Introduction: In many forest plantation ecosystems, concerns exist regarding nutrient removal rates associated with sustained whole-tree harvesting. In the coastal North American Pacific Northwest, we predicted the depletion risk of nitrogen (N), the region’s most growth-limiting nutrient, for 68 intensively managed Douglas-fir (Pseudotsuga menziesii var. menziesii [Mirb.] Franco) plantations varying widely in productivity.

Procedures: We projected stands to rotation age using the individual-tree growth model ORGANON and then calculated a stability ratio for each stand, defined as the ratio of N removed during harvest to total site N store (soil and forest floor). We assigned a risk rating to each site based on its stability ratio under whole-tree and stem-only harvest scenarios.

Results & Discussion: Under whole-tree harvest, 49% of sites were classified as potentially at risk of long-term N depletion (i.e., 10% N store removed in harvest), whereas under stem-only harvest, only 24% of sites were at risk. Six percent and 1% of sites were classified as under high risk of N depletion (i.e., 30% N store removed in harvest) under whole-tree and stem-only harvest, respectively. The simulation suggested that sites with 9.0 and 4.0 Mg ha\(^{-1}\) site N store are potentially at risk for long-term N depletion and productivity loss under repeated whole-tree and stem-only harvest, respectively. Sites with 2.2 and 0.9 Mg/ha site N store are at high risk of N depletion under whole-tree and stem-only harvest, respectively. The simulation suggested that sites with 9.0 and 4.0 Mg ha\(^{-1}\) site N store are potentially at risk for long-term N depletion and productivity loss under repeated whole-tree and stem-only harvest, respectively. Sites with 2.2 and 0.9 Mg/ha site N store are at high risk of N depletion under whole-tree and stem-only harvest, respectively. The areas with the highest concentrations of at-risk sites were those with young, glacially derived soils on Vancouver Island, Canada, and in the Puget Sound region of Washington. Recent studies of deep soil N stores show that sampling deeper than 1 m can result in much larger N pools than 1 m. Though strong correlations between productivity and soil depth have been shown in previous studies, is unknown at this time whether these additional pools of N can be exploited by new plantations and whether this normally unmeasured N can decrease stability ratios further, and increase resiliency to biomass harvesting further.

Figure 3. Stability ratios for whole-tree and stem-only harvest in 68 coastal Pacific Northwest Douglas-fir plantations, by site N store (total soil N to 1.0-m plus forest floor).

Figure 4. Total N found at depth at 22 of the sites sampled for the sustainability evaluation.