Bioassessment: A Tool for Managing Aquatic Life Uses for Urban Streams

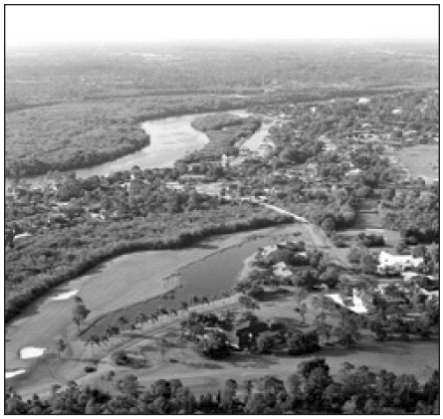
The maintenance of healthy ecosystems in urban watersheds has long been a challenge for water quality managers because of multiple land use activities and cumulative stressors that occur in urban areas. Streams in urban settings are constantly influenced by the activities of densely populated catchments. This relationship, recently termed the "urban stream syndrome," has confounded the ability of environmental managers to accurately characterize the potential of urban streams. There is a critical need to begin looking at all water quality and environmental impacts on a catchment (i.e., watershed) basis and to more effectively involve local catchment stakeholders in decisions relative to determining designated uses and implementing controls.

Urban catchments or watersheds are invariably influenced by chemical input from discharges and runoff, as well as nonchemical stressors such as land development along the stream corridors and within the catchment. It has proven difficult to isolate stressors and describe their influence on urban ecosystems. This, in turn, has made it challenging to design assessment approaches that lead to effective restoration and protection plans for urban areas. Urban ecosystem assessors, therefore, must develop measures of urbanization and appropriate response indicators that consistently describe the major disturbances in the urban landscape.

Developing Benchmarks

Bioassessment—the evaluation of a waterbody using biological surveys and other direct measurements of the resident biota in surface waters—has long been considered the most appropriate means of evaluating the health of an ecosystem for supporting aquatic life. Heavily urbanized catchments present a problem for facilities and water quality managers struggling to balance the socioeconomic needs of urban areas with aquatic life use standards. The challenges include defining an appropriate benchmark for expected biological conditions under a range of urban intensities, and diagnosing specific stressors or partitioning the effects of multiple stressors for management decisions regarding the protection and restoration of the aquatic resource in urbanized catchments. Most standards either do not recognize the limitations on achievable biological condition in urban areas, or set attainment goals too low by not addressing biological potential for improvement.

This research addresses the utility of bioassessment for managing aquatic life uses in urban and/or urbanizing catchments and specifically defines a process for developing viable biological benchmarks for aquatic life use in urban catchments.



This bioassessment tool enables users to identify targets for management activity to improve ecological condition of aquatic life uses in urban areas.

BENEFITS

- Defines a nationally applicable measure of urbanization and a process for developing urban-specific biological indicators.
- Establishes empirically defined and realistic aquatic life use benchmarks for urban areas.
- Provides dischargers with a tool to address the relative aquatic life use condition of receiving waters in urban areas.
- Provides municipalities and agencies with a tool to prioritize waterbodies for management action in urban catchments.

RELATED PRODUCTS

Distinguishing the Relative Influence of Habitat and Water Quality on Aquatic Biota (98WSM1)

Physical Effects of Wet Weather Flows on Aquatic Habitats (00WSM4)

Workshop on Partitioning Multiple Stressors: Approaches, Information Gaps, Tools (03ECO1)

Protocols for Studying Wet Weather Impacts and Urbanization Patterns (03WSM3)

RELATED ONGOING RESEARCH

Linking BMP Systems Performance to Receiving Water Protection to Improve BMP Selection and Design (SW1R06)

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EXECUTIVE SUMMARY

The research was conducted across three distinct climatic regions and describes a three-step process: 1) developing primary and alternative urbanization gradients, using simple landscape and socio-economic measures of urbanization and other data and resources, as available; 2) assembling an appropriate urban biological index, using a subset of commonly measured biological metrics; and 3) defining biological potential, using quantile regression, that describes the highest biological condition currently achieved along the urban gradient.

What this Research Digest Provides

- An assessment tool for characterizing stressor (Step 1) and biological (Step 2) gradients and defining biological potential (Step 3) of urban streams in a context relevant to aquatic life uses and that is applicable in different regions of the country
- Guidance on developing and calibrating a scientifically valid biological potential model for restoration goals
- Supplemental tools, such as a comprehensive scientific literature database and an innovative Flow Time Series Estimation (FTSE software package; Tetra Tech, Inc., 2006)

Benefits and Applications of the Bioassessment Tool

- Describes a nationally applicable measure of urbanization and its effect on aquatic systems
- Outlines a process for developing urban-specific biological indicators
- Establishes empirically defined and realistic aquatic life use benchmarks for urban watersheds
- Provides dischargers with a tool to address the relative aquatic life condition of receiving waters in urban areas
- Equips municipalities and agencies with a tool to prioritize waterbodies for management action in urban catchments
- Defines a process for identifying likely targets for management decisions to improve ecological condition of aquatic life uses in urban areas

FAQs for WERF Subscribers

Q: *What are the uses of the Research Digest and the accompanying tools?*
A: Users can develop project guidance for developing realistic criteria for aquatic life uses in urban watersheds. This guidance can be used by agencies to establish restoration goals.

