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.*

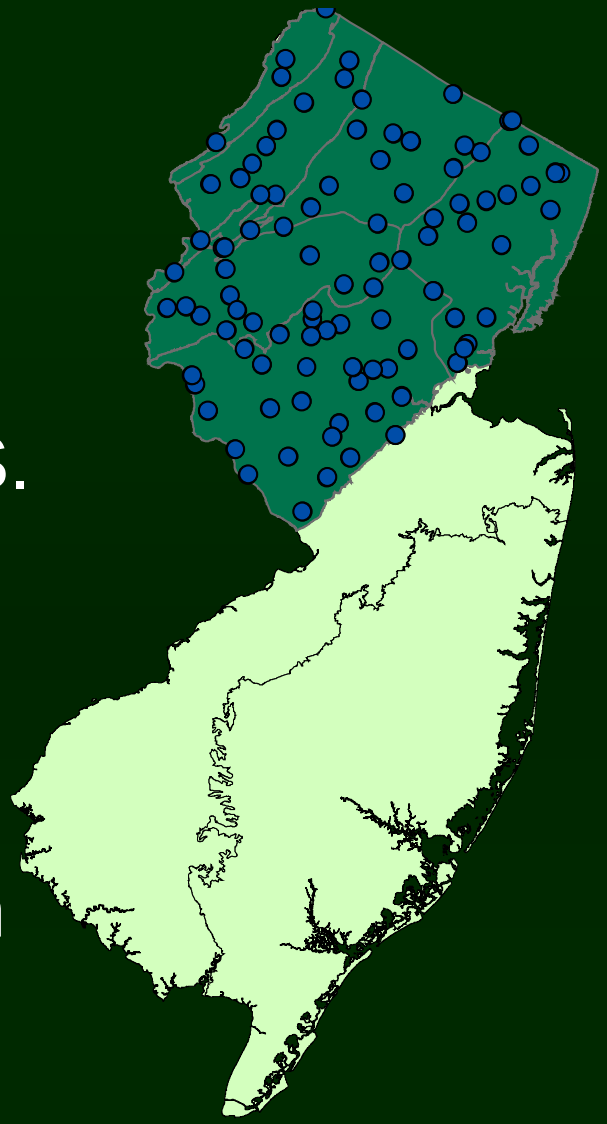
Criterion 3. *The measure must be sensitive to the environmental conditions being monitored.*

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.*

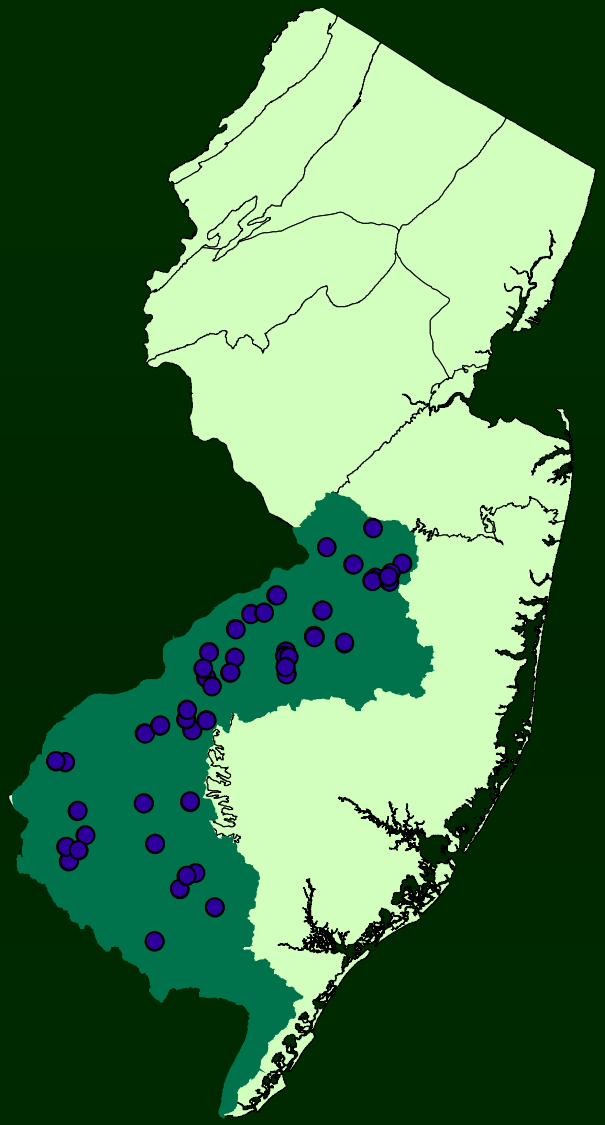
Northern Fish IBI



- 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

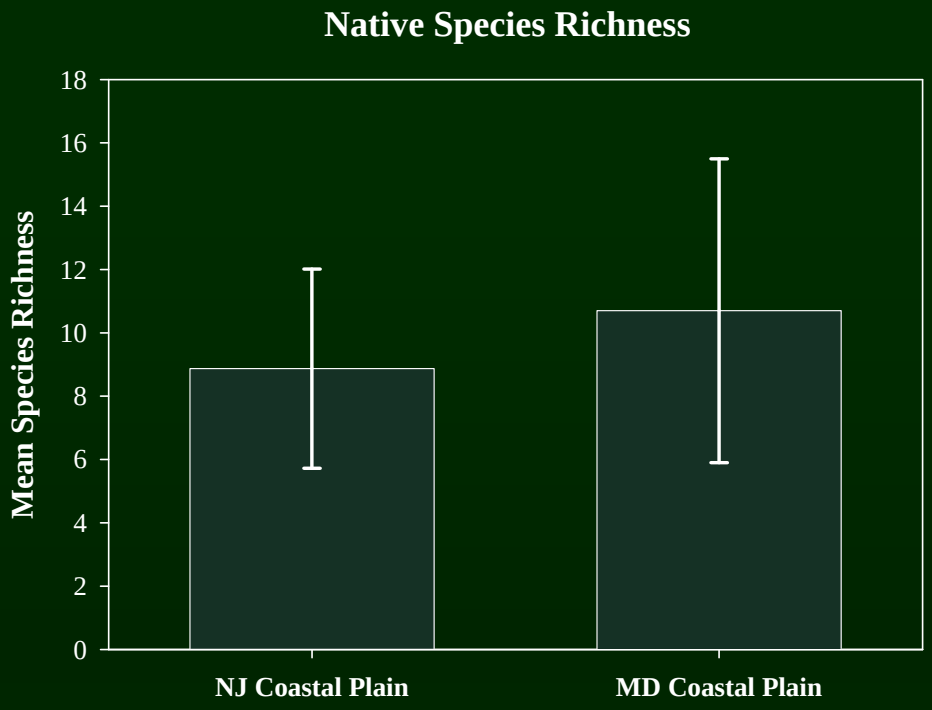
Southern IBI Development

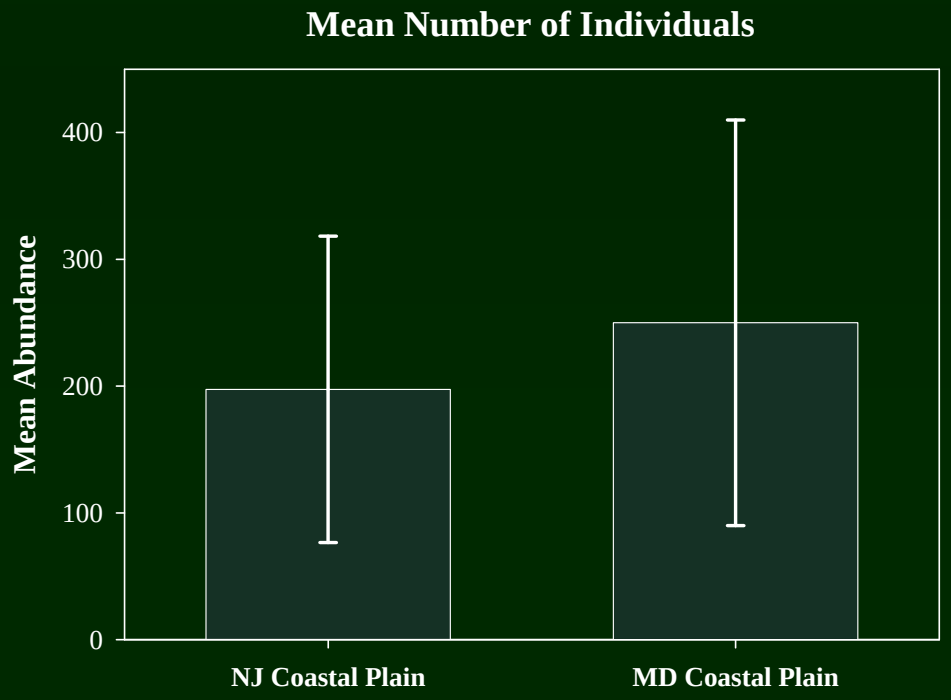
- Used Maryland, Virginia, North Carolina, South Carolina, and Georgia Programs as models for developing NJ Inner Coastal Plain Fish IBI
- All of these states have similar fish species to NJ
- Maryland has an established Coastal Plain Fish IBI and has completed recalibration
- Results present to MD DNR,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





