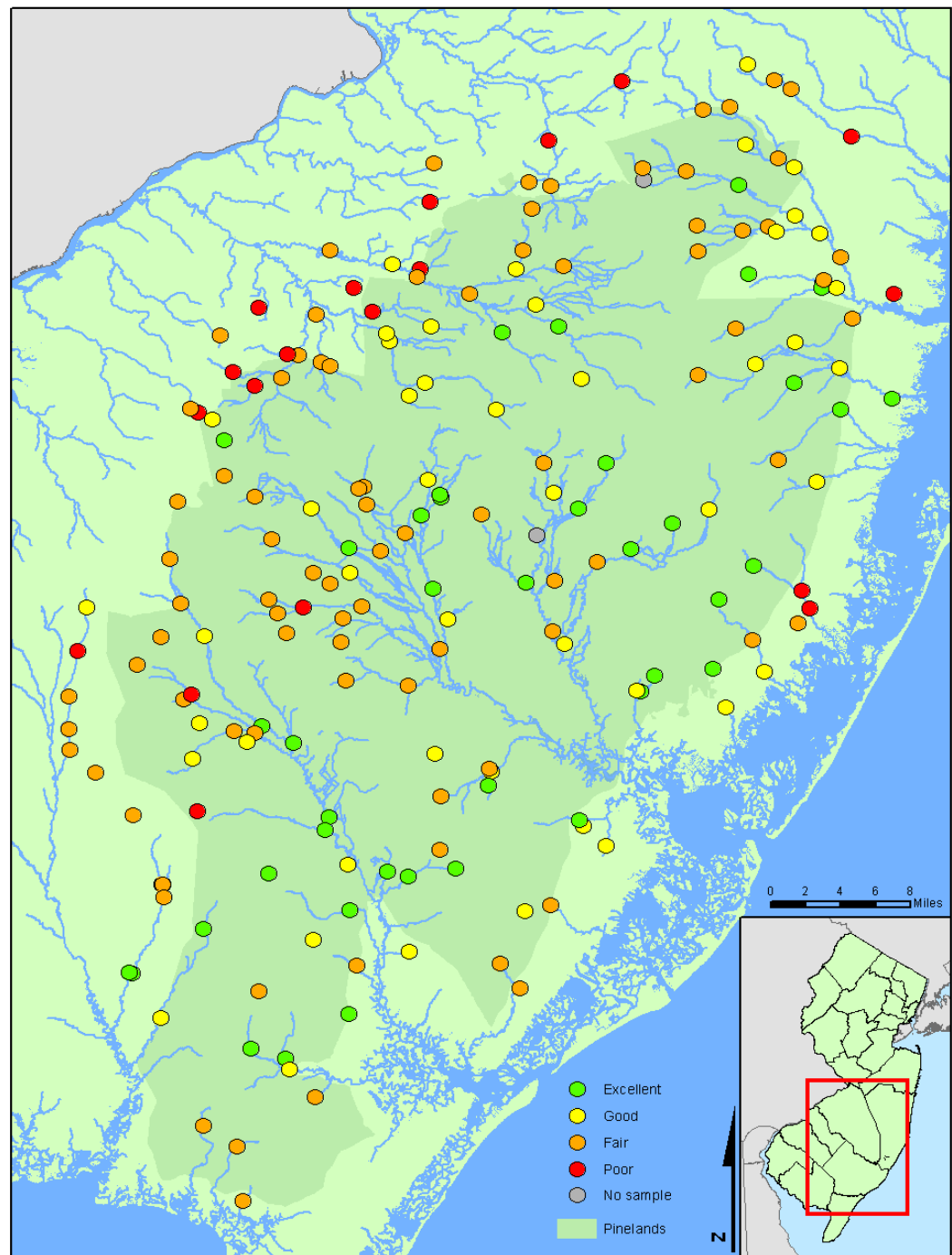
## Regional Indices

- High Gradient Macroinvertebrate Index (HGMI)
- Coastal Plain Macroinvertebrate Index (CPMI)
- Pinelands Macroinvertebrate Index (PMI)

