A Chesapeake Bay Basin-wide Benthic Index of Biotic Integrity

Katie Foreman[1], Claire Buchanan[2], Andrea Nagel[2], Jacqueline Johnson[2], Caroline Wicks[3], Sara Powell[3] Bill Dennison[4]

Regional Monitoring Subcommittee Meeting

Washington, DC

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[1]University of Maryland Center for Environmental Science-Chesapeake Bay Program Office
[2]Interstate Commission on the Potomac River Basin
[3]Ecocheck/NOAA UMCES partnership
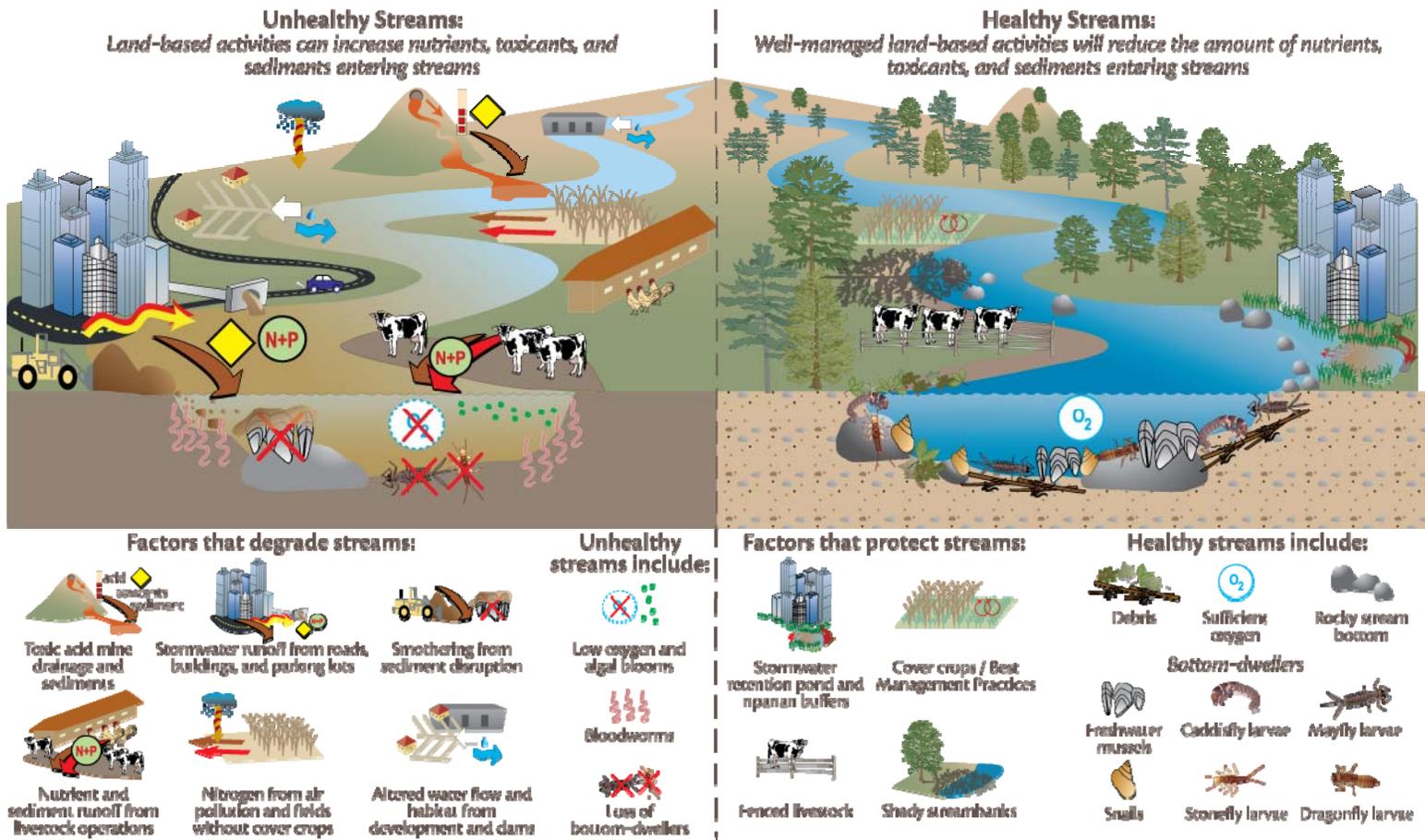[4]University of Maryland Center for Environmental Science