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

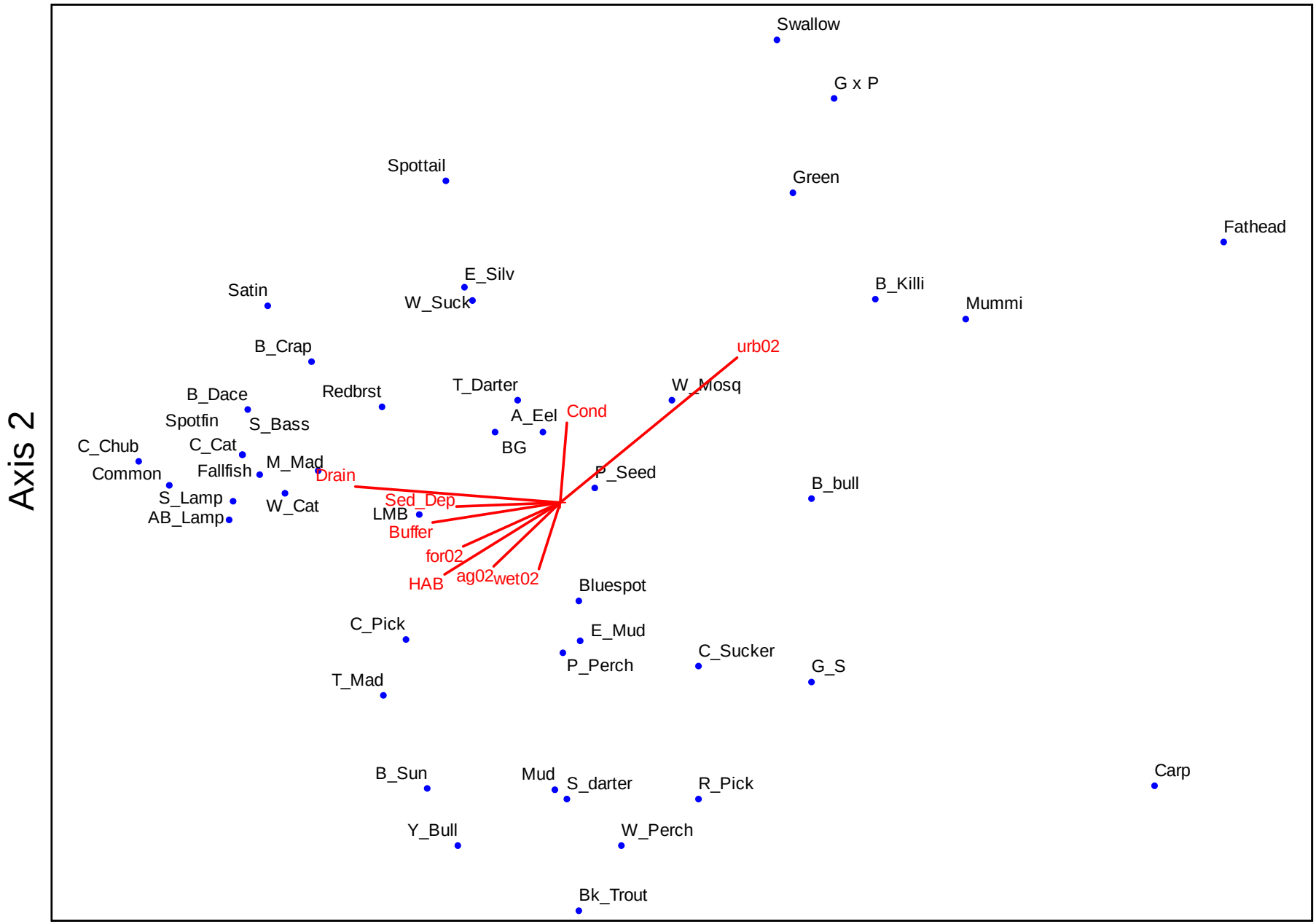
Condition	Least Impacted N=21	Most Impacted N=24
%Forest/Wetland	>50%	<35%
%Urban	<20%	>60%
%Impervious Cover	<5%	>19%
pH	>5.5	None
Instream Habitat	Optimal or Sub-optimal	None
Fish Abundance	>100	None
Fish Richness	>5	None

Results of Metric Testing

Mann-Whitney (M-W)
Kolmogorov-Smirnov (K-S)

	Reference n = 21 Impaired n = 24		Pearson Correlation n = 111	
Metric	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

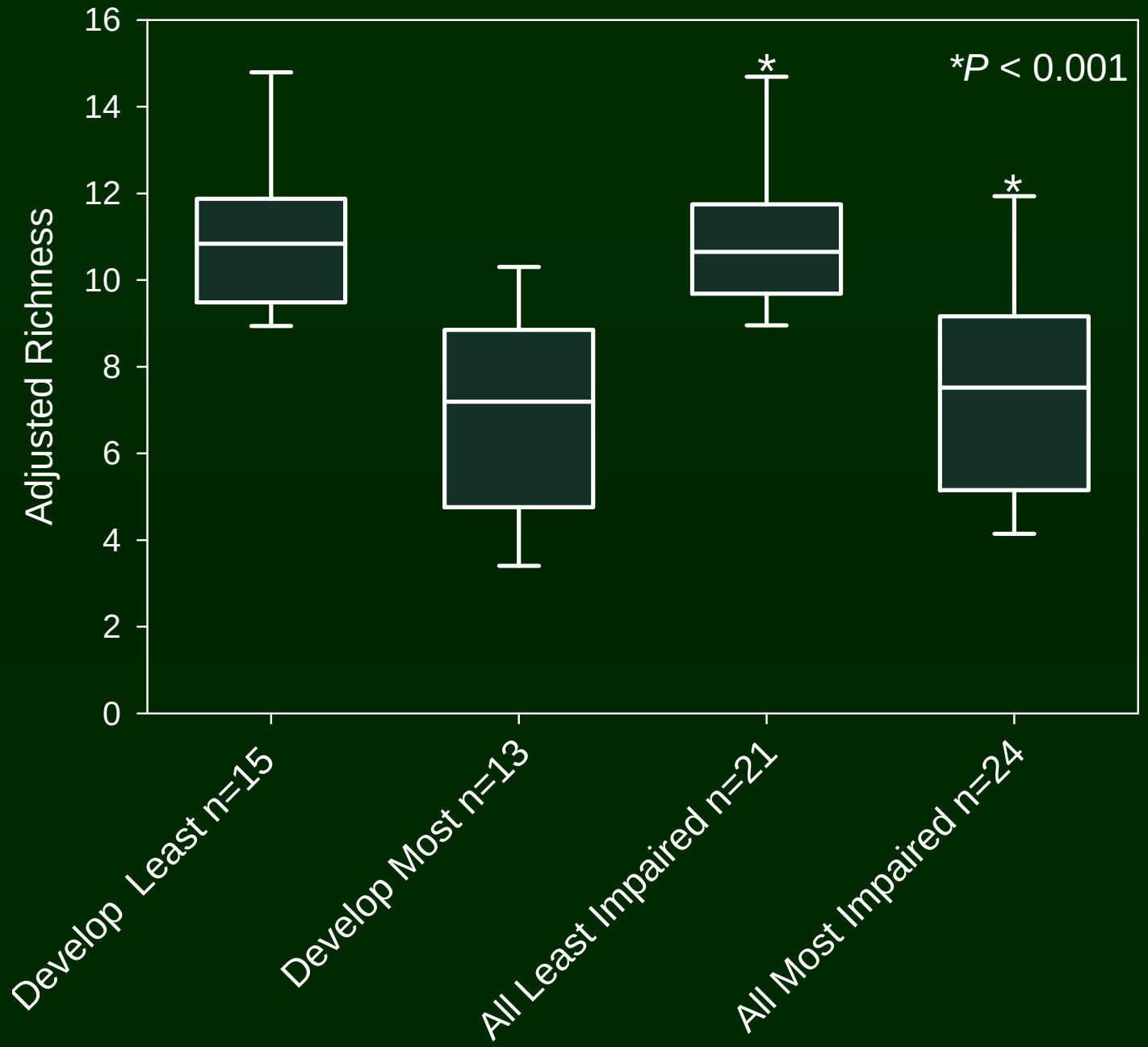

Swallow
G x P
Spottail
Green
Fathead
E_Silv
Satin
W_Suck
B_Killi
Mummi
B_Crap
urb02
T_Darter
W_Mosq
B_Dace
Redbrst
Cond
A_Eel
Spotfin
S_Bass
BG
C_Chub
C_Cat
M_Mad
Common
Fallfish
Drain
P_Seed
B_bull
S_Lamp
W_Cat
Sed_Dep
LMB
AB_Lamp
Buffer
for02
HAB
ag02
wet02
Bluespot
C_Pick
E_Mud
C_Sucker
P_Perch
G_S
T_Mad
B_Sun
Mud
S_darter
R_Pick
Carp
Y_Bull
W_Perch
Bk_Trout
Axis 2
Axis 1

