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Understanding Groundwater Contamination Risk and the Potential Implications of Changing Watershed Conditions

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Summary

Many rural regions rely heavily on groundwater for water supply. In such areas, groundwater vulnerability and pollution potential are important considerations for water managers and private well users given stressors such as agricultural activity and the prevalence of septic systems. Index-overlay methods are a popular approach for assessing groundwater vulnerability given that they are typically not limited by computational challenges or inadequate data availability. These methods involve the overlay of indexed physiographic attribute maps which are used to generate a scored vulnerability range (National Research Council 1993). The DRASTIC method (Aller et al. 1987) is a widely used index-overlay method developed by the U.S. EPA as a systematic approach for evaluating groundwater pollution potential and has been used extensively worldwide (e.g. Kazakis and Voudouris 2015; Hamza et al. 2017).

In order to determine overall groundwater contamination risk, assessment of intrinsic groundwater vulnerability must be combined with some assessment of pollutant loading. Pollutant loading may be examined through incorporation of land use data whereby human activities are linked to contaminant potential. The DRASTIC-LU method is a popular technique that uses this approach (e.g. Noori et al. 2018; Kumar and Krishna 2019). While groundwater contamination risk is commonly examined in a static manner, it is possible that spatial patterns may be altered by changing climate and land use. Canada's Changing Climate Report (Bush and Lemmen 2019) indicates the likelihood for continued warming in addition to changing precipitation patterns. Projected changes in seasonal temperature as well as changes in the timing, magnitude, intensity, and phase of precipitation may lead to fundamental water cycle modifications, including changes to groundwater recharge. These effects may be compounded by changing land use and associated pollutant loading patterns.

This research aims to produce a framework for evaluating changes in groundwater contamination risk due to variability in future watershed conditions that is based upon the DRASTIC-LU method. The Upper Parkhill watershed (Figure 1) in southwestern Ontario serves as a case study for method application. This watershed (~130 km^2) is an agricultural headwater catchment within a low permeability, glacial till setting. The Upper Parkhill watershed was previously identified as vulnerable to the impacts of climate change based on a sensitivity assessment completed by the Ontario Ministry of the Environment, Conservation and Parks (MacRitchie et al. 2010), therefore highlighting this area as an important region of study. Watershed intrinsic properties and land use data are combined in a GIS environment to assess the spatial variability of groundwater contamination risk and the sensitivity of input factors. Using this baseline evaluation, potential changes in contamination risk as a function of variable land use, water table depth, and recharge are evaluated. Groundwater and land management strategies may be informed by study results with consideration given to changing future conditions.

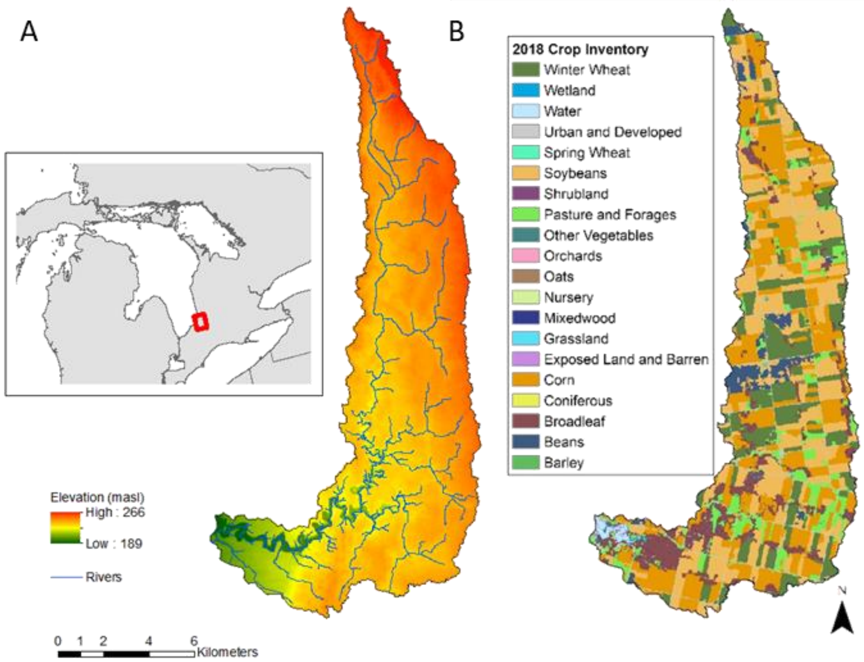

Figure 1. (A) Upper Parkhill watershed and location within the Great Lakes Basin; (B) 2018 Agriculture and Agri-Food Canada Crop Inventory as an example of typical land use within the Upper Parkhill watershed.

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