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Vegetation change in the Blue River Landscape Study: 1998-2005

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Introduction

The Blue River Landscape Study (BRLS) is an adaptive management project in the western Cascades of Oregon intended to implement, evaluate, and refine a landscape management strategy based on natural disturbance regimes (Cissel et al. 1999). This strategy is an alternative approach to the interim guidelines in the Northwest Forest Plan for “matrix” lands where timber production is a primary goal (NWFP, USDA and USDI 1994). The BRLS is intended to meet those goals while providing landscape structures and composition that better reflect the natural range of variability for the area. Tailoring harvest patterns to emulate the historic effects of natural disturbance may produce the ecosystem processes and habitats for organisms adapted to those natural disturbances more readily than management focused on the needs of each individual species or of selected “indicator” species. Comparison of the BRLS landscape with those managed under the interim NWFP guidelines using field data and long-term simulations will help evaluate those ideas.

The primary natural disturbance in the western Cascades of Oregon is fire. Studies in the Blue River watershed have determined that the fire regime was of mixed severity and varied greatly with elevation and aspect in the watershed (Teensma 1987, Morrison and Swanson 1990, Weisberg 1998). In general, fire in the lower elevations was of moderate frequency and intensity and resulted in partial mortality of trees, while fire in the higher elevations was of low frequency and high intensity and resulted in mortality of most of the trees. The size of disturbed patches tended to be smaller in the lower elevations than in the higher elevations. Topography played an important role in affecting local fire severity and tree survival, with a tendency towards higher severity on dry upper slopes and lower severity in moist draws (Weisberg 1999). Tree species vary in their resistance or tolerance of fire effects (Minore 1979), so the composition of surviving trees varied across the landscape.

The BRLS identified three different “Landscape Areas” in which management of different frequency and intensity would be applied. Landscape Area 1 (LA1) is in the lower elevations of the watershed and the timber management was based on a rotation age of 100 years with an overstory retention level of 50% canopy cover after harvest. The timber management approach of Landscape Area 2 (LA2), found in the middle elevations of the watershed, was based on a rotation age of 180 years with an overstory retention level of 30% canopy cover after harvest. Landscape Area 3 is in the highest elevations of the watershed and the timber management was based on a rotation age of 260 years with an overstory retention level of 15% canopy cover after harvest. Post-logging prescribed fire is common to treatments in all landscape areas. The landscape area strategies address many other components of management, including spatial pattern of retention, stream buffers, snag and log retention and/or creation, reforestation, and intermediate thinning (Cissel 2002). Landscape areas are not necessarily contiguous blocks, but consist of areas of similar ecological conditions and disturbance regimes.

Each Landscape Area was divided into blocks of different sizes, to which the prescriptions would be applied over time. The actual prescription for any block, while intended to meet the overall goals for the Landscape Area, is tailored to the topography, geomorphology, vegetation, and stream network found in the block (Cissel 2002). Detailed assessments of each block, and the prescriptions designed for them, are kept on file at the McKenzie Bridge ranger station of the Willamette National Forest.

This report describes the vegetation portion of the implementation and effectiveness monitoring for the BRLS (Cissel and Swanson 2001). This report describes results through 2005 and is the first one to address post-harvest effects; earlier reports described the pre-treatment vegetation of the different blocks (Acker 2000a, 2000b). The vegetation monitoring was comprised of two components that differed in design and measurements: upland vegetation and riparian vegetation. Each component was designed to answer specific monitoring questions:

Upland vegetation monitoring questions:

1. What are the growth and mortality rates of residual trees, and how do they vary by residual tree density?
2. How does residual tree density affect tree regeneration composition, growth and mortality?
3. What are the growth rates of understory trees, and how do they vary over time by residual tree density?
4. How does residual tree density affect understory plant composition and biomass?
5. How does the amount, size, and decay class of logs and snags vary by residual tree density?

Riparian vegetation monitoring questions:

1. Is the composition or abundance of riparian-associated herbs, shrubs or trees changed by implementation of the landscape management plan prescriptions?
2. Are changes in the composition or abundance of riparian-associated herbs, shrubs or trees related to residual tree density?
3. What is the rate of recovery by riparian-associated herbs, shrubs or trees?