Overview

- Introduction- justification for the B-IBI
- Methodology for the basin-wide B-IBI
- Result and analysis
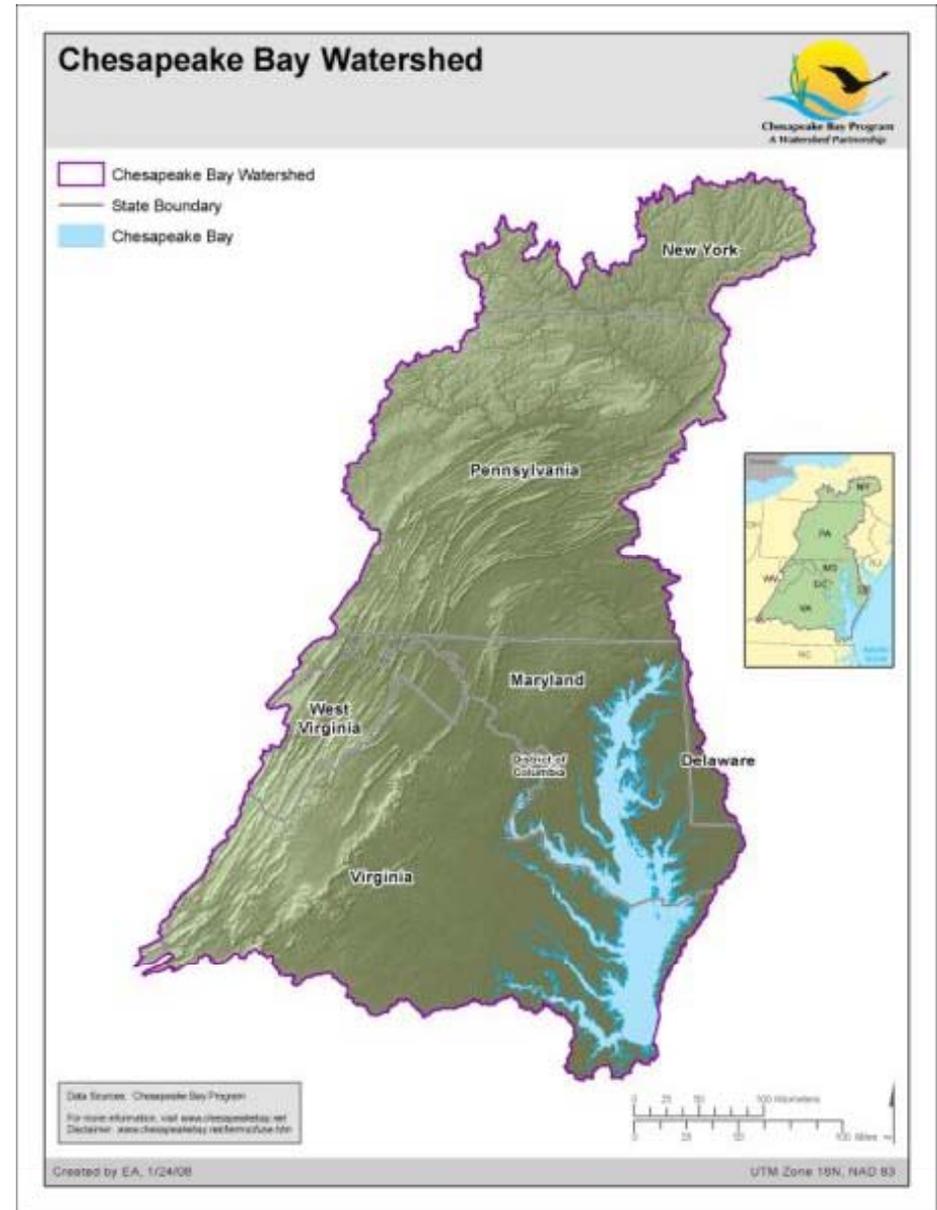- Discussion and next steps

Introduction

Benthic macroinvertebrates are a good indicators of stream health

Introduction

## There is a need for a standardized index

- 64,000 square mile watershed – 6 states, District of Colombia

- Many different methodologies for monitoring and assessment (benthic, fish, habitat, water quality)

- There is a need to evaluate stream health in a uniform manner and in the context of the entire Chesapeake Bay watershed.

Chesapeake Bay Watershed

- Chesapeake Bay Watershed
- State Boundary
- Chesapeake Bay

New York

Pennsylvania

Maryland

West Virginia

District of Columbia

Delaware

Virginia

Introduction
Developing indicators with 303(d) /305(b) data was not sufficient

- ■ Results incomparable:
  - ❑ Different sampling methods, criteria, and scales
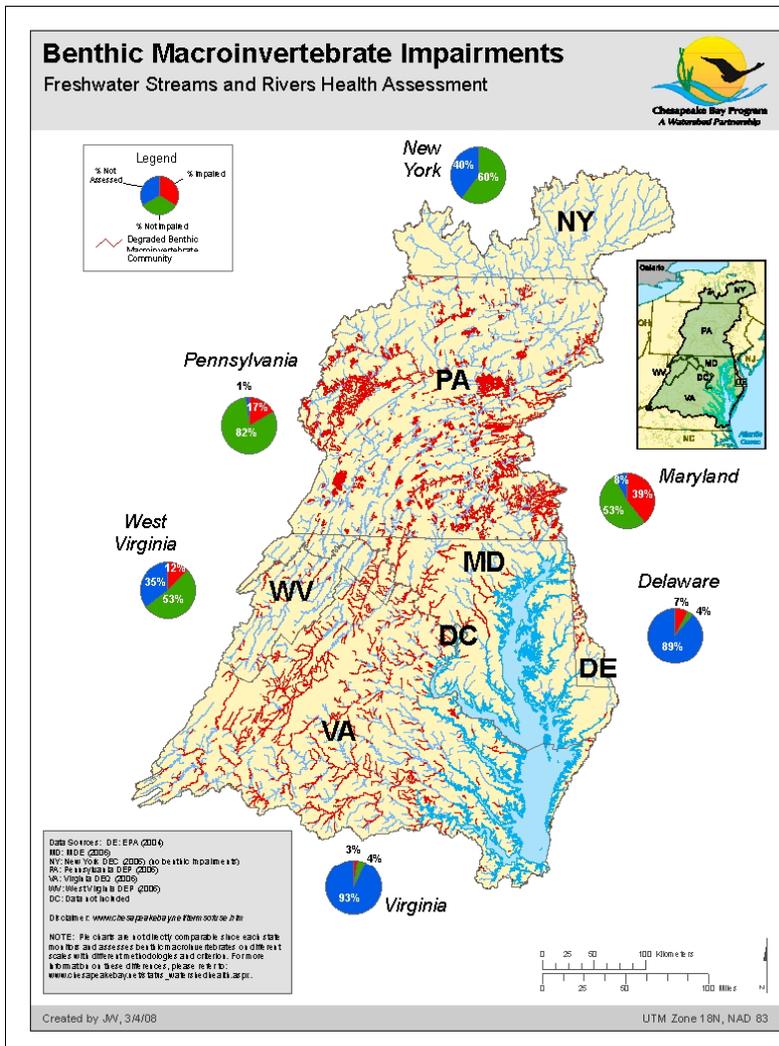
Methodology