Native Species Richness

- All species collected except the following:

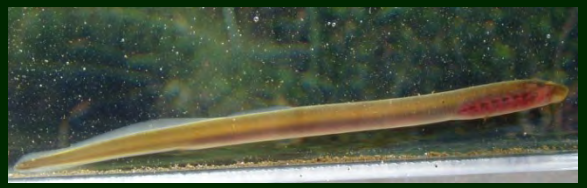
  Goldfish, Common Carp, Fathead Minnow, Channel Catfish, Western Mosquitofish, Warmouth, Rock Bass, Green Sunfish, Bluegill, Largemouth Bass, and Black Crappie

Native Species Richness

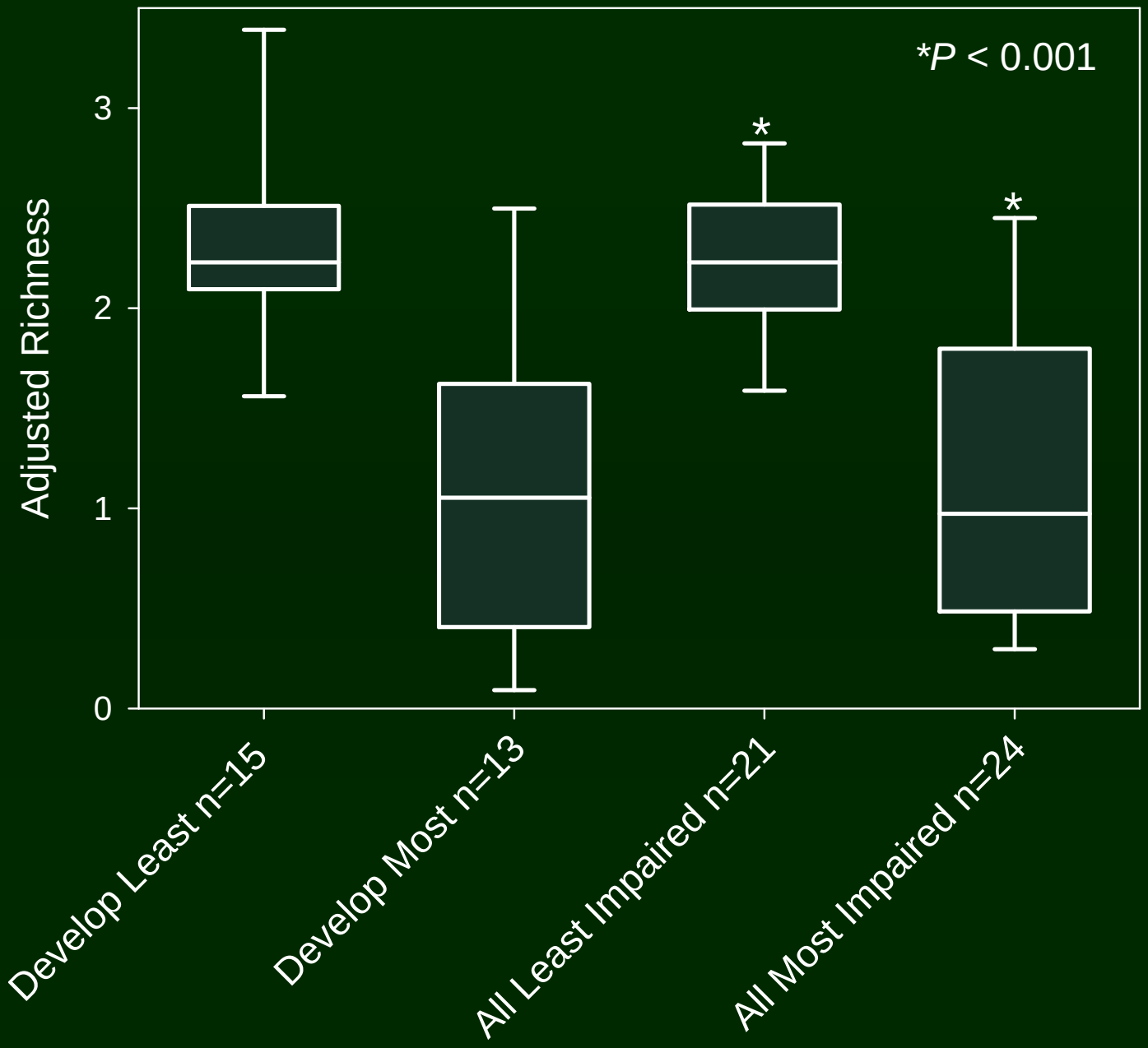


Benthic Species Richness

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

