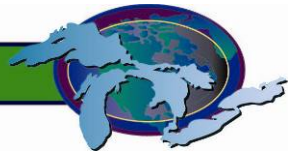

Inland Water Quality Index

Overall Assessment

Status: Fair

Trend: Undetermined

Rationale: The average Water Quality Index (WQI) value for 95 Canadian tributaries to the Great Lakes was 70/100.

Lake-by-Lake Assessment

Lake Superior

Status: Good

Trend: Undetermined

Rationale: Average WQI value for 9 tributaries was 80/100.

Lake Michigan

Status: Undetermined

Trend: Undetermined

Lake Huron

Status: Good

Trend: Undetermined

Rationale: Average WQI value for 29 tributaries was 83/100.

Lake Erie

Status: Fair

Trend: Undetermined

Rationale: Average WQI value for 18 tributaries was 45/100.

Lake Ontario

Status: Fair

Trend: Undetermined

Rationale: Average WQI value for 33 tributaries was 66/100.

Other Spatial Scales

St. Lawrence River

Status: Good

Trend: Undetermined

Rationale: Average WQI value for 6 tributaries was 81/100.

Purpose

- To communicate the overall water quality status of Great Lakes tributaries with the Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI).
- To infer the influence of land use activities on the surface water quality of streams in the Great Lakes basin.

- To provide context for the effects of tributary water quality on Great Lakes aquatic ecosystems, particularly the nearshore.

Ecosystem Objective

This indicator supports the objective of ensuring that surface waters in the Great Lakes basin are of a quality that is protective of aquatic life.

Ecological Condition

Measure

The WQI (CCME 2011*b*) provides a mathematical framework for synthesizing water quality monitoring results for multiple samples and parameters into a single value representing overall water quality conditions at a given site. The WQI is based on three measures (factors) of compliance with water quality criteria (guidelines and objectives) for the protection of aquatic life. The first factor (scope) measures the percentage of the number of parameters that comply with water quality criteria. The second factor (frequency) measures the percentage of individual water quality tests that comply with criteria. The third factor (magnitude) measures by how much criteria are exceeded. The three factors are combined into a single unitless value between 0 and 100 where higher numbers indicate better water quality. Computation of the WQI is described in detail in CCME (2001*a*,*b*). The sensitivity of the WQI to user-driven variations in formulation and application has been studied by Khan et al. (2004), Davies (2006), Gartner Lee Limited (2006), Statistics Canada (2007), de Rosemond et al. (2009), and Kilgour and Associates Limited (2009).

For this SOLEC indicator, WQI values were calculated using measurements of total concentrations of eight water quality parameters: ammonia (unionized), chloride, copper, iron, nitrate, nitrite, phosphorus and zinc (Table 1). Water quality data (2002-2009) were acquired from the Ontario Provincial Water Quality Monitoring Network (OMOE 2011). The most downstream monitoring site on each stream draining to the Great Lakes was selected, including tributaries to the Great Lake connecting channels and the St. Lawrence River. The most recent four years of results were used for the index calculations. For most (83/95) sites the 2006-2009 data were used. The 2002-2005 data were used for some (12/95) sites that were monitored infrequently (< 10 samples) between 2006 and 2009. Sources of the water quality criteria include CCME water quality guidelines for the protection of aquatic life (CCME 2011*a*) and the Ontario interim provincial water quality objective for total phosphorus (OMOE 1994).

Endpoint

The WQI calculates a value between 0 and 100 for each monitoring site. The developers of the WQI recommended fitting the calculated values into five categories that describe water quality conditions: Excellent (95-100); Good (80-94); Fair (65-79); Marginal (45-64); and Poor (0-44). The category range describes sites where the water quality complies with water quality criteria virtually all of the time (Excellent) or hardly any of the time (Poor).

For this SOLEC indicator, the five original categories developed by CCME were dissolved into three descriptive categories: Good (80-100), Fair (45-79) and Poor (0-44).

