# Using biological and habitat metrics to determine the effectiveness of TMDLs: A Case Study

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## Goals and Objectives

### Goals

Summarize and link watershed-based cleanup efforts to responses in biological communities (macroinvertebrate and periphyton) and habitat.

### Objectives

- Collect baseline macroinvertebrate, periphyton, habitat, and water quality data for the characterization of most and least disturbed monitoring stations.
- Develop a method for estimating human disturbance based on parcel-scale land uses within watershed.
- Use baseline data to develop watershed-based biological indicator metrics and a biotic integrity model.

## Methods

### Data Collection

***Biological and habitat assessments*** were conducted in 2009 and 2010 at nine stations in the Deschutes River Watershed , WA to establish and evaluate baseline conditions. Post total maximum daily load (TMDL) data will be collected in 2012 and 2013 and again in 2019 to evaluate biological response to TMDL implementation (Collyard and Von Prause, 2010).

### Land Use Analysis

***Landscape Development Intensity Index*** was used to evaluate and rank land use between sampling stations and to identify the least and most disturbed sample locations. Biological and habitat data collected from sample stations with Landscape Development Intensity analysis (LDI) scores of <2 were used to test biological metrics for responsiveness and to build multi-metric models (Figures 1 & 2).

***Agglomerative hierarchical clustering analysis*** *(Struyf et al., 1996)* using Bray Curtis similarity measures was performed on log-transformed biological data to identify and categorize stations based on macroinvertebrate and periphyton species composition (Figure 3).

### Indices of Biotic Integrity (IBI)

***Watershed-based IBIs*** were developed by evaluating biological metrics that respond to variations between the most and least disturbed sites. Metrics that demonstrated a significant ($p < 0.05$) discrimination between site groupings were used in the calculation of IBI scores (Figure 4).

***TITAN threshold indicators analysis*** was used to identify potential biological threshold responses in relation to LDI scores and identify species that decline in abundance relative to increased land use disturbance (Baker and King, 2011). Species will be used to develop indicator metrics for establishing biological targets to determine effectiveness of TMDL implementation (Figure 5).

## Calculation of Landscape Development Intensity Index


**Figure 2.** Weighted LDI scores within treatment areas were calculated by summing the area of individual land parcels within a 100 m buffer of stream segments and multiplying it by the corresponding LDI coefficient (Brown and Vivas, 2005).

## Deschutes River Watershed Landuse Analysis

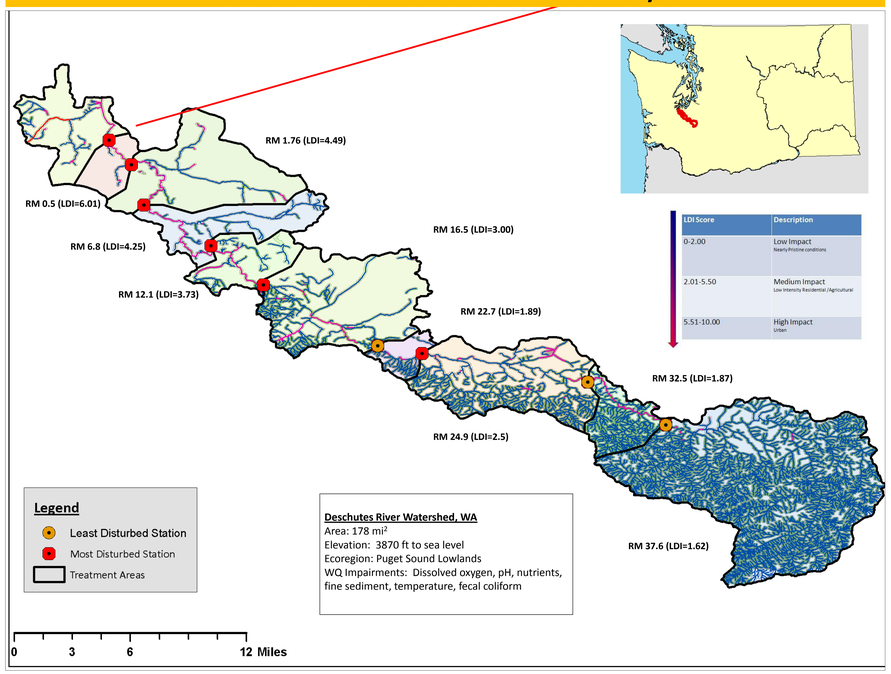


Figure 1. Land use analysis of the Deschutes River Watershed using the Landscape Development Intensity Index (Brown and Vivas, 2005). Least and most disturbed monitoring stations used in IBI index development were selected based on LDI scores.

## Hierarchical Clustering

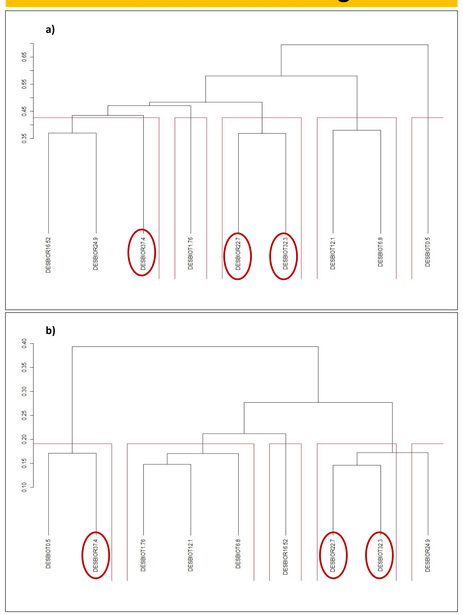


**Figure 3.** Results from the hierarchical clustering analysis for macroinvertebrates (a) and periphyton (b). Dendrograms represent similarity between sample sites based on species composition. Stations with circles indicated least disturbed stations identified using weighted LDI values.

