

Inner Coastal Plain Fish IBI



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Why Use Fish as Biological Monitors?



- Fish are long-lived and are therefore good indicators of long-term disturbances
- Fish assemblages generally consist of a number of trophic levels
- Fish are at the top of the food chain in aquatic environments and are consumed by humans
- Fish are easy to collect and identify
- Fish account for nearly half the endangered vertebrates of the U.S.

What is a Fish Index of Biotic Integrity?



- Using fish assemblages to assess the overall health of a stream ecosystem
- A scoring system based on multiple attributes (metrics) of a fish assemblage
- Individual metrics are summed and overall score used to determine health of a water body
- Metrics selected based on how well they indicate anthropogenic stressors

Validity of the Index of Biotic Integrity

Karr et al. 1986

Criterion 1. *The measure must be biological.*

Criterion 2. *The measure must be interpretable at several trophic levels or provide a connection to other organisms not directly involved in the monitoring.*

Criterion 3. *The measure must be sensitive to the environmental conditions being monitored.*

Criterion 4. *The response range of the measure must be suitable for the intended application.*

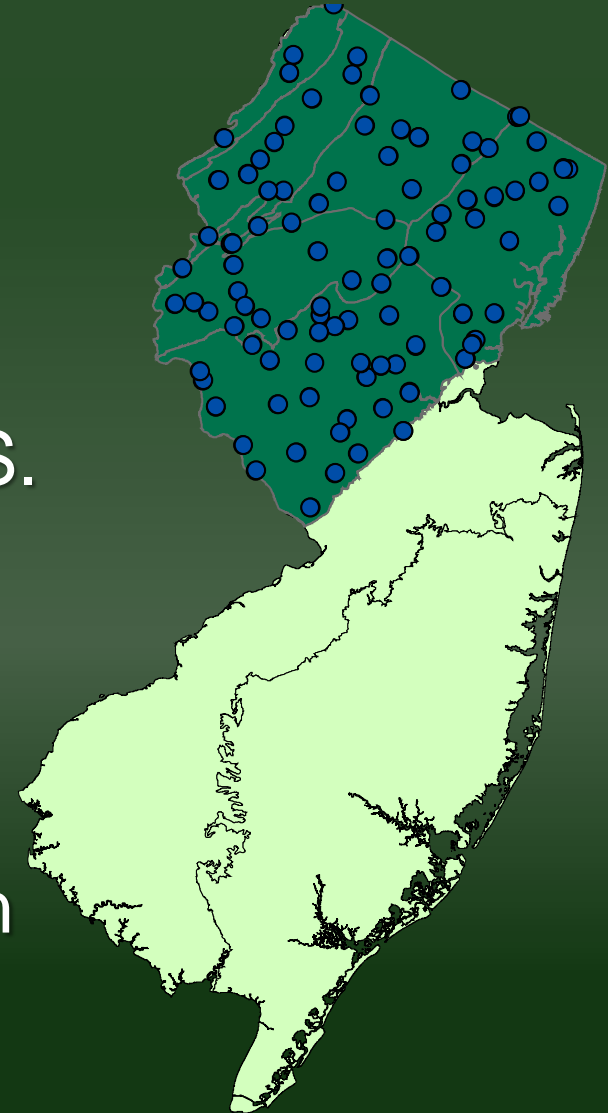
Criterion 5. *The measure must be reproducible and precise within defined and acceptable limits for data collected over space and time.*

Criterion 6. *Variability of the measure must be low.*

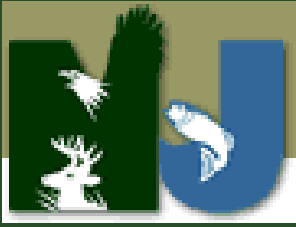
Northern Fish IBI



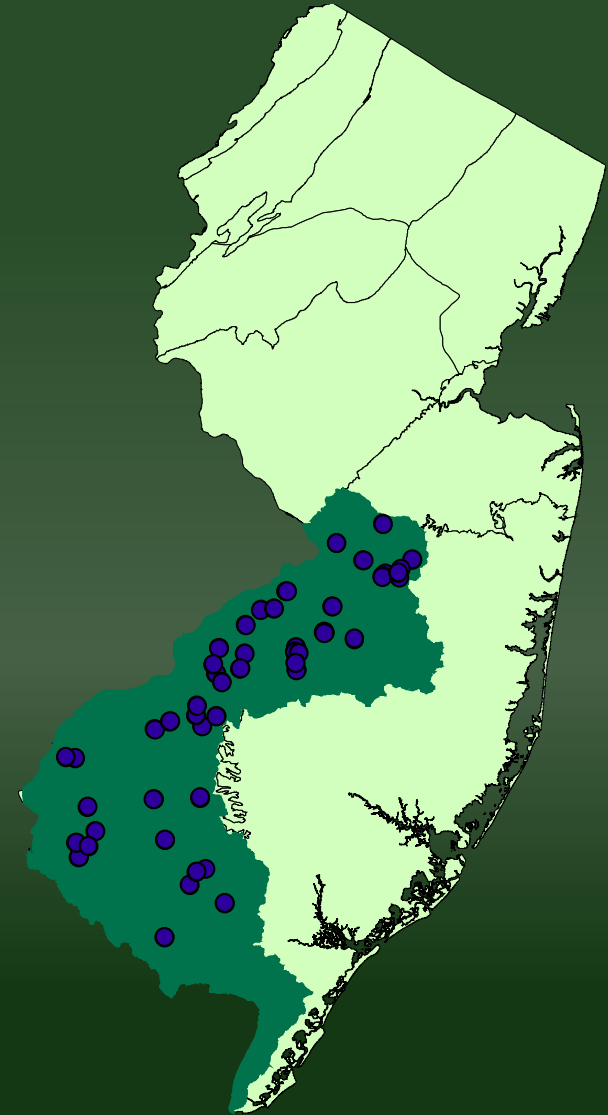
- Northern Fish IBI developed by U.S. EPA Region 2
- BFBM initiated monitoring in 2000
- 98 site network consisting of fixed, random, sentinel sites
- 26-32 sites per year, 5 year rotation
- Index period – June through Mid-October
- Currently in 3rd round of monitoring



Southern Fish IBI



- Pilot project to develop a fish IBI started by NJ Fish & Wildlife in 2000
- BFBM initiated redevelopment in 2008
- Scoring criteria and validation finalized spring 2012
- 43 site network consisting of fixed, random, sentinel sites



North vs. South



Northern Streams

- High gradient
- Cobble/boulder
- Riffle/run/pool
- More diverse

Southern Streams

- Low gradient
- Sand/gravel
- Run/pool
- Lower diversity

Methods

Backpack Electrofishing



Barge Electrofishing



Healthy Fish Community



Impaired Fish Community



Southern IBI Development



- Used Maryland, Virginia, North Carolina, South Carolina, and Georgia Programs as models for developing NJ Inner Coastal Plain Fish IBI
- All of these states have similar fish species to NJ
- Maryland has an established Coastal Plain Fish IBI and has completed recalibration
- Results present to MD DNR, EPA Regions 2 and 3, Versar Inc, and NJ Fish IBI Workgroup

