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Growth of Redwood and Douglas-fir Leave Trees Using Variable Retention

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Abstract

Three even-aged second-growth redwood stands were harvested using a silvicultural system commonly referred to as Variable Retention. The stands were approximately 80 to 100 years of age at the time of harvest. A total of 12, 14, and 18 conifer trees were retained per acre within the units sampled. Trees were retained in a dispersed arrangement. Remnant residual old-growth trees present within the stands were also retained. Four years following cutting, the growth rate of the residual trees had increased dramatically with the basal area increment of the young redwood increasing three-fold, from 0.86 to 2.54 percent per year. The growth of young Douglas-fir also increased, but not nearly to the extent of the redwood. The few residual old-growth redwoods demonstrated a substantial increase in basal area increment. This growth rate increase has implications for accelerating the development of large trees and for impacts to the developing understory.

Location and Application of Harvest Method

Three separate stands were harvested in 1999 using a silvicultural system called variable retention (Franklin et al. 1997; Mitchell and Beese 2002). The initial plan was to harvest the stands while retaining between 5 and 10 conifer trees per acre. Leave trees were to be scattered and well spaced. Dominant or codominant trees of all species present were to be the primary targets for retention. The five treated stands are located in Jackson Demonstration State Forest (JDSF) within the South Fork of the Noyo River watershed and within the Oski timber sale area. Prior to cutting, the stands were even-aged second-growth redwood (*Sequoia sempervirens*) forest. The average conifer basal area before cutting was 198 square feet per acre in unit J, 365 square feet in unit L, and 514 square feet in unit T, of which 67% was redwood, 13% was Douglas-fir (*Psuedotsuga menziesii)*, 4% grand fir (*Abies grandis*) and hemlock (*Tsuga*

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heterophylla), and 16% tanoak (*Lithocarpus densiflorus*). The post-harvest basal area was 44, 52 and 44 square feet per acre for units J, L and T respectively.

Methods

Three stands (units J, L, and T) were sampled during 2003 to determine 1) the number, species, and diameter of live conifer trees retained and 2) the rate of diameter and basal area growth before and after cutting. A total of 55 one-fifth acre circular plots were established systematically at grid points within the units at a density of approximately one plot per acre. Within each plot, all live conifer trees greater than 11 inches DBH were measured and placed into 2-inch diameter classes, by species. Within each plot, two trees were systematically selected for increment sampling. DBH to the nearest 1/10 inch was obtained from each of these trees and an increment core was taken to determine radial increment since harvest, and for an equivalent period of years prior to harvest (4 years). The increment measurements were used to estimate DBH at two previous points in time, 1) four years prior to cutting, and 2) at time of cutting. Only one radial increment core was taken from each tree. To reduce bias associated with increment, the core was always taken at a point facing plot center. No estimate of bark growth was taken, so total increment is slightly underestimated. After cutting, tanoak represented a very small percentage of the residual stocking and was excluded from further consideration in this study.

Results and Discussion

The variable retention silvicultural system is generally instituted in an attempt to achieve specific habitat objectives, including retention of habitat elements and species life-boating (Franklin et al. 1997). This study did not evaluate habitat objectives, but was intended to help foresters understand how residual trees respond to cutting of this nature (Mitchell and Beese 2002). The growth and development of the overstory component of these stands will have a potentially large effect upon the growth and development of the new understory due to limitations in the amount of available light and moisture.

Although the initial plan was to retain between 5 and 10 conifer stems per acre, tree retention within the three cutting units averaged 15 trees per acre. Whether this is the result of marking conducted prior to harvest, or the result of the logger leaving trees intended for cutting, could not be determined. In any case, the crews that marked the leave trees were instructed to estimate retention tree numbers, not to precisely count them. It appeared, however, that a greater number of small-diameter trees (12-22 inches) were retained than originally intended. Figure 1 shows the pre and post harvest diameter distribution for unit L.

