Supplementary Materials: Changing Nitrogen Deposition with Low δ^{15}N-NH_4^+ and δ^{15}N-NO_3^- Values at the Experimental Lakes Area, northwestern Ontario, Canada

Jason J. Venkiteswaran*† Sherry L. Schiff‡ Michael J. Paterson§
Nicholas A. P. Flinn‡ Honghao Shao‡ Richard J. Elgood‡

This document contains five figures.

*Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, Ontario, Canada, N2L 3C5

†Corresponding author: jvenkiteswaran@wlu.ca

‡Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1

§IISD – Experimental Lakes Area, 111 Lombard Ave, Suite 325, Winnipeg, MB, Canada, R3B 0T4

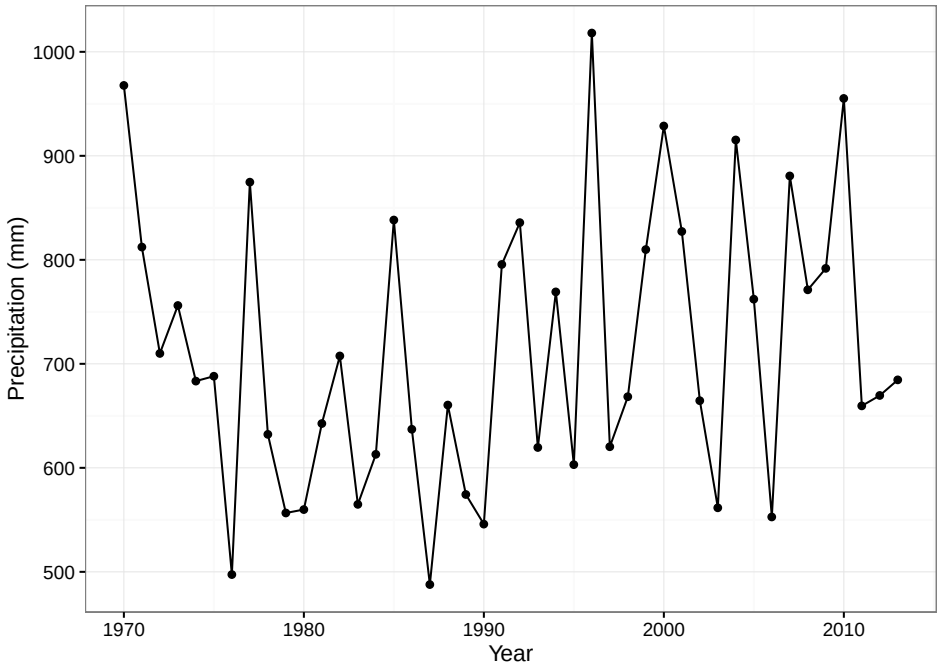

Figure S1: Annual precipitation at the Experimental Lakes Area for the period 1970 to 2013.