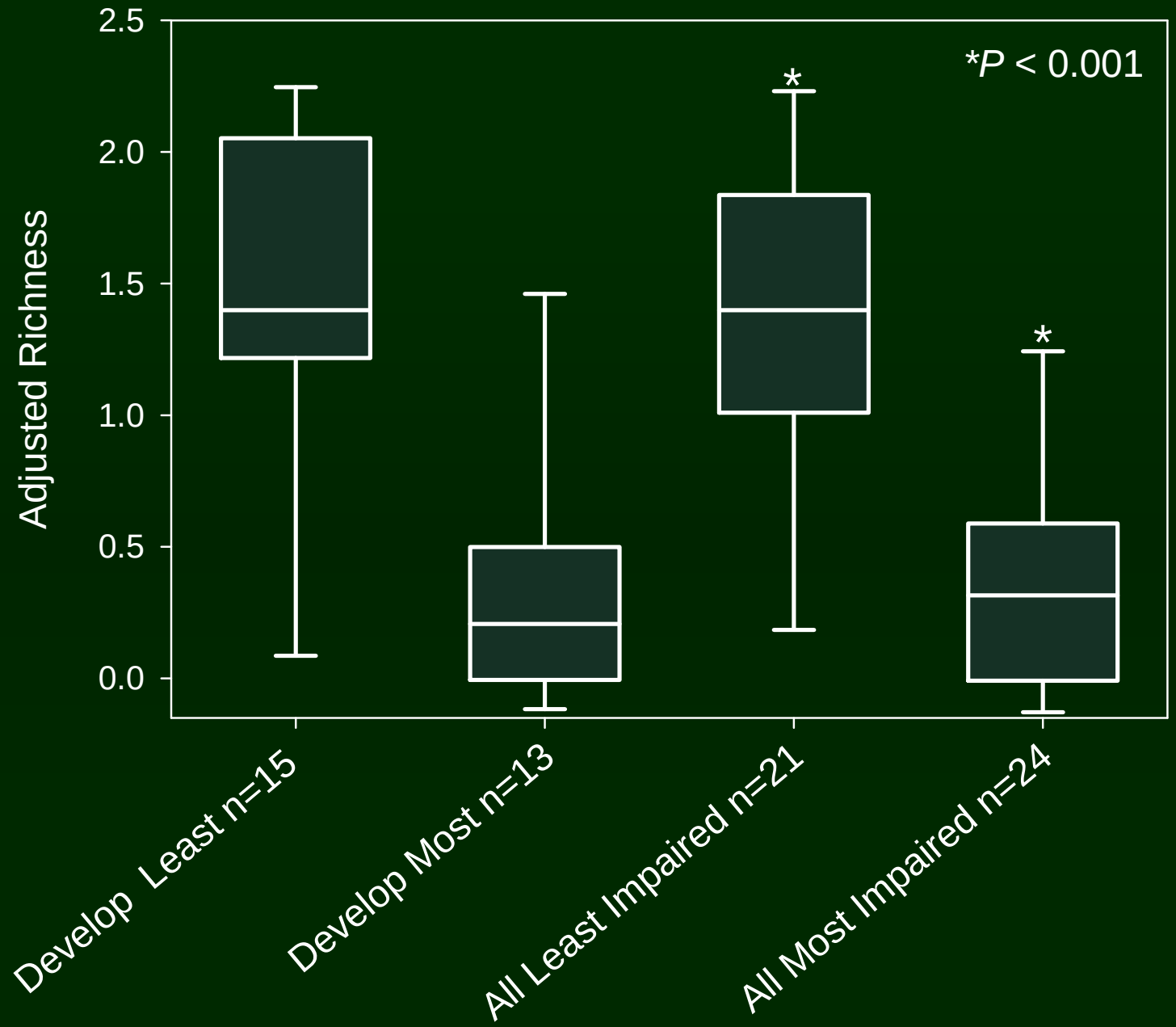

Benthic Species Richness



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

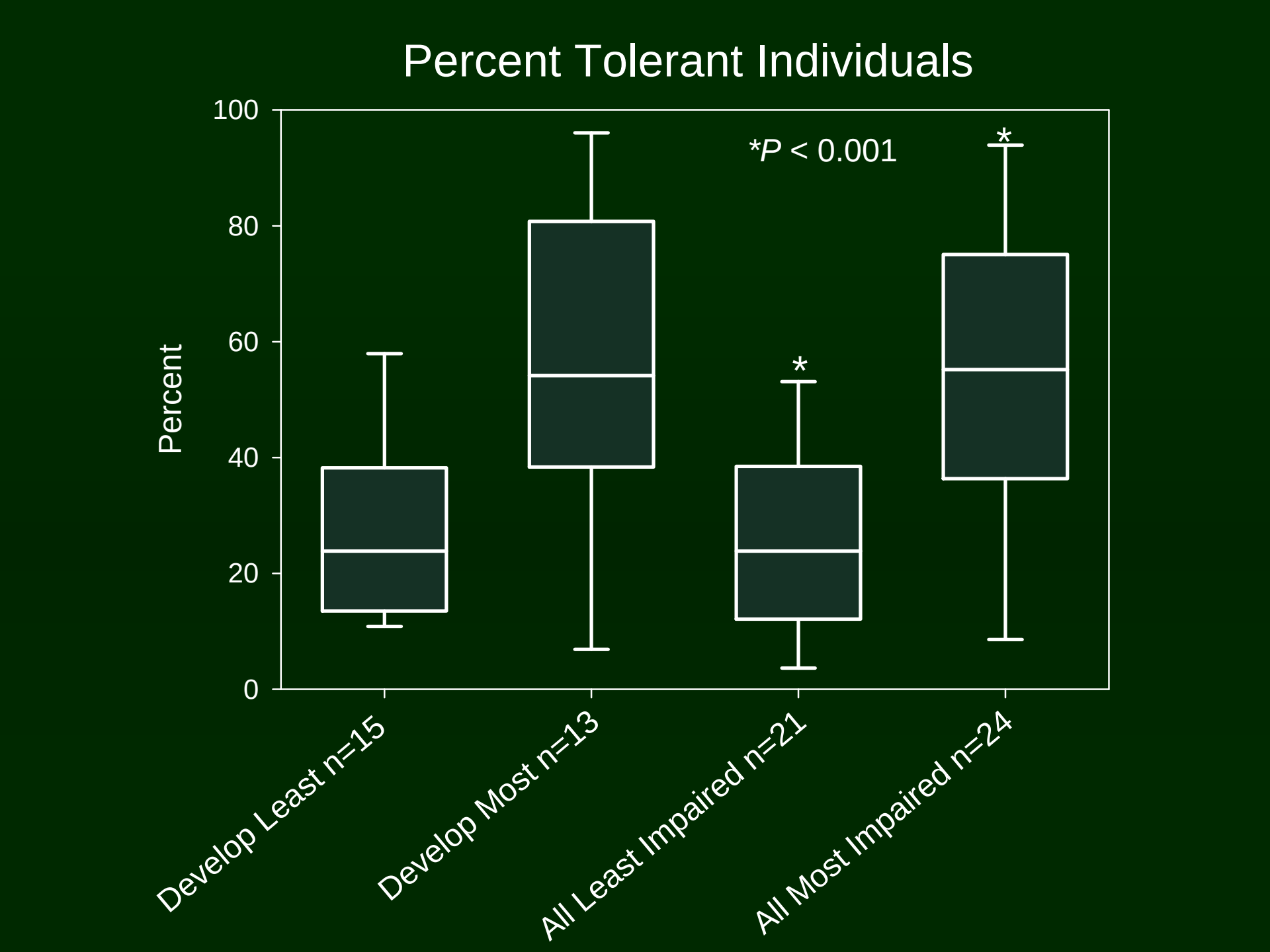


% Abundance of Tolerant Species

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



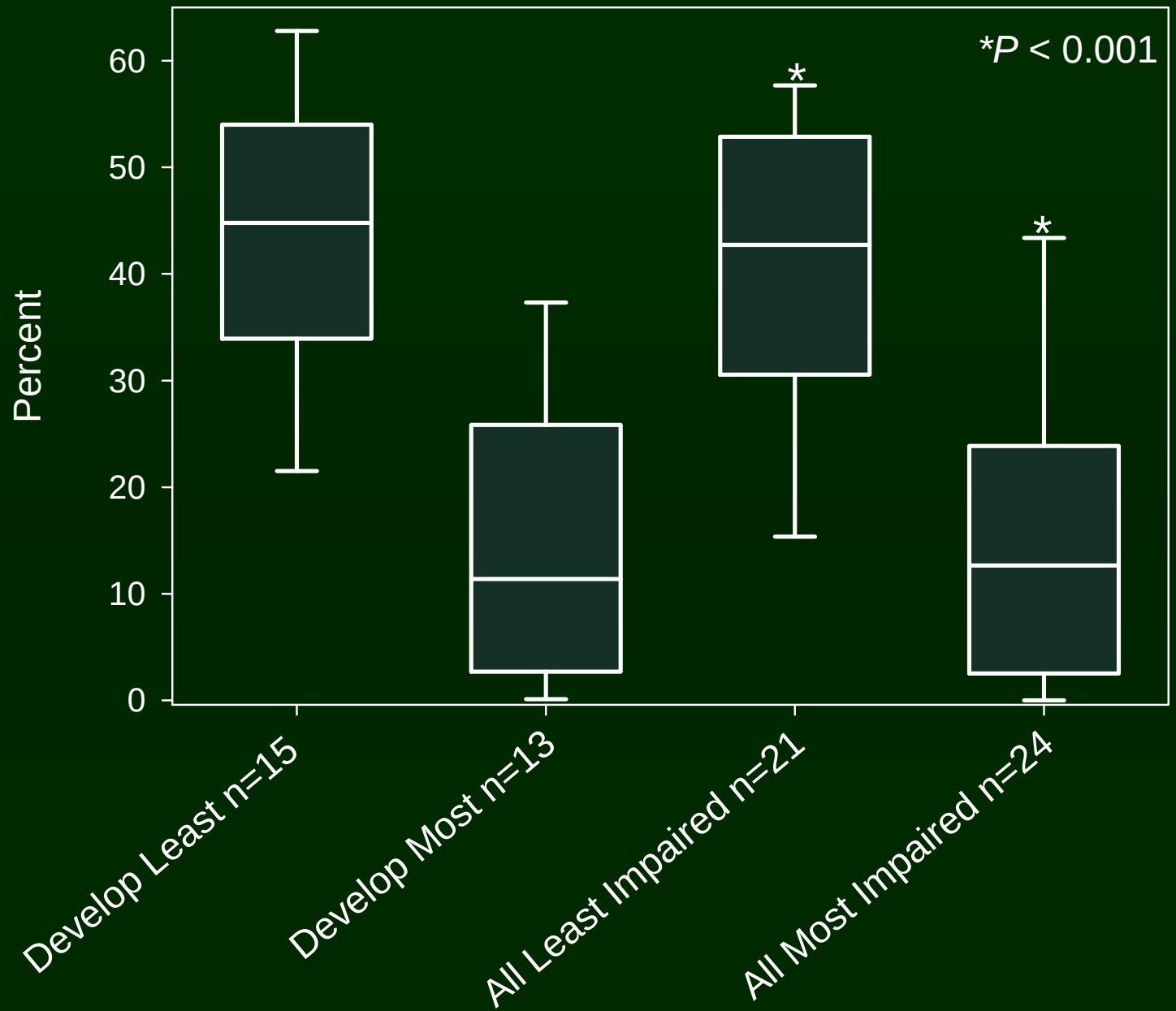



Percent Tolerant Individuals
*P < 0.001
Percent
100
80
60
40
20
0
*
*
Develop Least n=15
Develop Most n=13
All Least Impaired n=21
All Most Impaired n=24