## IBI Development

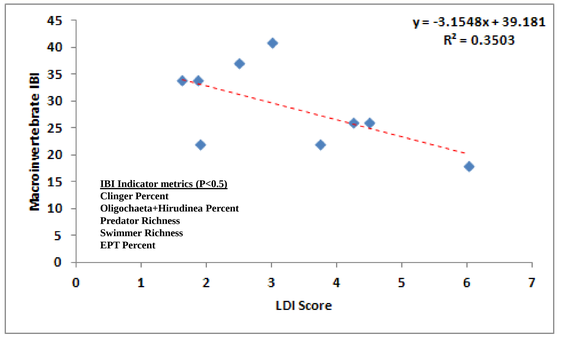


**Figure 4.** T-testing of macroinvertebrate response metrics provided 5 metrics that demonstrated significant ($p<0.05$) discrimination between the least and most disturbed sites. These metrics were used to develop a watershed based IBI for macroinvertebrates. Sample station IBI scores indicated a significant correlation with LDI scores.

## TITAN Analysis

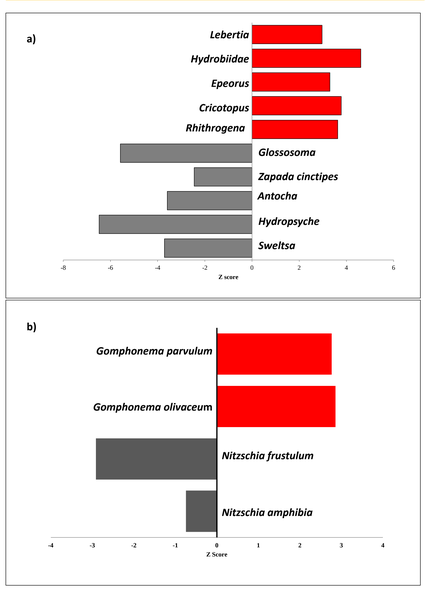


**Figure 5.** Results of macroinvertebrate (a) and periphyton (b) groupings produced by the TITIAN analysis. Taxa with negative Z scores indicate low occurrences of relative abundance in relation to land use disturbance while corresponding species with positive Z score indicate high occurrence of relative abundance.

## Metric Development

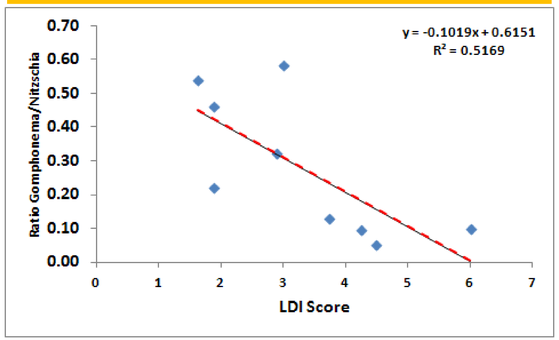


**Figure 6.** TITAN threshold analysis identified two periphyton species that had a strong response to changes in LDI values. A ratio of *Gomphonema* to *Nitzschia* was used as a response metric which was then correlated to LDI scores.

## Conclusions

- Clustering results moderately correspond with the LDI analysis for defining least and most disturbed stations; however, strength of relationship needs to be evaluated further (Figures 1-3).
- Evaluation of metric responsiveness to the least and most disturbed stations produced 5 significant biological response metrics for macroinvertebrates (Figure 4).
- No significant response metrics were identified for periphyton.
- TITAN threshold indicator analysis identified positive and negative thresholds of relative abundance for several macroinvertebrate and two periphyton taxa in response to variations in LDI scores (Figure 5).
- Results for the periphyton TITAN analysis indicate a negative relationship between the ratio of *Gomphonema* to *Nitzschia* with increasing LDI scores (Figure 6).

## Next Steps

- Further strengthen the watershed LDI by incorporating habitat parameters such as riparian condition, stream-channel modification, and road density.
- Continue to identify key sensitive taxa affected by land-use disturbance and develop appropriate response metrics.
- Develop relationships between response metrics and source land-use type.
- Develop methods to account for the effect of natural variations in biotic communities.
- Incorporate BMPs into LDI scoring procedure and link to changes in biological and habitat conditions over time.

## References

Baker, M.E., R.S. King, 2011. A new method for detecting and interpreting biodiversity and ecological community thresholds. Methods in Ecology and Evolution 2010, 1, 25-37.

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Struyf, A., M. Hubert, and P. Rousseeuw, 1996. Clustering in an Object-Oriented Environment. Journal of Statistical Software 1. www.jstatsoft.org/v01/i04.

This poster will be available on the WA State Department of Ecology, Effectiveness Monitoring Web site: http://www.ecy.wa.gov/programs/eap/tem/index.html or directly at www.ecy.wa.gov/biblio/1203133.html.

It was presented at the National Water Quality Monitoring Council Conference in Portland Oregon, May 1-4, 2012. For more information, contact Scott Collyard at 360-407-6455 or scott.collyard@ecy.wa.gov.

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