A Comparison of Two Index of Biotic Integrity (IBI) Calculations for Benthic Macroinvertebrates and Fish at a Mitigation Site

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First National
STREAM RESTORATION
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Objectives

- Review and compare the field use, calculations, and application of two Maryland-based Index of Biotic Integrity (IBI) scoring metrics
- Determine appropriate field use for IBI scoring types based on various project considerations

Presentation Outline

- Introduction to the Index of Biotic Integrity (IBI)
- IBIs for MBSS and MCDEP
- Example Study for IBI application – Brookeville, MD
- B-IBI Metrics Comparison
- F-IBI Metrics Comparison
  - In-depth metrics review
  - Species comparison
- F-IBI Scores
- IBI Applications

Index of Biotic Integrity (IBI)

- IBI: Indicator value of stream quality based on a series of metrics
  - Allows for stream quality comparison both spatially and temporally
  - Originally developed by Karr (1981) and Karr et al. (1986)
  - Critiqued evaluations of metrics
  - Metrics catered to specific regions
  - Calculations require specific protocols during sampling
  - Developed for specific taxonomic groups
- B-IBI and F-IBI
  - B-IBI = Benthic Index of Biotic Integrity
  - F-IBI = Fish Index of Biotic Integrity
  - Unique metrics and sampling protocols based on taxa community of interest
  - Both provide supportive information in determining stream quality

Index of Biotic Integrity - MBSS

- Maryland Biological Stream Survey (MBSS) IBI
  - Developed by Maryland Department of Natural Resources and Versar Inc. (Roth et al. 2000; Southerland et al. 2005) and Tetra Tech, Inc. (B-IBI; Stribling et al. 1998)
  - Need to identify ecological strata for sampling location → Eastern Piedmont, Coastal Plain, Highlands
  - B-IBI
    - Sample window: March 1 – April 30
    - Sample frequency: once a year
    - Gear type: D-frame dip net
    - Scoring: Averaged 5-point scale
  - F-IBI
    - Sample window: June 1 – Sept 30
    - Sample frequency: once a year
    - Gear type: Electrofishing anodes
    - Scoring: Averaged 5-point scale

Index of Biotic Integrity - MCDEP

- Montgomery County Department of Environmental Protection (MCDEP) IBI
  - Based on metrics and protocols described in MCDEP (1997)
  - Developed for Montgomery County Water Quality Monitoring Program
  - Requires knowledge of sample location stream order and soil type

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  - B-IBI
    - Sample window: Mar 15 – Apr 15/Oct 15 – Nov 15
    - Sample frequency: twice a year
    - Gear type: kick net
    - Scoring: Unaveraged 40-point scale
  - F-IBI
    - Sample window: June 1 – mid-Oct
    - Sample frequency: once a year
    - Gear type: Electrofishing anodes
    - Scoring: Averaged 5-point scale

Other IBI Scoring Criteria

- Tidal Chesapeake Bay B-IBI (Versar 2002) (https://data.chesapeakebay.net/LivingResources - thru 2013)
  - Entire Chesapeake Bay Watershed (MD/VA)
  - Metrics dependent on habitat classification (tidal FW – polyhaline)
- Non-tidal Ches. Watershed B-IBI (Buchanan et al. 2011)
- EPA Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999)
- New Jersey F-IBI (EPA Region 2)
  - Regionally-defined metrics
- Pennsylvania B-IBI (PA DEP 2015)
  - Scoring adjusted for stream size
- Tennessee B-IBI (Kerans and Karr 1994; Arnwine and Denton 2001)
  - Regionally-defined metrics
  - Seasonally-defined metrics for specific regions
- …Plus Many More

Example Study – Brookeville, MD

- Pre-Construction Monitoring Study – Reddy Branch (Patuxent R. Tributary)
- Bypass and Mitigation Sites
- Two rounds of sampling (2016-2017)
- MBSS Protocols for Benthics and Fish
- Eastern Piedmont strata (MBSS)
- Silt Loam soil type, 1st & 2nd Order Streams (MCDEP)
- 2016
  - Seven Benthic Locations (3 mainstem, 4 tributaries)
  - Four Fish Locations (2 mainstem, 2 tributaries)
- 2017
  - Five Benthic Locations (3 mainstem, 2 tributaries)
  - Two Fish Locations (2 mainstem)