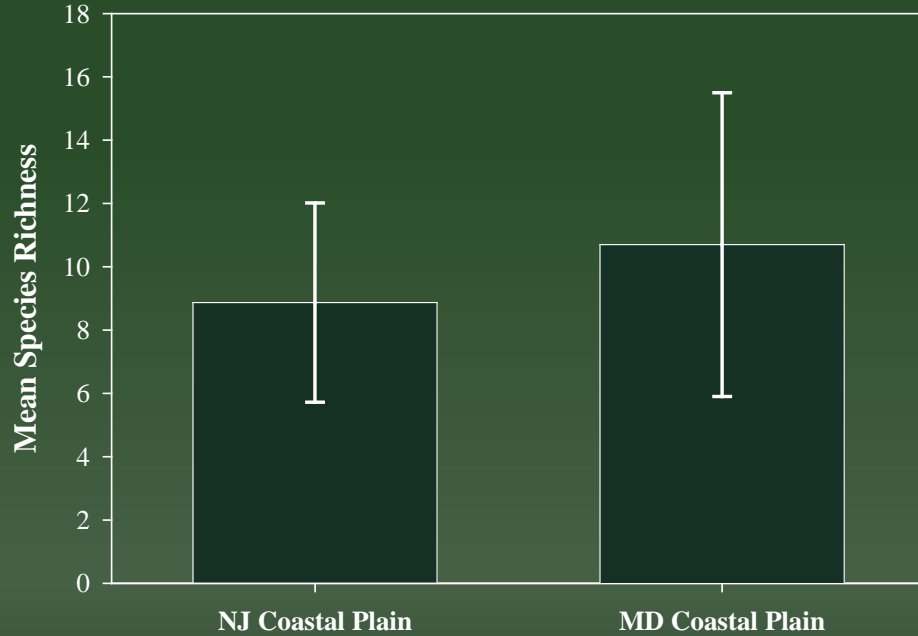
Steps



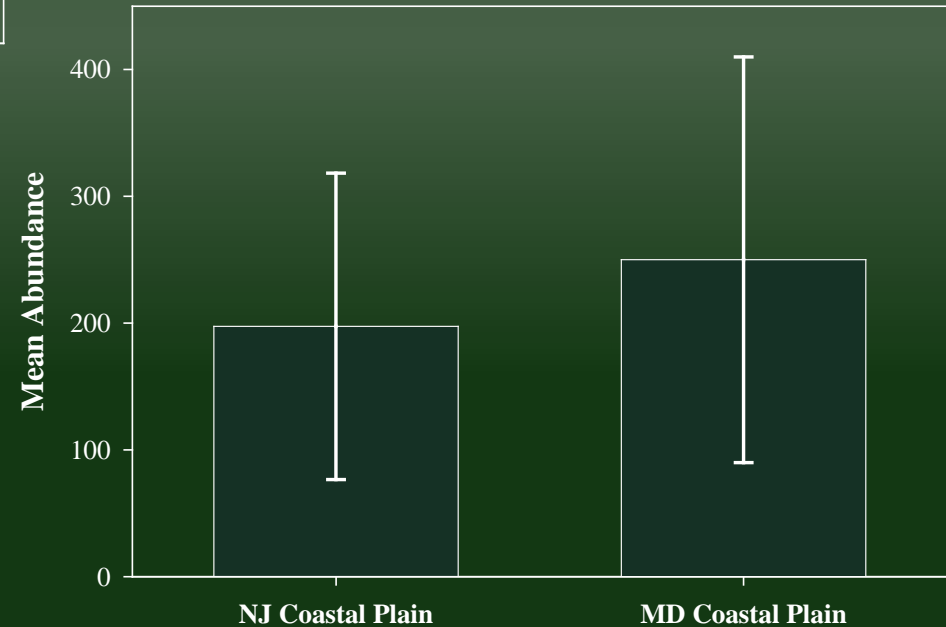
- Researched historical fish distributions within Inner Coastal Plain
- Identified and sampled “least impacted” and “most impacted” sites within Inner Coastal Plain
- Researched applicability of Coastal Plain Fish IBI’s from other states
- Used Maryland DNR Coastal Plain Fish IBI as a template for data analysis and metric development
- Tested Coastal Plain metrics, Northern NJ IBI metrics, and Karr’s original fish metrics

New Jersey vs. Maryland

Native Species Richness



Mean Number of Individuals



Analysis



- 111 sites were sampled for development including 21 least impaired and 24 most impaired sites
- Completed n-1 Jackknife validation
- Completed Bootstrapping validation
- Evaluated minimum drainage size
- Completed evaluation of different scoring techniques
- Completed network design to include fixed, sentinel, and probabilistic sites

Southern IBI Metrics

Richness & Composition

1. Native Species Richness
2. Benthic Species Richness
3. Intolerant Species Richness
4. Proportional Abundance Tolerant Species

Trophic Composition

5. Proportional Abundance Insectivores
6. Proportional Abundance Piscivores

Fish Abundance & Condition

7. Abundance minus Tolerant Species
8. DELT Anomalies

Impact Classification

Condition	Least Impacted N=21	Most Impacted N=24
%Forest/Wetland	>50%	<35%
%Urban	<20%	>60%
%Impervious Cover	<5%	>19%
pH	>5.5	None
Instream Habitat	Optimal or Sub-optimal	None
Fish Abundance	>100	None
Fish Richness	>5	None

Results of Metric Testing

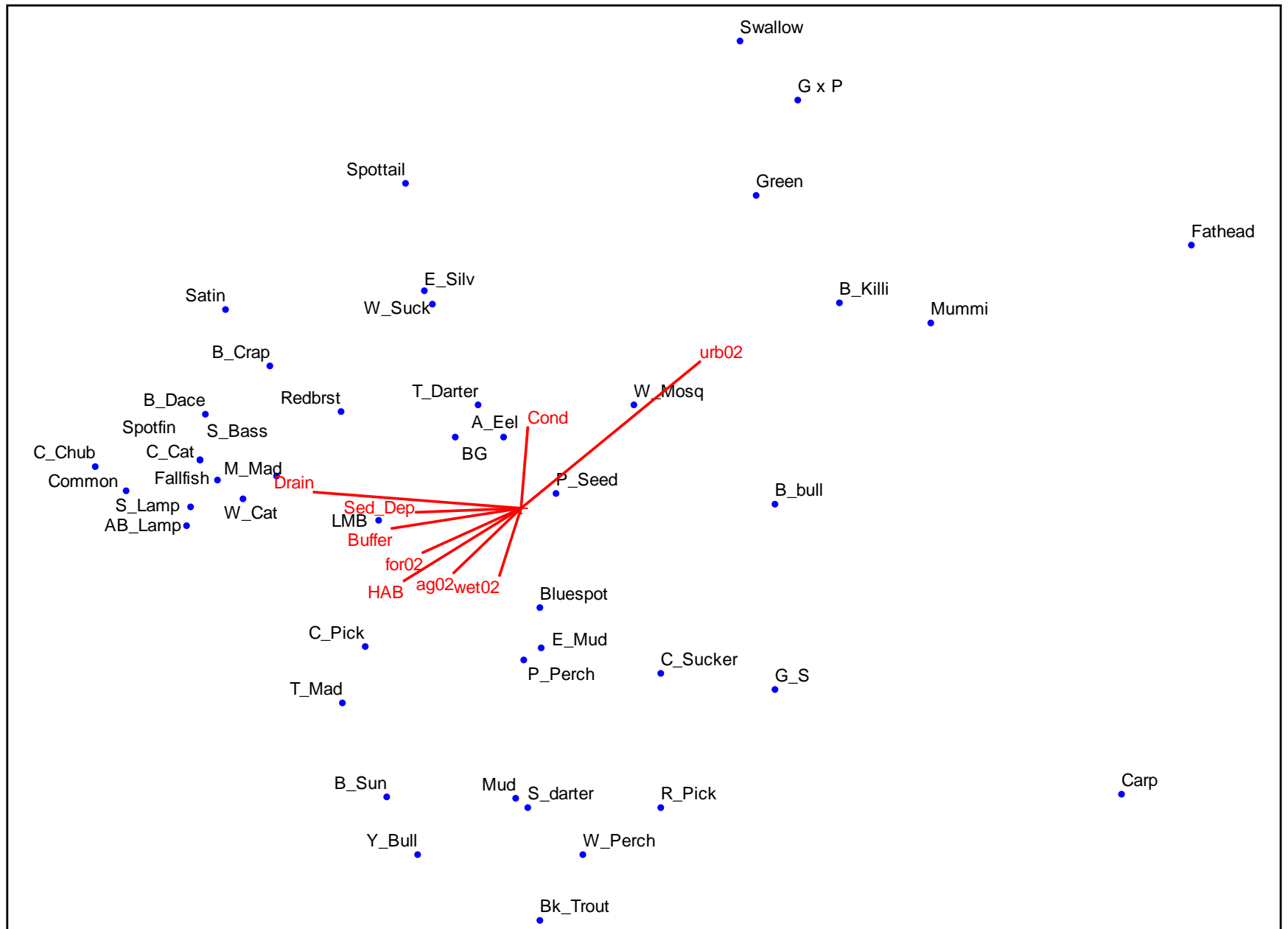
Mann-Whitney (M-W)

Kolmogorov-Smirnov (K-S)

Metric	Reference n = 21 Impaired n = 24		Pearson Correlation n = 111	
	M-W	K-S	Urban	Forest
Native Sp.	$P < 0.001$	$P < 0.001$	-0.29	0.39
Benthic Sp.	$P < 0.001$	$P < 0.001$	-0.48	0.35
Intolerant Sp.	$P < 0.001$	$P < 0.001$	-0.41	0.46
% Tolerants	$P < 0.001$	$P = 0.001$	0.47	-0.27
% Insectivores	$P < 0.001$	$P < 0.001$	-0.48	0.30
% Piscivores	$P = 0.002$	$P = 0.001$	-0.18	0.24
Abundance	$P = 0.002$	$P = 0.001$	-0.21	0.07

