Young Stand Thinning and Diversity Study (YSTDS)
Post-treatment Woody Detritus Inventory Final report

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Study Objectives:
The objective of theYoung Stand Thinning and Diversity Study is to determine if different thinning, underplanting, and snag creation treatments can accelerate the development of late-successional habitat in 35-50 year old plantations.

Post-treatment Woody Detritus Inventory objectives:
The objective of this inventory is to provide post-thinning, base line information characterizing the aboveground woody detritus stores for each YSTDS treatment area. Our goals are to provide estimates of weight of each type of woody detritus per unit area, and, by using literature values of elemental concentrations of woody materials, when available, provide crude estimates of nutrient contents of each detritus component.

Introduction:
With the on-going harvest of productive older forests on federal lands, public, scientific and managerial interest has grown in determining if the ecological functions and processes of late succession habitats can be rapidly restored in young plantations. Traditional thinning practices have been questioned because of the resulting lack of large live trees, large dead wood in the form of snags and logs, vertical and horizontal variation in tree canopies, and a lack of a significant broadleaf tree component. Some key characteristics of late succession habitats include advanced stand age, large snags, large quantities of downed woody detritus, diverse plant and animal communities, multi-layered canopies and variation in stand densities (Franklin and Spies 1991, Kimmins 1987, McComb et al. 1993, Nyberg et al. 1987). Woody detritus (logs, snags, stumps, branches and litter) serves important ecological functions in forest ecosystems. It stores and supplies nutrients and water to organisms, contributes to soil development, supplies energy for microbes and provides habitat for vertebrates and invertebrates.

The Young Stand Thinning and diversity study was initiated to see if plantations can be altered through management activities to resemble naturally-initiated young stands, or to more quickly restore features characteristic of older forests. The detritus inventory component of this ongoing study is designed to estimate mass and nutrient stores of aboveground detritus with a relatively low level of detail and expense. Inventory of woody detritus is required for comparison between treatments, comparison with old-growth stands and for comparison with future entries into the YSTDS stands. These values can also be useful for statistical blocking in future analysis of other ecological features as well.

Methods:
Five woody detritus fractions were measured to estimate total detritus values for the sampling areas. The forest floor component consists of material above mineral soil and less than 1/4 inch in diameter at the large end. Fine woody debris is material greater than 1/4 inch and less than 1 inch in diameter at the large end. Coarse woody debris is separated into two classes, 1 inch to 3 inches in diameter, and greater than 3 inches in diameter at the large end.

Stumps and snags were individually measured in 0.1 ha fixed plots that varied from 13 to 33 plots per treatment, depending on the size of the treatment area.

A modified version of Van Wagner's (1968) method for estimating wood volume from line intercepts was used for this section of the study. The modifications included addition of species and log decay classes to the >3" woody detritus data.

Fine woody debris was measured in $1m^2$ fixed plots and the forest floor was sampled using 0.1 m^2-sampling rings. All sample areas were randomly placed in the treatment area. All data was checked using a double entry technique to reduce data-entry error. The complete down-wood sampling protocol is on file at the Blue River Ranger Station.

Results and Discussion:
Table 1 shows treatment area descriptions for each sampling area. The summary values of all size fractions of woody detritus are shown by treatment in Table 2. The summary values for all size fractions of woody detritus according to treatment area code (TAC, or plot), are shown in Table 3. There was no significant difference in total detritus levels between treatments. There were, however, significant differences between treatments in fine wood (0.25" to 1" diameter), coarse wood (1" to 3" diameter), snag and stump detritus levels. See Table 2. for means separations. The controls were consistently lower in detritus levels except for the coarse wood > 3" class. This is most likely an artifact of slash piling and burning which occurred on the treatment plots. See Blue River Ranger District, Willamette National Forest, for the complete details on the slash piling and burning prescription.

Nutrient concentrations of woody detritus were found in the literature for stumps, snags, coarse wood greater than 3-inches and for forest floor. No nutrient concentrations for fine wood, 0.25 inch to 1-inch diameter, or for coarse wood, 1 inch to 3-inch diameter, were found in the literature.

The lack of nutrient concentration data in the literature, for these size classes, is not surprising. These size classes constitute a large proportion of the individual pieces of detritus on the landscape, are not easily identified by species, and do not have a standardized method of decay class identification. Furthermore, the nutrients in these materials are relatively labile and variable as a result of interactions with microsite, chemical composition, geographic position, soil fertility, moisture and resident fauna.

