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# Predicting Redox Conditions in Groundwater at a National Scale Using Random Forest Classification

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Redox conditions in groundwater markedly affect the fate and transport of nutrients, volatile organic compounds, and trace metals, with significant implications for human health. While many local assessments of redox conditions have been made, regional or national scale assessments have been limited due to the spatial variability of redox reaction rates. In this study, redox conditions in groundwater were predicted for the continental United States using random forest classification by relating measured water quality data from over 20,000 wells to natural and anthropogenic factors. The model correctly predicted the oxic/suboxic classification for 78% and 79% of the samples in the out-of-bag and testing data sets, respectively. Variables describing geology, hydrology, soil properties and hydrologic position were among the most important factors affecting the likelihood of oxic conditions in groundwater. Important model variables tended to relate to aquifer recharge, travel time, or the prevalence of electron donors, which are key drivers of redox conditions in groundwater. Partial dependence plots suggested that the likelihood of oxic conditions in groundwater decreased sharply as $8^{th}$-order streams were approached and as the depth below the water table increased. The probability of oxic water increased as base flow index increased, likely due to the prevalence of well drained soils and geologic materials in high base flow index areas. Conversely, the likelihood of oxic conditions decreased as topographic wetness index increased. High topographic wetness index values occur in areas with a propensity for standing water and overland flow, conditions that limit the delivery of dissolved oxygen to groundwater by recharge. Model predictions of redox conditions in groundwater in the continental United States can identify regions of the country with elevated groundwater vulnerability and stream vulnerability to groundwater-derived contaminants.