



Index of Biotic Integrity

Presented to NJ Water Monitoring Coordinating
Council

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Funding



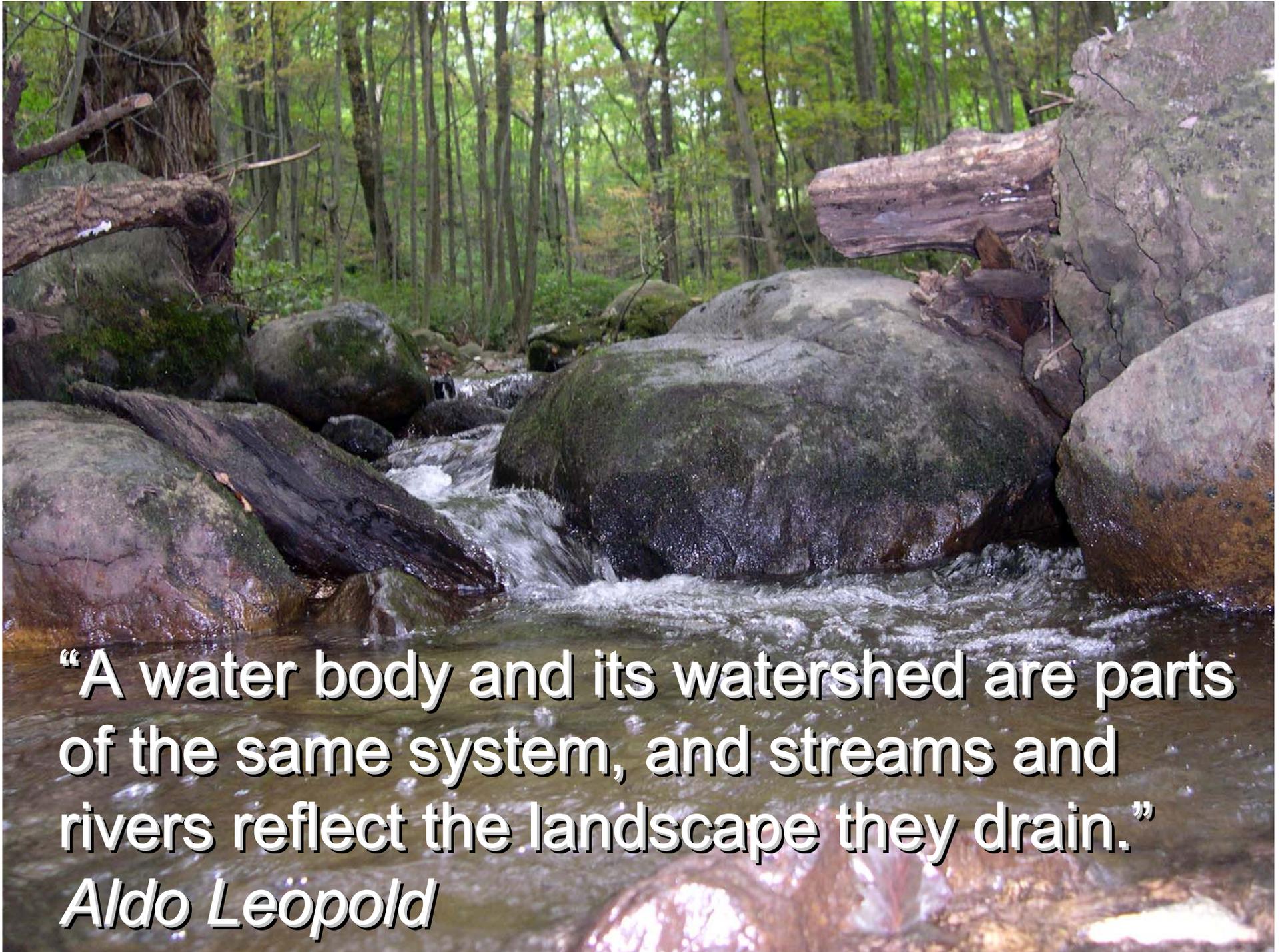
Corporate Business Tax Research Program
via the DEP's Division of Science, Research,
and Technology (2000, 2001, 2002, & 2004)



319 Program via the Division of Watershed
Management (2000)



Division of Fish and Wildlife (2003)



“A water body and its watershed are parts of the same system, and streams and rivers reflect the landscape they drain.”

Aldo Leopold

A photograph of a concrete-lined creek channel. The water is very clear and reflects the surrounding environment, including trees and buildings. The channel is flanked by concrete walls. In the background, there are trees and a building with a sign that says "ANTIQUE".

**“Crystal clear, distilled water
running down concrete channels
does not constitute quality
water resources.”**

James Karr

**North Branch of
Rancocas Creek
in Mt. Holly**



Goals

- Assist the Department's efforts towards a holistic biological assessment of the State's Aquatic Resources.
- Develop a Fish Index of Biotic Integrity for wadeable streams of the Lower Delaware River Drainage.

Classification based on the suitability for trout

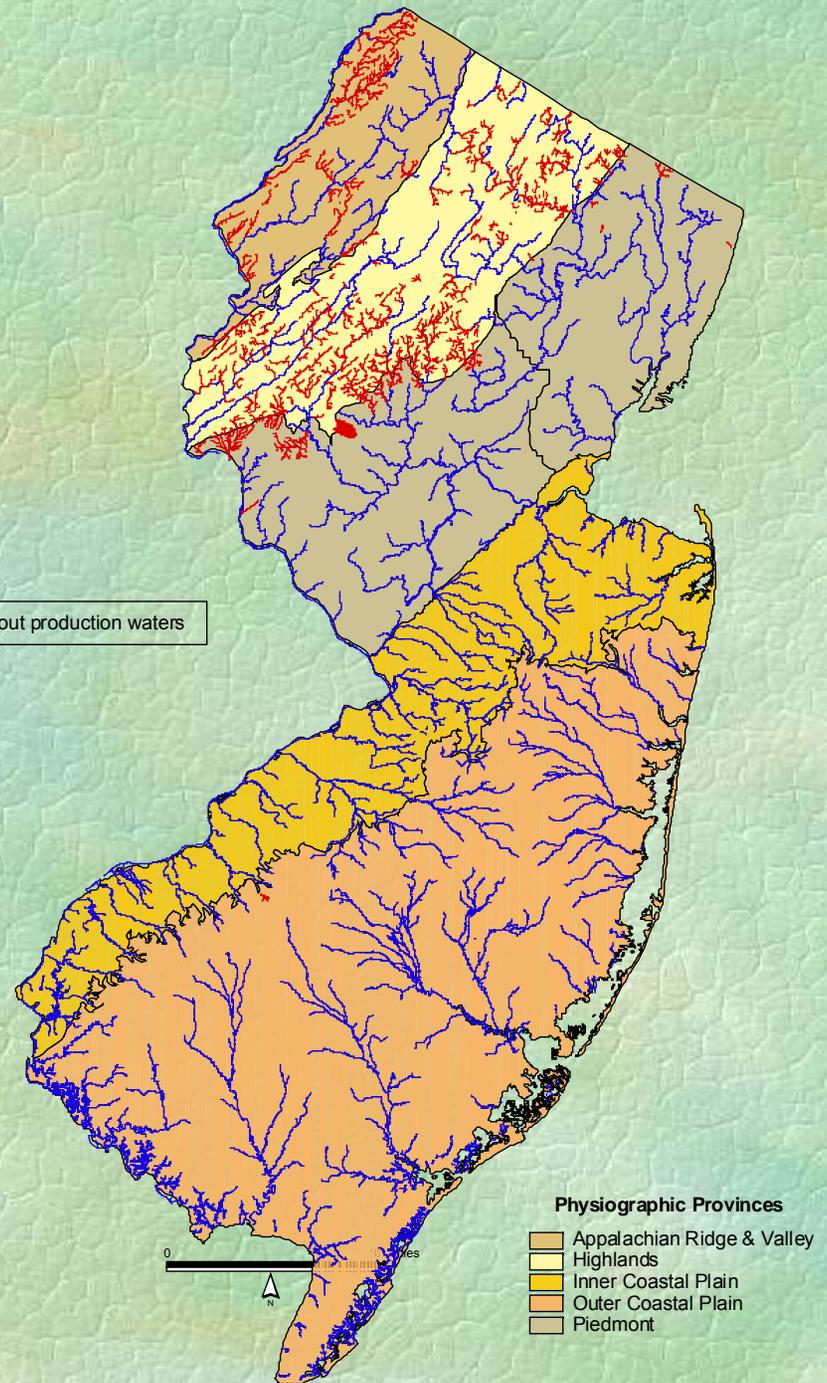


- Trout production
- Trout maintenance
- Non-trout

Trout Production



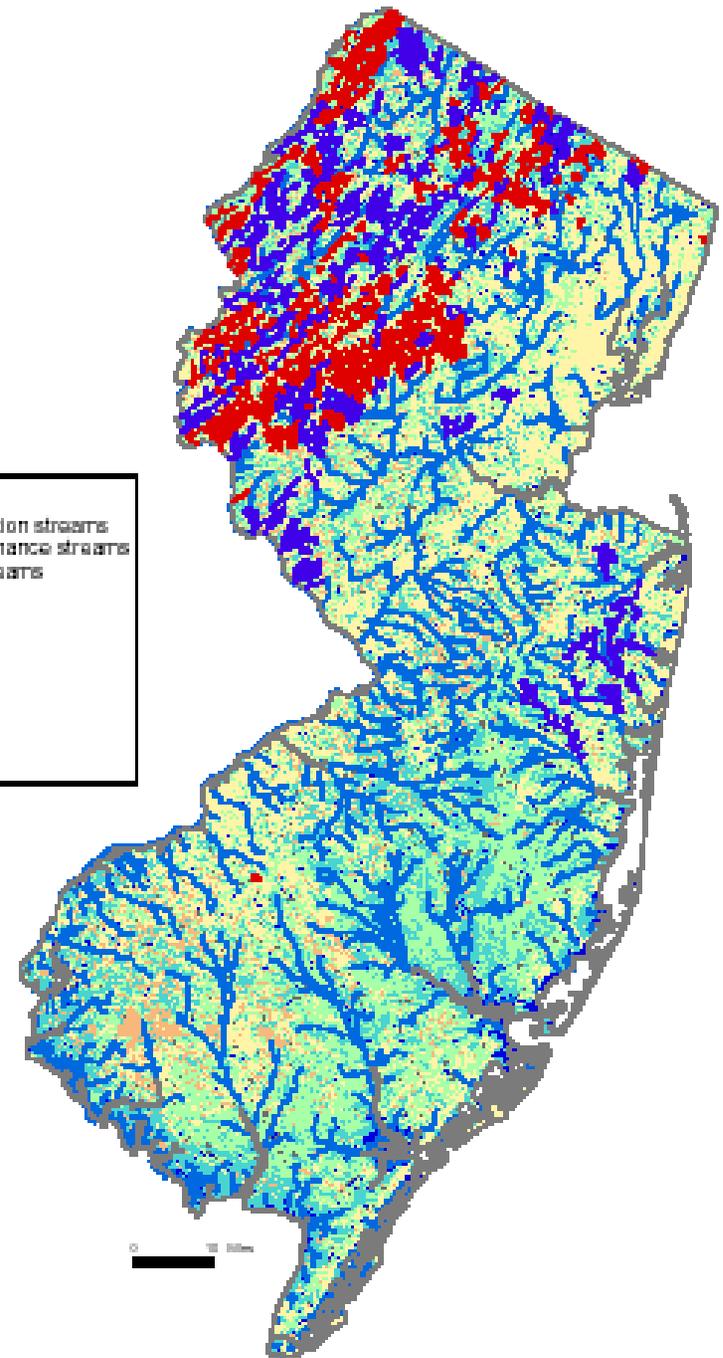
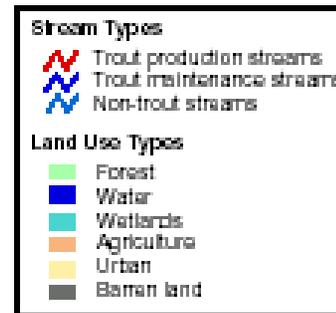
■ Trout production waters



Trout Maintenance

Incidence of Occurrence

Preponderance of fish species commonly associated with trout.