DCA

Axis 2



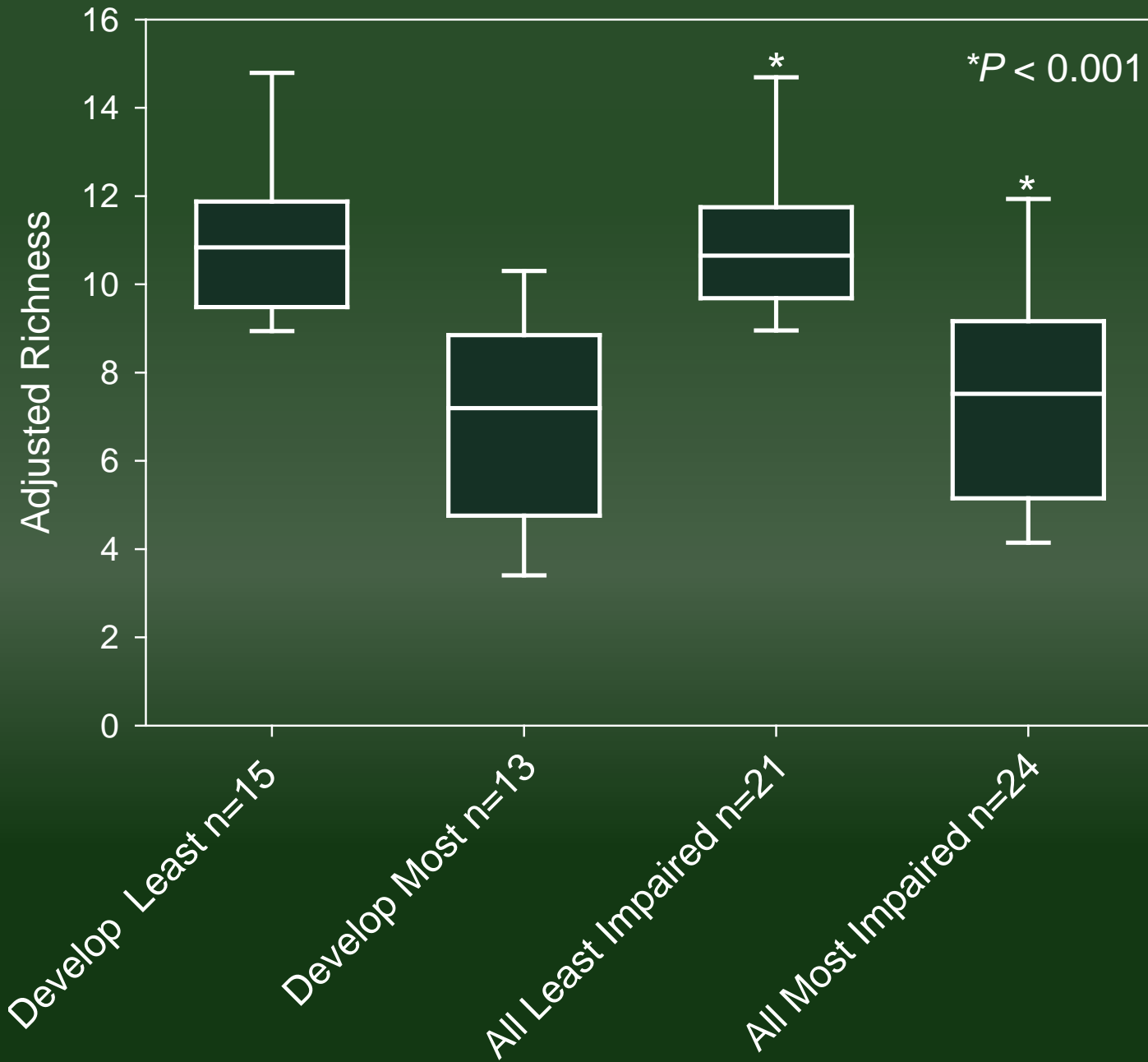
Axis 1

Native Species Richness

- All species collected except the following:
Goldfish, Common Carp, Fathead Minnow,
Channel Catfish, Western Mosquitofish,
Warmouth, Rock Bass, Green Sunfish,
Bluegill, Largemouth Bass, and Black
Crappie

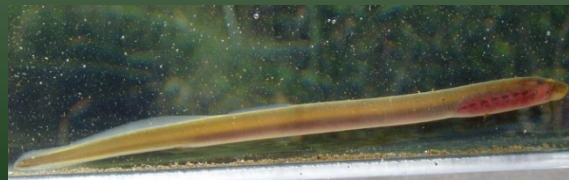


Native Species Richness

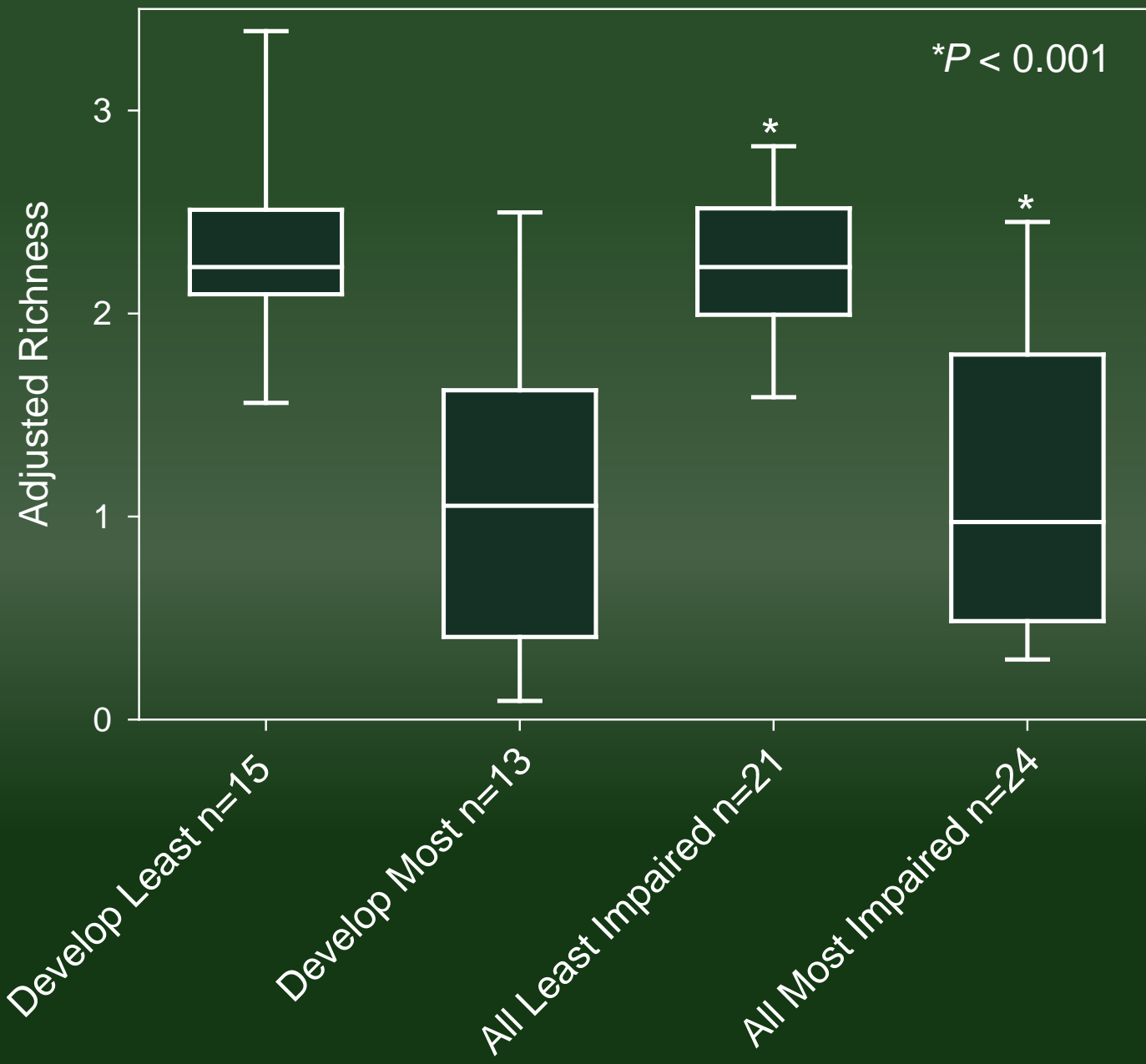


Benthic Species Richness

- Includes the following species:
Sea Lamprey, American Brook Lamprey,
Margined Madtom, Creek Chubsucker,
Tadpole Madtom, Swamp Darter,
Tessellated Darter, and Yellow Perch