% Insectivorous Species

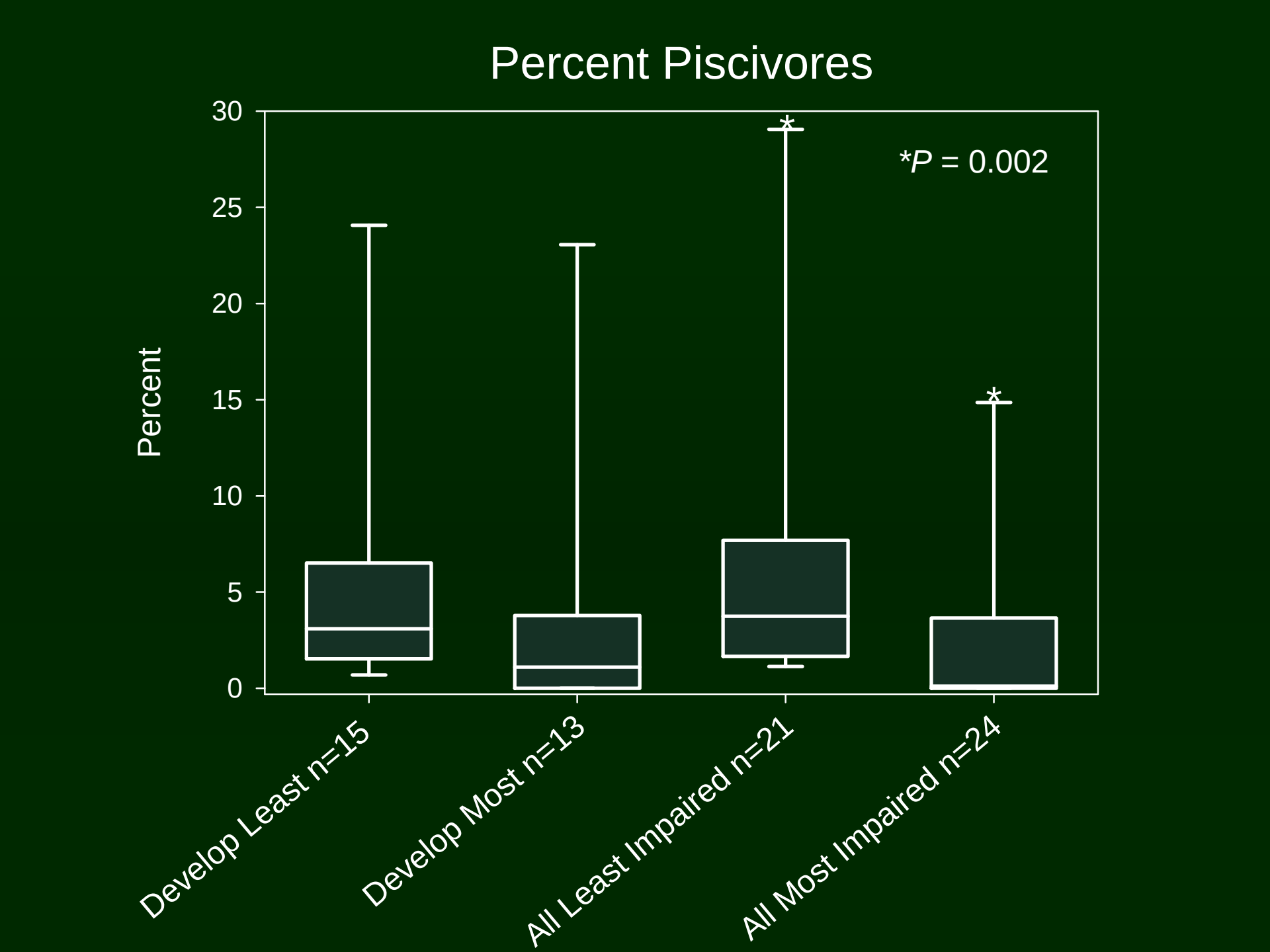
- Includes the following species: Redbreast Sunfish, Pumpkinseed, Warmouth, Mud Sunfish, Blackbanded Sunfish, Bluespotted Sunfish, Banded Sunfish, Pirate Perch, Comely Shiner, Satinfin Shiner, Ironcolor Shiner, Swallowtail Shiner, Spotfin Shiner, American Shad, Eastern Mudminnow, Blacknose Dace, Fallfish,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