Non-Trout

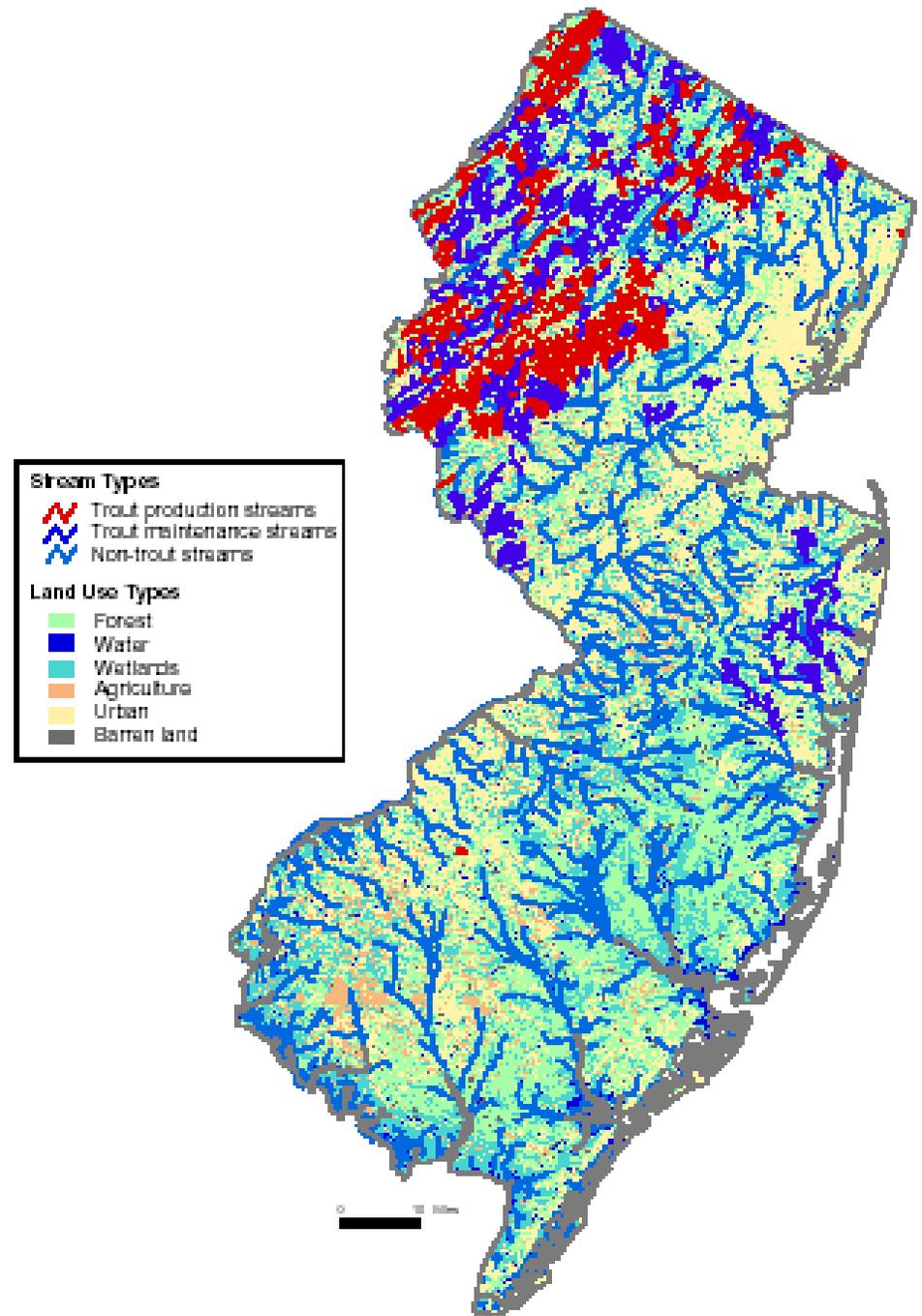
- Streams that are not designated TP or TM.
- Generally not suited for trout because of their physical, chemical, or biological characteristics, but are suitable for a wide variety of other fish species.

Surface Water Quality Standards

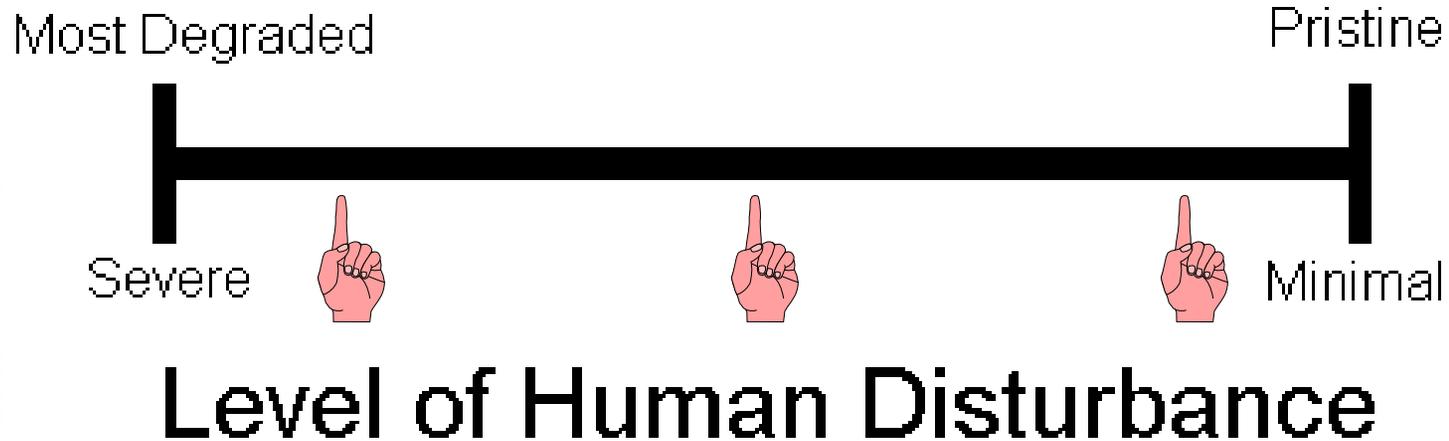
- Strongest line of defense in protecting open state waters (DEP Land Use Regulation program)
- Trout Production streams are nominated as Category One Waters (C1)
- Anti-degradation policy - no measurable changes to the existing water quality
- Trout Maintenance streams receive intermediate levels of protection
- Based on sound science - requirements of trout are well understood

- The occurrence of trout and trout associated species is closely related to cold and high gradient waters.

- Low and moderate gradient streams are by nature, not conducive to trout, therefore trout are not an appropriate indicator species for these waters.

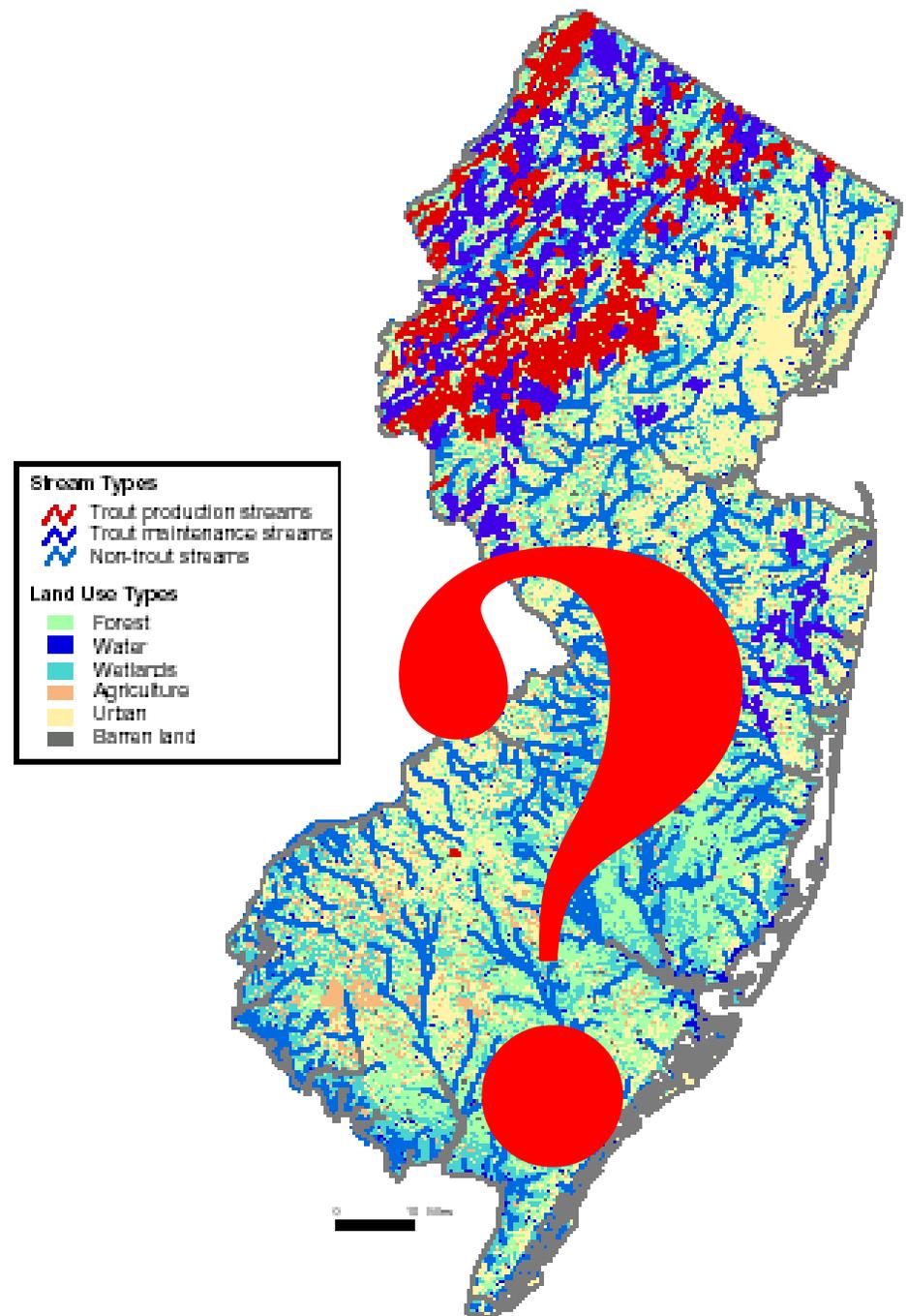


Unfortunately, NT waters are assumed to have minimum biological value.



There is a large gradient of water qualities within the non-trout classification.

- Since high quality non-trout streams can not be identified, they do not receive additional protection.
- Two-thirds of NJ is currently classified as “non-trout.”
- We must remember, high quality streams exist outside of trout country.
- Are there fish species that are indicative of high quality warmwater streams?



**1985 - attempt to further classify
non-trout waters**



Smallmouth bass

**Not successful - specific
habitat and temperature
requirements.**



Yellow perch



IBI



What is Biological Integrity???



- The ability of the ecological system (waterbody) to support and maintain “a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of a natural habitat of the region.” ***James Karr***



Index of Biotic Integrity

- Dr. James Karr (1981)
- Analytical tool to quantify biological condition
- Integrates multiple characteristics of the fish assemblage
- Results in a numerical index scaled to reflect ecological health
- One of the most widely accepted tools
- We do not have an IBI that can be used here



What is the IBI used for?

- Address the goals of the CWA
- Assess the impacts of land-use changes on biota
- Identify high quality streams for protection
- Identify degraded streams in need of restoration
- Evaluate restoration efforts
- Fill a void in our Surface Water Quality Standards

Important Steps

- Know your region (collect data)
- Recognize ecological theory
- Identify anthropogenic stressors in watershed
(habitat loss, altered landuse, biological interactions)
- Evaluate relationship between fish and various degrees of human impact
- Select metrics are biologically meaningful
(empirically)
- Compile best metric set into an index
(6-12 metrics)

A photograph of a rocky stream with water flowing over mossy rocks in a forest. The water is clear and creates small white rapids as it flows over the dark, wet stones. The surrounding area is lush with green vegetation, including moss and ferns. The overall scene is a natural, undisturbed waterway.

IBI's
must
be
region
specific.