A Family Level Regional B-IBI was developed by a team of scientists

- Developed in 2008 by Chesapeake Bay Program's Nontidal Water Quality Workgroup (Federal, State, County, River Basin Commissions scientists)

- Adapted from Astin 2006, 2007. Basin-wide B-IBI for the Potomac River Basin

  - Assumption: A standardized regional B-IBI can be developed from multi-jurisdictional data if family level benthic data collection and RBP protocols are employed by each organization. Differences in sampling size, gear used, etc. are not significant at the family level of assessment.
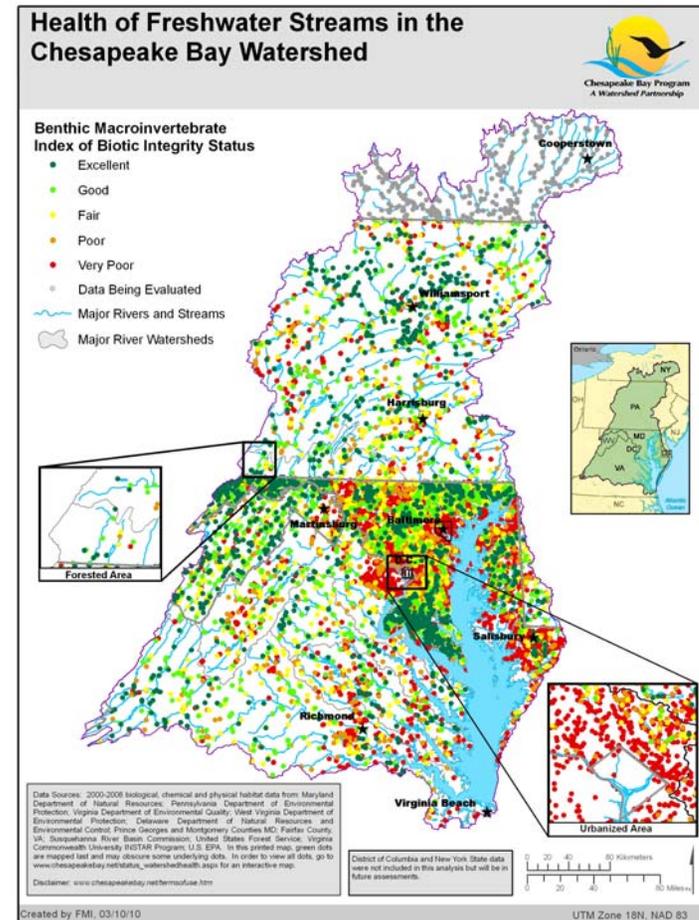
Methodology
There are multiple advantages to using a basin-wide B-IBI

- Larger data sets increase rigor of metric testing and reference site selection

- Broader geographic distribution
  - Less unintentional bias in results

- Consistent scoring across jurisdictional boundaries
  - Inequalities due to different state assessment methods are minimized allowing for regional water quality assessments
  - Tool can be used to help managers target areas for stream restoration and protection

Courtesy of ICPRB, 2007

Methodology
The B-IBI contains many data sources and station locations

STATE	Stations	Sampling Events
Pennsylvania	2331	6177
West Virginia	917	2432
District of Columbia	7	8
Maryland	7856	11888
Delaware	117	1010
Virginia	2194	5483
New York	457	1544

Health of Freshwater Streams in the Chesapeake Bay Watershed

Methodology
Eight steps to calculate the B-IBI

1. SAMPLING
Scientists sampled 3,291 different stream sections during different times of the year from 2000–2006.

2. COLLECTING
Numerous bottom-dwellers are collected from a variety of stream habitats over one stream section.

3. SORTING
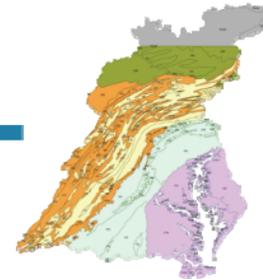Scientists sort the samples and count how many and what kind of bottom-dwellers are in each sample.