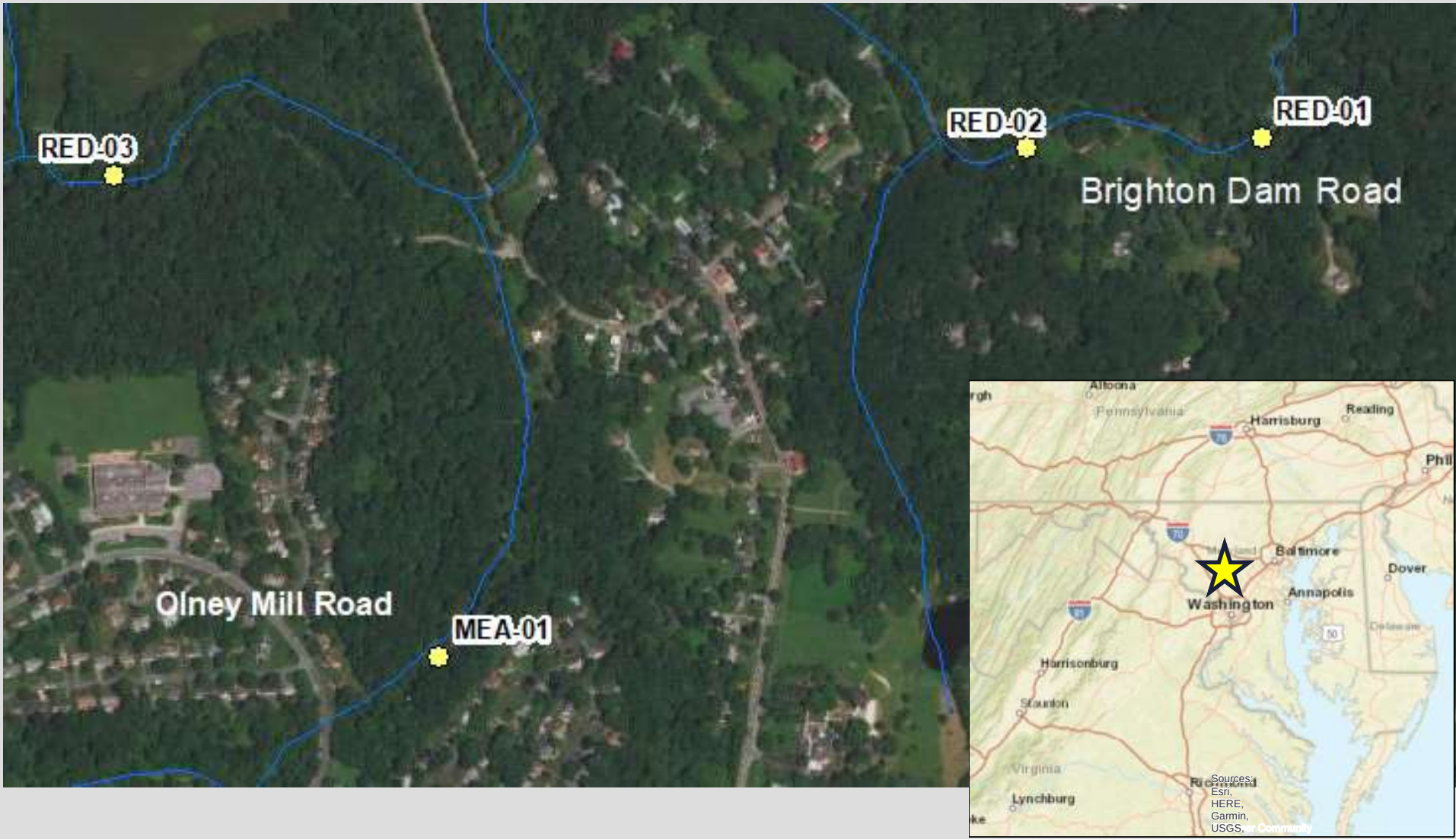

Bypass Site – Meadow Branch


Mitigation Site – Reddy Branch

Example Study – Brookeville, MD

- Field Sampling Methods – Benthics
  - MBSS-style sampling protocols
  - D-frame dip net
  - Target preferred habitats (riffles, woody debris)
  - Collect 20ft^2 from 75-m site
- Field Sampling Methods – Fish
  - MBSS-style sampling protocols
  - 2-pass electrofishing
  - 75-meter site
  - Block nets on either end of site plus tributaries/seeps