Q: *How can this product facilitate cooperation among watershed stakeholders?*
A: This product can be used to demonstrate the merits of bioassessment and the need to collect necessary data. These data can then be applied using the methods described in the report to develop region-specific aquatic life use criteria relevant to urbanized watersheds.

Q: *What are the benefits of bioassessment compared to chemical concentration-only based approaches for assessing water quality?*
A: Bioassessment is capable of detecting multiple stressors (chemical and nonchemical) in a more holistic manner than chemistry measurements (which can be highly variable both spatially and temporally). The biological potential and outlier analysis methods presented in Section 2.3 of the Research Digest provide a stepping stone to identifying the individual stressors affecting urban systems.

Q: *If the indicators (biological and urban) provided in this digest do not seem applicable to a subscriber's region, will the Research Digest still be useful?*
A: Yes. The most important lesson is the process for characterizing a relevant urban gradient or developing realistic biological endpoints in urban settings rather than specific attributes. In many areas, a biological index has been calibrated and validated, and can be used in the process described here.

Q: *What is the value of the literature database provided as a supplement to the Research Digest?*
A: This database is a comprehensive review of the most relevant scientific literature regarding the use of biological indicators of water quality, particularly focused on urbanization.

Q: *What benefit does the Flow Time Series Estimation Tool provide as a supplement to the Research Digest?*
A: The FTSE tool provides a powerful means for predicting hydrologic behavior for any ungauged stream site.

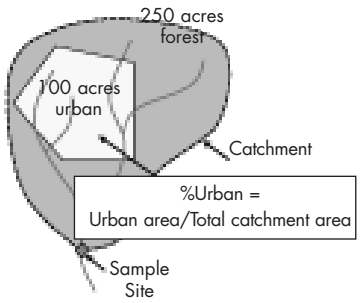
Stepwise Process	Technical Procedures	Comments/Rationale

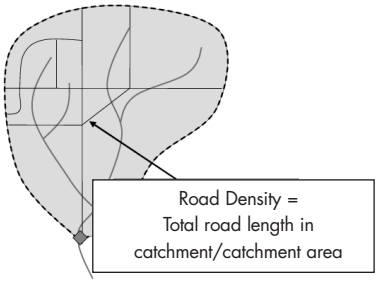
Step 1

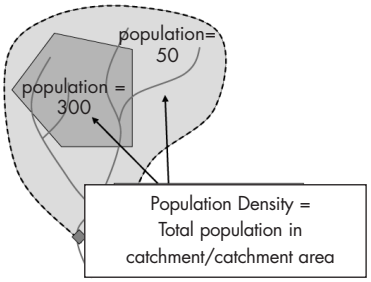
Build urban gradient of stressors.

Calculate primary gradient — average of: a) %urban LULC, b) road density, and c) population density by catchment.

Alternative gradients — supplemental to primary, include chemistry and/or hydrology.







Step 2

Develop urban ***biological index*** that responds to urban gradient.

Calculate individual metrics (EPT richness, filterer richness, %clinger), scale, and average to arrive at final biological index.

The biological indicator developed here has been specifically designed for urban systems. In some regions, however, it is possible that an already existing state-developed index may be better suited for evaluating urban ecosystems.

EPT richness = Total # of taxa in the classes Ephemeroptera (Mayflies), Piecoptera (Stoneflies), and Trichoptera (Caddisflies).

Filterer richness — Total # of taxa in the filterer feeding group. These organisms feed by filtering fine particles of food from the water.

%clinger — Percentage of organisms in a sample that cling to rocks and other stream substrates. These organisms are relatively sensitive.

Step 3

Define urban **biological potential** along urban gradient.

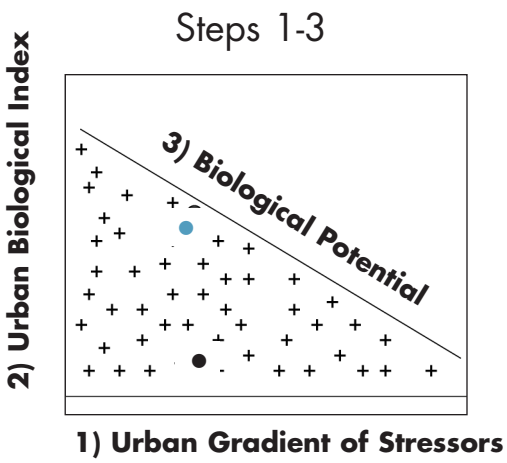
Define upper boundary of wedge-shaped relationship of biological indicator to primary gradient.