Methods

Study area

The 23,900 ha Blue River Watershed is located in the McKenzie River drainage, a tributary of the Willamette River in western Oregon. Except for 1,490 ha of privatelyowned land in parcels at the lower and upper ends, the watershed in part of the Willamette National Forest and includes the H.J. Andrews Experimental Forest. The landscape is steep and dissected, with elevation ranging from 317 to1639 m, and precipitation abundant, with a mean annual precipitation greater than 250 cm. The watershed is mostly covered in conifer forest dominated by Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and Pacific silver fir (*Abies amabilis*).

Within the 22,417 ha of National Forest land in the Blue River watershed, several areas are managed in accordance with previous plans and are not covered by the BRLS. These areas include the H.J. Andrews Experimental Forest (5,876 ha), Late Successional Reserves (2,145 ha), and Special Interest Areas (482 ha). In addition, 2,060 ha were identified as Aquatic Reserves to provide late-successional forest conditions in important aquatic habitats. Of the remaining 11,854 ha, 4,081 ha (34%) was allocated to Landscape Area 1 (LA1), 3,065 ha (26%) to LA2, and 4,708 ha (40%) to LA3.

Monitoring design: upland vegetation

Many studies attempt to control as many sources of (unwanted) variation as possible in order to better answer the primary questions of interest. It was not possible to control for forest composition and potential productivity in the BRLS, however, because those attributes are highly correlated with the historic disturbance regimes which the different Landscape Areas represent. In addition, the mature stands being managed varied substantially in age and structure. Existing conditions in most blocks included stands of varying age and structure as a result of past management history. Logging treatments of appropriate stand age classes within each block were implemented with timber sale units.

The initial monitoring design for upland vegetation called for sampling combinations of harvest prescription, plant association, and seral stage which are common to a given Landscape Area (Acker 2000a). The treatment unit to be sampled was defined as a “patch”, which was a contiguous area within a timber sale unit, or a contiguous area spanning adjacent sale units. At least three separate patches per combination of harvest prescription, plant association, and seral stage would be monitored; patches would be selected randomly if more than three were present. In practice, similar plant associations were grouped, as determined from walk-through surveys of each unit. Seral stages (mature vs. old-growth) appear to have been differentiated based on the density of trees >100 cm diameter at breast height (DBH).

Within each patch, plots were to be established to sample upland vegetation. Plots were randomly placed within units within the following constraints: 1) plot boundaries must be $50 m from a patch boundary, 2) plot centers must be at least 100 m apart, and 3) plots must not be located within obvious riparian influenced areas (Acker 2000a). The goal was to establish 3 plots per patch, but more could be established in large patches, or fewer if patches were not large enough. The following method was used to locate the plot centers. The center of the first plot in the area was randomly selected within the first 100 m on the major axis of the harvest unit area and at any random point along the minor axis at the major axis location. The next plot within the same unit was located in a similar manner at a random point on the major axis of the unit between the 100 and 200 m point on this axis and at a random point on the minor axis. Each of the plot centers in a unit was selected in this random way to span much of the land in the unit.

Blocks and units within them have been identified for harvest in each of the Landscape Areas to date, stratified by landscape area and seral stage (Table 1a). There was no stratification of patches by plant association in landscape areas 1 and 2 because field personnel found the dominant vegetation in most of those units was dwarf Oregon grape and salal, with varying amounts of rhododendron (Acker 2000a), indicating plant associations with similar environmental characteristics in the western hemlock zone (McCain and Diaz 2002). The plant associations shown in Table 1a were determined through analysis of the pre-treatment vegetation data from individual plots, and confirms the similarity of patches. The number of patches initially sampled in old-growth stands in Landscape Area 2 was more than the minimum of three. In Landscape Area 3, Acker (2000b) noted that the plant association for one of the patches (21) indicated it was a more productive site than the others. However, the plant associations for the other three patches in LA3 are quite similar and could be considered replicates.

Plots were measured once prior to treatment, between 1998-2000. Units in LA1 were cut in 2000 and burned in the late spring of 2001. The mature units in LA2 were cut in 2002 and burned in the late spring of 2003. The old-growth units in LA2 have been cut and burned at various times since 2002, but not all patches have been treated yet and two have been dropped from the study. None of the patches in LA3 have been treated.