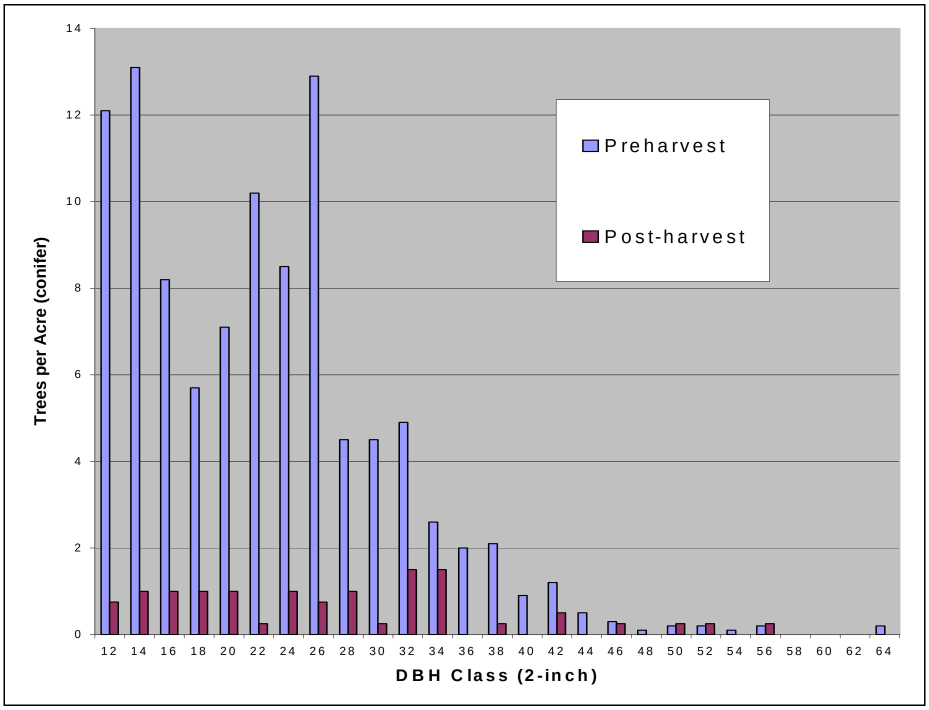

Figure 1. Pre and post harvest diameter distributions from Oski unit L (conifers only).

At the time of measurement, the number of residual conifer stems per acre was 12 in unit L, 14 in unit T, and 18 in unit J. Combining the units, 67% of the trees retained were second-growth redwood, 22% were second-growth Douglas-fir, and 11% were residual old-growth redwood. Residual old-growth redwood is present in many unmanaged even-aged second-growth stands, but generally at very low numbers. These old redwood trees tend to be bypassed remnants of the former old-growth forest and most appear to have once been either suppressed or highly defective trees within those original stands. Many of these remnant trees have large diameters relative to the surrounding second-growth due primarily to an acceleration in diameter increment in response to release created by the original “clear-cutting” of the old-growth.

The measurement of radial growth indicates that second-growth redwood is capable of almost immediate response to the more open conditions created by the cutting. The second-growth redwood increased in annual basal area increment (averaged over the three units) from 0.86 percent per year for the four years prior to cutting, to 2.5 percent for the four years after cutting; a tripling of basal area growth (Table 1, Figure 2). An increase in basal area increment was expected due to the known capability of redwood to respond to thinning (Oliver, et al. 1996). Lindquist (2004) studied the effects of various levels of thinning from below upon the growth of young redwood stands within JDSF. He found that a 50% retention (200 sq. ft. per acre) in stand basal area resulted in a small increase in annual basal area growth rate over a 5-year period when compared to a control stand (400 sq. ft. per acre): 3.5% per year vs. 3.4% per year. He found that a 25% retention in stand basal area resulted in a greater increase in growth (100 sq. ft. per acre): 4.4% per year vs. 3.4% per year. This equated to a 30 percent increase in growth when 25% of the basal area was retained. The stands sampled by Lindquist were approximately 55 years of age at the time of cutting.

Table 1. Basal area, basal area increment and number of trees (leave trees, before and after cutting).

Unit/Species	BA/Acre (sq ft, leave trees only) 1995	1999	2003	Periodic Annual BA% (sq ft) From Sample Incr. Trees Before cut	After cut	Trees/Acre 2003
Unit J rwd	23.82	24.74	27.40	0.96	2.68	13.26
Unit L rwd	22.47	23.15	25.40	0.76	2.43	8.50
Unit T rwd	19.20	19.84	21.80	0.84	2.46	9.50
Avg rwd (n=40)	21.83	22.58	24.87	0.86	2.54	10.42
Unit J D.fir	11.04	12.32	13.80	2.94	2.96	4.57
Unit L D.fir	9.60	10.27	11.10	1.72	2.03	1.75
Unit T D.fir	10.39	11.36	12.60	2.33	2.72	3.75
Avg D.fir (n=31)	10.34	11.32	12.50	2.35	2.61	3.36
Unit J old rwd	9.12	9.33	9.80	1.38	2.47	0.65
Unit L old rwd	19.93	20.65	21.40	0.90	0.91	2.50
Unit T old rwd	14.23	14.61	15.40	0.67	1.34	1.25
Avg old rwd (n=13	14.43	14.86	15.53	0.76	1.13	1.47
All Units						
young rwd	21.83	22.58	24.87	0.86	2.54	6.16
young D. fir	10.34	11.32	12.50	2.37	2.61	4.25
old rwd	14.42	14.86	15.53	0.76	1.13	4.83
All species	46.59	48.76	52.90	1.16	2.12	15.24