Background

The Provincial Water Quality Monitoring Network (PWQMN) collects stream water quality information from hundreds of sites across Ontario in partnership with Ontario's Conservation Authorities. Most of these sites are located in the Great Lakes basin, and many are located at or near the outlets of tributaries to the Great Lakes. Stream water samples from each site are collected approximately monthly and delivered to the Ontario Ministry of the Environment's laboratory where they are tested using consistent analytical methods for a consistent set of water quality parameters. Parameters are selected to indicate the influence of land used activities on stream water quality. For example, chloride is measured as an indicator of the influence of salt loading from winter de-icing. Field measurements including water temperature and pH are also taken at the time of sample collection using portable water quality meters. A complete set of water quality data (2002-2009) for all stream monitoring sites is available on the Ontario Ministry of the Environment public website (OMOE 2011).

Status of Water Quality in Great Lakes Tributaries

The overall water quality status of tributaries to the Great Lakes can be described as Fair (WQI_{avg}=70, n=95). 39%, 48% and 13% were categorized as having Good, Fair and Poor water quality, respectively (Figures 1 and 2).

Good water quality was found in certain tributaries to Lakes Superior, Huron and Ontario and the St. Lawrence River. Poor water quality was found in certain tributaries to Lakes Erie and Ontario. The WQI values at individual sites ranged from 7.6 (Sturgeon River, Lake Erie) to 100 (Montreal and Michipicoten Rivers, Lake Superior; Mississagi and Serpent Rivers, Lake Huron).

On a lake-by-lake basis (Figure 2), tributaries to Lake Superior (WQI_{avg}=80, n=9), Lake Huron (WQI_{avg}=83, n=29) and the St. Lawrence River (WQI_{avg}=81, n=6) can be described as having Good water quality. Tributaries to Lake Erie (WQI_{avg}=45, n=18) and Lake Ontario (WQI_{avg}=66, n=33) had Fair water quality.

Linkages

Calculated WQI values show a statistically significant negative association with two measures of watershed development: percent watershed area occupied by human land uses and road density (Figure 3). This suggests that overall water quality in Great Lakes tributaries, as represented by WQI values, is influenced by human land uses where minimally developed watersheds have the highest WQI values.

The WQI values indicate the potential for substances in stream water to impact aquatic life based on compliance with water quality criteria. However, the values are not a direct measure of impacts to aquatic communities, such as changes in fish and benthic invertebrate communities. The WQI values also infer the potential for discharge from tributaries to impact the Great Lakes, particularly at the tributary mouths and nearby nearshore areas.

Management Challenges/Opportunities

The WQI was developed to communicate water quality information to general audiences. It is not intended to replace rigorous technical analysis of water quality data for water resources management.

The water quality of many Great Lakes tributaries has been monitored since the 1960s. Calculation of WQI values for historical monitoring data is possible and could support an assessment of trends in the WQI over time. However, some of the anticipated challenges include: inconsistent laboratory methods and detection limits over time and incomplete datasets (missing parameters, missing years).

The WQI could be applied to water quality results from U.S. tributaries to the Great Lakes depending on the availability of the data. An anticipated challenge is that WQI results are not directly comparable between jurisdictions where different water quality parameters and criteria are used. This will be the case for any index.

Comments from the author

The CCME WQI is used extensively in Canada, most notably for the annual Canadian Environmental Sustainability Indicators report (Environment Canada 2011). The WQI has also been used and adapted by some of Ontario's Conservation Authorities for their watershed report cards. OMOE currently does not use the WQI for reporting; however, given its widespread use, the author accepts that it is a logical starting point for developing an indicator of Great Lakes tributary water quality for SOLEC.

The strengths and weaknesses of the WQI have been, and continue to be, discussed. A few reports on the sensitivity of the WQI are posted on the CCME website. The Gartner Lee Limited (2006) report is particularly helpful in understanding the nuances of the WQI.