**Flanders Brook
in Flanders**

Northern New Jersey

- high gradient streams
- limestone, shale, granite, sandstone, conglomerate, etc.
- cooler water temps.
- coolwater & coldwater fishes

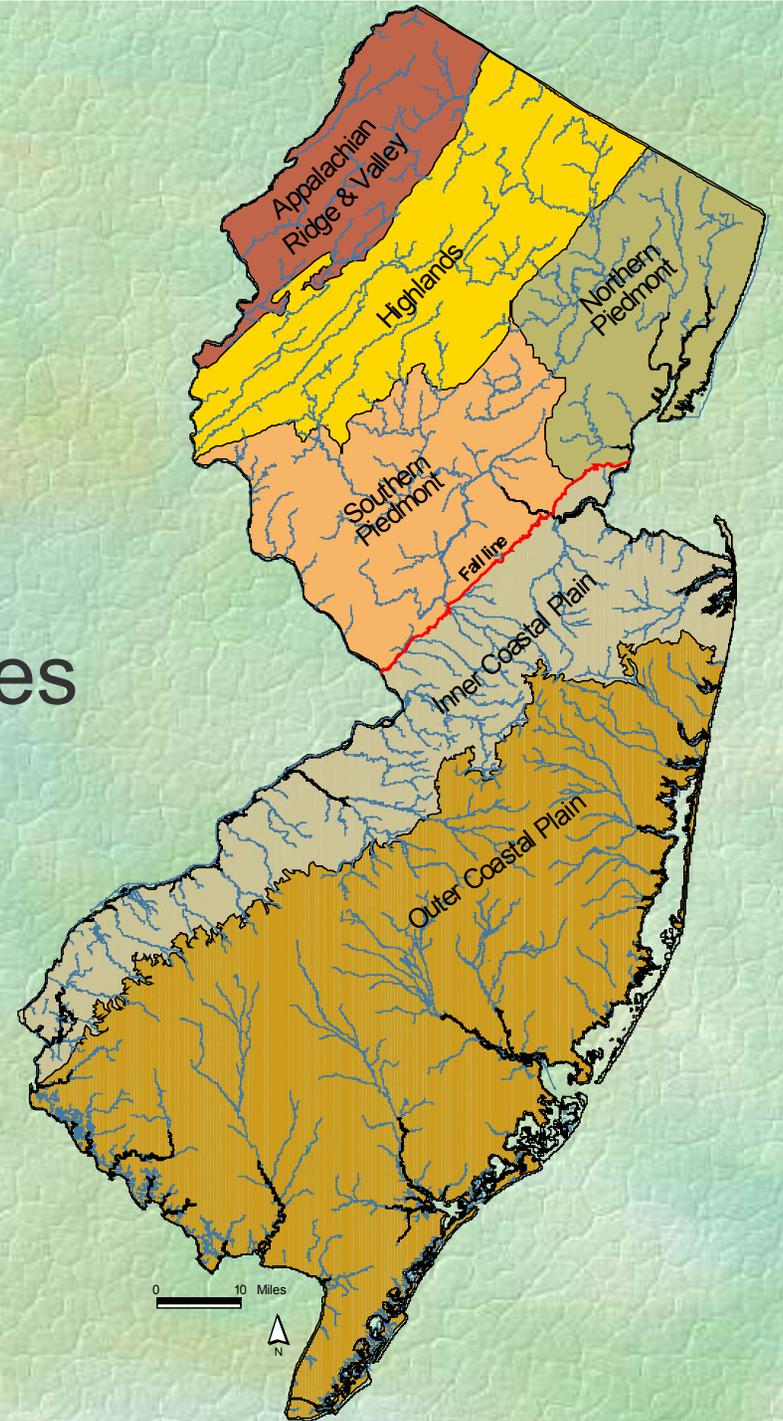
- trout



- sculpin



- minnows





IBI's must be region specific.

**Buckshutem Creek
outside of Millville**

Southern New Jersey

- low gradient streams
- sand, silt, clay, some gravel
- warmer water temps.
- warmwater fishes