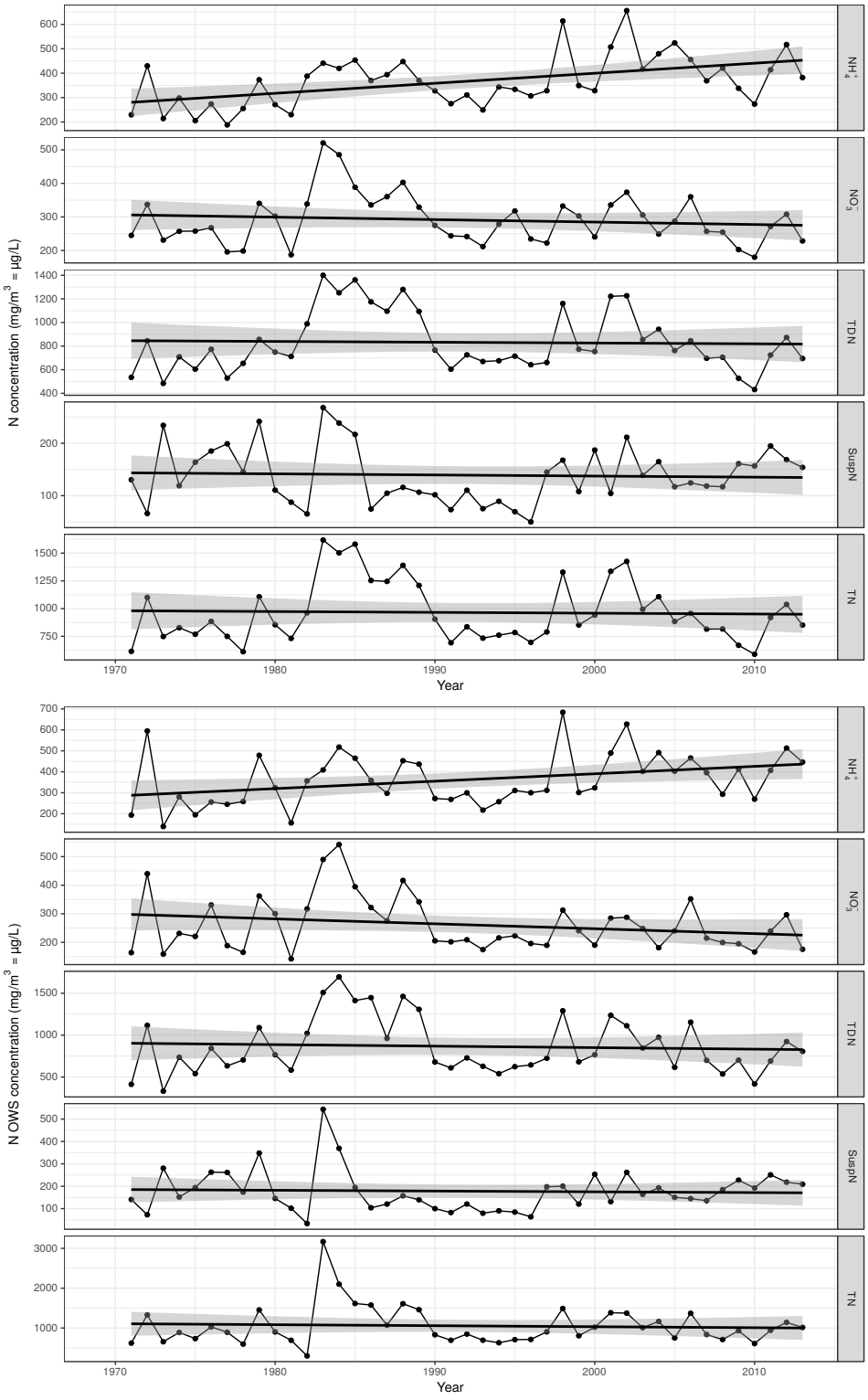

Figure S2: Annual (top) and open-water season (OWS, bottom) nitrogen concentrations at the Experimental Lakes Area for the period 1970 to 2013. Grey bands are the 95% confidence intervals around the linear regressions.