Most of the monitoring sites in the Ontario PWQMN are purposefully located in populated areas and areas where water quality impacts from varying land uses are known or expected. Minimally-impacted reference watersheds are likely under-represented in this SOLEC indicator.

The sites selected for this SOLEC indicator likely under-represent the upper Great Lakes, especially Lake Superior. A redundancy analysis or similar approach could be considered for future iterations of this indicator to omit some sites from the lower Great Lakes such that each of the Lakes is more equally represented.

Human influence is not the only cause of exceedances of water quality criteria. Parameters can exceed their

respective criteria in areas that are naturally rich in a given nutrient or metal. No considerations for naturally-occurring elevated concentrations of some parameters were made in the WQI calculations.

Assessing Data Quality

Insert "x" under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	x					
2. Data are traceable to original sources	x					
3. The source of the data is a known, reliable and respected generator of data	x					
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin		x				
5. Data obtained from sources within the U.S. are comparable to those from Canada						x
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report	x					
Clarifying Notes: Water quality data for U.S. tributaries to the Great Lakes were unavailable for WQI calculations.						

Acknowledgments

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Information Sources

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Canadian Council of Ministers of the Environment (CCME). 2011*a*. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated 2011. http://st-ts.ccme.ca/?chems=all&chapters=1&pdf=1

Canadian Council of Ministers of the Environment (CCME). 2011*b*. CCME Water Quality Index 1.1. http://www.ccme.ca/assets/xls/ccmewqi_calculator_1.1_en.xls

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Ontario Ministry of the Environment (OMOE). 2011. Provincial Water Quality Monitoring Network data (2002-2009). http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm#PWQMN

Statistics Canada. 2007. Behaviour study on the Water Quality Index of the Canadian Council of Ministers of the Environment. http://www.statcan.gc.ca/pub/16-001-m/16-001-m2007003-eng.htm

Information on the Ontario Provincial Water Quality Monitoring Network (PWQMN) – including a map of monitoring sites can be found here: http://www.ene.gov.on.ca/environment/en/monitoring_and_reporting/provincial_water_quality_monitoring_network/index.htm.

PWQMN monitoring sites (ESRI ArcGIS shapefile), 2002-2009 results (Microsoft Access and Excel) and metadata are posted on the MOE public website here: http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm.

The WQI Calculator (Microsoft Excel, v1.1, 2011), user's manual and technical report can be downloaded here: http://www.ccme.ca/ourwork/water.html?category_id=102.

List of Tables

List of Figures

Source: Ontario Ministry of the Environment

Figure 3. CCME Water Quality Index (WQI) values for Canadian Great Lakes tributaries (n=95) versus (a) percent watershed occupied by human land uses and (b) road density.

Source: Ontario Ministry of the Environment

Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2011

Indicator	Criterion	Source
Ammonia (unionized)	0.0152 mg L^{-1}-N	CCME
Chloride	110 mg L^{-1}	CCME (draft)
Copper	2 μg L^{-1} at water hardness of 0-120 mg L^{-1}-$CaCO_3$	CCME
	3 μg L^{-1} at water hardness of 120-180 mg L^{-1}-$CaCO_3$	
	4 μg L^{-1} at water hardness of >180 mg L^{-1}-$CaCO_3$	
Iron	300 μg L^{-1}	CCME
Nitrate	2.9 mg L^{-1}-N	CCME
Nitrite	0.06 mg L^{-1}-N	CCME
Phosphorus	0.03 mg L^{-1}	OMOE
Zinc	30 μg L^{-1}	CCME

Sources: CCME = Water quality guidelines for the protection of aquatic life (CCME 2011*a*); OMOE = Interim provincial water quality objective (OMOE 1994).

Table 1. Water quality criteria for the eight indicators used in the CCME Water Quality Index (WQI) calculations.

