25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Developing satellite-derived nitrogen stable isotope ratio grids to globally monitor terrestrial plant nitrogen availability for 1984–2022

Jinyan Yang [a], Haiyang Zhang [b], Yiqing Guo [c], Randall J. Donohue [a], Tim R. McVicar [a], Simon Ferrier [a], Warren Müller [a], Xiaotao Lü [d], Yunting Fang [e,f], Xiaoguang Wang [g], Peter B. Reich [h,i], Xingguo Han [j,k] and Karel Mokany [a]

[a] CSIRO Environment, Canberra, Australia
[b] College of Life Sciences, Hebei University, Baoding, China
[c] CSIRO Data61, Canberra, Australia
[d] Erguna Forest-Steppe Ecotone Research Station, CAS Key Laboratory of Forest Ecology and Management, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China
[e] CAS Key Laboratory of Forest Ecology and Management, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China
[f] Qingyuan Forest CERN, CAS Key Laboratory of Forest Ecology and Management, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China
[g] College of Environment and Resources, Dalian Minzu University, Dalian, China
[h] Institute for Global Change Biology and School for Environment and Sustainability, University of Michigan, Ann Arbor, United States
[i] Department of Forest Resources, University of Minnesota, St Paul, United States
[j] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, China
[k] University of Chinese Academy of Sciences, Beijing, China
Email: jinyan.yang@csiro.au

Abstract: Nitrogen (N) availability regulates the productivity of terrestrial plants and the ecosystem services they provide. There is evidence for both increasing and decreasing plant N availability in different biomes, but the data are fragmentary. How plant N availability responds to climate change, N deposition and increasing atmospheric CO_2 concentration remains a major uncertainty in the projection of the terrestrial carbon sink. The foliar N stable isotope ratio ($\delta^{15}N$) is an indicator of plant N availability but its usefulness to infer long-term global patterns has been limited by data scarcity.

Combining ground-based $\delta^{15}N$ and Landsat spectra, we derived annual global maps of Landsat-based foliar $\delta^{15}N$ as estimates of plant N availability during 1984–2022 using a random forest ensemble learning method. The model consistently achieved low error (NRMSE < 0.2) across continents and biomes. We found significant decreases in plant N availability for 44% and increases for 16% of vegetated Earth's surface with large spatial heterogeneity. Plant N availability mostly declined in woody-dominated ecosystems but increased in herbaceous-dominated ones. These $\delta^{15}N$ trends were consistently and negatively correlated with the trends of Normalised-Difference-Vegetation-Index as they varied across ecosystems, suggesting increasing plant cover could have led to decreasing plant N availability. Our results indicate possible future reductions in plant N availability in many terrestrial ecosystems and provide a useful way to monitor those changes globally.

Keywords: *Plant nitrogen availability, reflectance, vegetation monitoring*