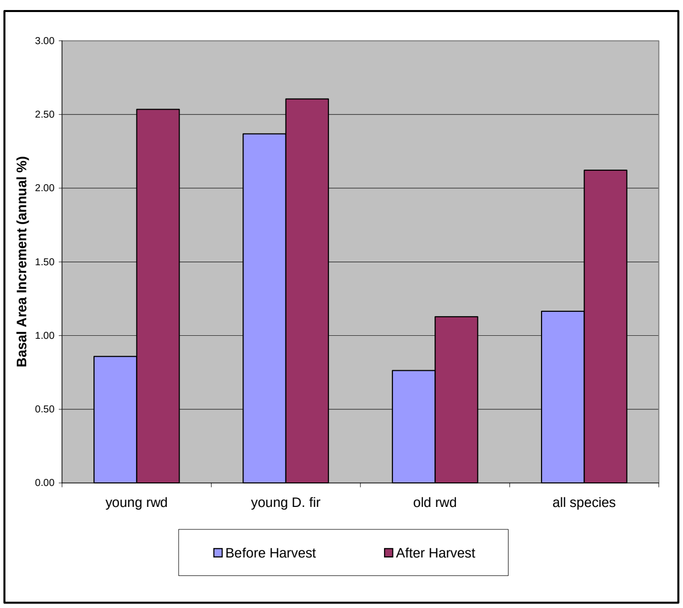

Figure 2. Basal area increment response, cutting unit average (periodic annual %).

The preharvest stands were estimated to average 359 square feet per acre conifer basal area. After cutting the average residual conifer basal area was estimated at 46 square feet per acre, which represented just 13% of the original stocking level. Considering all conifer species combined, the increase in basal area increment that resulted from cutting was approximately double on an annual basis over a four-year period. The Douglas-fir that was retained did not significantly increase in diameter growth with the harvest and was already growing at rates well above the redwood. Either the Douglas-fir simply takes longer to respond than redwood and will grow at a faster rate with time or the trees were already maximizing their increment due to dominant crown positions. While redwood is capable of rapidly increasing crown volume and building new lateral crown in response to an increase in available sunlight, Douglas-fir tends to build crown primarily at the branch tips and at the top, which tends to be a slower process.

The considerable growth rate increase observed has implications for both the development of larger trees over time and also for the development and production potential of the understory. Although the rate of growth is expected to decline slowly over time, the space available to most of the residual trees will remain abundant for the foreseeable future. This will allow growth to remain high relative to pre-harvest conditions and is expected to accelerate the development of large-diameter trees. This is especially true of redwood. The diameter growth increase observed was highly variable at the individual tree level. In the 4 years prior to cutting, the average second-growth redwood tree increased by 0.2 inches in diameter at breast height. Four years after cutting, the diameter increase was 1.04 inches.

Due to the increase in exposure resulting from substantial removal of the canopy, some mortality was expected to occur. Mortality provides desirable habitat elements, such as snags and down logs. It was anticipated that mortality would be greatest among the Douglas-fir and whitewoods (grand fir and hemlock). No whitewoods were encountered in the sample plots. No evidence of mortality was found in units J and L, but four dead trees were encountered in unit T (three Douglas-fir and one small-diameter young redwood). However, we could not determine when the trees died (before or after cutting), so they were excluded from the sample. If they died subsequent to cutting, which is suspected, they represent 2 trees per acre and over 4 square feet of basal area per acre in unit T. The dead Douglas-fir represent approximately 40 percent of the total number of fir sampled in the unit.

While the variable retention system is designed to promote habitat values, it is generally intended to provide timber production as well. Many future management options exist for timber production, including eventual harvest of the overstory trees, and growth and harvest of the understory. For this reason, the growth and development of the understory canopy is of particular importance. Just as the open conditions have increased the growth rate of the dispersed leave trees, it has created an opportunity for the development of a new understory. The variable retention prescription created a stand between the green tree retention and shelterwood described by Drever and Lertzman (2002). Based on their study of understory light conditions under a range of Douglas-fir overstory densities, the percentage of full sun in this study would be approximately 50%.

This study did not attempt to determine the condition of the developing understory, although the understory is fully stocked. As the stand progresses post-harvest, the rapidly expanding crowns of the residual overstory trees are expected to intercept a growing proportion of the light. This is expected to result in a decline in the growth of the understory, but the extent of this decline is unknown. After thinning from below, Lindquist (1996) found that the retention of just 25% of overstory basal area (100 sq. ft. per acre) resulted in substantially lower regeneration growth levels when compared to an area that had been clearcut. Further study will be necessary to determine the effects that overstory has upon the growth of the understory over longer periods of time.

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