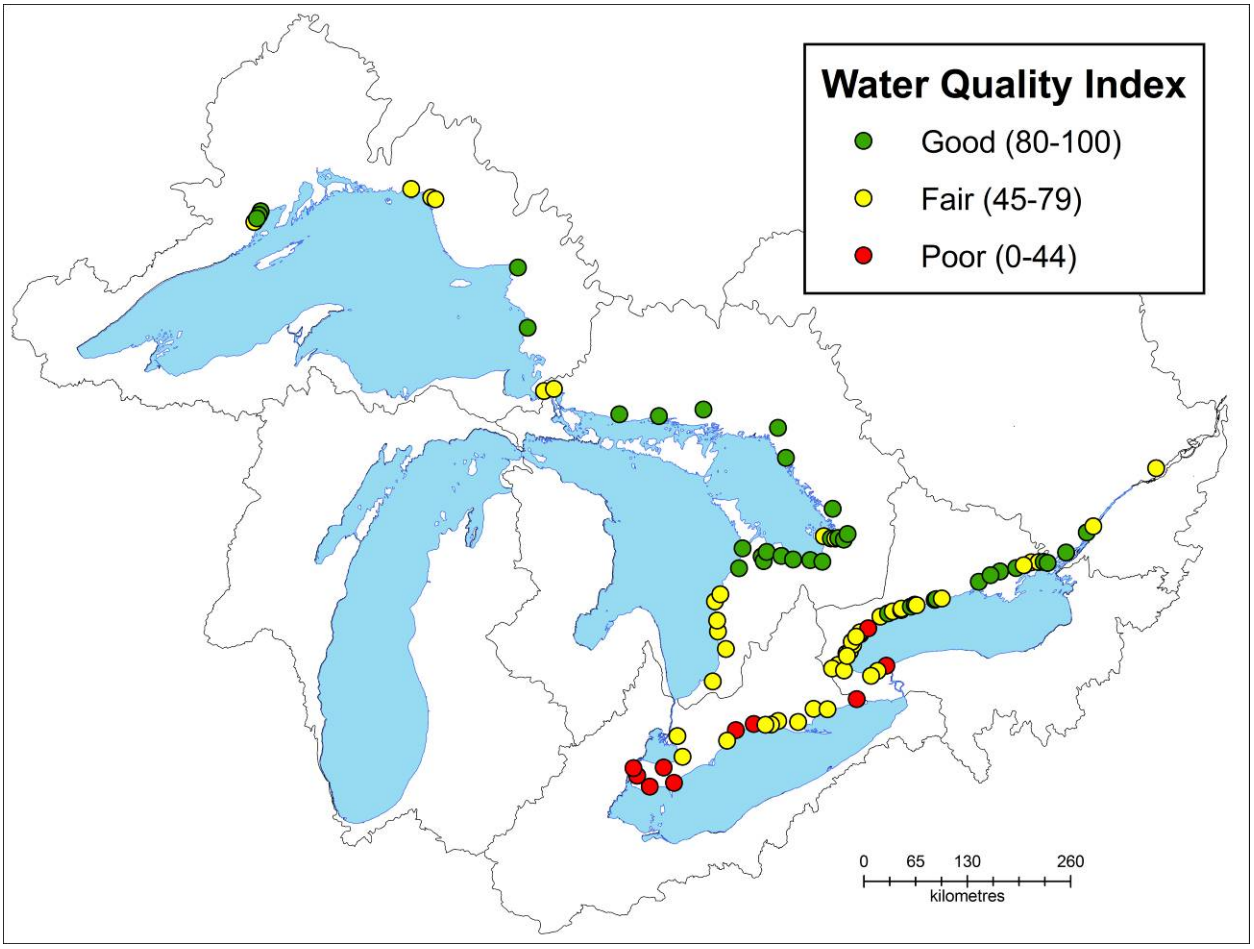

Figure 1. CCME Water Quality Index (WQI) values for 95 Canadian tributaries to the Great Lakes.