Results are used by each Bay state to assess impaired status for regulatory purposes. *This is a different method than used for the new indicator.*

Samples are used by the Chesapeake Bay Program to communicate the health of the bay to citizens.

4. CLASSIFYING
Samples are classified into one of five eco-regions:
- ■ Northern Appalachians
- ■ Highlands
- ■ Valleys
- ■ Piedmont
- ■ Coastal Plain
- ■ Data being evaluated

Example of threshold values for each metric

Metric	Thresholds for Piedmont	
	Best	Worst
% Clinger Taxa	76.8	42.4
% Collector Taxa	77.3	53.5
% Dominant Taxa	47.0	27.9
% may-, stone-, & caddisfly taxa	79.1	49.8
Family-level Hilsenhoff Biotic Index (unitless)	4.39	3.16
# of may-, stone-, & caddisfly taxa (count)	7	5

5. SETTING THRESHOLDS
Within each eco-region, threshold values are determined for key metrics based on a comparison to "best sites." Best and worst quality sites were identified from water quality and habitat quality information.

6. SCORING
The basin-wide Benthic Index of Biotic Integrity scores various abundance, diversity, pollution tolerance, and feeding and habit characteristics of each sample with eco-region-specific thresholds, and provides an overall numeric score for each site. For a list of all scored metrics see References.

7. RANKING
Results are grouped into five qualitative categories based on their comparison to thresholds of the best and worst sites on one of two unitless scales.

	N. Appalachians, Highlands, Valleys, Piedmont	Coastal Plain
Excellent	≥27	≥3.86
Good	23–26.9	3.29–3.85
Fair	19–22.9	2.71–3.28
Poor	14–18.9	2.00–2.70
Very poor	<14	≤2.00

8. MAPPING
Bottom-dweller community health at each location indicates the general health of the stream.

Methodology
Same biometrics used in Astin 2006, 2007

Non-coastal Plain

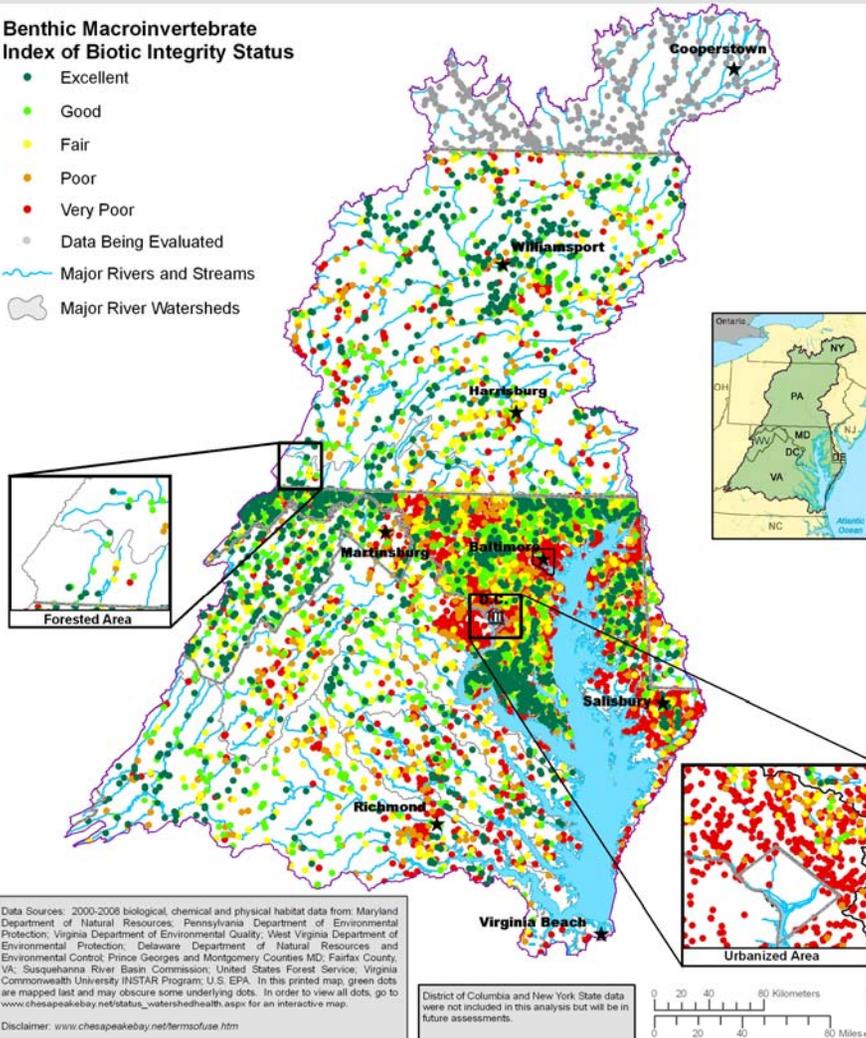| Metric	Description	Measures
EPT Taxa	Number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa	Taxonomic richness
TR	Taxa richness	Taxonomic richness
%EPT	Proportion of EPT individuals	Composition
FBI	Family-level Hilsenhoff Biotic Index: is based on the number of individuals in each tolerance class	Tolerance
%Dom1	Percent contribution of the dominant taxa	Tolerance
%CO	Proportion of collector taxa	Feeding
%CL	Proportion of clinger taxa	Habit

Coastal Plain

Metric	Description	Measures
EPT Taxa	Number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa	Taxonomic richness
TR	Taxa richness	Taxonomic richness
EphemTaxa	Number of Ephemeroptera taxa	Composition
%Ephem	Proportion of Ephemeroptera taxa	Composition
DipteraTaxa	Number of Diptera (true flies) taxa	Composition
SensitiveTaxa	Number of taxa considered intolerant	Tolerance
BecksBI	Beck's Biotic Index: the weighted sum of intolerant taxa	Tolerance

Health of Freshwater Streams in the Chesapeake Bay Watershed

Results

Most of the stream health is characterized as very poor to fair (>half the sites).