Benthic Species Richness

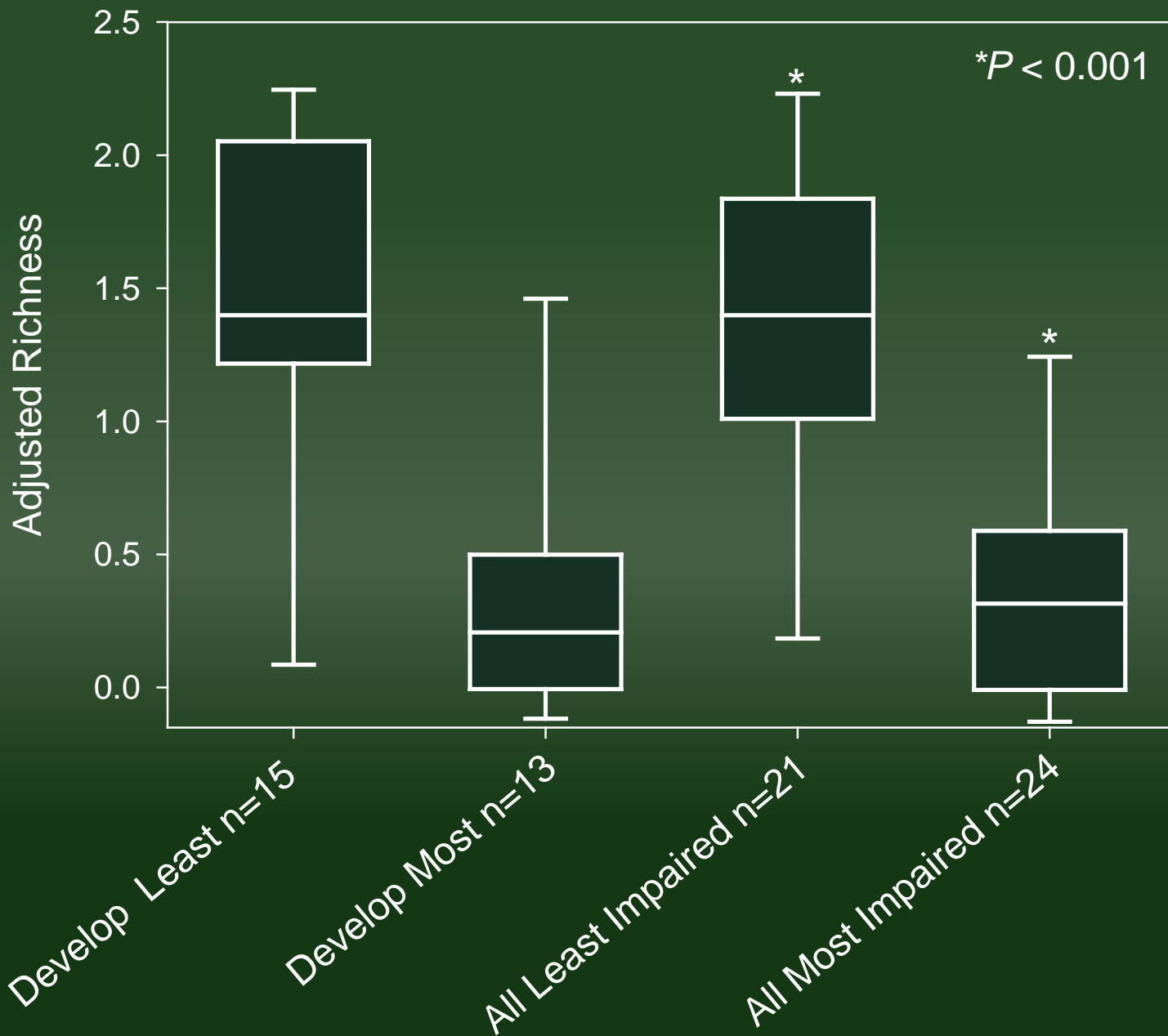


Intolerant Species Richness

- Includes the following species:
Bluespotted Sunfish, Banded Sunfish,
Blackbanded Sunfish, Sea Lamprey,
American Brook Lamprey, Tadpole
Madtom, Margined Madtom, and Swamp
Darter



Intolerant Species Richness

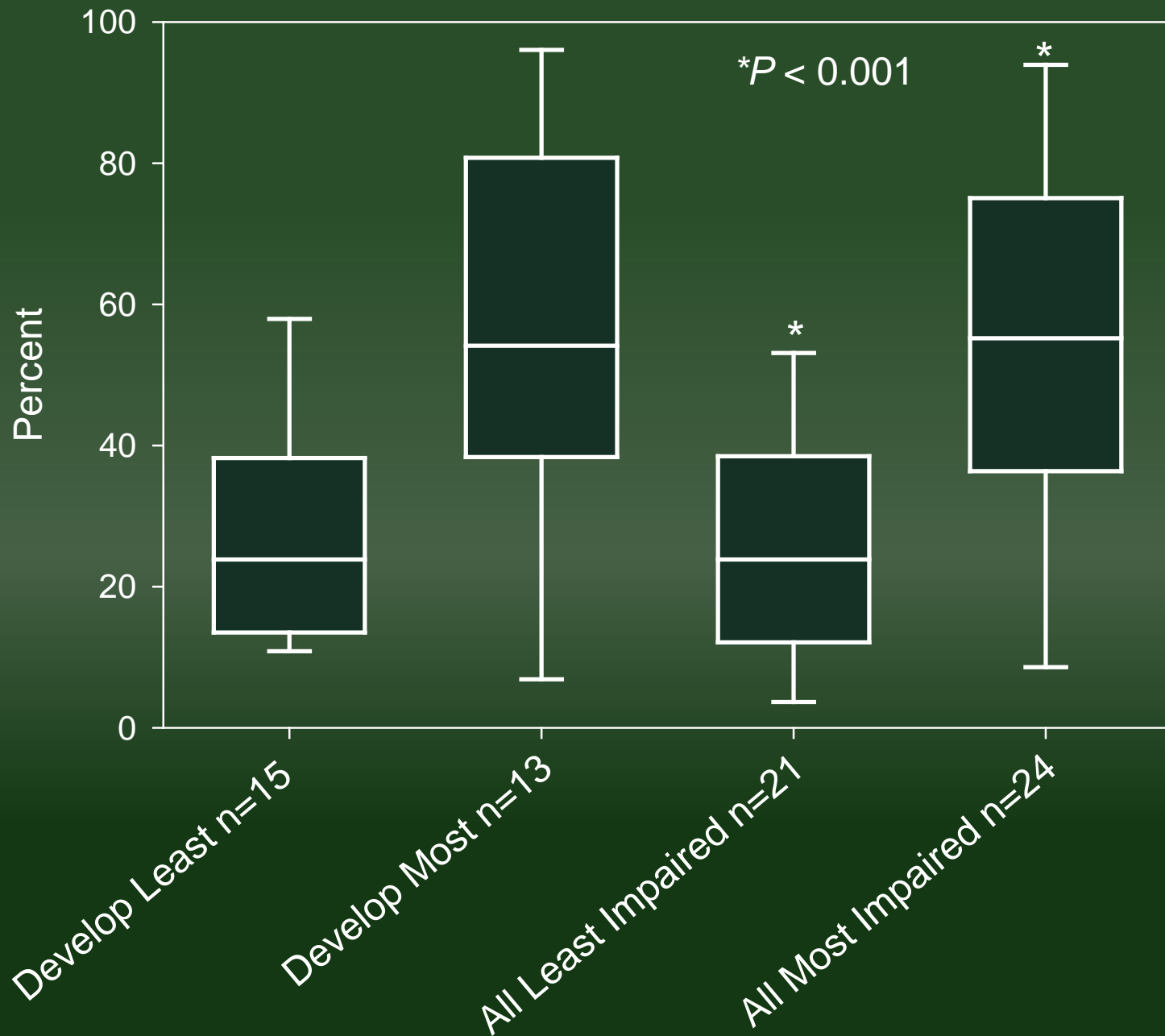


% Abundance of Tolerant Species

- Includes the following species:
American Eel, Green Sunfish, Bluegill, Banded Killifish, White Sucker, and Mummichog



