Whole-tree Harvesting N Risk in Coastal PNW

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Abstract

The growth of 68 intensively managed, mid-rotation, Douglas-fir stands in western Oregon, Washington, and British Columbia was projected to 50-55 years of age using the SMC variant of the ORGANON growth and yield simulator. From the ORGANON output, component biomass removal was estimated for stem-only harvest and a more intense whole-tree harvest. Utilizing published equations which estimate tree component N content based on biomass and total site nitrogen from the 68 sites, nitrogen removal under the two harvest intensities is expressed as a proportion of total site nitrogen store. Based on the proportion of N removed to the total site store, the 68 sites were assigned a risk rating, and regional patterns were assessed. Based on the simulation results, nearly half of the stands in the study were at risk of N depletion or site productivity loss under whole-tree harvest, while most stand ranked in the lowest risk category under stem-only harvesting. The highest concentration of stands at risk of long term site productivity loss from N depletion is on young glacial soils in Vancouver Canada and the Puget Sound region of Washington. This simulation also suggests that stands of similar planting density and age on sites with less than approximately 9000 and 4000 kg/ha of total site N will be at an elevated risk for long term site productivity loss under whole-tree and stem-only harvests respectively.

Objective

The objectives of this study are to present an easily replicated site-specific method of assessing the sustainability of stem-only harvest and whole-tree harvest using the stability ratio method of Evans (1999) and apply that method to 68 representative sites within the Douglas-fir regional of the coastal PNW to identify region patterns in sustainable harvesting relative to ecosystem nitrogen, which is the primarily growth-limiting nutrient in this region for Douglas-fir.

Methods

Beginning in 2008 the Stand Management Cooperative (SMC), a research cooperative of universities, government agencies, and private timber companies, began installing paired-tree fertilizer trials in 15-30 year old Douglas-fir plantations in western Oregon, Washington, and British Columbia (Littke et al. 2011). The objectives of that study were primarily to understand relationships between site factors and productivity, and to predict sites with high likelihood of response to fertilization. The 68 sites cover a range of latitudes and site conditions representative of Douglas-fir plantations in the region (Figure 1). The evaluations of the sites included complete tree measurements, understory, forest floor and nutrient pools to 1 m depth. ORGANON-SMC was used to similate the future growth of the stand at each plot (Hann, 2011). Biomass of tree components was estimated from Jenkins et al. (2003) equations, and samples taken from tree tissues. ORGANON simulated tree growth on a five year interval so each plot was simulated to a stand age of 50-55 years. Estimates of total above-ground biomass and stemwood+stembark biomass of each tree were summed for each plot. The N content of Douglas-fir TAB and stemwood+stembark was estimated using equations from Augusto et al. (2000) at each plot. N export from the site was estimated assuming the removal of TAB of all trees to simulate WTH and total stemwood+stembark of Douglas-fir to simulate SOH. The estimated N exported for both simulated harvest intensities was expressed as a percent of total site N store (soil N to hardpan or 1m+forest floor N).

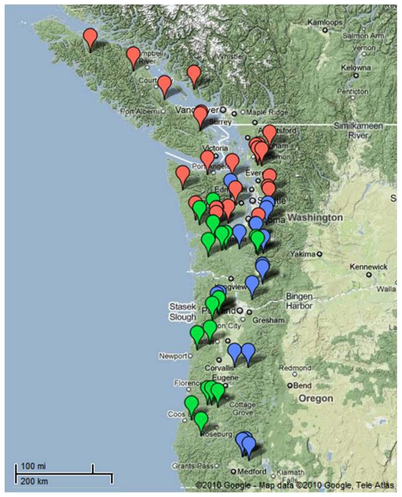

FIGURE 1. Location of Douglas-fir stands evaluated for this study.

- Red Markers – Glacial parent material
- Green Markers – Sedimentary parent material
- Blue Markers – Igneous parent material

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Results and Discussion

The stand stemwood volume estimates ranged from about 300 to 1130 m^3/ha with a mean of 830 m^3/ha for the 68 plots. Yield tables for managed Douglas-fir in the region predict a total stand volume of 297-1246 m^3/ha for 50-55 year-old unthinned stands planted at 300-400 trees/ha for the range of site index values in this study (Curtis et al., 1982). Normal yield tables from McArdle et al. (1949) suggest a lower range, but they were developed from unmanaged naturally-regenerating stands that had lower levels of productivity than modern intensively-managed Douglas-fir plantations. Estimated harvest exports of N from WTH ranged from 366 to 1218 kg/ha of N with a mean export of 886 kg/ha of N. Stem-only harvest N export estimates ranged from 165 to 737 kg/ha of N with a mean of 495 kg/ha of N. Table 1 compares the N export estimates of this study with those of similar aged stands in the literature.

