Groundwater nitrate and the fate of native soil fertility with cultivation

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Elevated nitrate in groundwater is commonly observed in agricultural areas, likely reflecting decades of increasing N fertilization. In the Judith River Watershed of central Montana, high fertility of native grasslands initially allowed for dryland wheat production without N fertilization, and elevated nitrate levels were frequently observed in shallow aquifers prior to widespread fertilizer application. These observations, together with high contemporary nitrate leaching, raise fundamental questions about the source and fate of bioavailable N in this system. In the JRW, a hydrologically isolated strath terrace provides a well-constrained field setting for testing the effect of long term land use practices on groundwater and surface water nitrate. A landform scale mass balance relates high and increasing nitrate concentrations in groundwater to the combination of increased inputs (ongoing mineralization of native organic matter and increasing fertilizer N inputs) and increased transport potential due to agricultural practices (physical effects of cultivation, crop removal, and fallowing). Nitrate dual isotopes allow quantification of substantial loss to denitrification that occurs within soils, groundwater and surface water. We model the development, perturbation and fate of native soil fertility with cultivation on this landform, and discuss implications for regional conservation as rainfall and snowpack are transformed by climate change.