Rank	# of sites	Percent
EXCELLENT	1673	16
GOOD	1465	14
FAIR	1518	15
POOR	1518	15
VERY POOR	3941	38
NO SCORE	337	3
TOTAL	10452	100

Results

There is a link between stream health and land-based activities

Potomac River Watershed Example
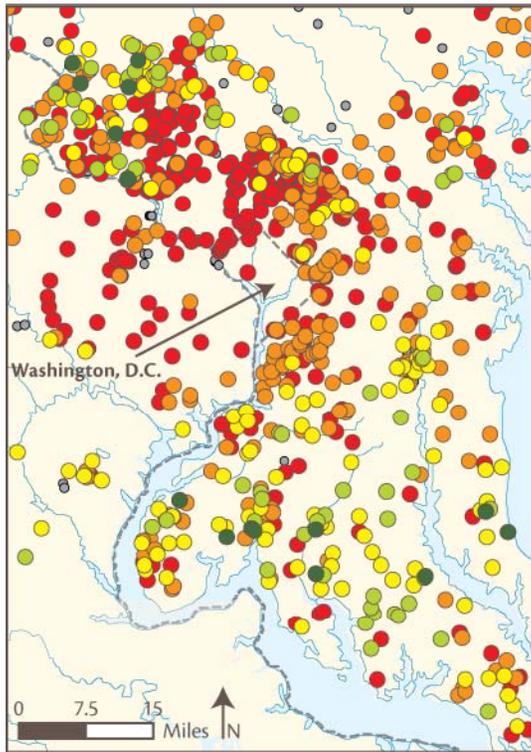
Lower Potomac River Watershed:
Predominately urban

Upper Potomac River Watershed:
Predominately forested

Results

Analyzing only random sites yield information on geographic patterns

Watershed Stream Health
Data Map

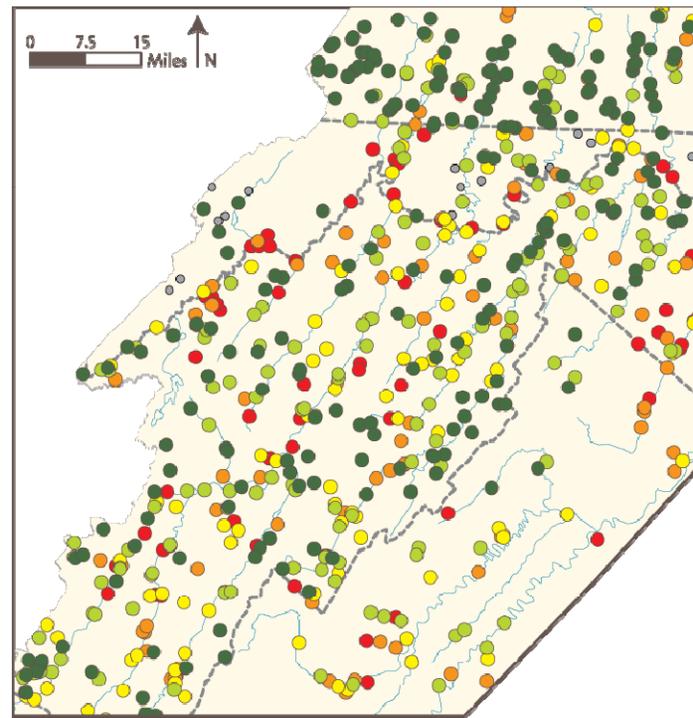| RANKING	# OF SITES
Total	4,245
Excellent	777
Good	689
Fair	714
Poor	668
Very poor	1,397
Data being evaluated	