The monitoring plan calls for measurement of vegetation plots in the first year after harvest (i.e., within a few months after the prescribed burn), and in the third and fifth years. Subsequent measurements would occur on a 5 year schedule.

<u>Monitoring design: riparian vegetation</u>

The riparian vegetation sampling was intended to assess different levels of retention of stream-side and stream buffer trees within logging units. Within each Landscape Area, three streams were selected; two were within harvest units and one was in a nearby uncut area (the “control”). The prescription for one of the streams in the harvest units (the “buffer”) called for a 61 m (200 ft) wide no-cut buffer centered on the stream. For the other stream in a harvest unit, the prescription called for increased canopy retention near the stream and no cutting of bank-side trees (the “streamside retention” stream). Streams were identified in selected units in each of the three Landscape Areas that contained intermittent Class IV or small Class III streams that were of similar size and topography. This sampling was co-located with areas used in the amphibian and stream temperature monitoring components of the BRLS (Hunter 1999). Sample plots were located just downstream of three of the five amphibian monitoring locations (Table 1b).

The schedule of treatments and measurements in the different landscape areas is the same as for the upland study.

Upland plot measurements

Much of the information in this section repeats that contained in Acker (2000a, 2000b), and Cissel and Swanson (2001) but is included here for completeness. In addition, any protocol changes or problems encountered during remeasurement are described. Upland areas were sampled with 0.1 ha plots and were slope-corrected (horizontal radius = 17.84 m). Plot centers were marked with rebar sunk into the ground and covered by pvc pipe and labeled with the plot number and establishment date. Declination was set to 19.5 degrees east for all azimuth measurements. Measurements taken at plot center during the pre-treatment installation included slope, aspect, and topographic position. GPS coordinates have been collected at most of the plots. Three witness trees surrounding the plot center were selected and were tagged, measured, and the bearing, distance, and slope to each tree from plot center was recorded. Multiple quadrats and transects within the 0.1 ha plots were used for a variety of vegetation measurements (Figure 1).

Canopy cover

During the pre-treatment sample, canopy cover was assessed at 12 points per plot with a moosehorn densiometer which was based on a design built for Tom Spies for other research projects. The moosehorn had a self-leveling gimbal, and a grid of 25 squares to aid in estimating canopy cover; the diagonal of the grid covers a view angle of approximately 12.7 degrees. Sample points were located at 5, 10, and 15 m from plot center in the four subcardinal directions (NW, NE, SE, SW). During post-treatment samples, however, canopy cover was measured at 5 points per plot, located at plot center, and at 5 m from plot center in the subcardinal directions.

Trees and snags

Live trees $5 cm diameter at breast height (DBH) and standing dead trees $10 cm diameter at breast height (DBH) were sampled in each 0.1 ha plot. Trees that were marked for retention and all sample trees <18 cm DBH (the lower limit for merchantability) were tagged at breast height with aluminum tags and nails, with tags facing plot center. For live trees, species, DBH, canopy class, vigor, and crown ratio were recorded at pretreatment measurement time. Species, DBH, and decay class were recorded for all snags, and total height and top diameter were recorded for snags with broken tops.

A subsample of live trees was selected during the pre-treatment sample for additional measurements of total height, height to crown base, 5- and 10-year diameter increment, sapwood thickness, bark thickness, and crown width. The subsample was selected from live trees $10 cm DBH from species with at least 5 trees measured on the plot. Only trees with no evidence of top damage, or other serious damage or disease, could be selected. All trees were selected for species with 5 to 10 individuals tallied. For species with more than 10 individuals, the range in DBH of all tallied trees was divided into thirds, and trees were randomly selected so that three trees were selected from the bottom and top thirds of the DBH range and four trees were selected from the middle third of the DBH range. Height was measured with tape and clinometer and all angles and distances recorded. Five- and ten-year growth and sapwood width were measured on two separate increment cores per tree. Horizontal crown radii were measured in the four cardinal directions on each selected tree.