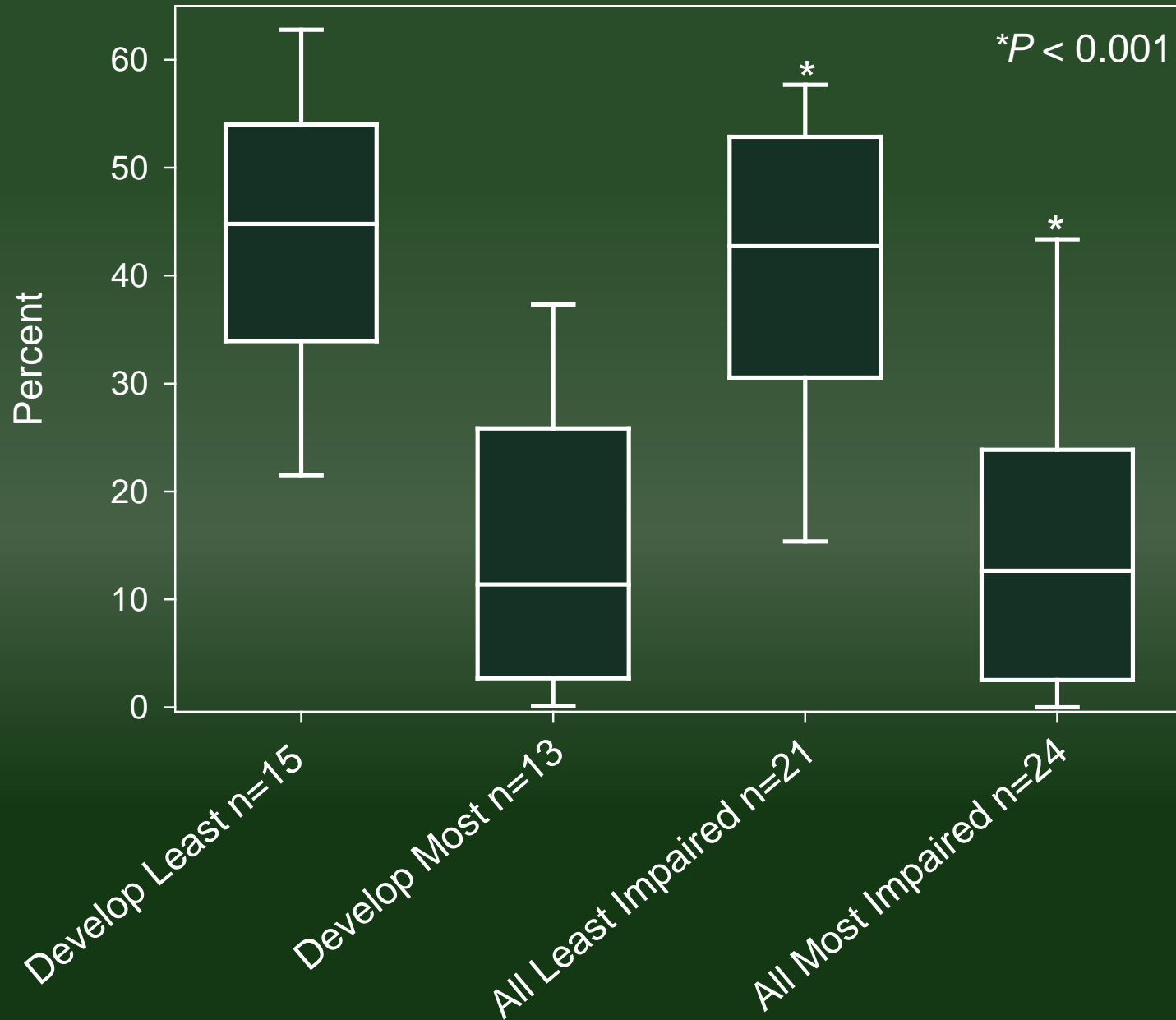
Percent Tolerant Individuals



% Insectivorous Species

- Includes the following species:
Redbreast Sunfish, Pumpkinseed, Warmouth, Mud Sunfish, Blackbanded Sunfish, Bluespotted Sunfish, Banded Sunfish, Pirate Perch, Comely Shiner, Satinfin Shiner, Ironcolor Shiner, Swallowtail Shiner, Spotfin Shiner, American Shad, Eastern Mudminnow, Blacknose Dace, Fallfish, Western Mosquitofish, Tadpole Madtom, Margined Madtom, Creek Chub, and Swamp Darter

Percent Insectivores

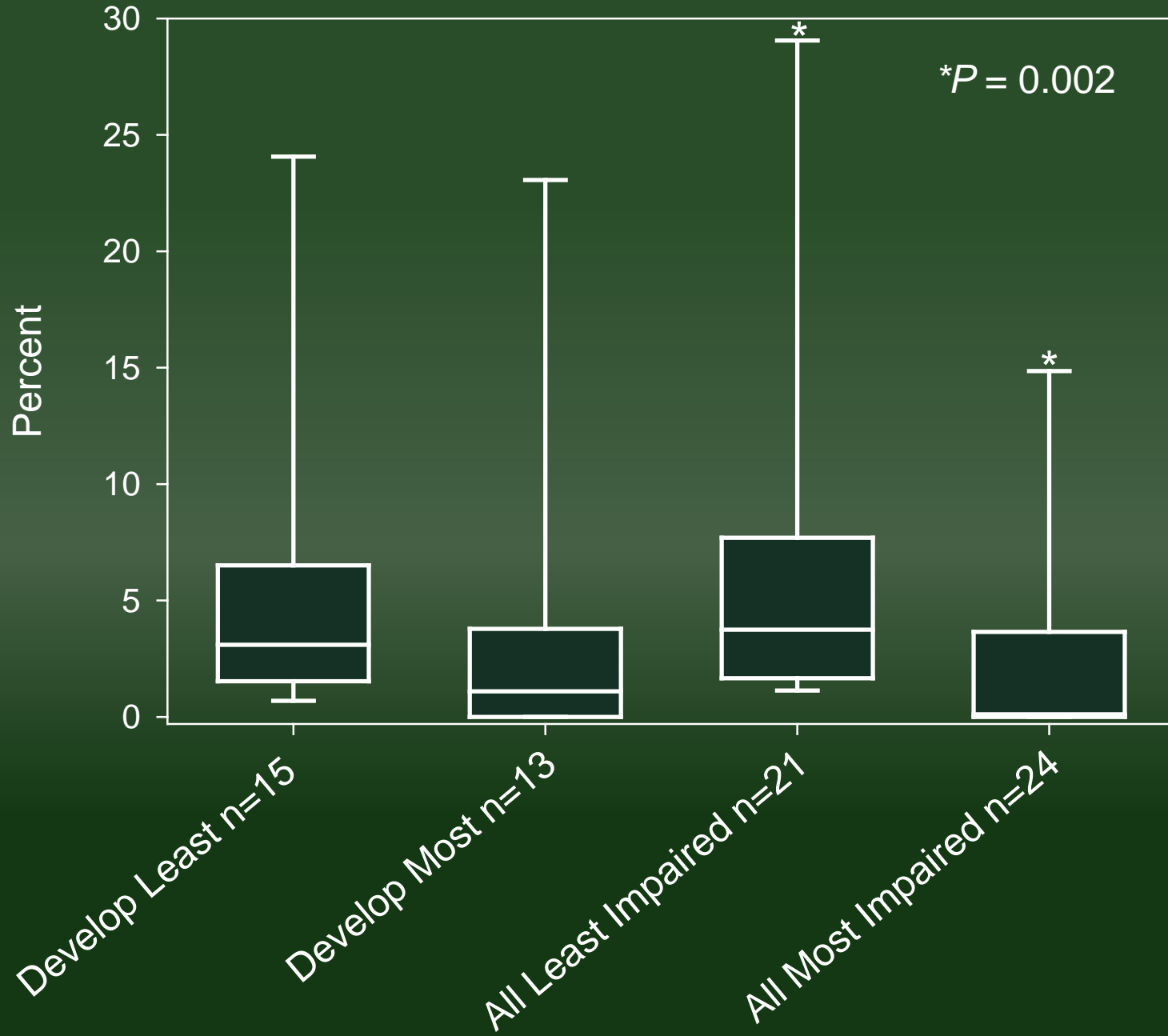


% Piscivorous Species

- Includes the following species:
White Perch, Redfin Pickerel, Chain Pickerel,
Striped Bass, Black Crappie, Largemouth Bass,
and Yellow Perch