Percent Insectivores

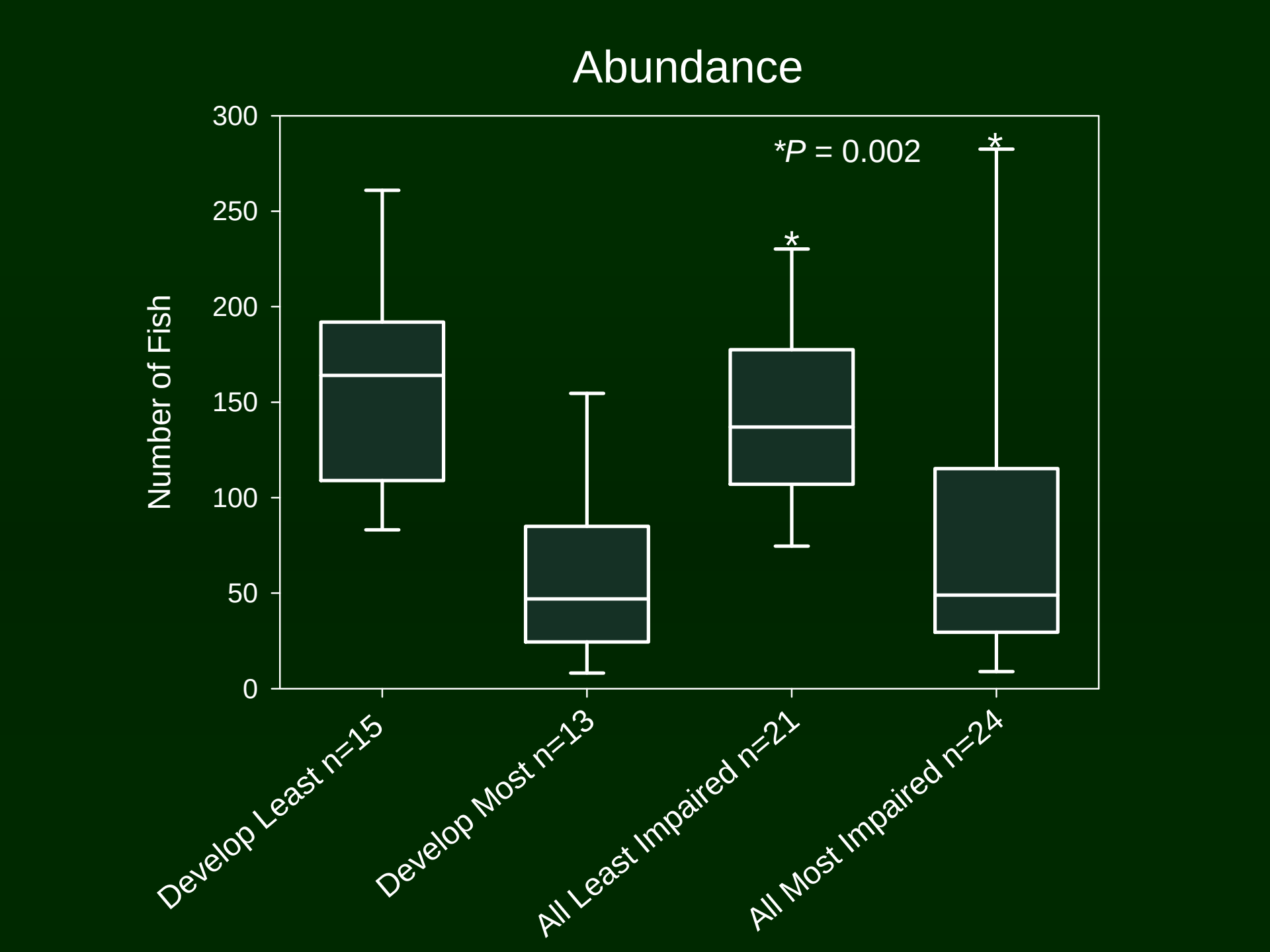


% Piscivorous Species

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

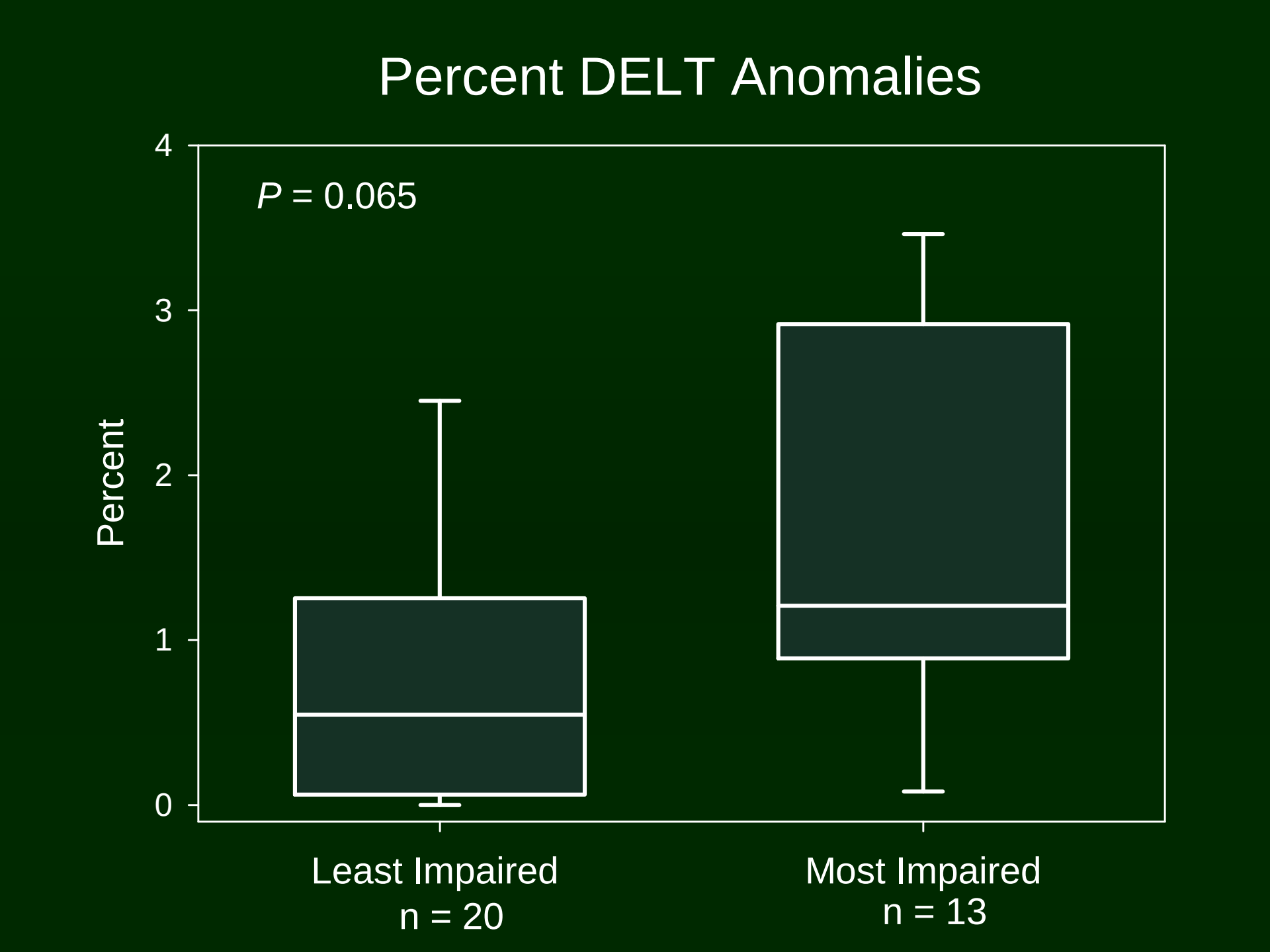

Percent Piscivores
*P = 0.002
Percent
30
25
20
15
10
5
0
Develop Least n=15
Develop Most n=13
All Least Impaired n=21
All Most Impaired n=24

Fish Abundance minus Tolerant Species


Abundance
*P = 0.002
Number of Fish
300
250
200
150
100
50
0
Develop Least n=15
Develop Most n=13
All Least Impaired n=21
All Most Impaired n=24

% DELT Anomalies

- Based solely on BFBM data


Percent DELT Anomalies
P = 0.065
Percent
4
3
2
1
0
Least Impaired
n = 20
Most Impaired
n = 13

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

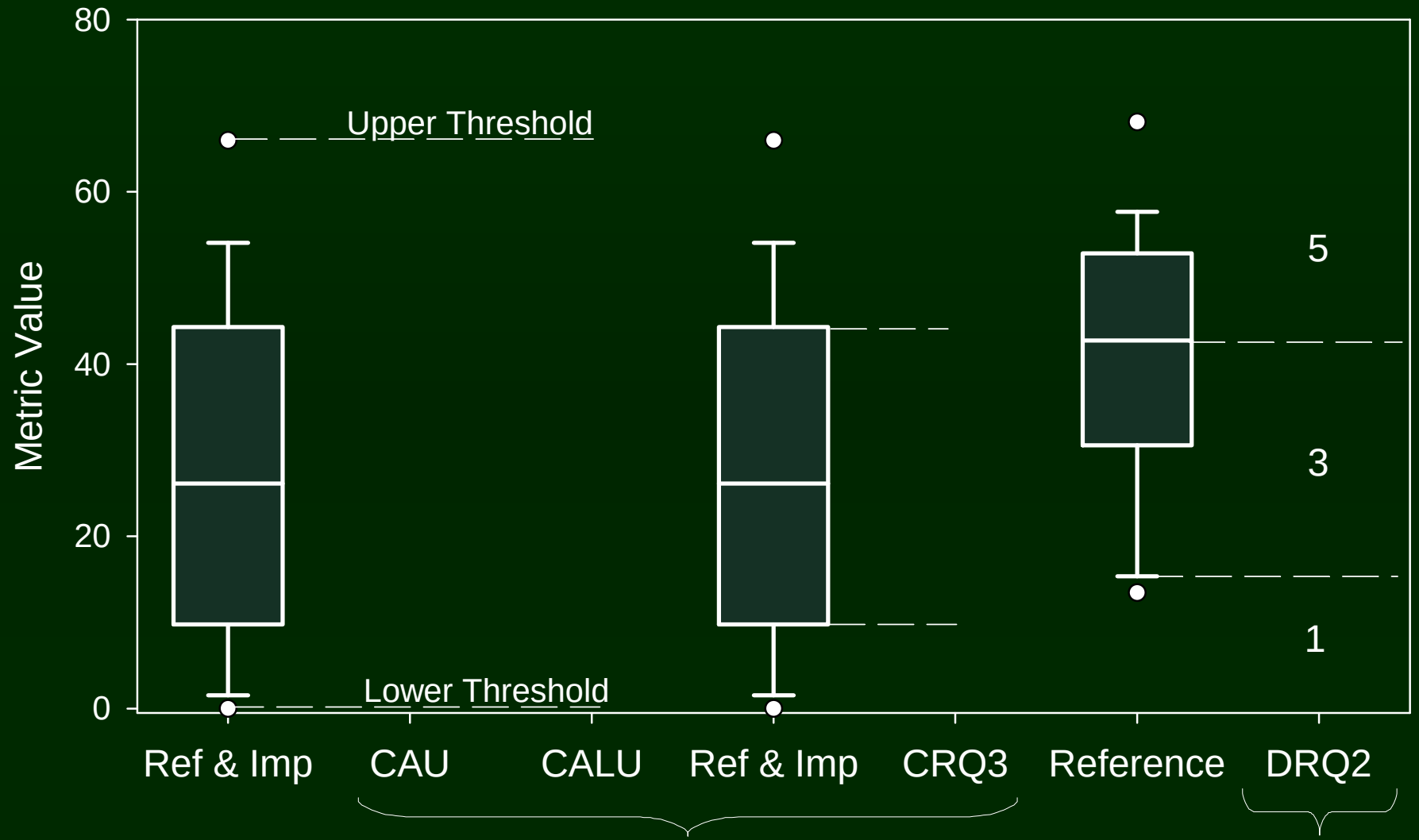
Validation

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

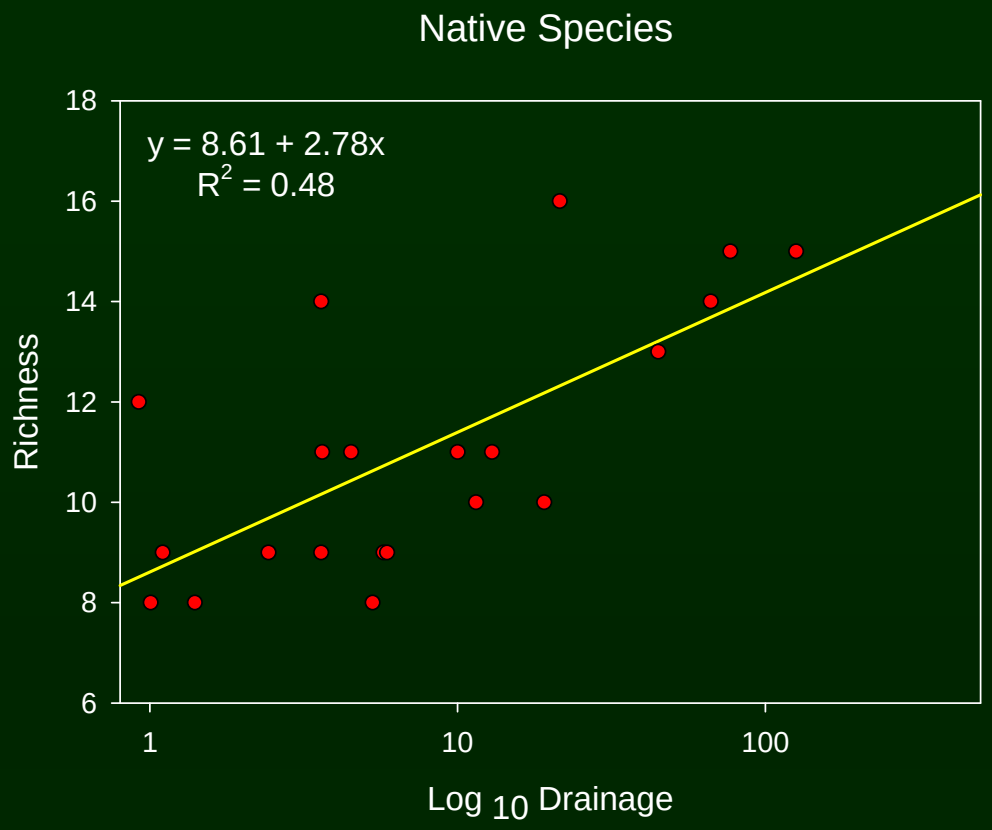
Continuous Scoring = 0 – 100
Discrete Scoring = 1 – 3 – 5