During the first post-treatment measurement, trees were relocated as best as possible given that many of the tags had melted in the prescribed burns. Nevertheless, there were many live trees and snags recorded that could not be unambiguously matched to a pre-treatment tree or snag and were given new tag numbers. Azimuth from plot center was recorded for all tallied live trees and snags to aid in relocation. According to the written field protocols, trees live at pre-treatment and still alive were to have been measured for species, DBH, vigor, and fire damage. For “new” live trees that were apparently not measured during pre-treatment the additional measurements of crown class, crown ratio, height, crown base height, vigor, and fire damage were supposed to have been recorded. Trees that were live at pre-treatment sample and found to be dead were to have been measured for species, DBH, decay class, height, and whether the top was broken; if knocked over, no measurements were taken and the comment "dead and down" was written. For trees that were snags at pre-treatment and were remeasured as snags: an "X" was entered in the DBH column. In practice, what was actually recorded for any tree ran the gamut, with little discernable consistency. In unit 8A, so little was recorded during the first remeasurement that it was not possible to determine which of the tallied stems were alive and which were snags.

For the second and third remeasurements, trees were usually successfully relocated and species and DBH were generally consistently recorded. Additional measurements were taken in unit 8A (e.g., fire damage) that had been forgotten at the first remeasurement.

Underståory vegetation and ground cover

Within each plot two transects were established for line-intercept cover measurements of tall shrubs (defined by species) and trees <5 cm DBH. The transects were approximately 14 m long and the end points of the lines were 10 m horizontal distance from the center of the plot in the sub-cardinal directions. Line 1 ran from the NW point to the NE point and line 2 ran from the SE point to the SW point. The locations of each species’ canopy edges over a tape along the transect were recorded, along with the transect length.

Three 1x1 m quadrats were placed on each transect with the upper left-hand corner of the quadrat on the line at 1, 6, and 11 m from the transect starting point (quadrat always on the plot center side of the transect). In each quadrat, species cover of herbs and low shrubs (defined by species) was recorded to the nearest percent, trees <5 cm DBH rooted in the quadrat were counted by species and height/DBH class, and basal diameters of tall shrubs rooted in the quadrat were recorded. The codes and names for all vascular plant species found in this study to date are in Appendix A, with the lifeform definitions used to determine which cover protocol (quadrat or line intercept). All codes were reconciled or converted to the USDA NRCS (2000) PLANTS database species codes, although in practice there was a great deal of mixing with the Garrison and Skovlin (1976) codes previously used in the region. In addition, a complete list of all vascular plant species on the 0.1 ha plot was recorded.

For the pre-treatment and first post-treatment measurements, soil disturbance and forest floor depth were recorded. One of four categories of soil disturbance were recorded for each quadrat after those used by Halpern (1988). Also during the first post-treatment measurement, the depth of the organic layer (litter and duff) above the mineral soil horizon was recorded next to each quadrat.

Beginning with the post-treatment measurements, the cover of substrates (e.g., litter, mineral soil, wood) in each quadrat was also recorded.

Coarse woody debris

All logs $10 cm in diameter and $1 m in length within the 0.1 ha plot were measured during the pre-treatment and first post-treatment sample periods (except for unit 8A, where post-treatment measurements were never taken). Upright pieces that were not self-supporting were considered logs. For each log, species, decay class, small and large end diameters, and length in the plot were recorded. Decay-class definitions for snags and logs follow Maser et al. (1988). If portions of logs were hollow, the length and average diameter of the hollow portion were recorded.

<u>Riparian plot measurements</u>

Many of the measurements in the riparian plots were similar to those of the upland plots, although the configuration differed somewhat. The riparian plots were 0.1 ha in size, but there were two transects 20 m in length (slope distance) that were centered on the stream and ran perpendicular to the stream. The center of transect A coincided with the center of the 0.1 ha plot, while the center of transect B was 5 m downstream. The “zero” point on each transect was on the left slope when facing upstream. Transect ends were permanently marked with rebar. Quadrats 1x1 m in size were placed along the entire length of each transect, on the downstream side.

Some confusion with plot placement occurred in unit 2E (buffer). Because the amphibian plots were quite close together and would have caused several trees to be measured in two different plots, plots were not installed in the standard locations of points 2, 3, and 4, but at points 2, 4, and 5. However, in 2005 plot measurements were mistakenly taken at points 2, 3, and 4, and it appears the transects were always measured at 2, 3, and 4. A similar non-standard plot placement was used in the unit 20 control (plots 1, 3, and 5), which will need to be done correctly if/when remeasured.