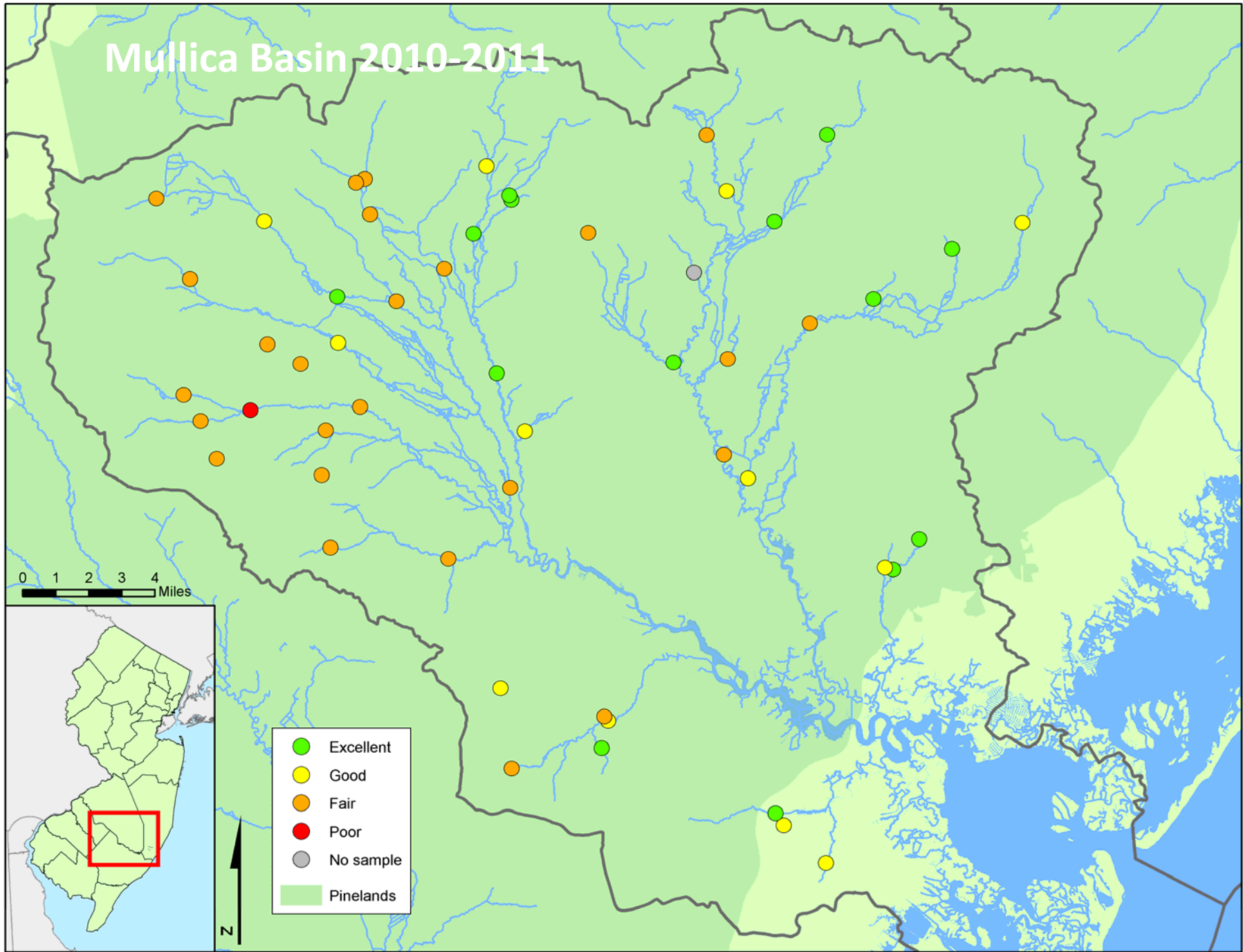


Currently, 197 sites assessed using PMI

Atlantic Basin data- 2010-11  
Lower Delaware Basin data- 2006-07



# Mullica Basin 2010-2011



# Development of the New Jersey Pinelands Macroinvertebrate Index (PMI)

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March 2005  
*Final Report*





# Stewardship-Level Macroinvertebrate Index Development

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# NJDEP Volunteer Biomonitoring Protocol

- 2000-2005 protocols based on presences/ absences of taxa, developed by Save Our Streams, a program of the Izaak Walton League of America
- 2005-2010 added counting number of individuals
- One size fits all approach to metrics was not working
- Unreliable in the Pinelands & Coastal Plain Ecoregions

# VPMI

- 1 Percent Crustacea & Mollusca Taxa (+)
- 2 Number of Insect Taxa (-)
- 3 Number of EPT Taxa/(Number of Tolerant Taxa + 1) (-)
- 4 Percent Worm, Leech & Lunged Snail Individuals (+)
- 5 Number of Tolerant Taxa (+)