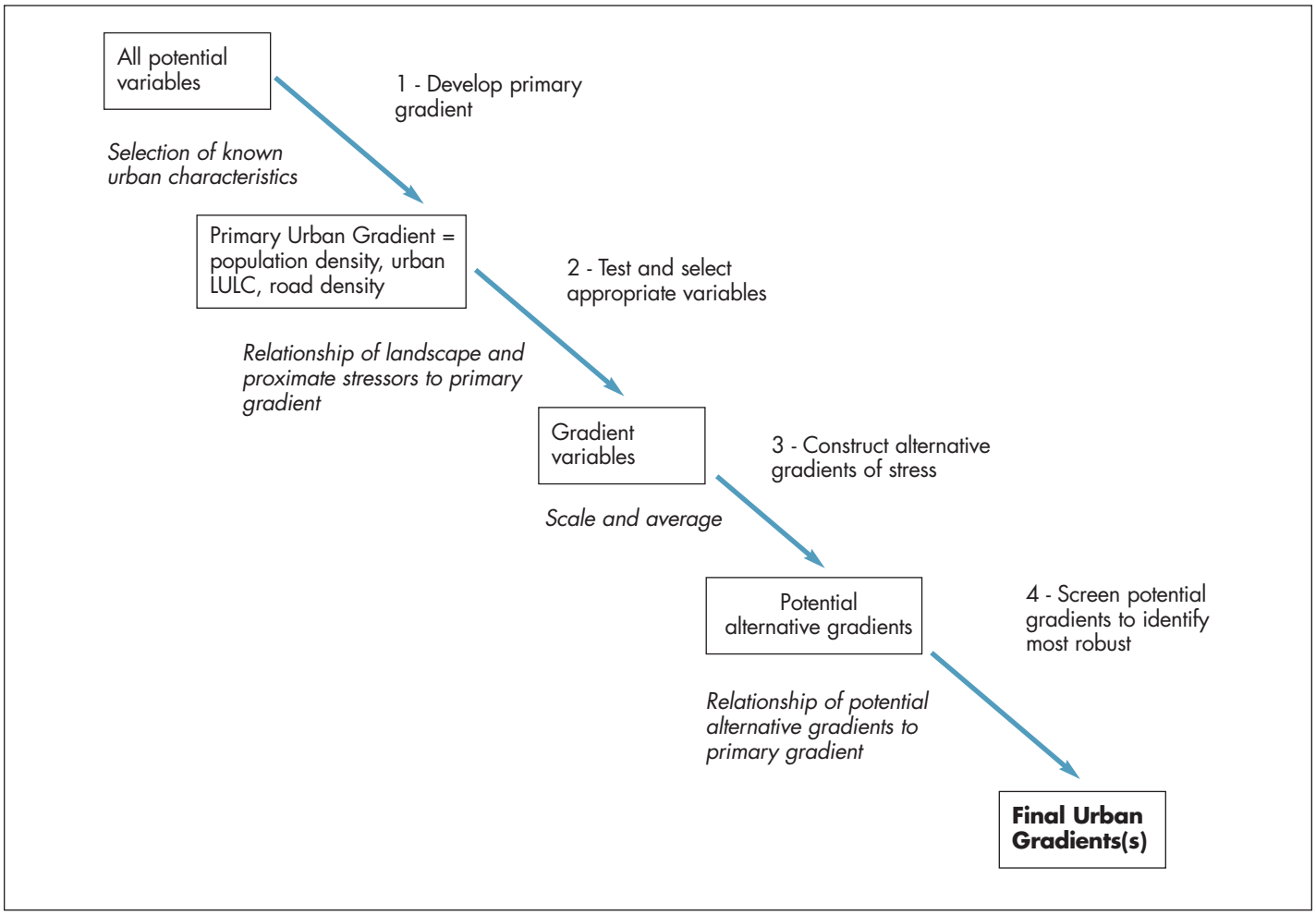
Outlier analysis to assess why some sites:

- meet or exceed their potential,
- while others are below potential.

This final analytical step defines the biological potential along the primary gradient of urban stress.

Establishes a reasonable benchmark for all urban streams.





The Process for Building Primary and Alternative Urban Gradients
LULC = land use/land cover

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CONTRACTOR

Michael T. Barbour, Ph.D.
Tetra Tech, Inc.

PROJECT TEAM

David W. Bressler
Michael J. Paul, Ph.D.
Tetra Tech, Inc.

Ed Rankin
Midwest Biodiversity Institute

Alison Purcell O'Dowd
Vincent H. Resh, Ph.D.
University of California, Berkeley

PROJECT SUBCOMMITTEE

Michael Bastian (Chair)
CH2M HILL

Scott Dyer, Ph.D.
The Procter & Gamble Company

Irwin Polls
Formerly of Metropolitan Water Reclamation District of Chicago

Robin Reash
American Electrical Power Corporation

Paul Stacey
Connecticut Department of Environmental Protection

William Swietlik
U.S. Environmental Protection Agency

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