Canopy cover was measured with the moosehorn at the 1, 5, 10, 15, and 20 m points on each transect. As with the upland plots, live trees and snags were measured in the 0.1 ha plots. However, trees were never tagged or azimuths taken, presumably to save time. During the 2005 field season, all trees and snags were tagged and azimuth recorded after it was decided that the inability to track individual trees and errors in determining whether trees were in the plot or not were limiting the utility of the data. Unlike the upland plots, no intensive tree measurements were taken during the pre-treatment sample, and crown class, crown ratio, and fire damage were not recorded for live trees during any sample period.

The cover measurements for understory vegetation in the riparian transects and quadrats were identical to the those in the upland plots. Trees <5 cm DBH were also counted by height/DBH classes in each quadrat. No biomass measurements were taken.

The geomorphic profile of each transect was recorded by recording the start and stop points of different surfaces (e.g., active channel, gravel bar, valley wall) on each transect during the pre-treatment sample. Photos were apparently taken at the center of the upper transect looking upstream, downstream, and to either side, but it is not clear what kind of equipment was used and where the photos are.

There were separate measurements of channel morphology and coarse woody debris that were done along the length of each sample stream during each sample period by the same crews that sampled vegetation, but the design and analysis is addressed in the "stream channel morphology and large wood" monitoring component (Cissel and Swanson 2001).

Data Management

Data was keypunched (usually, but not always, using double-entry and reconciliation) and stored in the OSU Forest Science Data Bank (FSDB). The project codes are TV048 for the upland data, and TV048R for the riparian data. Metadata, table structure definitions, and code definitions are stored with the FSDB data, and initial data and logic checks are run after data entry.

Substantial additional data checking was done in the process of compiling the initial pre-treatment reports (Acker 2000a, 2000b) and this report. Errors and resolutions are described in file folders for pre-treatment data. For the post-treatment data, general errors and resolutions are described in *BRLS_compilation.wpd*, with specific data edits contained in the SAS files that implemented them (*Upland_data_setup.sas*, *Upland_data_2005.sas*, *Remeas_tree_setup.sas*, *Remeas_tree_2005.sas*, *Riparian_data_setup.sas*, and *Riparian_data_2005.sas*). Final cleaned datasets were used for analysis and to update FSDB databases.

The upland tree data required the most work in order to match pre-treatment trees with intensive measurements (data recorded on separate datasheets and many trees expected to be harvested weren't tagged) and to track trees through time in order to estimate harvest, mortality, and growth. This was difficult to do between the pre-treatment and first remeasurement, since many of the tree tags were melted in the prescribed burns and azimuths were not available for the pre-treatment data to relocate trees. Each tree was assigned a unique ID independent of the tag number in the field, since many trees were either not tagged or tags changed over time. Matching of trees across sample periods and assessment of growth, mortality, and ingrowth was done by comparing species and DBH. In general, tree tracking was reliable for the upland trees following treatment. Of the trees that were tracked between pre-treatment and first remeasurement, many had smaller DBHs after treatment. In addition to errors in relocating DBH and straightening measurement tapes, reduced DBH measurements could reflect consumption of bark by fire: 54 of the 67 trees that shrank in DBH were scorched >3 m up the bole. Comments on the datasheets were used when available to resolve tree status questions. When tree or snag attributes were blank for a particular sample period (e.g., DBH or species), data was copied from measurements of the same tree from the nearest sample period in time. The type of DBH and height records (measured, copied, or estimated) was identified with codes in the database.

For the riparian tree data, comments were found on datasheets from 2003 that said that only snags that appeared to be new were recorded (riparian plot trees were not tagged until 2005). Therefore, all snags from the previous measurement of the same plot were copied and given a 2003 record in the database.

Some edits of the vegetation data were required. Species codes were not consistent, sometimes using codes from Garrison (1976), sometimes from NRCS PLANTS (USDA NRCS 2000). In most cases the intended species could be readily determined from the code; the list of vascular plants found in the H.J. Andrews (McKee 2005) helped in determining the likely intended species. Although there were some incorrect measurements of species (e.g., small shrubs measured with the line transect instead of the quadrats), in most cases it was apparent that the species was not being double-sampled on the plot (e.g., on both quadrat and line intercept). Where it was clear the same species was being double-sampled on the same plot, the records were deleted from the incorrect category before analysis (data are still in the database, however). The species recorded to date, and the codes used in this report, are found in the Appendix A.