Given these factors, meaningful field experiments are expensive and yield narrow scopes of inference. The lower proportion of available and potentially available nutrients in these size classes verses the nutrients in the forest floor and root biomass, and the lack of data for input rates in the systems, makes nutrient concentration data of little utility for stand level experiments.

Researchers of different ecological functions and processes often need data in different forms and of different types. The forms of data available from this detritus inventory are shown in Table 4.

Tables 5-8. show nutrient estimates of the woody debris components where published concentrations were available. Because nutrient concentration constants were applied to mass estimates, the means separations from Table 2 can be applied to the nutrient estimates.

Datasets:

The accompanying compact disc includes all the woody detritus inventory data organized in database fashion and stored as Excel 97 and 5.0/95 workbooks. The coarse wood data for 1" to 3" and the > 3" size classes are stored as CWD.xls. The fine woody debris data and the forest floor data are stored as FFFWD.xls. The stump and snag data is stored as STSN.xls. Included on the CD is a subdirectory labeled FSDB with all raw data as stored on the Forest Science Database. Also, the subdirectory titled Warilla Documents includes all files from Jim Warilla the research assistant who designed the sampling protocol and helped initiate the data collection fieldwork. See Table 4 for type of data available.

Areas for further research:

Levels of detail:
The next level of detail for the YSTDS woody detritus study would involve estimates of mortality rates from permanent plots and estimates of decomposition rates from chronosequences. Woody detritus densities and nutrient concentrations would be site specific instead of from literature values. A next higher level of detail would include estimates of decomposition rates of the dominant species using time series, and, the highest level of detail for a woody detritus study would account for seasonal respiration patterns, nutrient leaching, insect utilization of detritus and rates of nitrogen fixation (Harmon and Sexton, 1996).

Nutrient Input accounting-
To gain an accurate picture of nutrient inputs to a forest ecosystem it would be difficult but very important to account for the root biomass. Because roots are incorporated into the soil, microbial decomposition and nutrient cycling are not hindered by moisture deficiency or climate fluctuation. The surface area of detritus in contact with favorable microbe environments also affects decomposition rates resulting in a potentially rapid

decomposition of fine roots and a flush of available plant nutrients. Fungal associations and root grafting may further confound a nutrient budget approximation.

Only the aboveground volume of each stump was measured in this study yet each tree harvested resulted in input into the detritus pool of below ground root biomass. If we consider the *decay class 1* stumps as an indicator of the root detritus input as a result of imposing the treatments, then, the input of root detritus varied significantly between the controls and the thinning treatments ($p=0.0001$). The total aboveground stump biomass ranged from 15,000 to 33,000 kg/ha while the *decay class 1* aboveground stump biomass varied between 0 and 9,000 kg per hectare. The *decay class 1* aboveground stump biomass accounted for 0.8% to 31% of the total aboveground stump biomass depending on treatment area.

An Old-growth forest on the H.J. Andrews experimental forest contained an average of 150,000 kg/ha of living root biomass while the total detritus load was an average of 266,000 kg/ha (Kimmins, 1987, from Grier and Logan, 1977). Cutting that stand would have resulted in an increase in detritus load by 62% from root biomass alone.

Variability over time-
We cannot assume that detritus inputs of mass and nutrients will remain constant through time. The ecological processes and functions of woody detritus are affected by many variables: micro site physical variations (both vertical and horizontal), available moisture, litter chemical composition, mulching effects of detritus. As a stand matures these variables change and interact. As a stand develops and the inputs of detritus vary, the cation-exchange-complex may change and affect the productivity of the soil. Stand development may affect soil moisture competition and decomposition processes related to woody detritus. Also, as species composition of a stand changes, the quality and nutrient content of litter will also change and may affect the potential of the site.

Table 1. Treatment area code (TAC) descriptions.

TAC	Treatment	Block	Site name
1	Control	1	Cougar Reservoir
2	Heavy	1	Cougar Reservoir
3	Light	1	Cougar Reservoir
4	Lt. w/ gaps	1	Cougar Reservoir
5	Control	2	Mill Creek
6	Heavy	2	Mill Creek
7	Light	2	Mill Creek
8	Lt. w/ gaps	2	Mill Creek
9	Control	3	Christy Flats
10	Heavy	3	Christy Flats
11	Light	3	Christy Flats
12	Lt. w/ gaps	3	Christy Flats
13	Control	4	Sidewalk Creek
14	Heavy	4	Sidewalk Creek
15	Light	4	Sidewalk Creek
16	Lt. w/ gaps	4	Sidewalk Creek

Table 2. Young Stand Thinning and Diversity Study treatment summary of post-treatment woody detritus fractions.