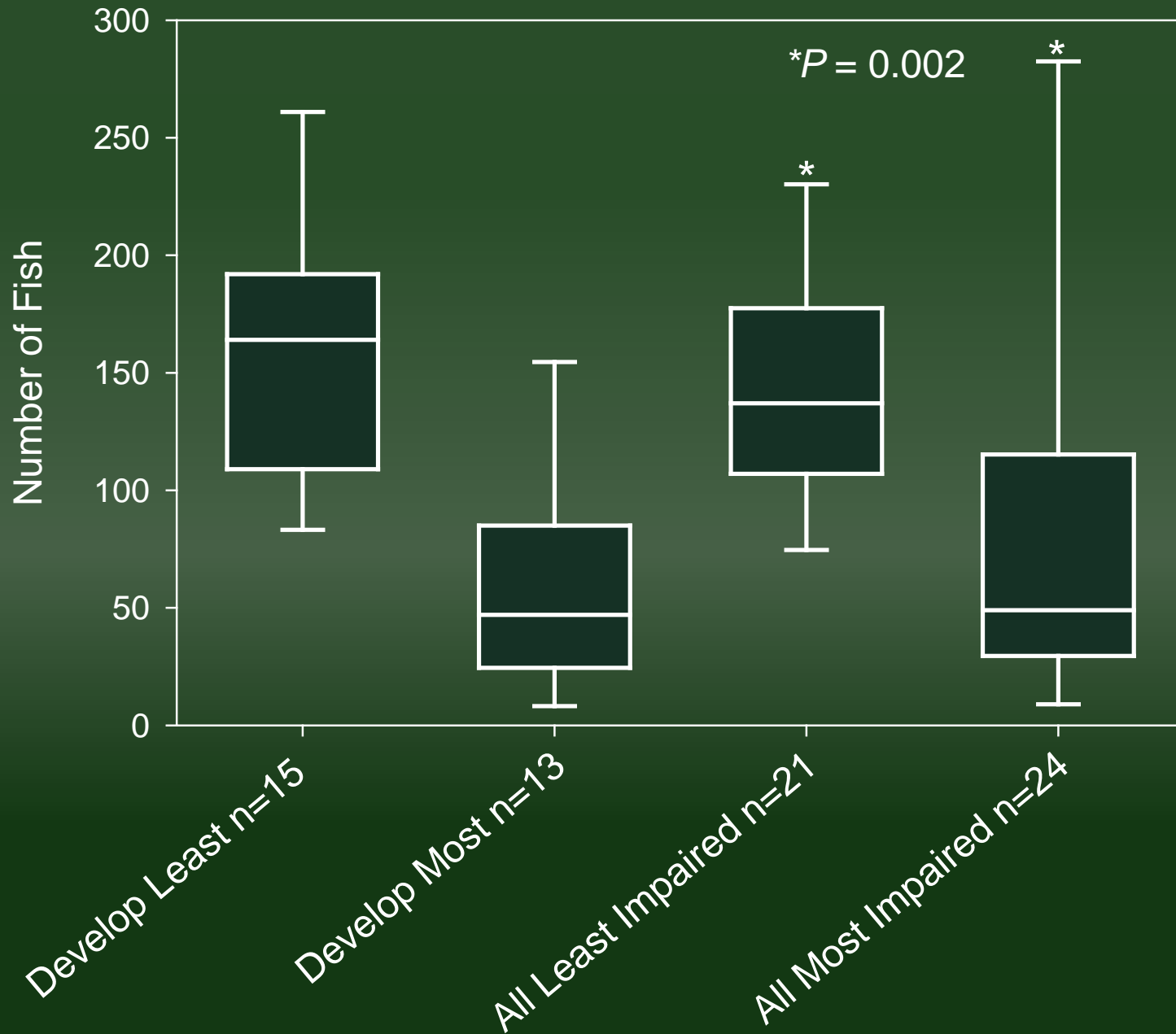
Percent Piscivores



Fish Abundance minus Tolerant Species

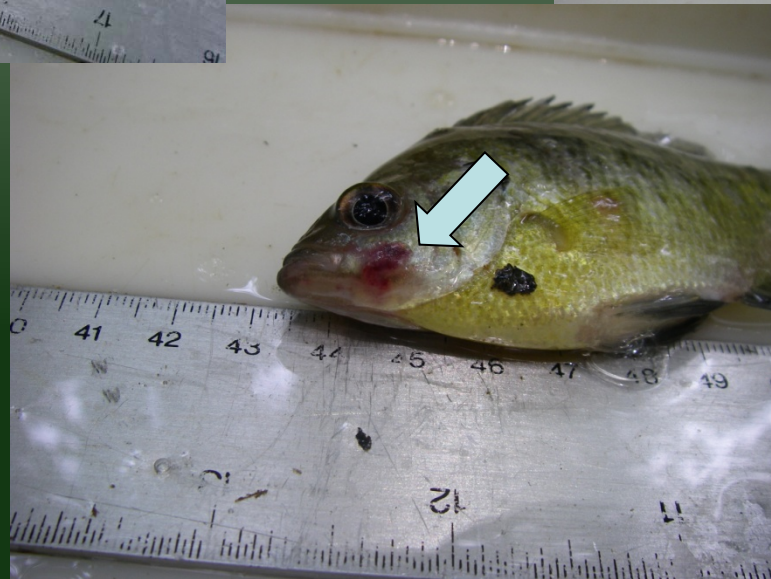


Abundance

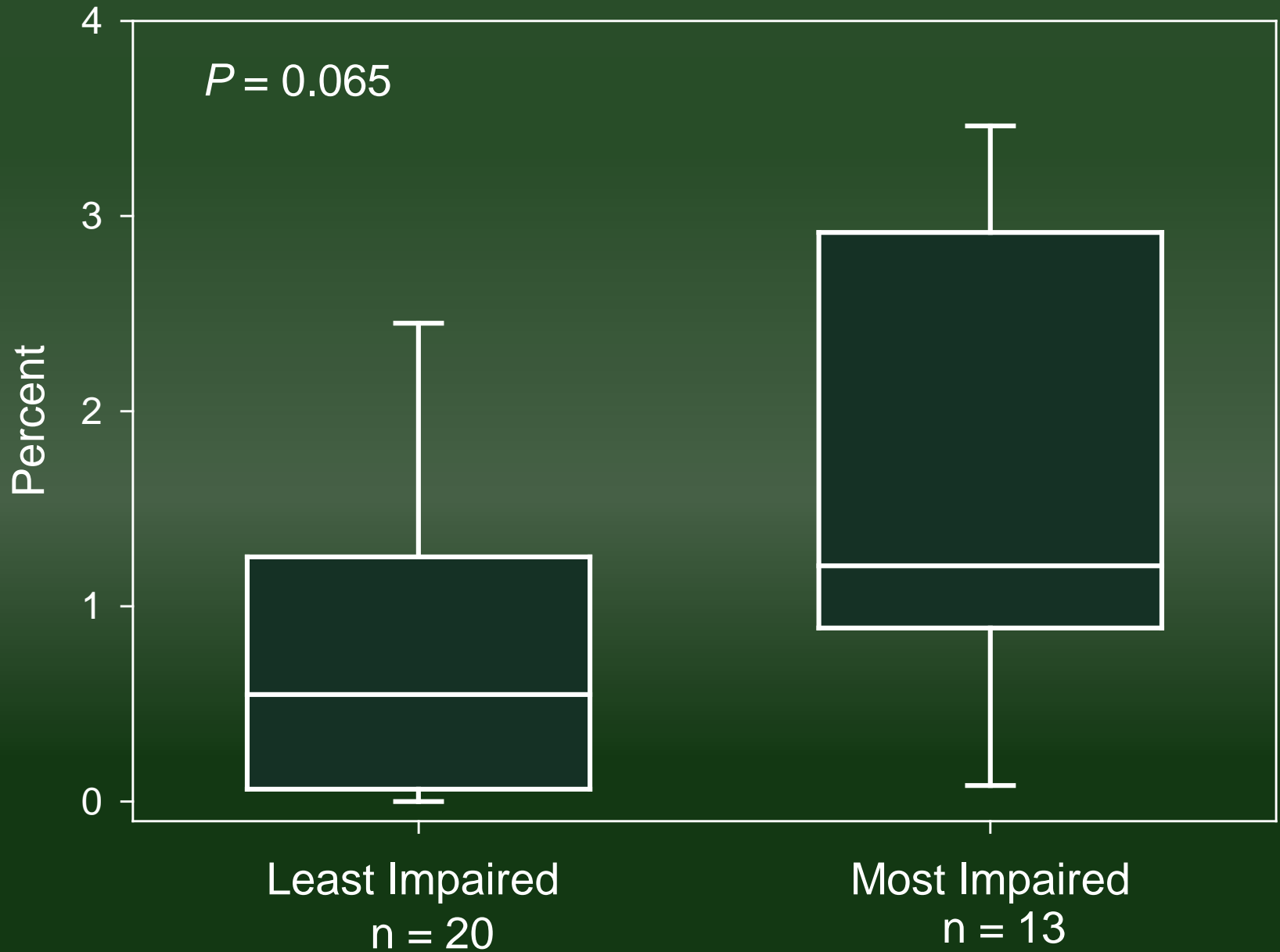


% DELT Anomalies

➤ Based solely on BFBM data



Percent DELT Anomalies



Metric Redundancy

Metrics	Native	Intol	%Tol	%Insec	%Pisc	Abun
Benthic Sp.	0.59	0.68	-0.42	0.32	0.14	0.37
Native Sp.	-	0.46	-0.27	0.17	0.11	0.44
Intolerants	-	-	-0.22	0.28	0.18	0.15
%Tolerants	-	-	-	-0.66	-0.40	-0.51
%Insectivores	-	-	-	-	0.17	0.39
%Piscivore	-	-	-	-	-	0.04

Validation

*Mann-Whitney Results for Jackknife generated Pairwise Comparisons (n-1)
(Least Impaired vs Most Impaired)*

Metric	No. Significant Cases n = 45	Significance	Range for Non-significant cases
Native Sp.	All 45	$P < 0.001$	N/A
Benthic Sp.	All 45	$P < 0.001$	N/A
Intolerant Sp.	All 45	$P < 0.001$	N/A
% Tolerants	All 45	$P = 0.001$	N/A
% Insectivores	All 45	$P < 0.001$	N/A
% Piscivores	All 45	$P < 0.05$	N/A
Abundance	All 45	$P < 0.05$	N/A
DELTs	7 of 33	$P < 0.05$	$P = 0.053$ to 0.114