Example Study – Brookeville, MD



B-IBI Calculation Comparison

- **MCDEP B-IBI Metrics (scoring not directly comparable to MBSS)**

Metrics	Definition	Information Needed
Taxa Richness	number of unique taxa	Taxa ID
Biotic Index	calculated using taxa tolerance values to determine dominance of pollution-tolerant taxa	MCDEP Tolerance Values
Ratio of scrapers	number of scrapers to the summed total of scrapers and filterers	MCDEP Trophic Level
Proportion of EPT individuals	proportion of Ephemeroptera, mayflies; Plecoptera, stoneflies; Trichoptera, caddisflies (EPT) individuals to the total number of individuals in a sample	Taxa ID, total abundance
Total number of EPT taxa	measure of the richness of generally intolerant (sensitive) insect orders	Taxa ID
Proportion of *Hydropsyche* and *Cheumatopsyche*	total individuals in these genera (i.e., pollution-tolerant caddisflies) divided by the total number of EPT individuals in a sample	Taxa ID, total abundance
Proportion of dominant taxa	most abundant taxon individuals divided by the total number of individuals in the sample	Taxa ID, total abundance
Proportion of shredders	proportion of individuals that chew plant tissue, woody debris, and detrital material	MCDEP Trophic Level

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B-IBI Calculation Comparison

- **MBSS B-IBI Metrics – Eastern Piedmont (scoring not directly comparable to MCDEP)**

Metrics	Definition	Information Needed
Taxa Richness	number of unique taxa	Taxa ID
Total number of EPT taxa	measure of the richness of generally intolerant (sensitive) insect orders	Taxa ID
Number of intolerant urban	number of taxa collected that are intolerant to urban or suburban areas	MDNR Tolerance Values
Number of Ephemeroptera taxa	the number of taxa collected that are mayflies	Taxa ID
Percent Chironomidae	percent of taxa collected that are midges	Taxa ID
Percent clingers	percent of taxa collected that are adapted to living in riffle habitat	MDNR Habit

B-IBI Calculation Comparison

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F-IBI Calculation Comparison

- **MCDEP F-IBI Metrics (scoring may be directly comparable based on Time of Year)**

Metrics	Definition	Information Needed
Taxa Richness	number of unique taxa	Taxa ID
Number of riffle benthic insectivorous individuals	count of individuals that typically feed on benthic insects that can be found in riffle habitat	MCDEP "Riffle Benthic" Label
Number of minnow species	number of unique species in the family Cyprinidae	Taxa ID
Number of intolerant species	number of fish species present that have been categorized as intolerant to environmental pollution	MCDEP Tolerance Level
Number of individuals excluding tolerant species	number of individual fish collected minus the individuals labeled as tolerant species	MCDEP Tolerance Level
Proportion of tolerant individuals	Number of individual fish labeled as tolerant divided by the total number of fish	MCDEP Tolerance Level
Proportion of individuals as omnivores/generalists	number of individuals that are omnivorous or generalists divided by the total number of fish	MCDEP Trophic Level, total abundance
Proportion of individuals as pioneering species	number of individuals that are typically the first species to colonize a new area and are tolerant of environmental changes divided by the total number of fish	MCDEP "Pioneer Status" Label, total abundance
Proportion with diseases/anomalies	number of individuals identified with a disease or other negative physical anomaly divided by the total number of fish	Examine fish for disease/anomalies

F-IBI Calculation Comparison

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F-IBI Calculation Comparison

- **MBSS F-IBI Metrics (scoring may be directly comparable based on Time of Year)**

Metrics	Definition	Information Needed
Percent tolerant species	percent of fish species that are tolerant to environmental impacts	MDNR Tolerance Value
Percent generalists/ omnivores/insectivores	percent of taxa collected that are generalists, omnivores, or insectivores	MDNR Trophic Status
Abundance of fish per square meter	average number of fish per square meter of the study area	# Fish, area (m^2) of study site
Number of benthic species	number of benthic fish species adjusted for catchment size	MDNR “benthic” label, catchment size (acres)
Biomass per square meter	average biomass of fish per square meter study area	Total Fish Biomass, area (m^2) of study site
Percent of lithophilic spawners	percent of fish that live on the tops of plant or sediment substrates and lay eggs over a substrate	MDNR “lithophilic spawner” label

F-IBI Calculation Comparison

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Biomass per square meter	average biomass of fish per square meter study area	Total Fish Biomass, area (m^2) of study site
Percent of lithophilic spawners	percent of fish that live on the tops of plant or sediment substrates and lay eggs over a substrate	MDNR "lithophilic spawner" label