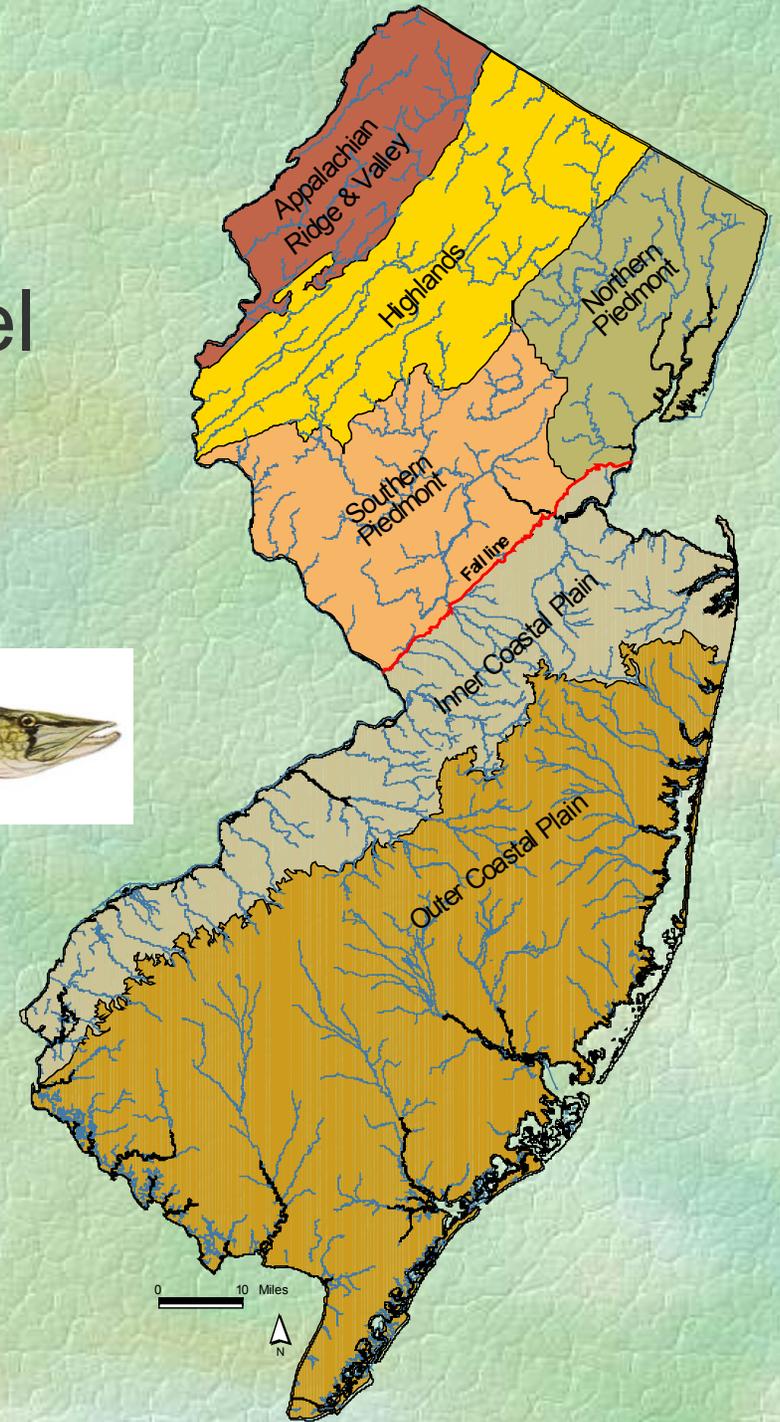
- pickerel



- sunfishes

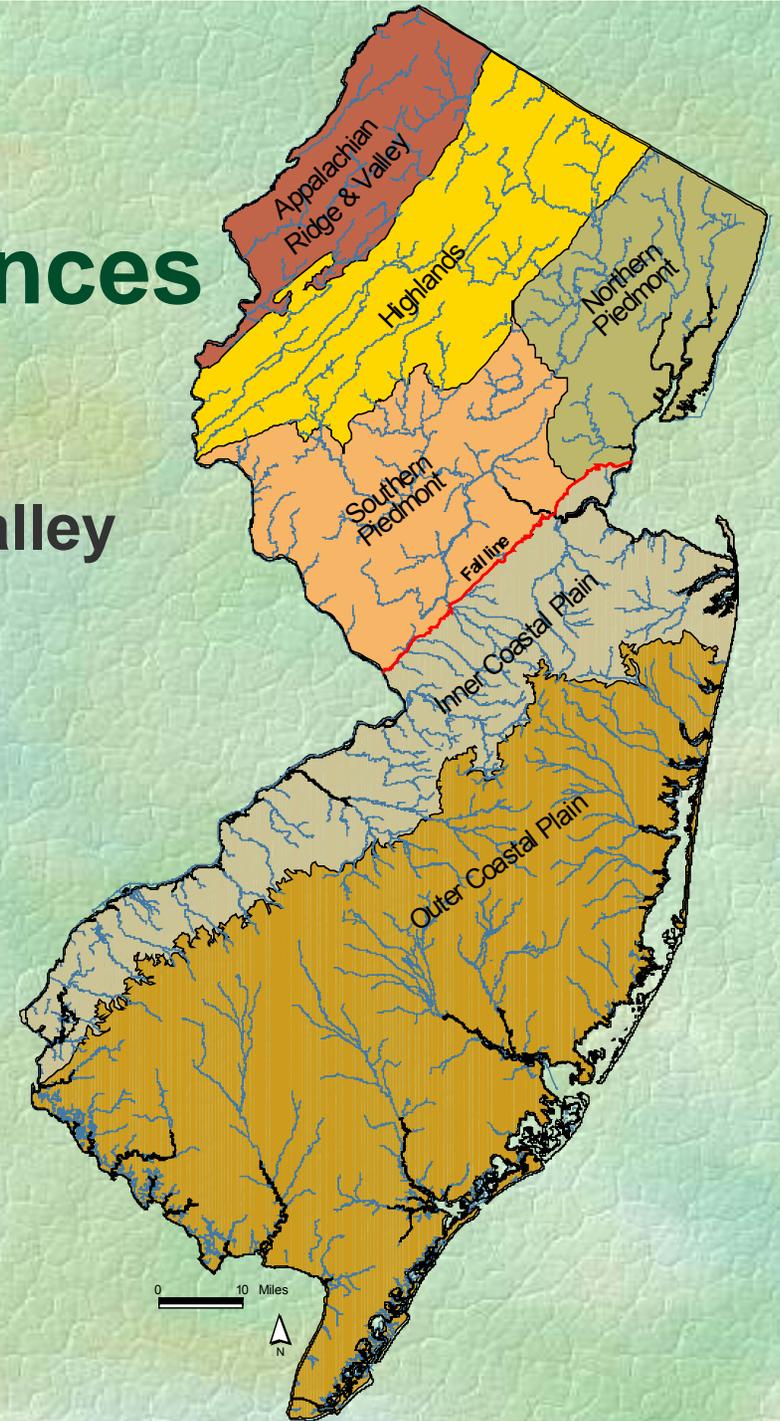


- darters

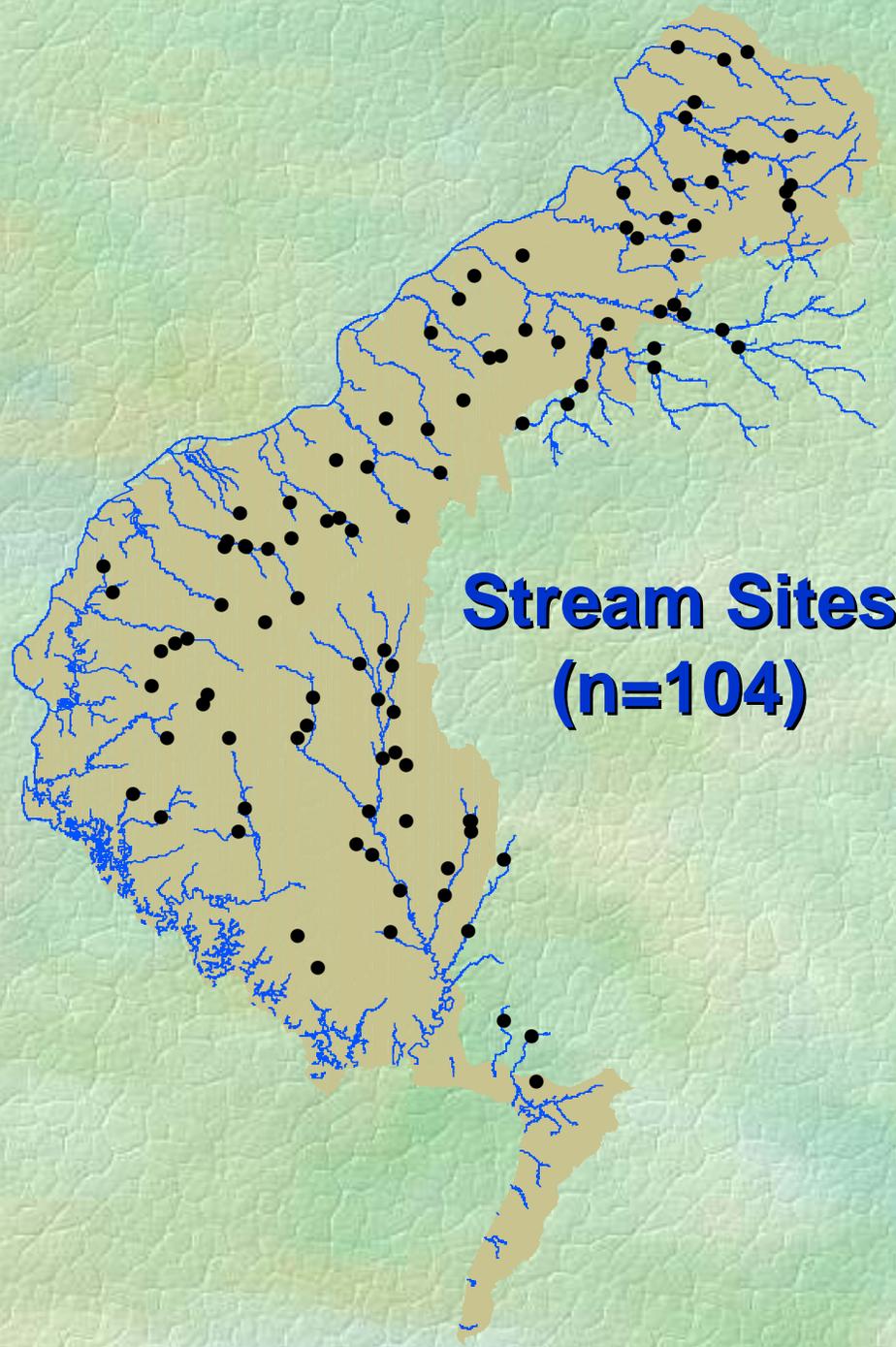
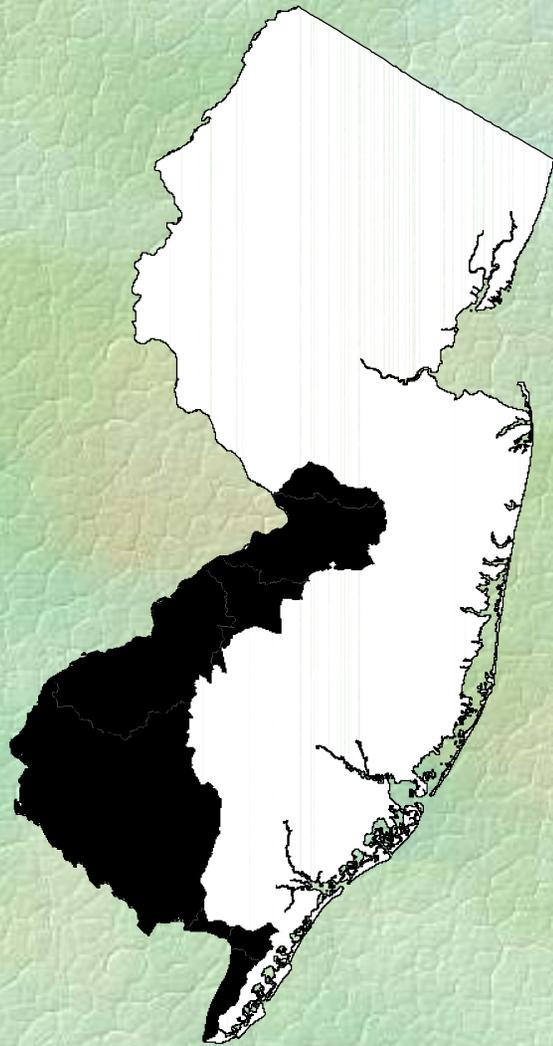


New Jersey's Physiographic Provinces

- Appalachian Ridge & Valley
- Highlands
- Northern Piedmont
- Southern Piedmont
- Inner Coastal Plain
- Outer Coastal Plain



Study Area: LDRD



**Stream Sites
(n=104)**



Electrofishing 150 meter stretch

**Fish are collected
and sorted.**



Fish are identified and counted.

Length measurements are taken on game species.





2000-2004

- 120 sites
- 16,109 fish
- 50 species





Habitat Assessments

- In-stream Habitat: substrate, logs and snags, pool structure, undercut banks
- Bank and Riparian: bank stability, vegetative pro., riparian width

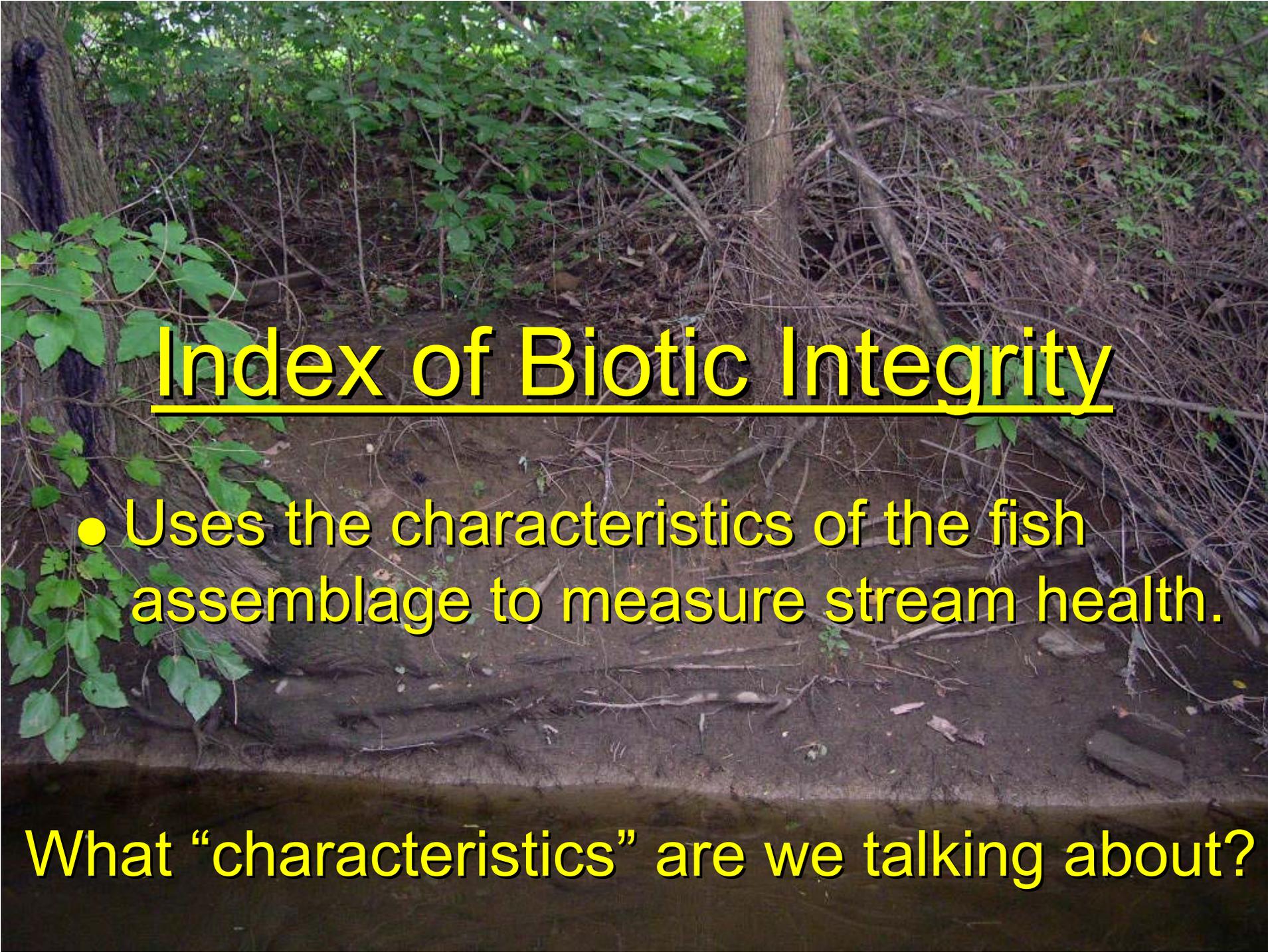
**Little Timber Creek
Hadden Heights, Camden**



**Indian Run
in Pittsgrove**



**North Branch of
Cooper River
in Cherry Hill**

A photograph of a stream bank. The foreground shows a dark, calm stream. The bank is composed of dark soil and is heavily vegetated with green leaves and numerous bare, brown branches and twigs. The background is filled with more dense green foliage and trees.

Index of Biotic Integrity

- Uses the characteristics of the fish assemblage to measure stream health.

What “characteristics” are we talking about?

Native

vs.

Non-native

Native Species - originated in NJ prior to human colonization (naturally found here)

- brook trout, chain pickerel, brown bullhead, pumpkinseed

Non-native Species - introduced to NJ (intentionally or unintentionally)

- brown trout, largemouth bass, channel catfish, bluegill
- snakehead, flathead catfish

Non-native species can disrupt the natural ecosystem.

- (competition and predation) “bio-pollution”

Pristine (Healthy)
many Natives



Degraded (Unhealthy)
few Natives

Tolerant
vs.
Intolerant

Intolerant Species - can not tolerate degradation
(sensitive / good habitat / good H₂O quality)

- brook trout, sculpin, blackbanded sunfish, swamp darter

Tolerant Species - can withstand degradation
(not sensitive / poor habitat / poor H₂O quality)

- bullheads, carp, white suckers, eels

Pristine (Healthy)
many Intolerants



Degraded (Unhealthy)
many Tolerants

Trophic Levels

a.k.a.

Feeding Groups

Generalist Species - opportunistic (will eat whatever is available)

- combination of invertebrates, algae, plants, detritus
- white suckers, carp, golden shiners, etc.