*In this map, green dots may obscure other underlying dots. In order to view all dots, please click on the 'Interactive Google Map with data overlay' link.
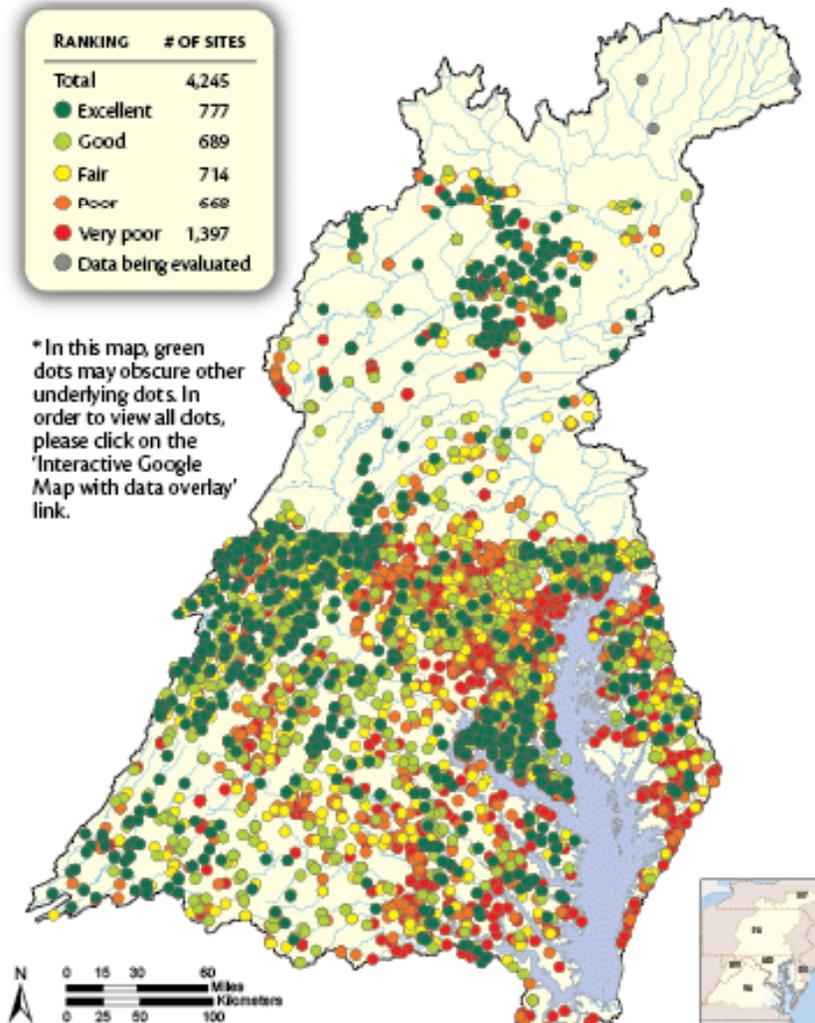
Watershed Stream Health
Average Stream Health

Ranking	Score
Excellent	3.86-5.00
Good	3.29-3.85
Fair	2.71-3.28
Poor	2.01-2.70
Very poor	1.00-2.00

Results

There is a link between stream health and land-based activities

Watershed Stream Health
Percentage of sites meeting healthy criteria

Watershed health
Very poor — Excellent
0 20 40 60 80 100%
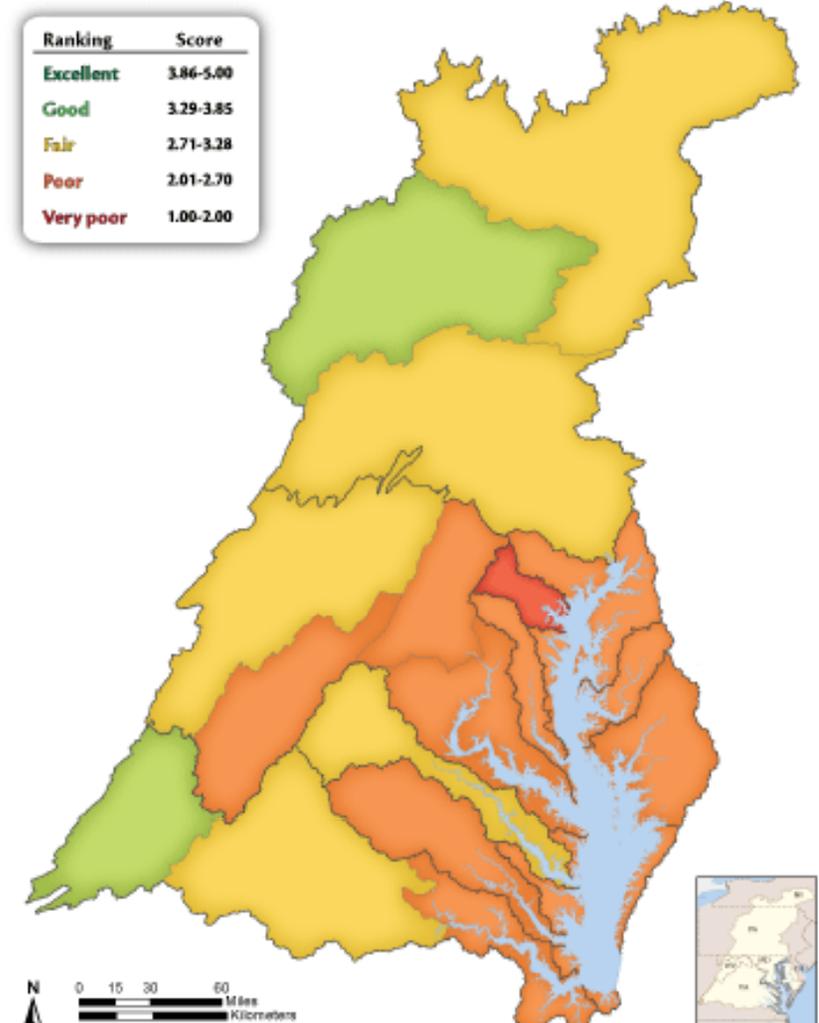
- <u>Unhealthiest streams-</u> urban and agricultural landuse (Patapsco, Back, and Lower Potomac Rivers, Eastern Shore, MD)