Treatment	Forest floor	Fine wood	Coarse wood 1" to 3"	Coarse wood > 3"	Snags	Stumps	Total
	kg/ha						
Control	26,868	2,981 *a*	2,512 *a*	189,631	8,696 *a*	19,205 *a*	249,892
Heavy	57,347	8,798 *b*	7,936 *b*	176,274	1,853 *b*	25,022 *ab*	277,231
Light	49,890	6,630 *b*	6,524 *b*	194,496	4,930 *ab*	22,530 *ab*	285,000
Lt. w/ gaps	45,369	7,912 *b*	6,402 *b*	186,293	2,373 *b*	28,345 *b*	276,693

Note: Values for the detritus size fractions followed by the same letter or no letter are not significantly different ($p < 0.05$) based on an analysis of variance and LSD multiple comparison test.

Table 3. Young Stand Thinning and Diversity Study plot summary of post-treatment woody detritus fractions.

Treatment Area Code (TAC)	Forest floor (<0.25")	Buried wood	Fine wood (0.25"-1")	Coarse wood (1" - 3")	Coarse wood (>3")	Snags	Stumps	Total
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1	35,285	459	2,604	2,073	214,532	6,586	19,901	281,440
2	78,183	9,388	13,948	6,706	195,488	2,205	29,528	335,446
3	35,040	456	6,297	7,630	113,079	6,559	20,300	189,359
4	31,171	4,269	10,685	7,771	222,159	3,242	33,448	312,744
5	33,089	430	3,769	3,309	131,899	10,250	19,737	202,483
6	44,218	8,895	8,276	10,879	167,079	2,624	22,549	264,520
7	26,839	349	7,274	7,133	224,460	10,720	21,201	297,976
8	43,499	4,362	7,578	8,087	169,452	2,697	31,284	266,960
9	11,936	487	3,284	3,067	261,310	12,875	21,552	314,510
10	24,285	316	6,452	7,874	201,311	1,594	32,904	274,735
11	47,588	619	5,410	7,203	233,105	1,781	28,657	324,363
12	40,095	4,477	6,220	7,223	212,419	2,374	28,205	301,013
13	25,455	331	2,268	1,598	150,783	5,073	15,629	201,136
14	63,283	823	6,516	6,284	141,219	990	15,109	234,224
15	76,128	12,541	7,539	4,130	207,342	660	19,963	328,304
16	33,199	20,403	7,164	2,526	141,141	1,179	20,444	226,056

Table 4. Data summaries available on Excel spreadsheet.

Detritus Type	Raw data form	Species	Percent logging slash estimate	Decay class	Nutrient values from literature	Density from literature
Forest Floor	mass				x[1]	x[2]
Fine wood	mass					x[2]
Coarse Wood (1"-3")	volume (from line intercept)		x			x[2]
Coarse Wood (>3")	volume (from line intercept)	x		x	x[3]	x[3]
Stumps	volume	x		x	x[3]	x[3]
Snags	volume	x		x	x[3]	x[3]

* Sources: 1) Prescott and Preston, (1994), 2) Brown (1974), 3) Sollins et al. (1987)

Table 5. Forest floor nutrient content estimates.

	N	P	K	Ca
Control	401	24	24	325
Heavy	839	51	51	681
Light	625	38	38	507
gaps	670	40	40	544

Note: Nutrient concentrations from Prescot and Preston, 1994.

Table 6. Coarse wood nutrient content estimates for detritus greater than 3 inches in diameter.

	N	P	K	Ca
	kg/ha			
Control	175	8	30	266
gaps	169	8	29	261
Heavy	160	7	27	247
Light	176	8	30	272

Note: Nutrient concentrations from Sollins et al. 1987.

Table 7. Snag nutrient content estimates.

	N	P	K	Ca
	kg/ha			
Control	9	0	2	12
gaps	2	0	0	3
Heavy	2	0	0	2
Light	5	0	1	6

Note: Nutrient concentrations from Sollins et al. 1987.

Table 8. Stump nutrient content estimates.

	N	P	K	Ca
	kg/ha			
Control	21	1	3	23
Heavy	26	1	4	31
Light	23	1	3	27
gaps	29	1	4	34

Note: Nutrient concentrations from Sollins et al. 1987.

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