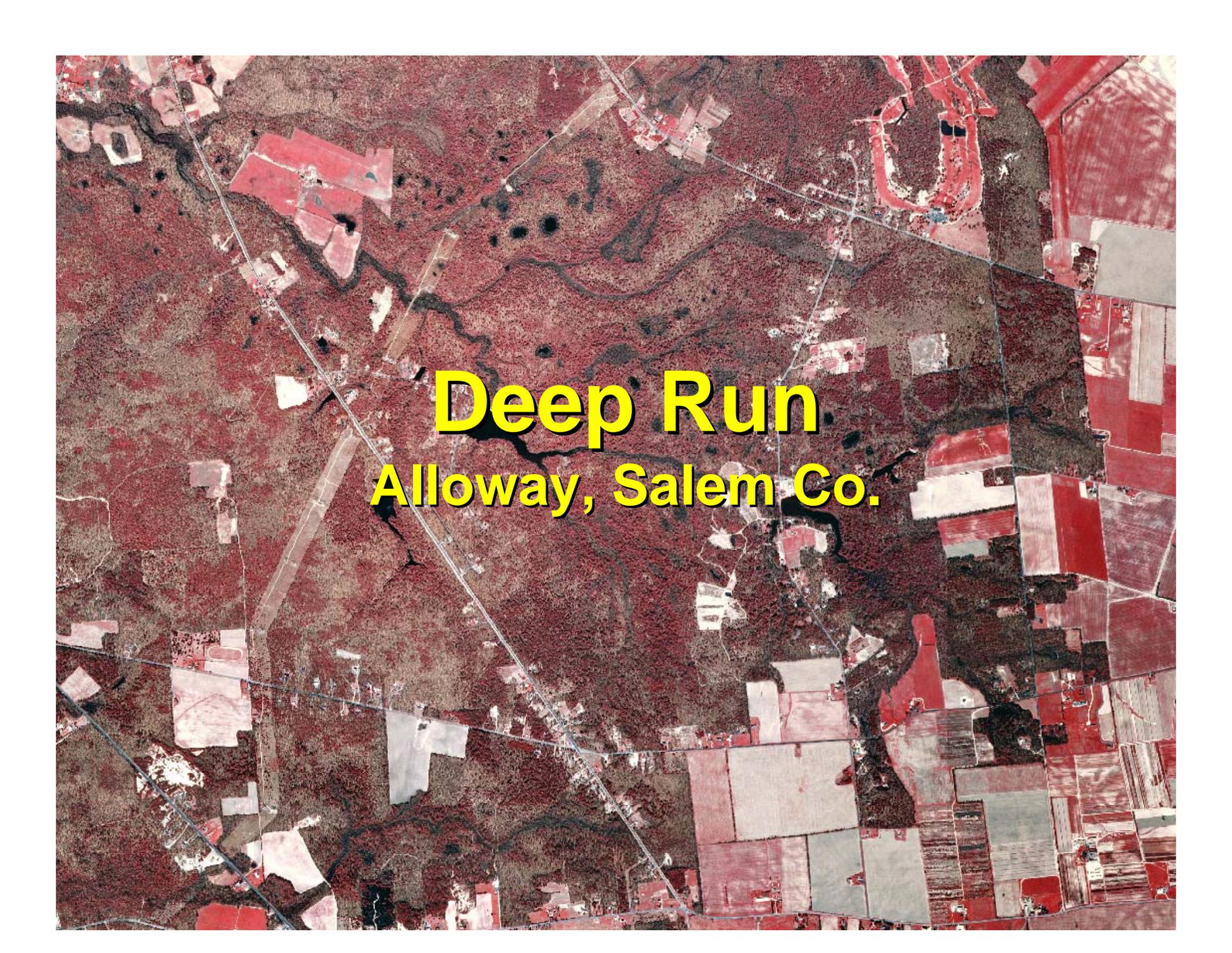
Pristine (Healthy)
few Generalists



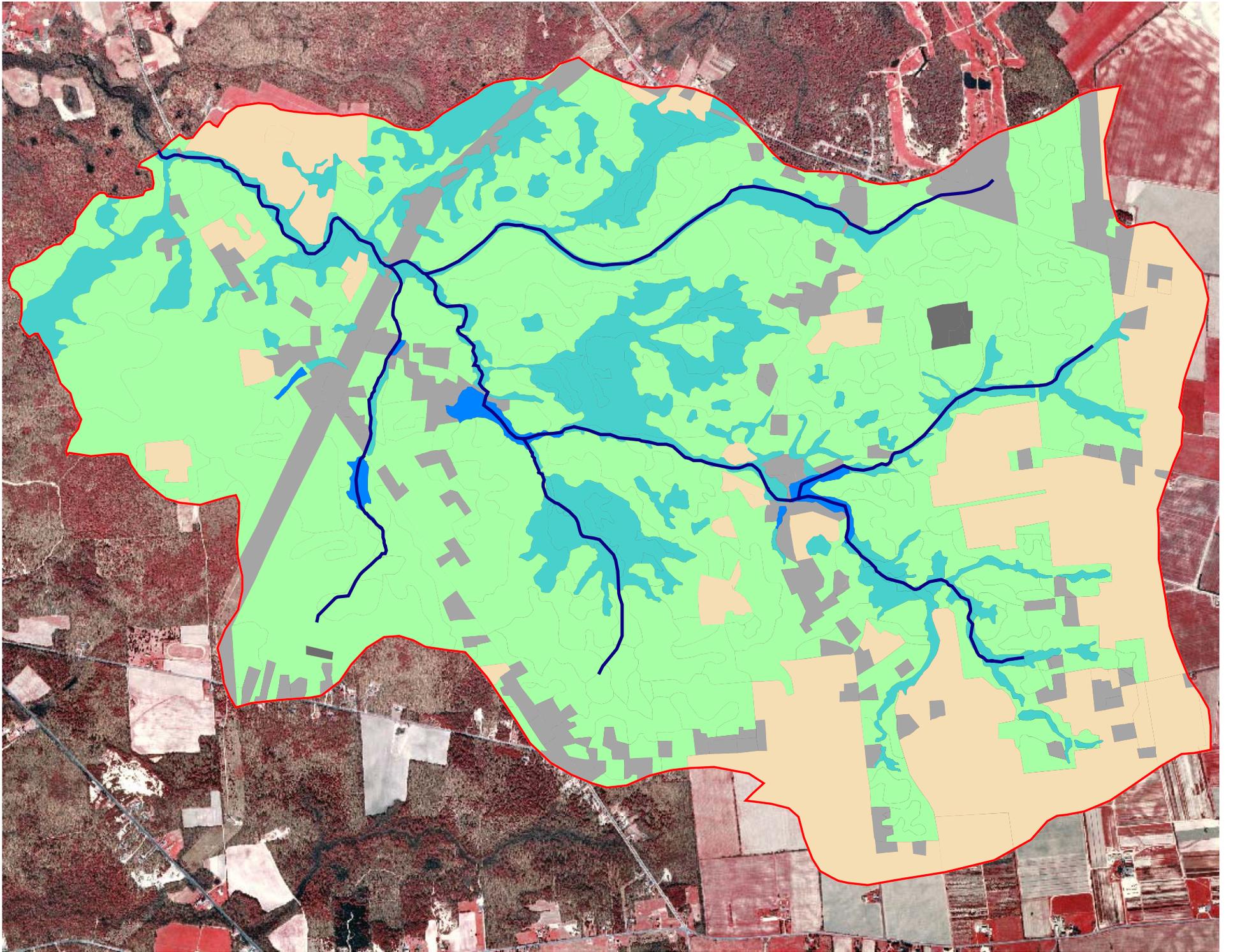
Degraded (Unhealthy)
many Generalists

An aerial photograph of a rural landscape. A winding river flows through the center of the image. The surrounding land is divided into numerous rectangular agricultural plots, some of which are planted with crops. The overall color palette is dominated by earthy tones, including browns, tans, and muted greens, with some areas appearing more vibrant. The word "Land-use" is overlaid in the center in a large, bold, yellow font with a black outline.

Land-use

An aerial photograph of a rural landscape. A winding river or stream flows through the center of the image. The surrounding land is divided into numerous rectangular agricultural fields, some of which are planted with crops, appearing in various shades of brown, tan, and light green. There are also some buildings and structures scattered throughout the landscape. The overall scene depicts a typical rural agricultural setting.

Deep Run
Alloway, Salem Co.

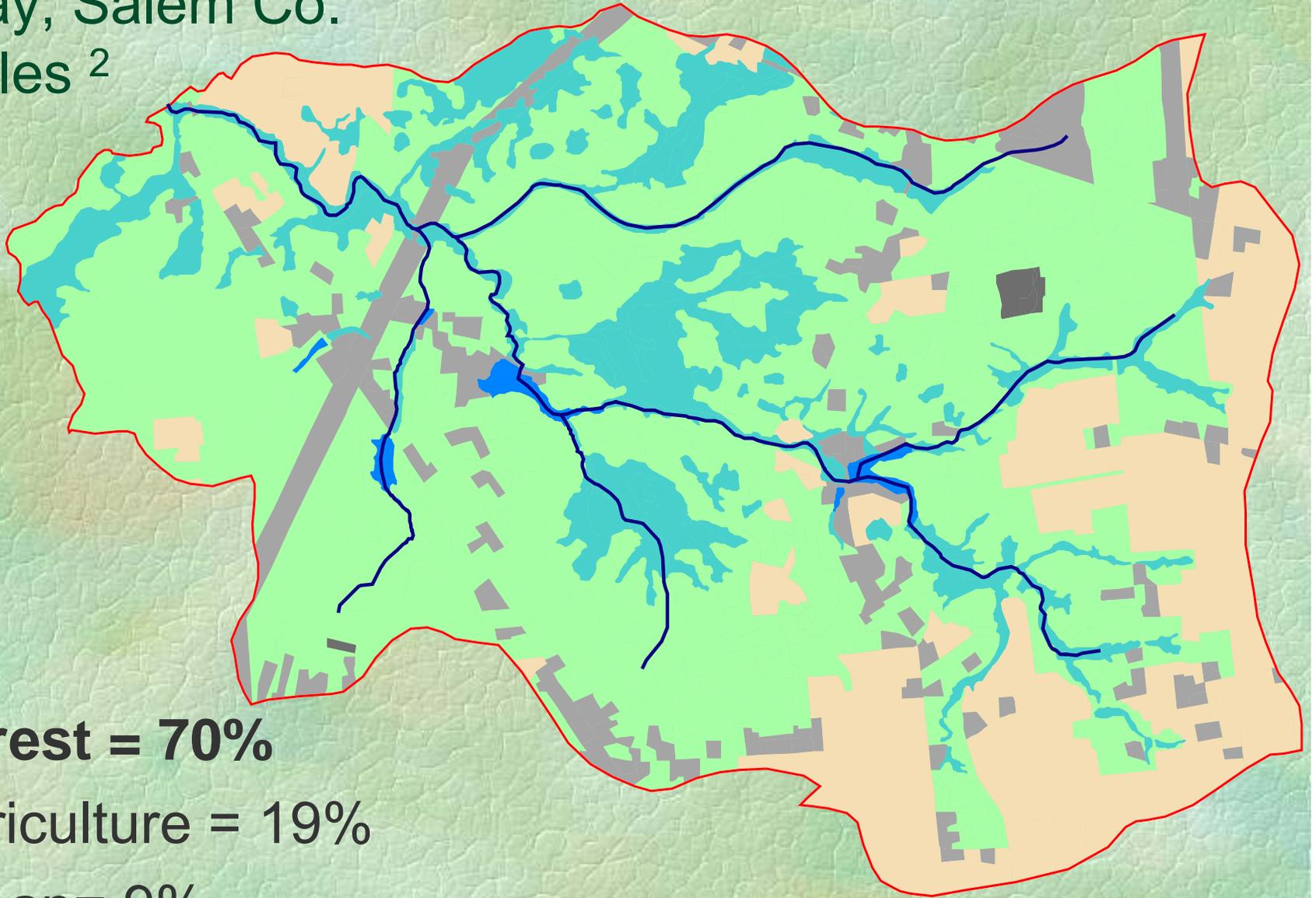


Deep Run

Alloway, Salem Co.

5.8 miles²

- Forest = 70%
- Agriculture = 19%
- Urban = 9%



Deep Run Survey Results

Well Forested

- Chain Pickerel
- Pumpkinseed
- Bluespotted Sunfish
- Mud Sunfish
- Brown Bullhead
- Creek Chubsucker
- Swamp Darter
- Pirate Perch
- Eastern Mudminnow