F-IBI Calculation Comparison

F-IBI Metric Comparison – Tolerance Value/Level

MBSS Metrics	Information Needed
Percent tolerant species	MDNR Tolerance Value

Tolerant (T)
Intolerant (I)
No Label (73%)

Sources:
MDNR Data
+12 literature sources
*includes Hall et al. (1993)

MCDEP Metrics	Information Needed
Number of intolerant species	MCDEP Tolerance Level
Number of individuals excluding tolerant species	MCDEP Tolerance Level
Proportion of tolerant individuals	MCDEP Tolerance Level

Tolerant (T)
Intermediate (M)
Intolerant (I)
Null (5%)

Sources:
Cummins (1987)
EPA (1989)
Hall et al. (1993)
DEP 1997 Protocol Authors

F-IBI Calculation Comparison

- F-IBI Metric Comparison – Overlaps?
  - 59 of 61 listed species in MCDEP are included in MBSS
  - 42 species have differing Tolerance Levels
    - Note that MBSS and MCDEP have different Tolerance Level categories
    - 32 species are listed as NOTYPE for MBSS but have TL for MCDEP
    - 10 species are listed as “M” for MCDEP and “I” for MBSS

F-IBI Calculation Comparison

F-IBI Metric Comparison – Trophic Level/FFG

MBSS Metrics	Information Needed
Percent generalists/ omnivores/insectivores	MDNR Trophic Status

Algivore
Filter Feeder
Generalist
Insectivore
Invertivore
Omnivore
Herbivore
Top Predator
None (18%)

Source:
Jenkins and Burkhead (1993)

MCDEP Metrics	Information Needed
Proportion of individuals as omnivores/generalists	MCDEP Trophic Level, total abundance

Algivore
Filter Feeder
Generalist
Insectivore
Invertivore
Omnivore
Herbivore
Top Predator
None (5%)

Sources:
Cummins (1987)
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F-IBI Calculation Comparison

- **F-IBI Metric Comparison – Overlaps?**
  - 59 of 61 listed species in MCDEP are included in MBSS
  - 42 species have differing Tolerance Levels from MBSS

    Note that MBSS and MCDEP have different Tolerance Level categories
    - 32 species are listed as NOTYPE for MBSS but have TL for MCDEP
    - 10 species are listed as “M” for MCDEP and “I” for MBSS
  - **2 species have differing Trophic Status from MBSS**
    - **Creek chubsucker (MBSS = IV; MCDEP = OMN)**
    - **Pearl Dace (MBSS = IV; MCDEP = NULL)**

F-IBI Calculation Comparison

- F-IBI Scoring (scoring may be directly comparable based on TOY)

2016/2017 F-IBI Results				
MCDEP F-IBI Results				
Year	**MEA-01**	**RED-01**	**RED-02**	**RED-03**
2016	3.67 Good	4.56 Excellent	4.56 Excellent	3.44 Good
2017		4.6 Excellent	4.6 Excellent	
MDNR F-IBI Results				
Year	**MEA-01**	**RED-01**	**RED-02**	**RED-03**
2016	3.67 Good	3.67 Good	3.67 Good	3.33 Fair
2017		4.0 Good	3.3 Fair	

IBI Application Comparison

- MCDEP IBI
  - Regionally specific metrics
    - Focus on local species and conditions
    - Developed area-specific protocols and analysis
  - County-level study and management
- MBSS IBI
  - State-wide metrics (freshwater stream habitat)
  - Larger-scale study and management
  - Publicly available information: https://maryland.maps.arcgis.com/apps/webappviewer/index.html?id=30ee9336f8d54e4ebf971c3a1a7576ed
  - Detailed data available upon request
- Other wider-range IBIs → EPA RBP, Chesapeake Bay IBI
  - Multi-state metric application and comparison
  - Suitable for larger projects

IBI Considerations

- Site Background Information
- Study Design and Budget
  - Sampling location
  - Time-of-Year
  - Frequency of sampling
  - B-IBI vs F-IBI vs Both
- Data Evaluation Goals
  - Long-term?
  - Regionally specific?
  - Access to local data for comparison?
- Project Goals
  - Regulation-based?
  - Construction-based?
  - Mitigation work?

Thank You!

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Brookeville Project Status Updates

- Bypass and Mitigation Construction is under way
  - Bridge construction nearly complete
  - Roadway laid out
  - Mitiation site is 50 percent complete
- Overall project completion is estimated for the end of 2022