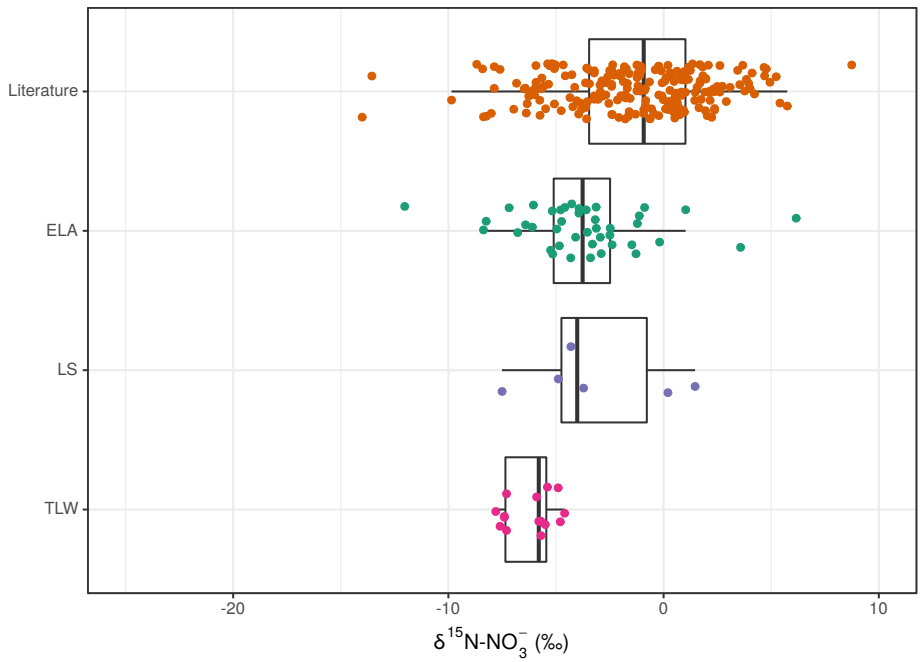

Figure S3: Precipitation δ^{15}N-NO_3^- values from the Experimental Lakes Area (ELA), Turkey Lakes Watershed (TLW) (Spoelstra, 2004; Spoelstra et al., 2001), Lake Superior (LS) (Finlay et al., 2007), and literature (Burns and Kendall, 2002; Freyer, 1978; Griffiths et al., 2016; Rose et al., 2015; Wexler et al., 2014; Williard et al., 2001).

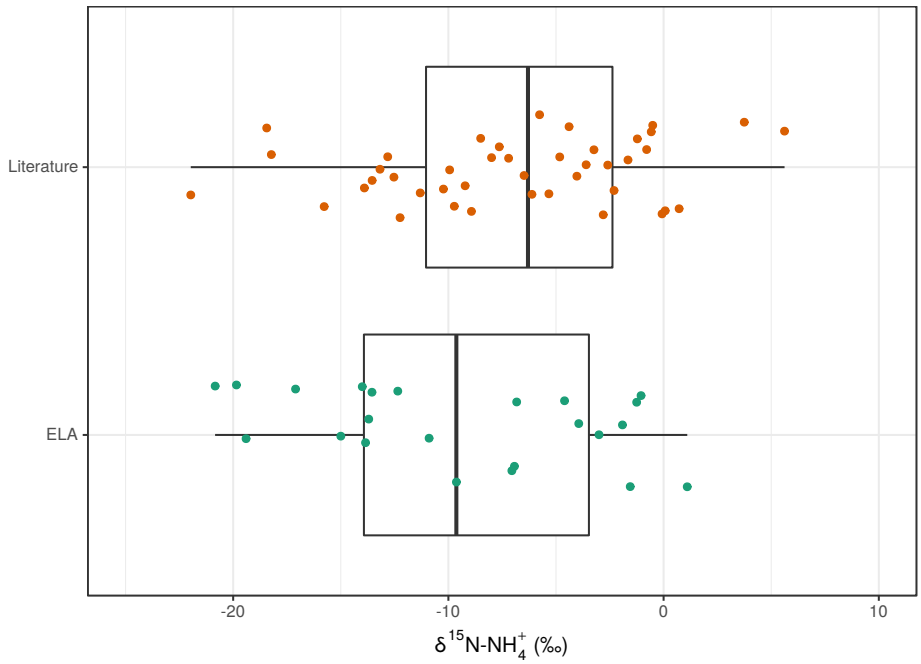

Figure S4: Precipitation δ^{15}N-NH_4^+ values from the Experimental Lakes Area (ELA) and literature (Freyer, 1978; Heaton, 1987; Xiao and Liu, 2002).