1. **All Native Species = 9**

2. **Non-Native Species = 0**

3. **Intolerant = 2**

4. **Moderately Tolerant = 5**

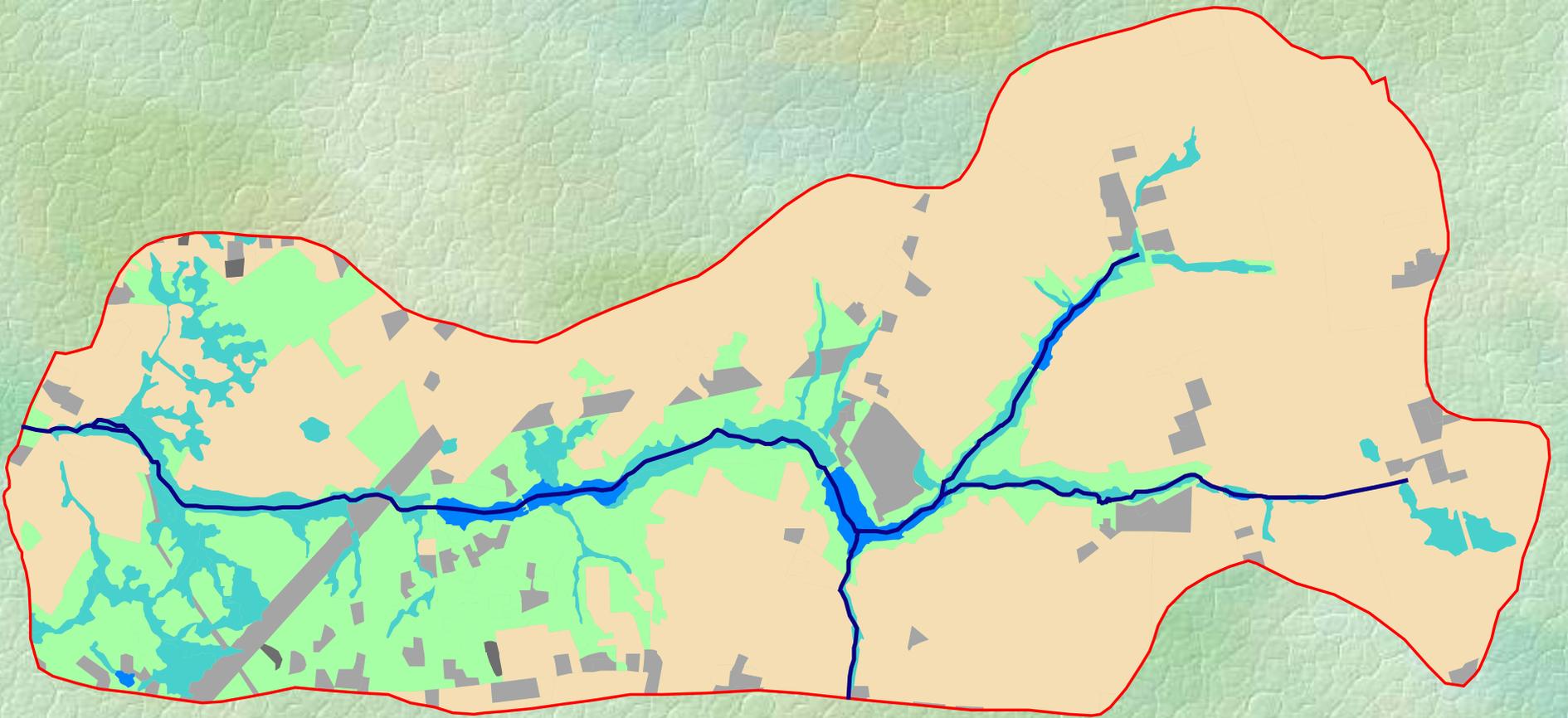
5. **Tolerant = 2**

Cool Run

Alloway, Salem Co.

5.0 miles²

- Forest = 26%
- **Agriculture = 66%**
- Urban = 7%



Cool Run Survey Results

Impact: Agriculture

- Largemouth Bass ●
- Pumpkinseed
- Bluegill ●
- Redbreasted
- Brown Bullhead
- White Sucker
- Tessellated Darter
- American Eel

1. **Native Species = 6**

2. **Non-Native Species = 2**

3. **Intolerant = 0**

4. **Moderately Tolerant = 4**

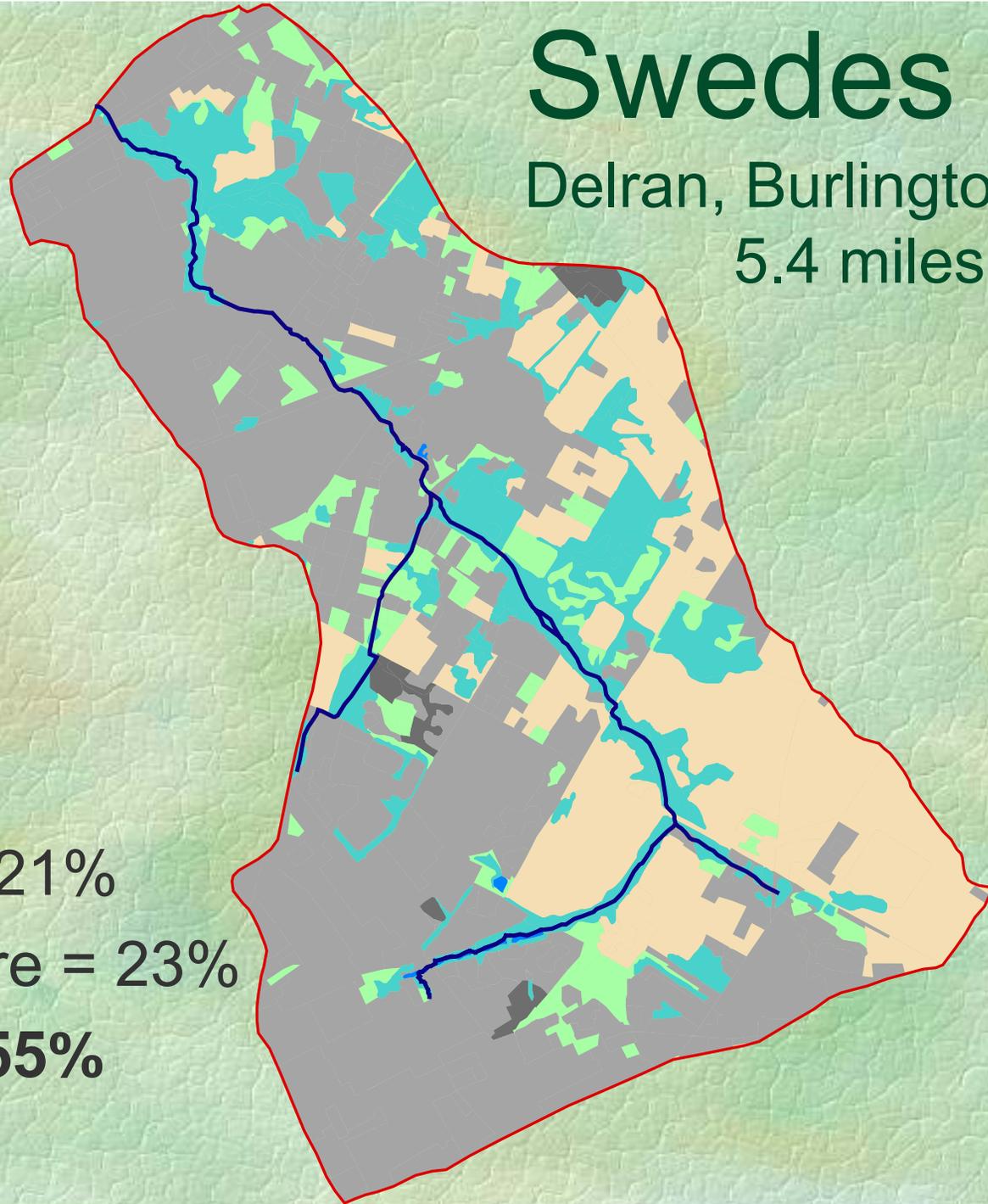
5. **Tolerant = 4**

Swedes Run

Delran, Burlington Co.

5.4 miles²

- Forest = 21%
- Agriculture = 23%
- **Urban = 55%**



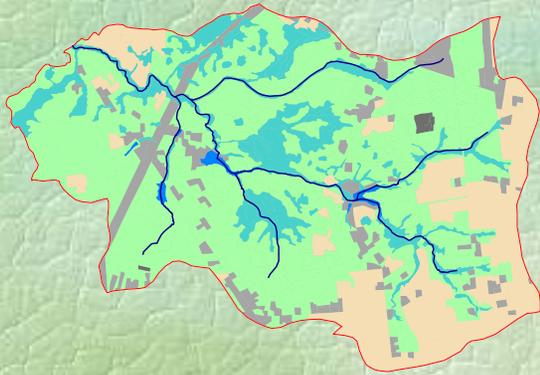
Swedes Run Survey Results

Impact: Urban

- Largemouth Bass ●
- Pumpkinseed
- Bluegill ●
- Brown Bullhead
- American Eel

1. **Native Species = 3**
2. **Non-Native Species = 2**
3. **Intolerant = 0**
4. **Moderately Tolerant = 2**
5. **Tolerant = 3**

Summary:

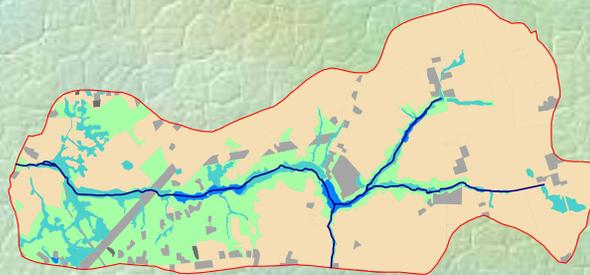


Deep Run

9 native fishes
0 non-natives
3 intolerant



**Healthy
Ecosystem**

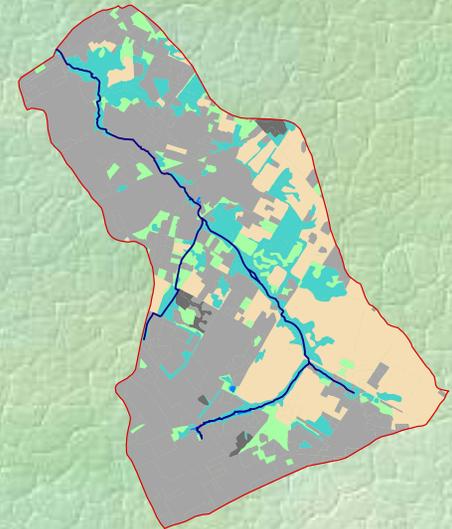


Cool Run

6 native fishes
2 non-natives
4 tolerant



**Degraded
Ecosystem**



Swedes Run

3 native fishes
2 non-natives
3 tolerant



**Degraded
Ecosystem**

Generic Fish IBI

Metric Types

Number

- Taxa richness 3-5
- Tolerance / Intolerance 2-3
- Trophic groups 2-4
- Individual health 1-2
- Other ecological groups 2-3

(reproductive, etc.)

Statistical Evaluation of Candidate Metrics

Spearman Rank Correlations

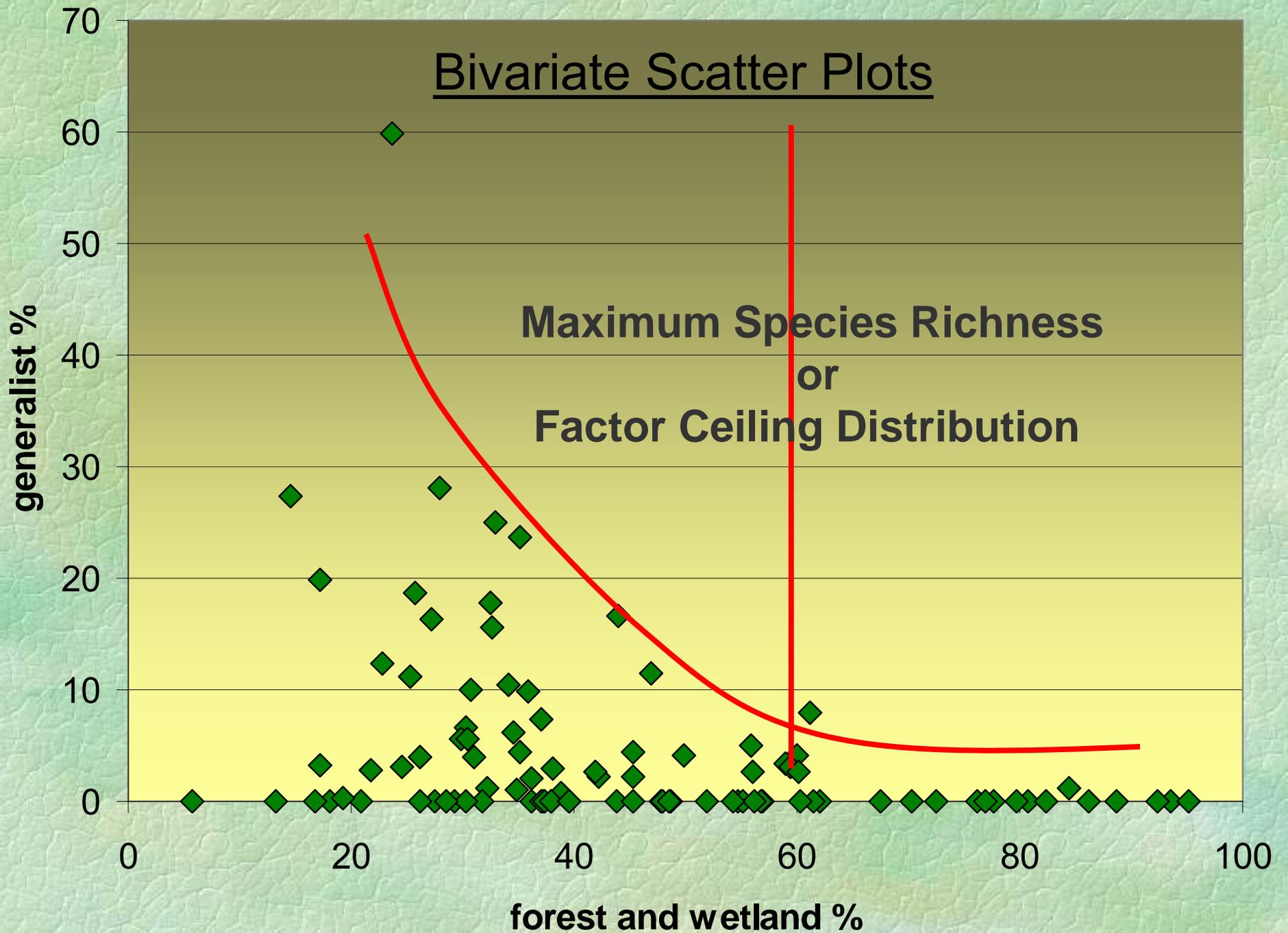
STATISTIX 7.1

	<u>r-value</u>	<u>p-value</u>
Species Richness	-0.1493	0.1443
Native Species Richness	-0.0866	0.3981
Non-native Rel. Ab.	0.1395	0.1725
Pickereel Rel. Ab.	0.3453	0.0006
DELT Anomaly Rel. Ab.	0.0202	0.8438