- <u>Healthiest streams-</u> natural forested and prairie land cover (Upper reaches of the James and the Potomac River, the West Branch of the Susquehanna River, and parts of the Rappahannock River)

Does non-tidal stream health influence Bay health?
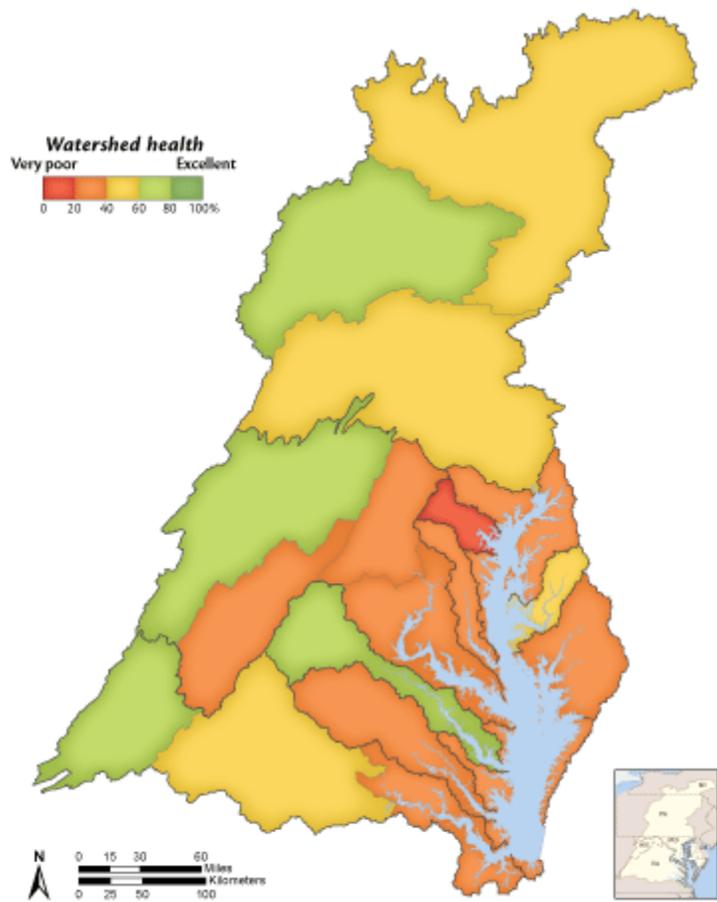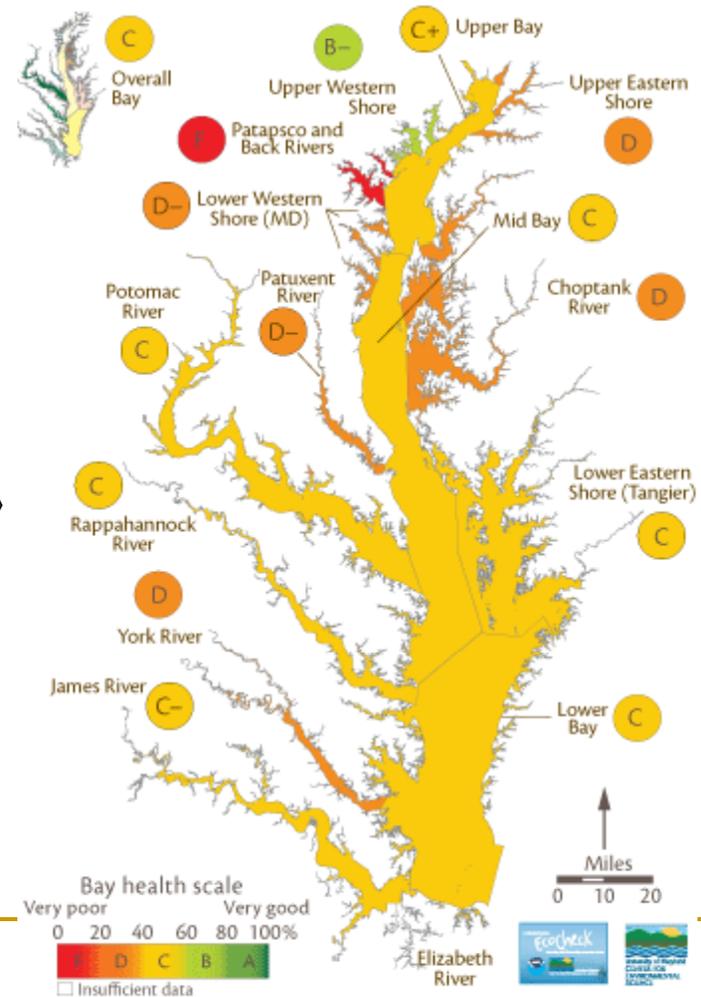
Results

There is a link between stream health and Bay health

Comparison of Bay Health Index Scores to Watershed Stream Health Index Scores

CHESAPEAKE

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Chesapeake Bay - Watershed Stream Health: 2008

Introduction | **Stream Health Map** | **Methods** | **Further Information**

STREAM HEALTH INDICATOR

HEALTH STATUS	# OF SITES
Total	3,291
● Excellent	510
● Good	546
● Fair	603
● Poor	741
● Very poor	891

