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Defining whole watershed nitrogen dynamics with ^{15}N

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Chronic elevated atmospheric nitrogen (N) deposition and a warming climate are likely to accelerate N cycling in the future. The environmental consequences of chronic N inputs on northeastern US forests are not yet well understood. The Bear Brook Watershed in Maine (BBWM) was established in November 1989 to bridge this knowledge gap. The BBWM is a long-term, paired watershed experiment established in Maine approximately 60 km north-east of Acadia National Park studying the effects of simulated N addition and acidification on the biogeochemistry of forested watersheds. The treated watershed, West Bear (WB, 10.3 ha), receives 25.2 kg N ha^{-1} yr^{-1} and 28.1 kg S ha^{-1} yr^{-1} continuously since November 1989. The biogeochemical reference is the East Bear watershed (EB, 11.0 ha). A major emphasis for this research has been the study of N cycling in these watersheds. Recently, a state-of-the art method using stable isotopes of N (i.e., the common ^{14}N and heavy but rare ^{15}N) has been used at the BBWM to detect subtle changes in ^{14}N and ^{15}N ratios of plants, soils, and stream water, which indicate changes in N transformations rates due to the long-term manipulation. The isotopic measurements were done at the natural abundance level as well as after a one time watershed-scale ^{15}N tracer (98 atom-% $(^{15}N\text{-}NH_4)_2\,SO_4$) addition. The latter was carried out by backpack sprayers in both watersheds at the dose of 0.4 kg ha^{-1} of ^{15}N tracer on June 5, 2012. Before and after the tracer application, we sampled forest components (e.g., tree foliage, litter fall, forest floor, mineral soil, stream water) and followed the redistribution of the ^{15}N tracer over time. Here we report the WB and EB forest components' $\delta^{15}N$ natural abundances before the tracer application as well as their $\delta^{15}N$ enrichments across the 2012 and 2013 growing seasons. Our results show that the long-term N+S additions in WB significantly increased $\delta^{15}N$ natural abundances in plant tissues, forest floor, and mineral soil compared to EB. Moreover, ^{15}N tracer enrichment was found to significantly increase the $\delta^{15}N$ in forest components over that of the natural abundances, indicating a successful experimental labeling with ^{15}N in both watersheds. Lastly, the most enriched forest component was the top layer of the forest floor in both watersheds, which persisted across two growing seasons. The lower layers of the forest floor were significantly more enriched in ^{15}N in WB compared to EB across two growing seasons but no evidence of enrichment was found in the mineral soil in any watersheds during the same period. We conclude from the enrichments that N transformations occur at higher rates in WB due to the long-term experimental N addition and acidification compared to EB.