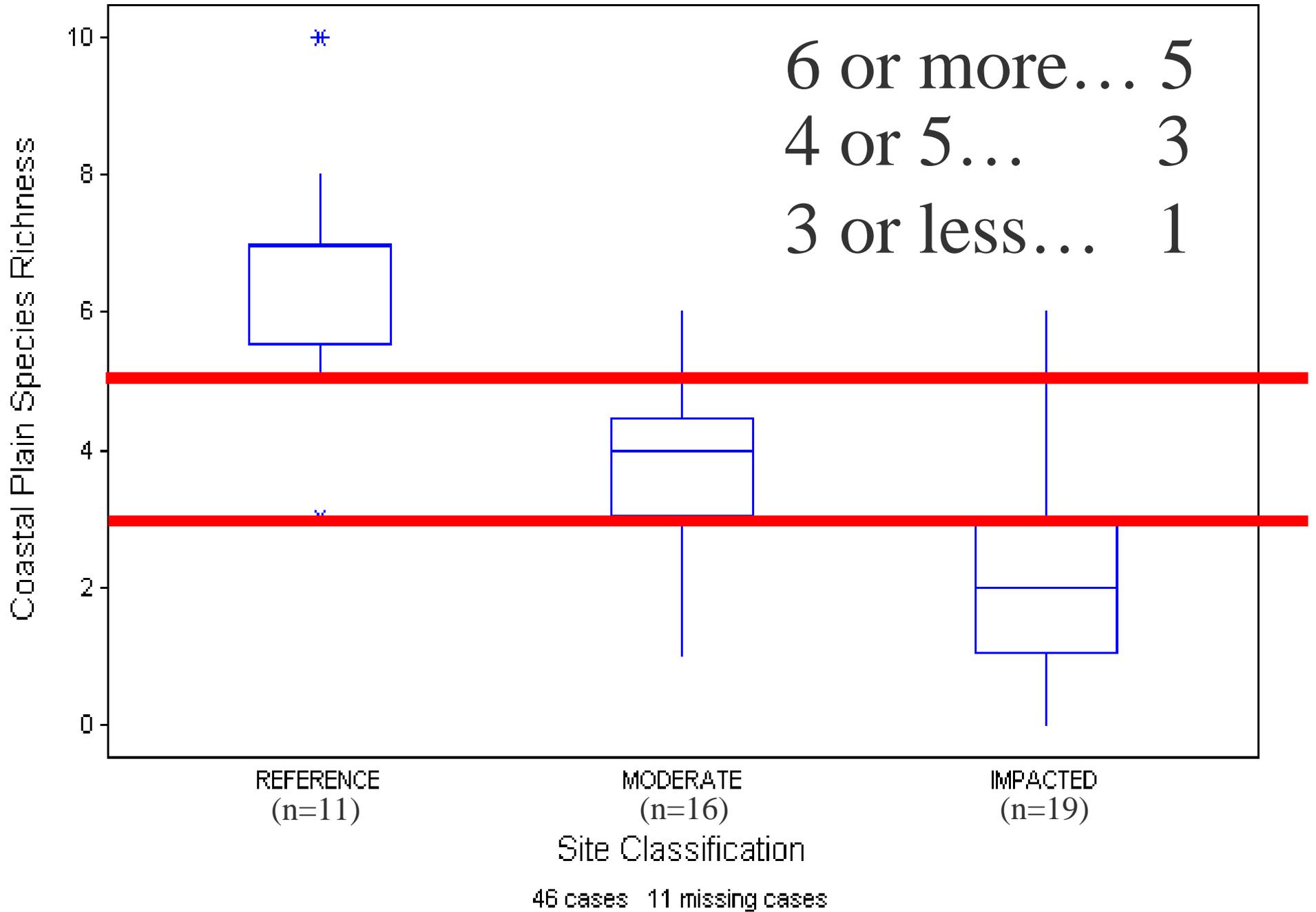
(significance >0.311 <0.001)

Bivariate Scatter Plots

Maximum Species Richness
or
Factor Ceiling Distribution



Box and Whisker Plots



Northern NJ Fish IBI

Metrics

Scoring Criteria

Species Richness

- | | | | |
|---------------------------------------|-------------------------|--------|------|
| 1. # of fish species | varies with stream size | | |
| 2. # of benthic insectivorous species | varies with stream size | | |
| 3. # of trout and sunfish species | varies with stream size | | |
| 4. # of intolerant species | varies with stream size | | |
| 5. Proportion of as white suckers | <10% | 10-30% | >30% |

Trophic Composition

- | | | | |
|--|------|--------|------|
| 6. Proportion as generalist | <20% | 20-45% | >45% |
| 7. Proportion of insectivorous cyprinids | >45% | 20-45% | <20% |
| 8. Proportion of non-stocked trout | >10% | 3-10% | <3% |

or

or

- | | | | |
|--------------------------|-----|------|-----|
| Proportion as piscivores | >5% | 1-5% | <1% |
|--------------------------|-----|------|-----|

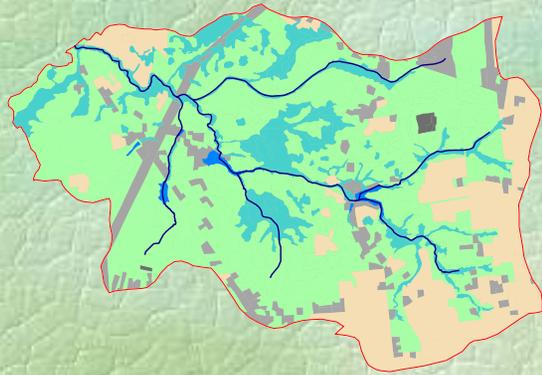
Fish Abundance and Condition

- | | | | |
|---|------|--------|-----|
| 9. # of individuals | >250 | 75-250 | <75 |
| 10. Proportion with disease and anomalies | <2% | 2-5% | >5% |

Preliminary LDRD fish IBI

Species Richness and Composition	5	3	1
Coastal Plain Species Richness (#)	≥6	4 or 5	0-3
Non-native Relative Abundance (%)	0%	0<x<10%	≥10%
Acid Tolerant Sunfish Species (#)	≥2	1	0
Disturbance Indicator Sp. Relative Abundance (%)	0%	0<x<20%	≥20%
Trophic Composition			
Native Piscivore Relative Abundance (%)	≥3%	0<x<3%	0%
Generalist Relative Abundance (%)	0%	0<x<8%	≥8%
Tolerance Composition			
Tolerant Species Richness (#)	0-2	3	≥4
Intolerant Relative Abundance (%)	≥5%	0<x<5%	0%
Note: Subtract 4 points from total if less than 4 native species.			
Note: Add 4 points to total if more than 10 species (Native or Non-native).			