Figure 2 shows harvest export estimates relative to site nutrient stores and lines representing the critical SR values of 0.1 and 0.3. Eighteen of the 68 sites would exceed an SR of 0.1 with SOH by removing more than the equivalent of 10% of site N stores, whereas WTH is estimated to exceed an SR of 0.1 at 33 of 68 sites. A SR of 0.3 was exceeded at only one site under SOH (0.47), and at six sites under WTH (0.37, 0.40, 0.45, 0.45, 0.49, and 1.02) by our estimates.

Conclusions

- Low risk of N depletion or productivity loss with single tree harvest, slight with WTH.
- Stands with elevated risk of N depletion or productivity loss tend to be concentrated on young glacial soils of B.C and the Puget Sound region.
- Based on the strong relationship of total site N to SR, it is predicted that sites with greater than about 9000 and 4000 kg/ha N are at low risk of productivity loss or N depletion throughout the region with WTH and SOH respectively.
- Rotation length, harvesting methods, and site preparation can have effects on N losses and should be considered in conjunction with harvest intensity.
- Fertilization may be a viable means of maintaining site productivity and nutrient stores under WTH regimes.

TABLE 1. Comparison of biomass and N content.

Source	Stand Age (y)	Trees/ha	Stand Volume (m^3/ha)	Stemwood Biomass (Mg/ha)	Total AG Biomass (Mg/ha)	Total N content of trees (kg/ha)	50 yr Site Class	Specific Gravity
Ares et al., 2007	47	DF=303 WH=324 Total=627	DF=500 WH=414 Total=914	DF=182.2 WH=126.2 Total=308.4	DF=234.2 WH=158.6 Total=392.8	DF=375.9 WH=228.6 Total=604.5	High 2	DF=0.36 WH=0.30
Bigger and Cole, 1983	55			281* 134*	318 165	728 325		
Ponette et al., 2001	54	243	747	293	363	440		0.39
Homann et al., 1992	50	1100		275	216			
Ranger et al., 1995	60	312		307	418	694		
Heilman, 1961**	52	1000	339	148	216	361	4	0.43
Turner, 1980	50	1110		319	404	737		
Turner and Long, 1975	49	1070		178	234		High 4	
Range for this study (mean)	50-55	353-1280 -698	302-1120 -829	162-624 -429	220-804 (577)	366-1220 -886	Low 4-High 1 (High 2)	0.44-0.47 (0.45)***

Comparison of all studies found with biomass calculations of Douglas-fir stands between the ages of 45-60. When stand volume was included in the publication it was used to calculate the specific gravity by the equation described in Methods. Fifty-year site class is King (1966). DF is Douglas-fir, WH is western hemlock, and values in parenthesis are the mean values from this study. The two numbers from Bigger and Cole are from two different stands of Douglas-fir.
*includes bark
**natural stand
***based on Western Wood Density Survey (USDA 1965)

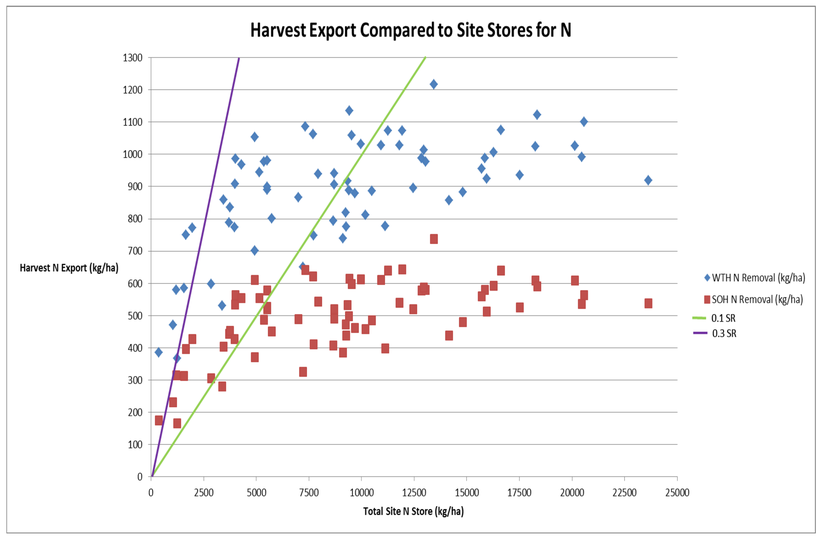

FIGURE 2. N export vs total-site N with 0.1 and 0.3 stability ratio lines.

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