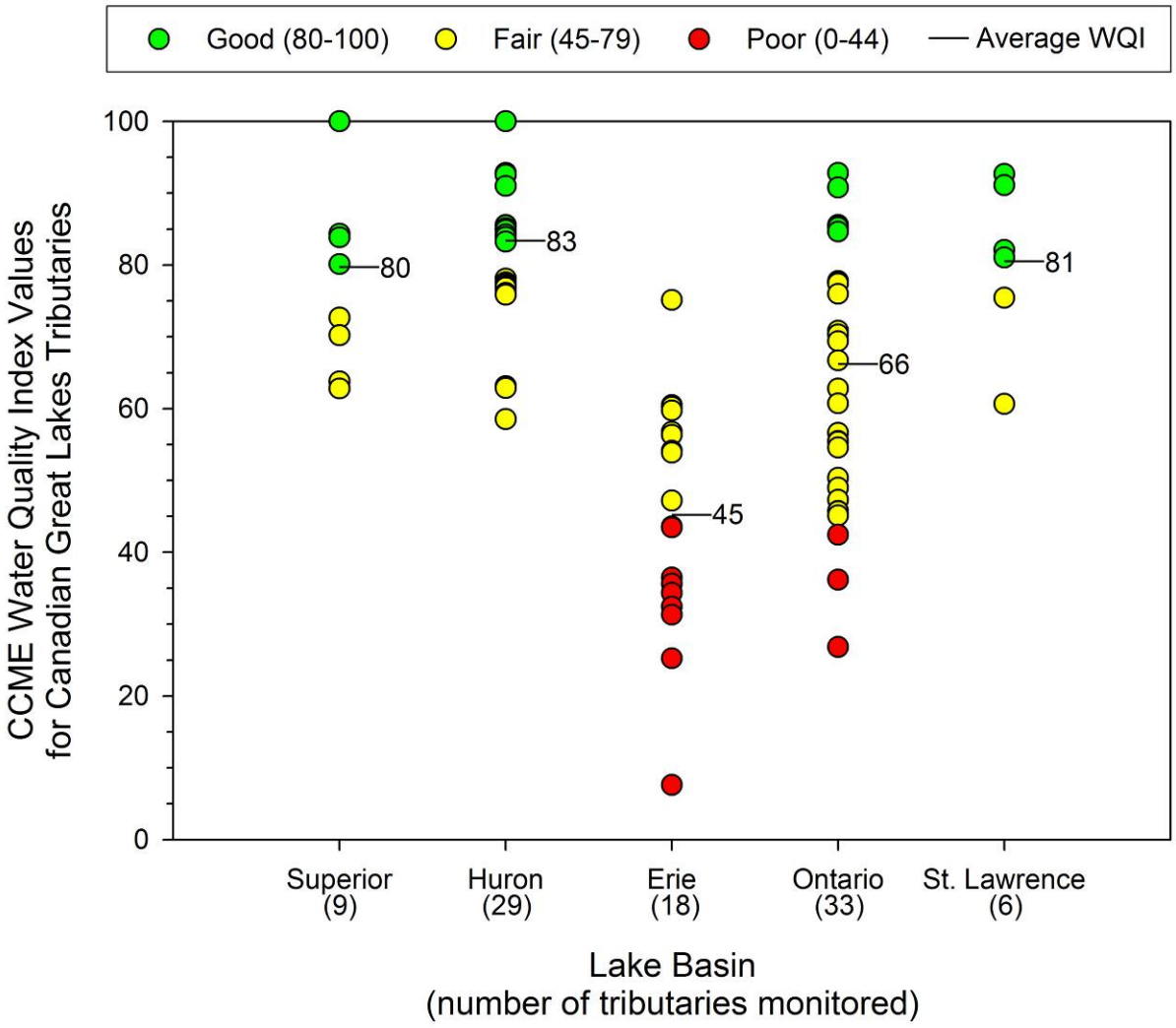

Figure 2. CCME Water Quality Index (WQI) values for Canadian Great Lakes tributaries by lake basin.