38 = good



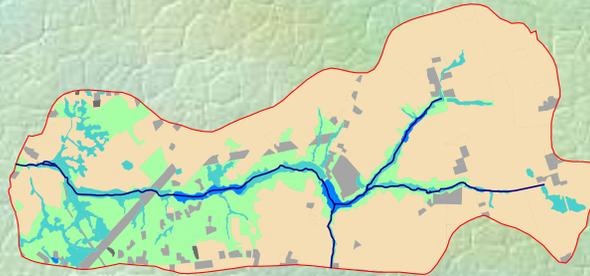
Deep Run

**9 native fishes
0 non-natives
3 intolerant**



**Healthy
Ecosystem**

8 = poor



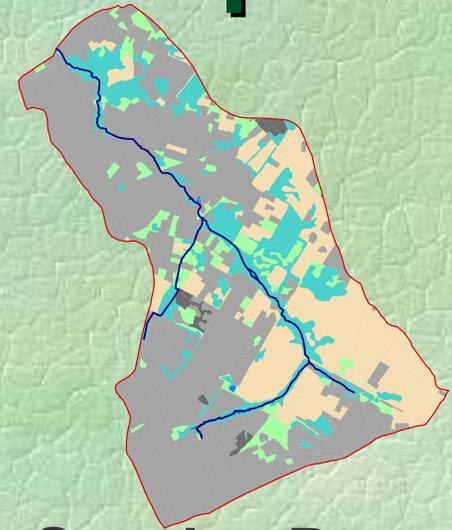
Cool Run

**6 native fishes
2 non-natives
4 tolerant**



**Degraded
Ecosystem**

14 = poor

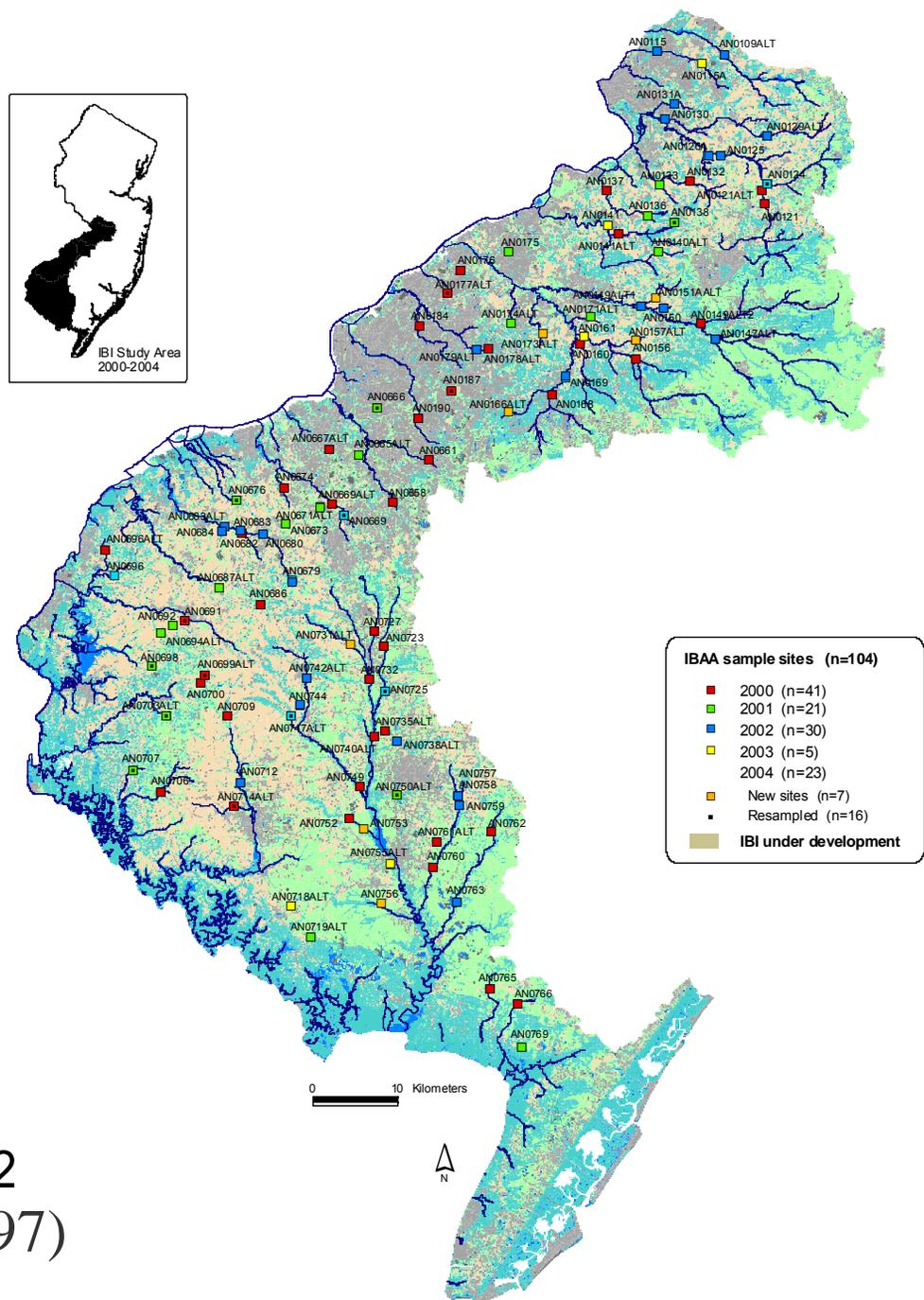
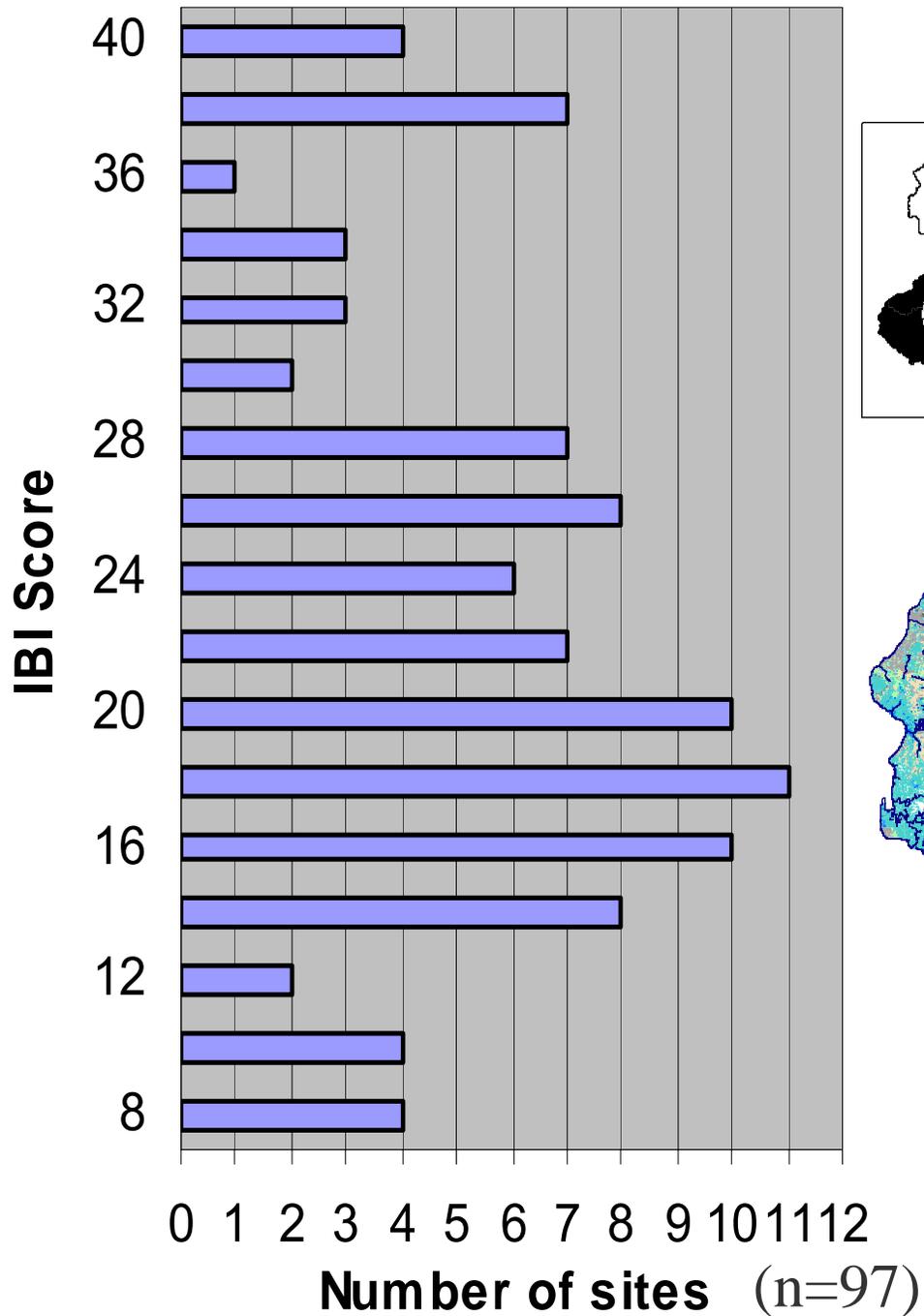


Swedes Run

**3 native fishes
2 non-natives
3 tolerant**



**Degraded
Ecosystem**





Technical Review

- DEP Division of Fish and Wildlife
- DEP Division of Science, Research, and Technology
- DEP Bureau of Freshwater and Biological Monitoring
- USEPA
- USGS
- Academy of Natural Sciences (Patrick Center)



Once the IBI is finalized...

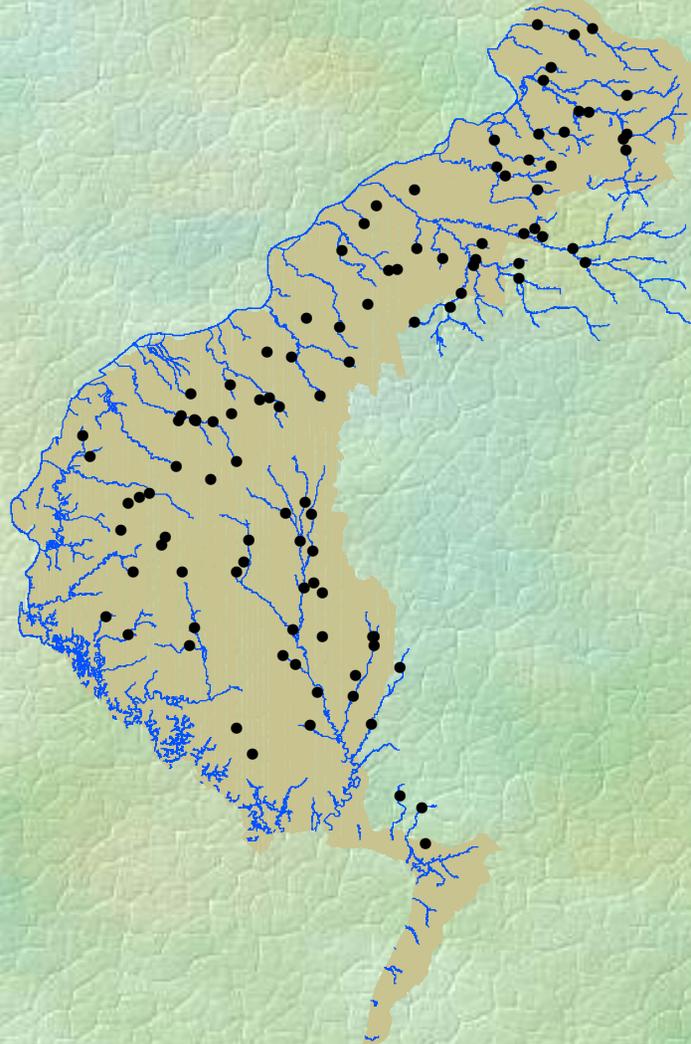
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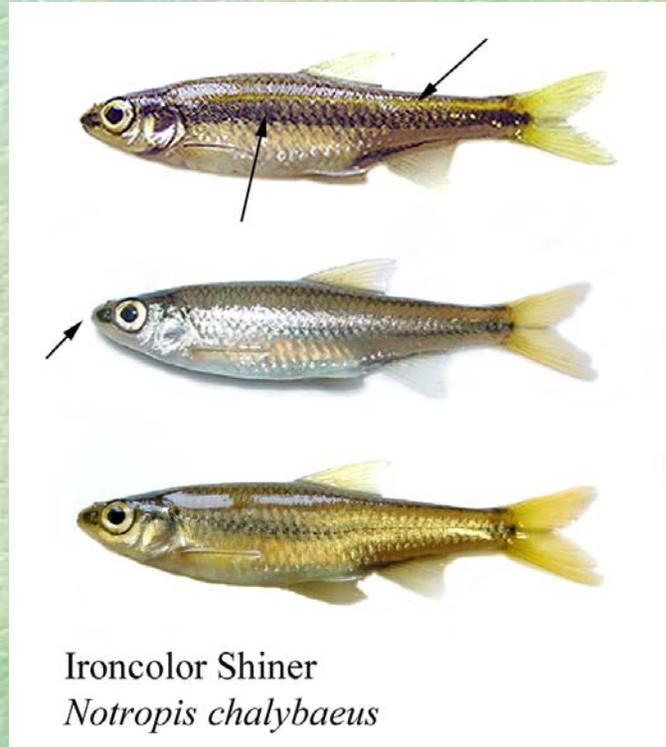
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ADDITIONAL BENEFITS



Fill large data gaps

ADDITIONAL BENEFITS



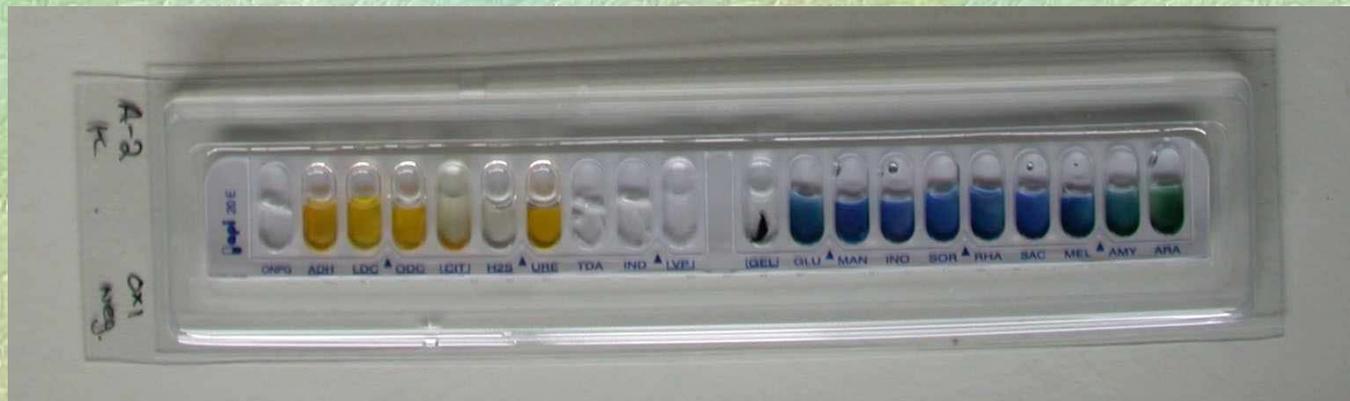
Mapping distribution of
non-game fish species

ADDITIONAL BENEFITS



Documentation of warmouth
(*Lepomis gulosus*)

ADDITIONAL BENEFITS



Identification of new bacteria
Edwardsiella ictaluri

ADDITIONAL BENEFITS



Fish Reference Collection

ADDITIONAL BENEFITS



Stream Classification
S/Br Rockaway Creek

ADDITIONAL BENEFITS



Modifications to Habitat
Assessment Low Gradient Streams

Bluespotted Sunfish
Enneacanthus gloriosus



Banded Sunfish
Enneacanthus obesus



Blackbanded Sunfish
Enneacanthus chaetodon



Chain Pickerel *Esox niger*



Redfin Pickerel *Esox americanus*



Warmouth
Lepomis gulosus



Pirate Perch
Aphredoderus sayanus

Konrad Schmidt



Tessellated Darter *Etheostoma olmstedii*



Swamp Darter *E. fusiforme*



Photo credit: Noel Burkhead/Howard Jelks

Tadpole Madtom *Noturus gyrinus*



Ironcolor Shiner
Notropis chalybaeus





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