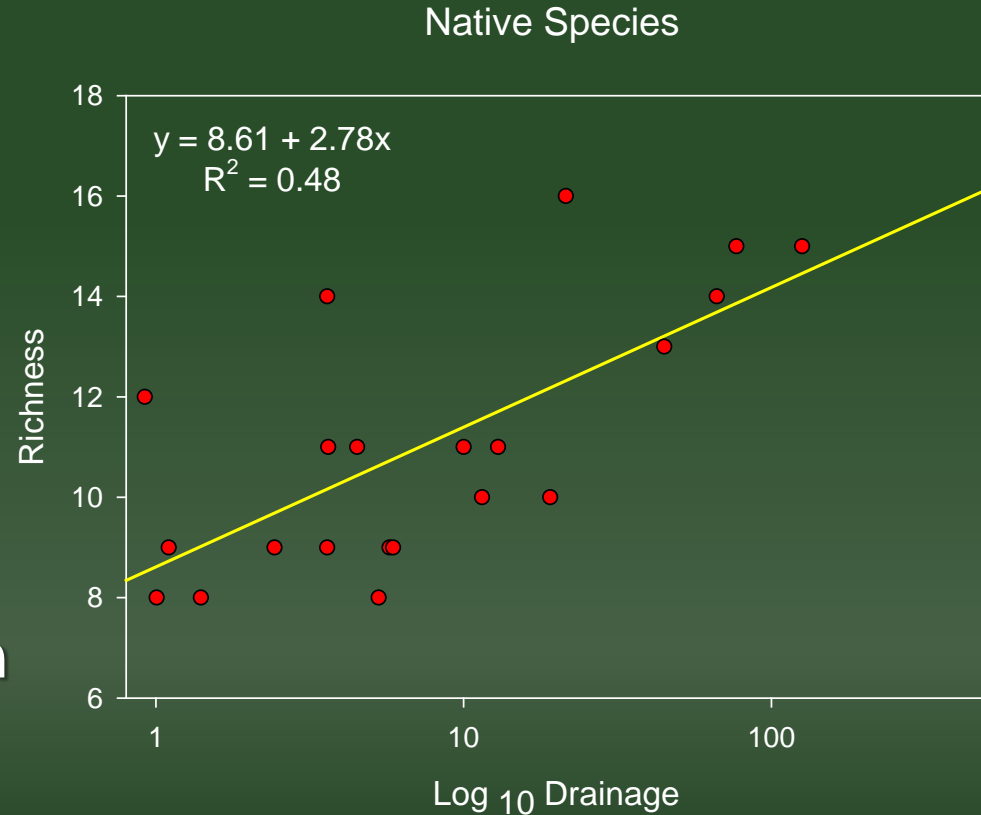
Validation

*Mann-Whitney Results for Bootstrap generated Pairwise Comparisons (n-10)
(Least Impaired vs Most Impaired)*

Metric	No. Significant Cases	Significance	Range for Non-significant cases
Native Sp.	All 45	$P = 0.001$	N/A
Benthic Sp.	All 45	$P < 0.05$	N/A
Intolerant Sp.	All 45	$P = 0.001$	N/A
% Tolerants	All 45	$P < 0.05$	N/A
% Insectivores	All 45	$P < 0.05$	N/A
% Piscivores	All 45	$P < 0.05$	N/A
Abundance	All 45	$P < 0.05$	N/A
DELTs (n-5)	10 of 33	$P < 0.05$	$P = 0.060$ to 0.847

Metric Scoring

- Metrics adjustments determined by Pearson correlations ($p < 0.05$) and by exhibiting strong linear relationship with drainage area ($R^2 > 0.25$)
- Metrics exhibiting a strong relationship with drainage area were adjusted using the following equation:



Adjusted value = mean reference + observed – predicted (Tetra Tech, Inc.)

*Where predicted value = $m * \log_{10}(\text{drainage area in } m^2) + b$*

Metric Scoring Criteria

Richness & Composition

Number of Native Species $11.05 + x - [\text{Log}_{10}(\text{Drainage Area} * 2.7828) + 8.6142]$

Number of Benthic Species $2.29 + x - [\text{Log}_{10}(\text{Drainage Area} * 0.6293) + 1.7354]$

Number of Intolerant Species $1.38 + x - [\text{Log}_{10}(\text{Drainage Area} * 0.7737) + 0.7043]$

Metric	Coefficient of Variability	Discrimination Efficiency	Response	Scoring
Native Richness	16.6	87.5%	↑	$100 * X / 15$
Benthic Richness	19.8	83.3%	↑	$100 * X / 3$
Intolerant Richness	44.3	91.7%	↑	$100 * X / 2$
% Tolerants	24.4	70.8%	↓	$100 * (93.5 - X) / 93.5$
% Insectivores	35.0	83.3%	↑	$100 * X / 61.2$
% Piscivores	126.9	70.8%	↑	$100 * X / 31.8$
Abundance	39.4	75.0%	↑	$100 * X / 299$
DELTs	32.3	46.2%	↓	$100 * (3.4 - X) / 3.4$

Index Discrimination

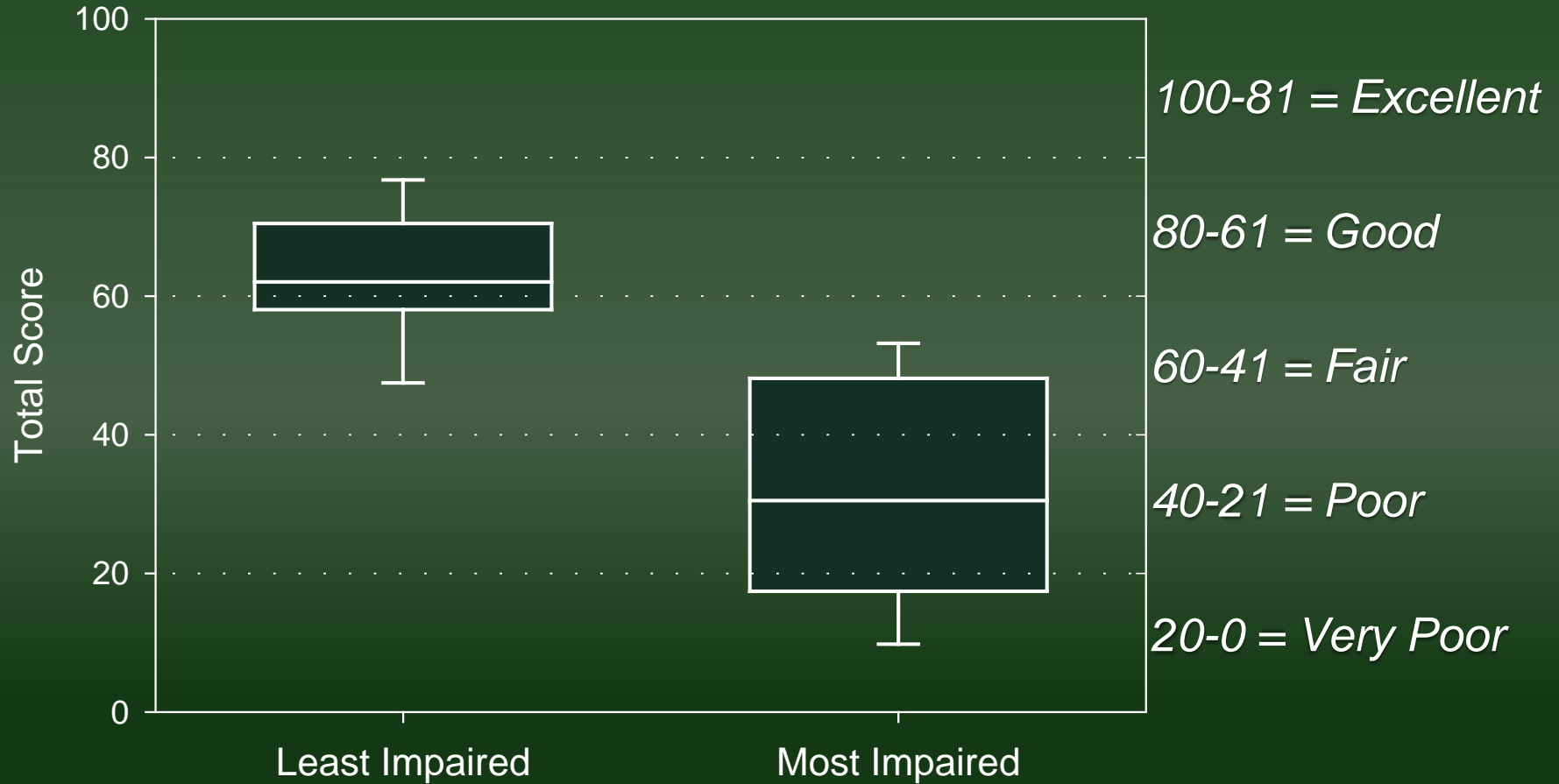
Reference Percentile	5th	10th	15th	20th	25th	50 th (Median)
Reference Value (n = 21)	45.4	48.9	51.6	56.0	58.3	62.1
% Impaired Sites Below (n = 24)	70.8%	79.2%	83.3%	95.8%	95.8%	100%

NJ Pinelands Macroinvertebrate Index (2005)