*Blocksom 2003

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} (drainage area in mi^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

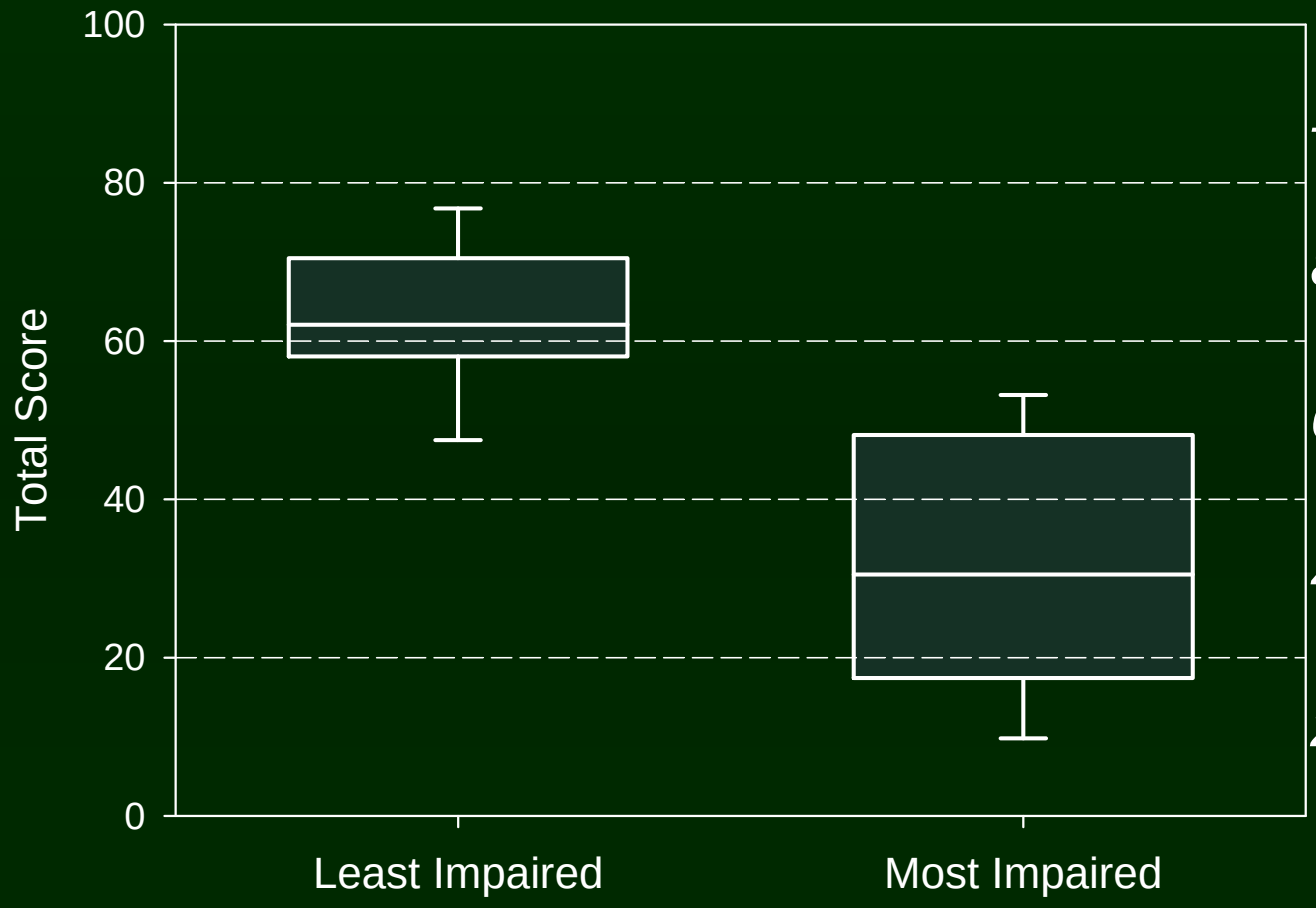
Index Discrimination

Reference Percentile	5th	10th	15th	20th	25th	50th (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