Analysis

Because the pre-treatment and post-treatment sample periods fell on different years in the different units, the sample periods will be referred to in this report using the following convention:

Term	Sample period
PTM	Pre-treatment sample period
Year 0	First remeasurement, within months of the post-logging prescribed burn
Year 2	Second remeasurement, two years after the first remeasurement
Year 4	Third remeasurement, two years after the second remeasurement

All data were analyzed in *BRLS_anal.sas* and *BRLS_ripanal.sas*, with results exported to Excel spreadsheets. Plots and units that were dropped from remeasurement were not included in the analyses (see Tables 1a and 1b). Although the sample points used for upland canopy cover measurements differed from pre- to post-treatment, all sample points were used for this descriptive report (12 points for pre-treatment, 5 for post-treatment). Direct statistical comparisons between pre- and post-treatment should probably only be done using the four points per plot that coincide between measurements.

For the tree analysis, the trees in unit 8A which were missing tree status information at Year 0 were given the same tree status as that found at Year2 (e.g., if tree was a snag at year 2 it was assumed to have been dead at year 0). We tried to analyze the recorded fire damage to trees and its relationship to mortality. However, only 152 of the 239 dead trees at year 0 (64%) had a fire damage recorded, so we couldn't examine early effects of mortality. For the live trees at year 0, 231 out of 253 (91%) had a fire damage recorded. Fourteen of the trees without a fire damage record were all in unit 5E in 2005, with two 5 cm hemlocks marked with a fire damage of 0. While it's not clear whether this unit was in fact burned prior to measurement, excluding the entire plot from analysis should not introduce any bias in the results (and less bias than assuming that blanks are actually zeros).

Tree volume and biomass were estimated for each live tree. Because only a subset of the trees were measured for height, it was necessary to estimate heights for the rest. Equations for different species or species groups were created using non-linear regression, following the equation form used in Hanus et al. (1999, eq. 1):

$$HT_{ft} = 4.5 + e^{\alpha_0 + \alpha_1 DBH_{in}^{\alpha_2}}$$

Because only three Pacific yew had measured heights and the 12 measured chinkapin varied little in DBH, the equations reported in Hanus et al. (1999) were used for those species. There were no measured heights for red alder, so 515 measured trees from the Forest Inventory and Analysis inventory of western Oregon were used (Waddell and Hiserote 2005). The parameters for the equation that were used for each species to estimate height in feet from DBH in inches are shown in Table 2. The equations can also be used to estimate height of snags with unbroken tops, which did not have measured heights.

Species-specific volume and biomass equations used by the Forest Inventory and Analysis program (FIA) in analyses of western Oregon timberlands were applied to the data (Azuma et al. 2004). Log volume was calculated using the equation for the frustum of a cone. Log biomass was calculated using the estimated log volume, species-specific wood densities from Forest Products Laboratory (1987), and decay-class biomass discounts from Waddell (2001).

Tree basal area growth rates were calculated from increment cores for pre-treatment growth and from remeasured DBH for post-treatment growth. Ten-year radial increment was averaged across the two cores (if available) and multiplied by 2.2 to approximate the diameter growth of wood plus bark (a standard FIA approach to estimating DBH increment). Diameter increment was subtracted from DBH measured at pre-treatment to estimate DBH 10 yrs prior to measurement. Finally, basal area was calculated for the two time periods and their difference divided by the intervening years to estimate annual basal area growth per tree. Post-treatment annual basal area growth was calcuated from the difference in DBH between year 0 and year 2, and year 0 and year 4, where available.

Descriptive statistical techniques were used to analyze the existing data, with the plot as the experimental unit. Values of interest were summed or averaged at the plot level, and then averaged across the plots in a treatment by seral-stage group. Means and standard errors are reported in tables and graphs. In general, where the standard error interval of one mean overlaps another mean, they are probably not significantly different.

