

GIS-Based Analysis of Environmental Data for Regional Watershed Risk Assessment: Recent Advancements in Ohio



Questions/comments?
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OVERVIEW

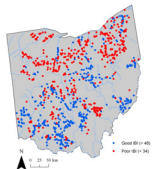
Application to Ohio Database (2000-2008) :

- Current study evaluated effects of multiple stressors in Ohio (USA) watersheds, building and improving upon previous studies utilizing a GIS-based weight-of-evidence and logistic regression approach (Ohio studies: Kapo et al. 2008 and 2006 ; ArcSDM for ArcGIS: Sawatzky et al. 2009).
- Updated comprehensive database (~1900 catchments) of biological, habitat, water chemistry, contaminant mixture toxicity, and landscape variables was utilized. See the Dyer et al., Holmes et al., Faggiano et al., and Posthuma et al. posters in the Ohio poster group for data and variable selection details.
- This study evaluated stressor-response relationships at the 1) statewide, 2) ecoregion (Eastern Cornbelt Plains, Erie Drift Plain, and Western Allegheny Plateau, and 3) urban land use-specific level to develop stressor hypotheses.

MATERIALS & METHODS

DATA

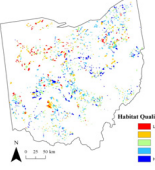
Response variable: Biological training point datasets



A training dataset of "impacted" sites based on biomonitoring data (Ohio EPA fish index of biotic integrity score of "fair to poor condition") was utilized for the analysis (red sites at left).

An additional training dataset of sites scored as "very good" (Ohio EPA) was also utilized to adjust for sampling bias when delineating biological response.

Predictor variables: catchment-level rasters (water chemistry, habitat, toxicity, and landscape factors)



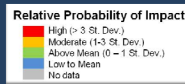
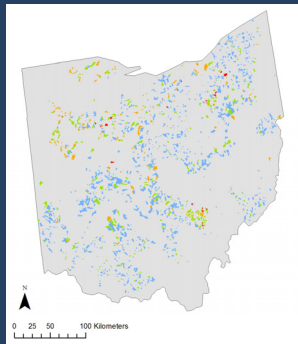
Catchment-level habitat quality categorized into 5 classes (based on classification of raw monitoring data by Jenk's Natural Breaks).

ABSTRACT

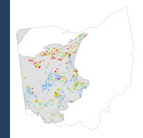
Large-scale (regional) watershed management remains a challenge due to uncertainty in stressor identification and prioritization in multi-stressor scenarios. This study expands and improves upon earlier applications of a GIS-based weights-of-evidence and weighted logistic regression approach for Ohio using the most recent database of biological, physical habitat, chemical, toxicological, and landscape factors. Catchment-level stressors and related probability maps for biological impairment yielded by the analysis highlighted the strong influence of habitat and water chemistry on overall fish community condition and provided output relevant to both current and future management strategies. Additionally, application of the analysis by ecoregion and land use provided stressor-response hypothesis for specific geographic and landscape scenarios. The application of data analysis techniques to archival data resources generates screening-level hypotheses for probable sources of ecological impact, with the practical benefit of utilizing existing data resources in order to optimize future data collection and research efforts.

RESULTS (I): Impact Probability Maps

Statewide Model



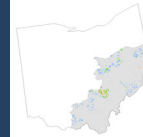
Eastern Cornbelt Plains Model



Erie Drift Plain Model



Western Allegheny Plateau Model



- WLR impact probability models based on quantitative stressor-response associations using binary stressor maps resulting from the WOE analysis.

- Delineated "high risk" catchments (red) for the occurrence of poor quality IBI based on stressor combinations present.

- WLR coefficients indicate the relative influence of various stressor types (increase in odds of site impact).