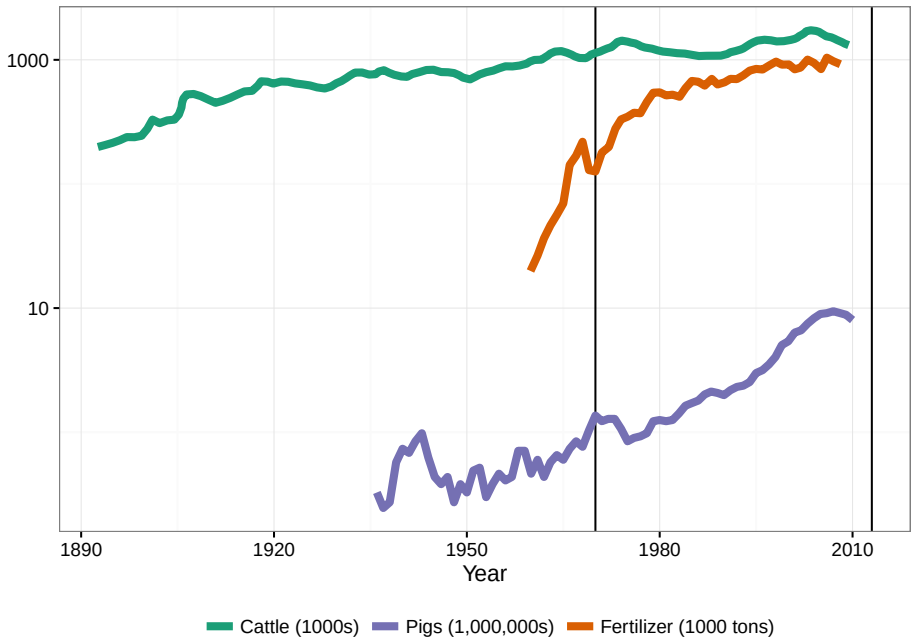

Figure S5: Historical heads of cattle, pigs on farms and tonnes of fertilizer purchased in Manitoba, Canada (Honey, 2010). Vertical lines at 1970 and 2013 illustrate the 43 years of record at ELA.

References

Burns, D.A. and Kendall, C. 2002. Analysis of δ^{15}N and δ^{18}O to differentiate NO_3^- sources in runoff at two watersheds in the Catskill Mountains of New York. Water Resources Research **38**(5): 9–1–9–11. doi:10.1029/2001WR000292.

Finlay, J.C., Sterner, R.W., and Kumar, S. 2007. Isotopic Evidence for In-Lake production of Accumulating Nitrate in Lake Superior. Ecological Applications **17**(8): 2323–2332. doi:10.1890/07-0245.1.

Freyer, H.D. 1978. Seasonal trends of NH_4^+ and NO_3^- nitrogen isotope composition in rain collected at Jülich, Germany. Tellus **30**(1): 83–92. doi:10.1111/j.2153-3490.1978.tb00820.x.

Griffiths, N.A., Jackson, C.R., McDonnell, J.J., Klaus, J., Du, E., and Bitew, M.M. 2016. Dual nitrate isotopes clarify the role of biological processing and hydrologic flow paths on nitrogen cycling in subtropical low-gradient watersheds. Journal of Geophysical Research: Biogeosciences **121**(2): 422–437. doi:10.1002/2015JG003189.

Heaton, T. 1987. ^{15}N/^{14}N ratios of nitrate and ammonium in rain at Pretoria, South Africa. Atmospheric Environment (1967) **21**(4): 843–852. doi:10.1016/0004-6981(87)90080-1.

Honey, J. 2010. Crops in Manitoba 2009-2010. Department of Agribusiness and Agricultural Economics, University of Manitoba, Winnipeg, Canada.

Rose, L.A., Elliott, E.M., and Adams, M.B. 2015. Triple Nitrate Isotopes Indicate Differing Nitrate Source Contributions to Streams Across a Nitrogen Saturation Gradient. Ecosystems **18**(7): 1209–1223. doi:10.1007/s10021-015-9891-8.

Spoelstra, J. 2004. Nitrate sources and cycling at the Turkey Lakes Watershed: A stable isotope approach. PhD thesis, University of Waterloo, Waterloo, Canada.

Spoelstra, J., Schiff, S.L., Elgood, R.J., Semkin, R.G., and Jeffries, D.S. 2001. Tracing the Sources of Exported Nitrate in the Turkey Lakes Watershed Using ^{15}N/^{14}N and ^{18}O/^{16}O isotopic ratios. Ecosystems **4**(6): 536–544. doi:10.1007/s10021-001-0027-y.

Wexler, S.K., Goodale, C.L., McGuire, K.J., Bailey, S.W., and Groffman, P.M. 2014. Isotopic signals of summer denitrification in a northern hardwood forested catchment. Proceedings of the National Academy of Sciences **111**(46): 16413–16418. doi:10.1073/pnas.1404321111.

Williard, K.W., DeWalle, D.R., Edwards, P.J., and Sharpe, W.E. 2001. ^{18}O isotopic separation of stream nitrate sources in mid-Appalachian forested watersheds. Journal of Hydrology **252**(1-4): 174–188. doi:10.1016/S0022-1694(01)00459-0.

Xiao, H.Y. and Liu, C.Q. 2002. Sources of nitrogen and sulfur in wet deposition at Guiyang, southwest China. Atmospheric Environment **36**(33): 5121–5130. doi:10.1016/S1352-2310(02)00649-0.