~ Major streams and rivers
● Data being evaluated
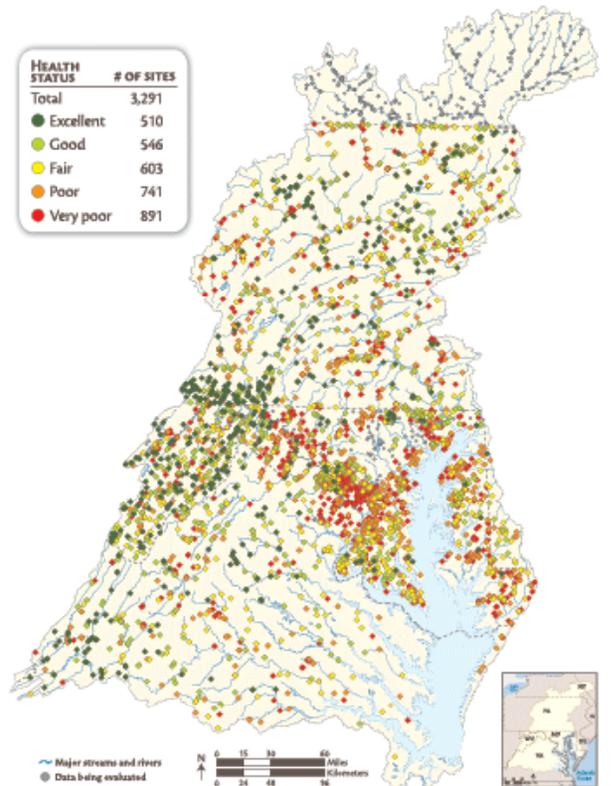
Water quality in Chesapeake Bay is linked to the health of the 64,000 square miles of land and associated streams and rivers that comprise its watershed. Land-based activities (e.g., development, agriculture) can add pollution, such as nutrients and sediment, to local streams and rivers, which ultimately flow into Chesapeake Bay. The new stream health indicator (Benthic Index of Biotic Integrity (BIBI) illustrates this link between stream health and land-based activities. For example, stream health conditions tend to be very poor to fair in areas that have extreme land disturbance, such as new construction, which results in high levels of pollution, altered water flow, and poor quantity and quality of streamside vegetation. Such unhealthy streams tend to be clustered around large urban areas such as metropolitan Washington, D.C. in the lower Potomac River watershed, and in areas that have land-uses dominated by agriculture (e.g., Eastern Shore of Maryland) and mining (e.g., parts of Pennsylvania and West Virginia). In contrast, stream health conditions tend to be good to excellent in areas with little land disturbance that offer low levels of pollution and natural in-stream and streamside habitat. Such healthy areas tend to be clustered around forested and prairie areas, such as the upper Potomac River watershed. The health of streams is variable throughout the Bay watershed and can vary even within a smaller subwatershed (e.g., the Potomac River watershed). Exceptions to these generalizations linking land-based activities to stream health are expected and are due to complexities within the ecosystem. Overall, 1,632 of the sites had very poor or poor health conditions and 1,056 sites had good or excellent conditions, out of a total of 3,291 sampling sites. Developing this indicator provides an important tool for managers and watershed groups who are focusing efforts to restore degraded streams and protect the quality of the healthiest ones.

Interactive Google Map with data overlay

http://www.eco-check.org/reportcard/chesapeake/2009/streamhealth/

Discussion

Improvements to the B-IBI are underway

- 2010: Address issues of concern in methodology
  - Assess the effects of differences in gear types, area sampled, subsample size, seasonality, limestone on B-IBI results
  - Revisit classification scheme, scoring approach and biometrics included
  - Determine the influence of targeted vs. random sampling design

Discussion

Future work will increase the robustness of the B-IBI

- Future: Additional analyzes
  - Further investigate the results in relationship to a healthy "goal"; can all sites be used?
  - Assess effect of local landuse of B-IBI score
  - Determine the ability of B-IBI to assess the effectiveness of restoration and preservation activities over time (trends)
  - Develop a Habitat Quality Index to accompany B-IBI as well as other measures of watershed and stream health
  - Incorporate into management decision support tools and regional assessments (e.g. RMS)
  - Further investigate the link between upstream and downstream stream and estuary health

Conclusion

The B-IBI is an effective tool for stream health assessments

- Standardizes and utilizes multi-jurisdictional data for regional water quality assessments
- Provides a tool for managers to:
  - determine relative health of local and regional waterways
  - investigate the impacts of BMPs and watershed protection measures
  - potentially evaluate trends in stream health
  - identify areas in need of restoration or protection

Acknowledgements

References

- Astin, L.E. 2006. *Data synthesis and bioindicator development for nontidal streams in the interstate Potomac River basin, USA.* Ecological Indicators 6: 664-685.

- Astin, L. E. 2007. *Developing biological indicators from diverse data: The Potomac Basin-wide Index of Benthic Integrity (B-IBI).* Ecological Indicators 7: 895-908.

- Foreman, K., Buchanan C., Nagel, A. 2008. *Development of ecosystem health indexes for nontidal wadeable streams and rivers in the Chesapeake Bay basin.* Report to the Chesapeake Bay Program Non-Tidal Water Quality Workgroup. 12/5/08.