- Model fit evaluation (% successful prediction of observed data):

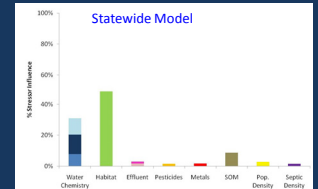
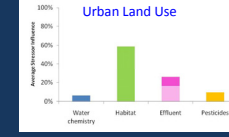
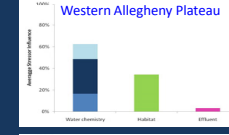
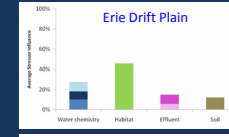
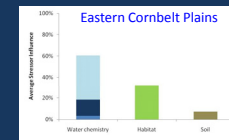
- Statewide model: 75%
- Eastern Cornbelt Plains: 66%
- Erie Drift Plain: 71%
- Western Allegheny Plateau: 69%
- Urban Land Use: 71%

Urban Land Use* Model



* Catchments with >20% urban cover (NASS 2007 Cropland Data - see Holmes et al. poster for details)

RESULTS (II): Stressor Influence



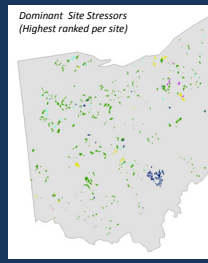
Charts: Overall average per-site stressor influence, shown by stressor category for each model. Results are based on the average (per-site) % contribution of each stressor variable to the odds of fish community impairment at a given site.

Variation in the influence of water chemistry variables is evident when comparing ecoregions.

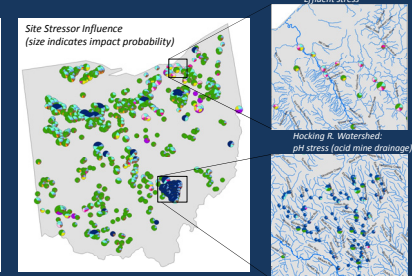
MODEL VARIABLES:

- Nutrients (PCA)
- pH/Total P (PCA)
- Conductivity (PCA)
- Habitat
- % Effluent
- Effluent toxicity
- Pesticide toxicity
- Metals toxicity
- Soil organic matter (SOM)
- Population density
- Septic system density

Below: Map of catchments with predicted impacts, shown by dominant (#1 ranked) site stressor (statewide model).



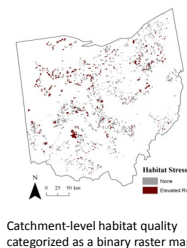
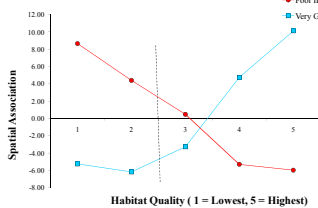
Below: Stressor influence (statewide) for sites with predicted impacts, presented utilizing a pie chart map display similar to the approach of De Zwart et al. (EPC pies).



ANALYSIS

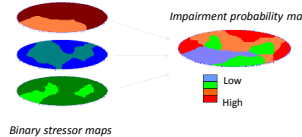
Weights of Evidence Analysis

- Spatial association of training site occurrence calculated over each 5-class stressor gradient
- Inverse trend indicates biological response to stressor.
- [1.95] = ~95% confidence.
- WOE used to select potential stressors and create optimized binary classifications (dotted line)



Weighted Logistic Regression

Binary map patterns statistically integrated by WLR analysis to calculate the relative probability of impaired site occurrence over the study area based on unique combinations of binary stressor variables (conceptual illustration at left).



CONCLUSIONS

- Significant spatial associations were delineated by the WOE/WLR approach between a variety of stressors and fish community condition (IBI) for Ohio in a variety of specific geographic scenarios. Models may be useful for quantitative interpretation existing conditions and/or the development of prognostic hypotheses to guide and assess management strategies
- This study evaluated moderately to severely impacted sites ("fair" to "poor" Ohio EPA classification). Modeled impact probability was positively correlated with the severity of impact.
- Habitat degradation was consistently a significant source of stress for sites with predicted impact in all models, with urban catchments having the highest amount of habitat stress. At the statewide level, habitat stress was the dominant stressor at 66% of the sites with predicted impact.
- Analysis by ecoregion and urban land use provided information specific to the characteristics of these geographic subsets of data, allowing for enhanced interpretation of analysis results.