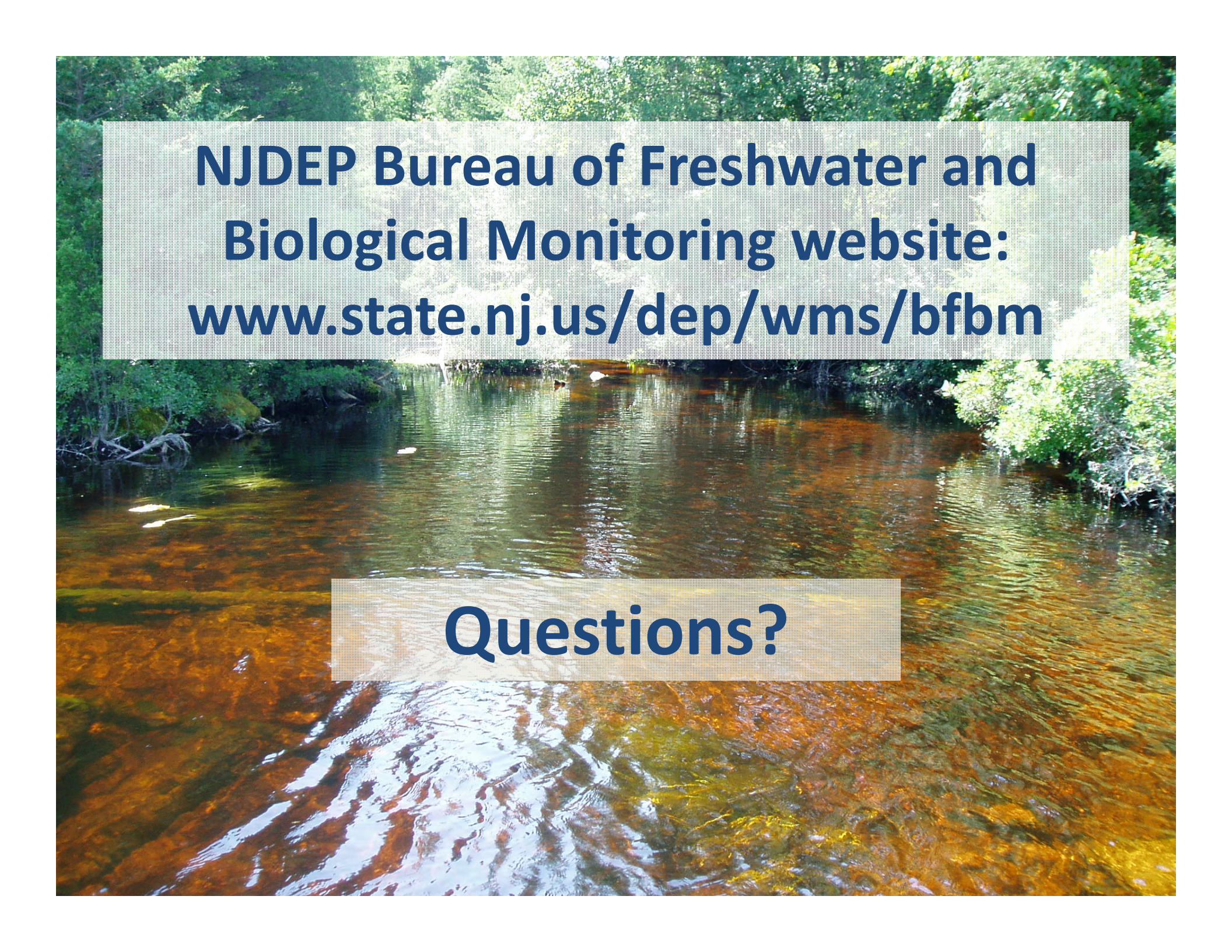


# Better Tools for Biomonitoring

- Multimetric Indices
- Sensitive to Ecoregions
  - High Gradient
  - Pinelands
  - Coastal Plain
- Align with NJDEP-BFBM multimetric indices
- User-friendly stream side identifications

**Stamp, J., and Benjamin Jessup, and Danielle Donkersloot. 2010. Stewardship-Level Macroinvertebrate Index Development for Northern NJ High Gradient, Pinelands and Coastal Plain Streams.**





**NJDEP Bureau of Freshwater and  
Biological Monitoring website:  
[www.state.nj.us/dep/wms/bfbm](http://www.state.nj.us/dep/wms/bfbm)**

**Questions?**