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Interactions between nitrogen enrichment, weathering of rock-derived nutrients, and logging: consequences for nutrient limitation and sustainability in forests

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Nitrogen frequently limits tree growth, but where nitrogen is abundant, nutrient limitation often shifts to phosphorus and base cations, depending on weathering of soil minerals. We used a process-based biogeochemical model to evaluate how multiple elements can limit long-term forest growth via interactions between soil nitrogen (low vs. high nitrogen), and weathering of rock-derived nutrients from soil minerals (comparing sedimentary vs. basaltic bedrock). The model (NutsFor) combines a daily water balance model, the mineral weathering module of the PROFILE model, along with nutrient cycling and forest ecosystem models. Simulations were run for 525 years with 40-year harvest intervals for managed Douglas-fir forests of the Oregon Coast Range. In low nitrogen sites, our preliminary results indicate that nutrient limitation switched after several centuries from nitrogen to phosphorus, as cycles of forest growth and harvest depleted soil organic phosphorus pools. In contrast, high nitrogen sites displayed severe base cation depletion and reduced tree growth within only one to two rotations, with sedimentary bedrock sites limited by calcium and basaltic sites by both calcium and potassium. Harvesting stimulated the largest fractional losses of nitrogen and potassium across all simulations, and additionally of calcium in high nitrogen sites. These multi-element simulations of interactions among weathering of rock-derived nutrients, harvesting, soil nitrogen, and bedrock type provide a set of testable predictions to guide monitoring and changes in management aimed at sustaining long-term forest productivity across a wide range of critical zone biogeochemical conditions.