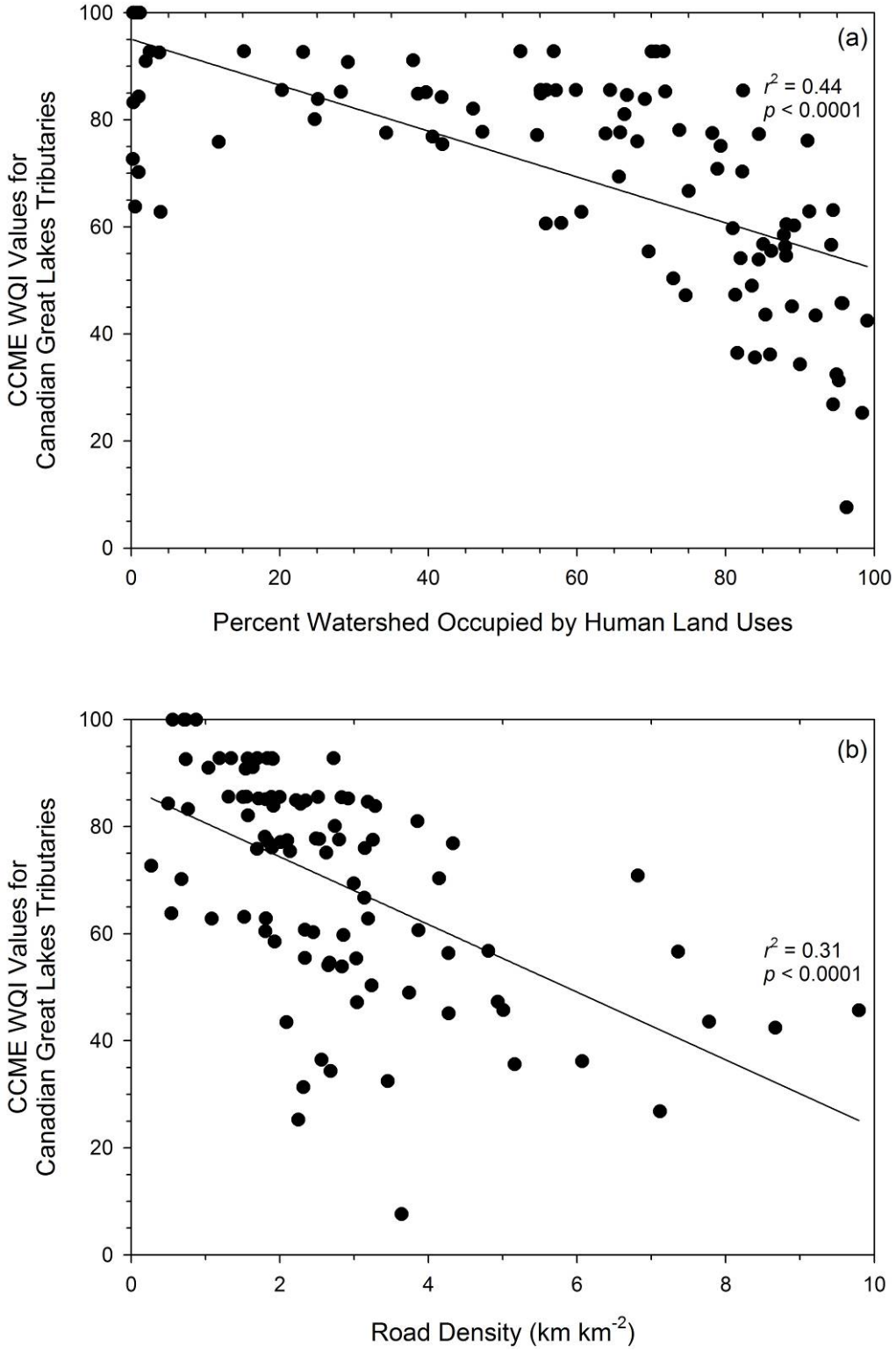

Figure 3. CCME Water Quality Index (WQI) values for Canadian Great Lakes tributaries (n=95) versus (a) percent watershed occupied by human land uses and (b) road density.