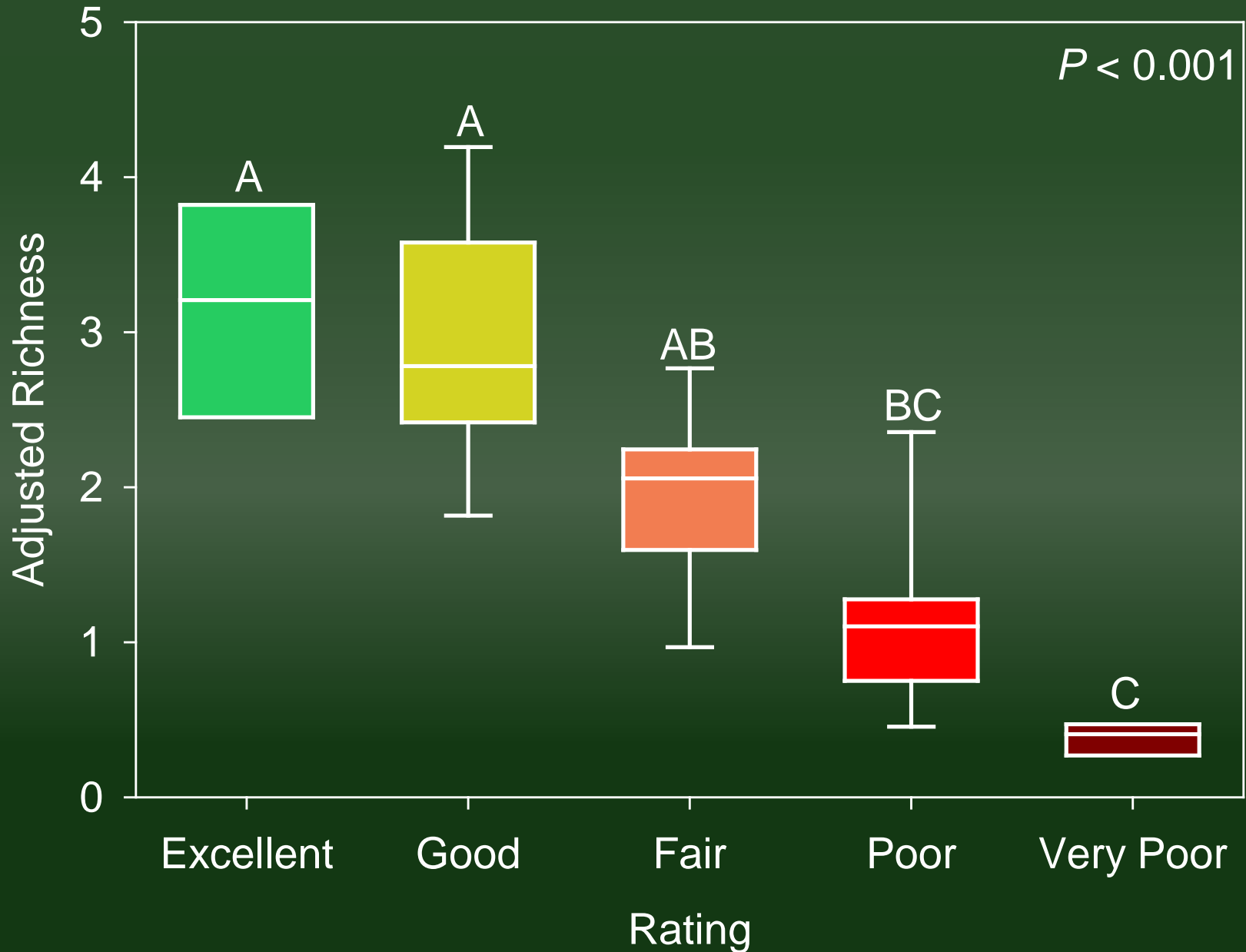
Reference Value	48.3	54.8	60.1	60.4	60.5	66.7
% Impaired Sites Below	44.4%	77.8%	88.9%	88.9%	88.9%	94.4%

Rating Categories

5 Categories



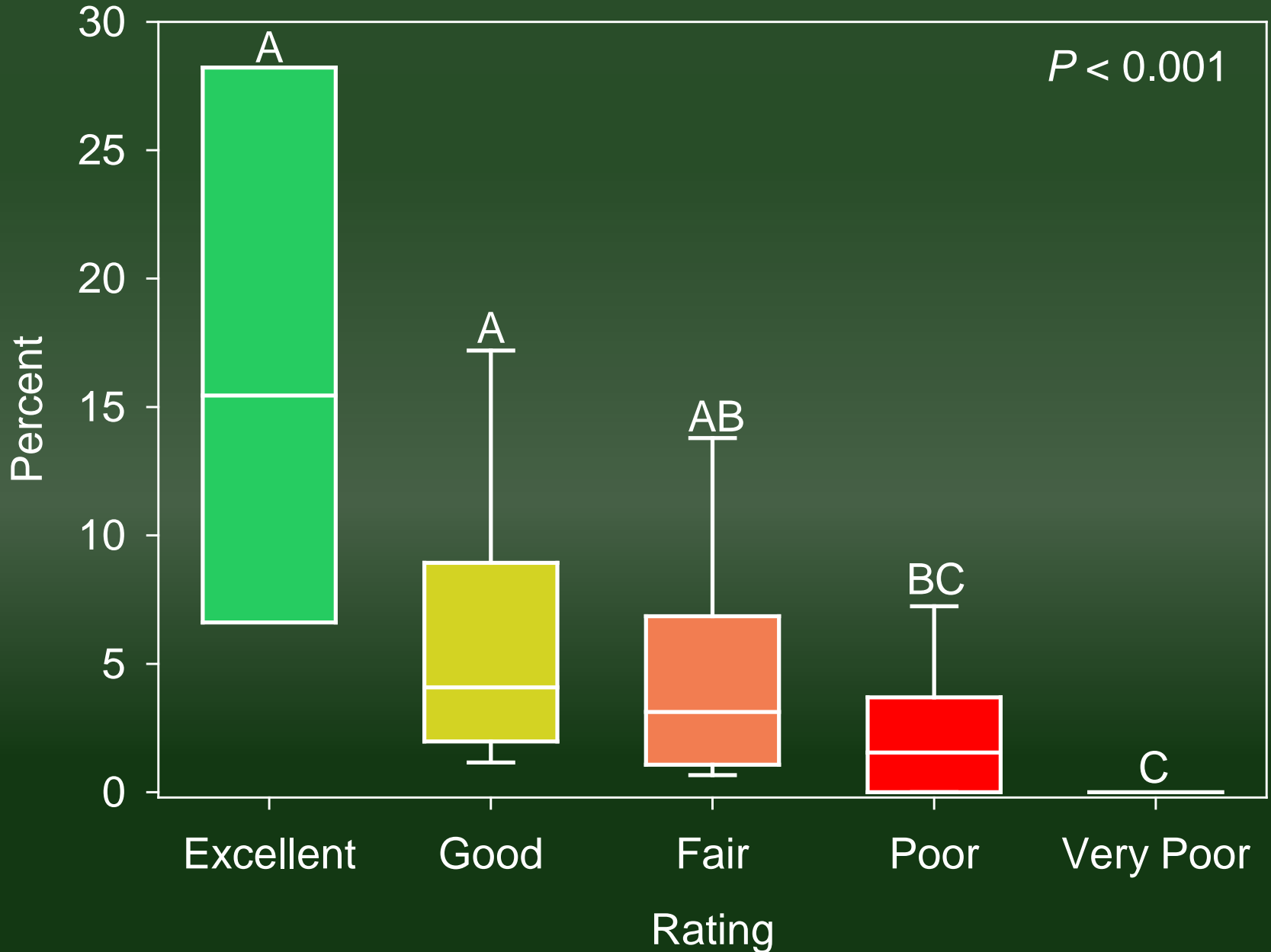
Benthic Species Richness



Percent Tolerant Individuals



Percent Piscivores



Case Study

FIBI213 Ivanhoe Brook

- 66% Forest/Wetland
- 13% Urban
- 3.5% Impervious Cover
- 3.6 Miles² Drainage
- Habitat score = 134
- IBI score = 77 Good

Results

- 14 Native Species
- 4 Benthic Species
- 2 Intolerant Species
- 20% Tolerant Species
- 51% Insectivore Species
- 4% Top Predator Species
- 132 Fish
- 0% External Deformities



Case Study

FIBI201 NB Pennsauken Creek

- 31% Forest/Wetland
- 60% Urban
- 19% Impervious Cover
- 4.0 Miles² Drainage
- Habitat score = 98
- IBI score = 36 Poor



Results

- 8 Native Species
- 1 Benthic Species
- 0 Intolerant Species
- 56% Tolerant Species
- 5% Insectivore Species
- 1.5% Top Predator Species
- 88 Fish
- 0% External Deformities



Southern IBI Network

- Regional sampling – 2013 N.IBI Network
- 26 S. IBI Fixed sites – every 5 years
- 15 S. IBI Probabilistic sites – 3 sites
- 2 S. IBI Sentinel sites – 1 site/year
- Atlantic drainage streams will be evaluated during Atlantic Coastal Plain Monitoring
- If S. IBI is applicable to Atlantic drainage streams, 9 additional fixed sites will be added in this region

**Any
Questions?**