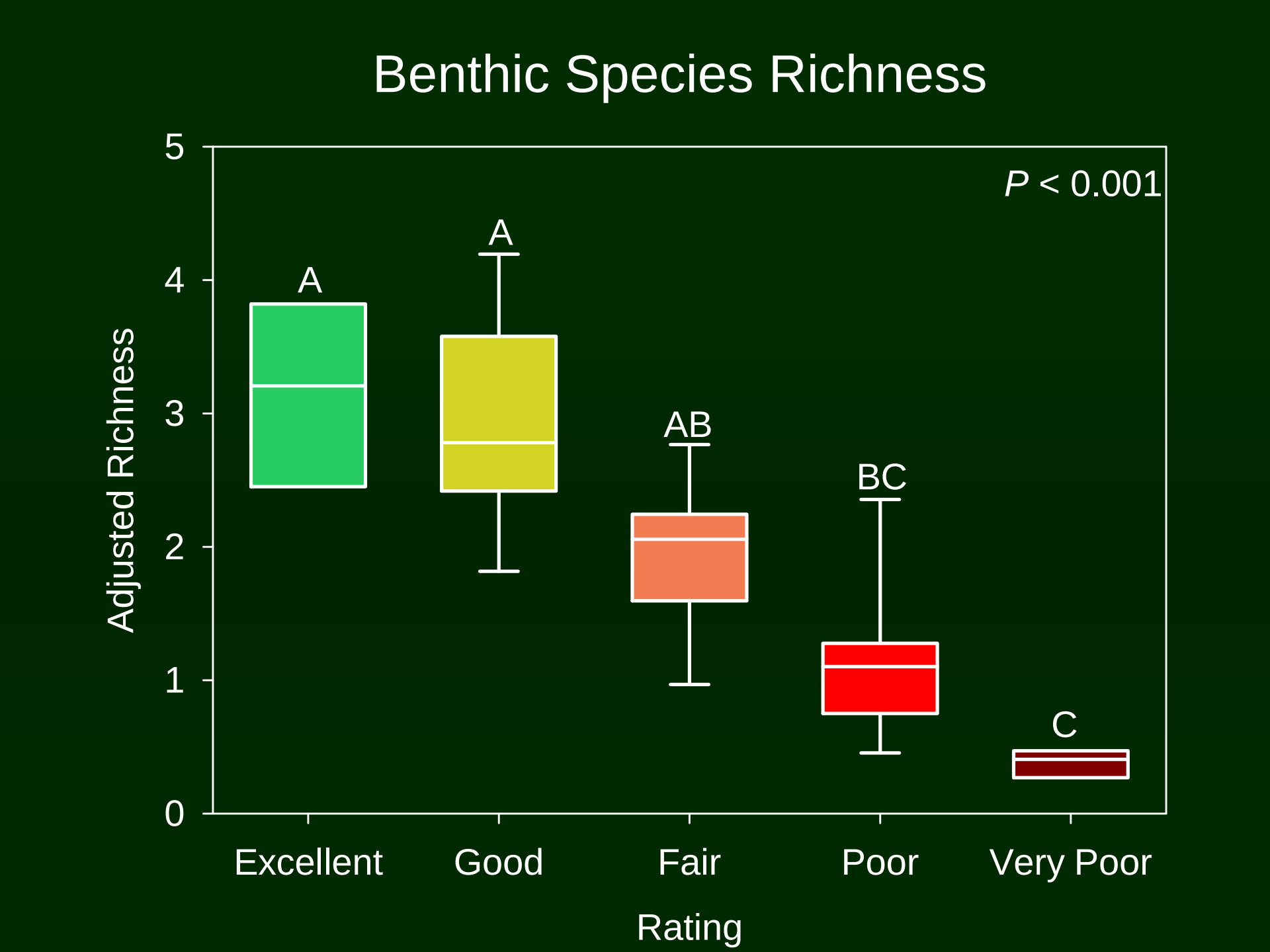
100-81 = Excellent

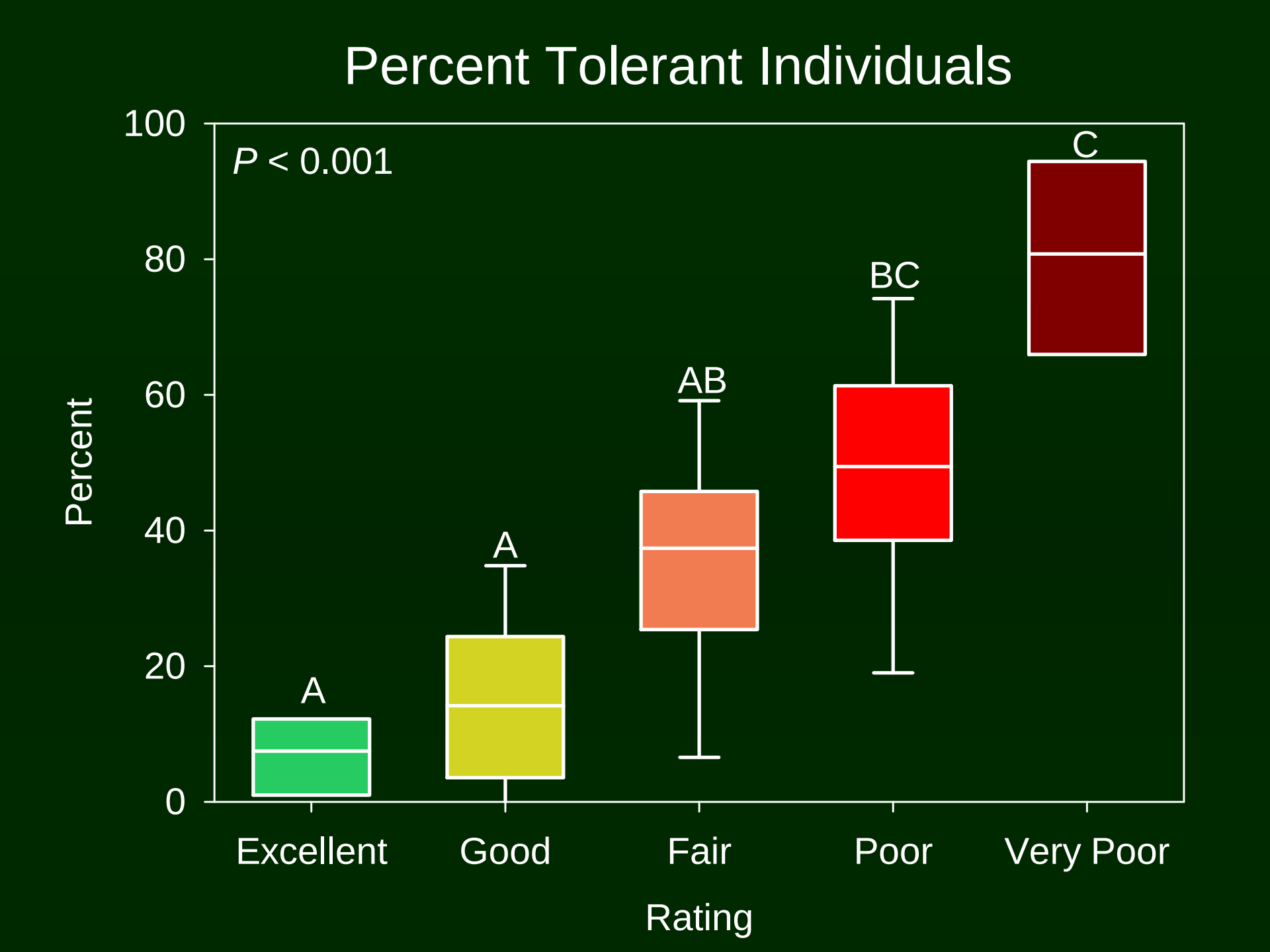
80-61 = Good

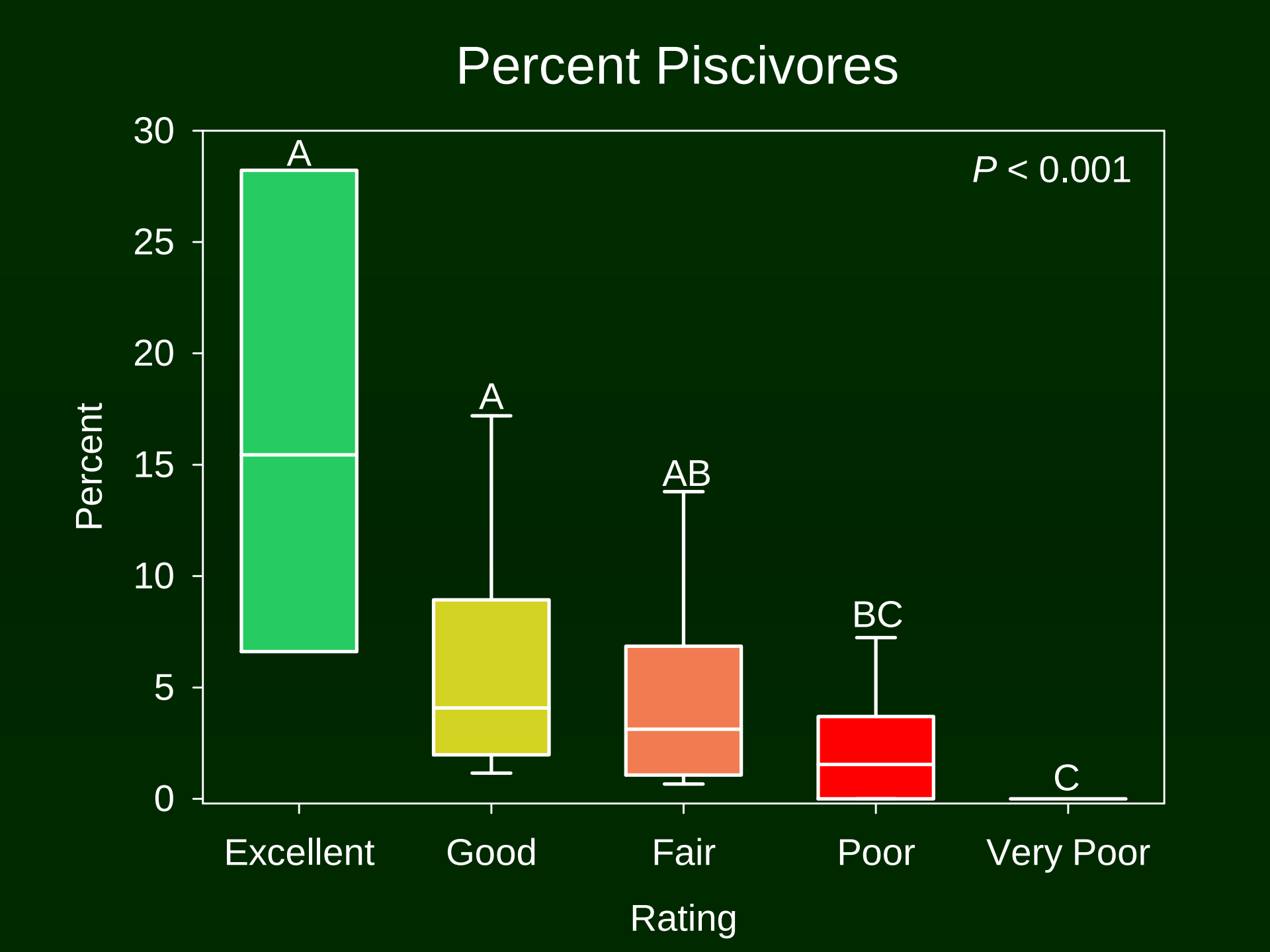
60-41 = Fair

40-21 = Poor

20-0 = Very Poor


Benthic Species Richness
P < 0.001
Adjusted Richness
5
4
3
2
1
0
A
A
AB
BC
C
Excellent
Good
Fair
Poor
Very Poor
Rating


Percent Tolerant Individuals
P < 0.001
100
80
60
40
20
0
Percent
A
A
AB
BC
C
Excellent
Good
Fair
Poor
Very Poor
Rating


Percent Piscivores
30
25
20
15
10
5
0
Percent
A
A
AB
BC
C
P < 0.001
Excellent
Good
Fair
Poor
Very Poor
Rating

Case Study

FIBI213 Ivanhoe Brook

- 66% Forest/Wetland
- 13% Urban
- 3.5% Impervious Cover
- 3.6 Miles^2 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 Miles^2 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 Northeast
- 26 S. IBI Fixed sites – every 5 years
- 15 S. IBI Probabilistic sites – 3 sites/year
- 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?