Results

Upland Plots

The number of plots used in the analysis of landscape areas and seral stage varied over time. The treatments have been fully implemented in LA1 and in the LA2 mature stands, and partially implemented in the LA2 old-growth stands (Table 3). Because treatment dates differ, the number of plots that have had the most complete number of remeasurements also differ. For the LA2 old-growth units, additional checks were conducted for the four plots that were measured through year 2 to evaluate whether trends differed from the full set of plots measured. Where sample size differs from Table 3 because of missing data for some variables and units, it is noted in the table or figure caption.

Canopy cover was lower after logging and prescribed burning on the upland plots, with lower cover levels found on LA2 than on LA1. The missing values and different plots between year 0 and 2 did not affect the results shown markedly; e.g., mean cover in year 0 for the same 4 LA2 old-growth plots that were measured in year 2 was 17.3%, compared to the overall average of 21.9%. The canopy cover levels found in the treated units were somewhat lower than the prescription targets of 50% in LA1 and 30% in LA2. One likely reason for this is that, by design, canopy cover was not uniform across the units. Because plot placement criteria avoided riparian areas and stand boundaries, areas where prescriptions often called for greater retention of live trees, plots would tend to be found areas with low canopy cover relative to the rest of the unit. In addition, it is likely that the prescription was based on estimates of **crown cover**, that is, the area covered by trees as estimated from their mean crown diameters. This figure will always be higher than **canopy cover**, because crowns are irregular in shape and often have gaps within them. Moosehorn measurements taken from cross-unit transects after treatment (Table 4) suggest that plot placement might be the more likely explanation.

Treatments reduced live tree density and basal area to different levels in each landscape area (Tables 5 and 6). Although density reductions varied between 71-93% among the landscape area by seral stage combinations, basal area reduction for the two mature treatments was similar at 48%. These results reflect the preferential removal of trees in the smaller size classes (Figure 3). The differences in density and basal area between years 0 and 2 for the LA2 old-growth were affected by the different number of plots sampled; mean density and basal area in year 0 for the same 4 LA2 old-growth plots that were measured in year 2 were 57.5 and 25.7, respectively. The results suggest that there was little mortality of trees after treatment in LA1, but some mortality in LA2, possibly related to differences in intensity of prescribed fire among areas.

Analysis of trees that had different levels of fire scorch recorded in year 0 illustrates that mortality was greater for trees with more severe scorch, and that trees that died were smaller than trees that survived a given level of scorching (Table 7). Quadratic mean diameter of live trees increased with treatment, and with the mortality of smaller trees after treatment (Table 8). Heights of the three tallest measured trees per plot increased from LA1 to LA2 to LA3 (Table 9). Independent measurements of height in the residual stands were not conducted but because the largest trees in each stand were retained, maximum height is not likely to have changed much in the time since pre-treatment. Species composition was moderately affected by treatment. All stand types were dominated by Douglas-fir prior to treatment, which made up 82 to 90% of the basal area in mature stands, and 64% in old-growth stands (Figure 4). The dominance of Douglas-fir relative to other species remained constant with treatment in LA1, but tended to increase in LA2. Changes in live tree volume and biomass are shown in Tables 10a-d.

The time elapsed since treatment was short, but an analysis of pre-treatment and post-treatment basal area growth rates was conducted to evaluate the approach. Trees were analyzed by diameter class to account for size-dependent differences in growth. The distribution of trees by species by size class was uneven across the plots within a landscape area, so the number of plots (and trees within plots) from which means were calculated varied. Growth rates for selected categories represented in at least a few plots across landscape areas is shown in Table 11. Growth rates tended to be higher in LA2 mature stands than in LA1 mature stands for most species by diameter class groups. There was also a tendency for greater increases in growth following treatment in LA1 mature stands than in LA2 mature stands. Future analyses might explore comparing regression lines of growth on DBH to increase the sample size of the analysis.

Treatments tended to increase density of snags in mature stands, but tended to decrease snag basal area, particularly in LA2 mature stands (Tables 5 and 6). The difference in density and basal area between years 0 and 2 for the LA2 old-growth was affected by the different number of plots sampled; mean density and basal area in year 0 for the same 4 LA2 old-growth plots that were measured in year 2 were 45.0 and 10.8, respectively. Although not consistent across area, there was a tendency for an increase in snags in the smaller DBH classes, and a decrease in some of the larger DBH snags (Figure 5). The prescriptions for each landscape area call for snag creation from existing live trees where levels are low. Snag creation had not yet happened in the units sampled to date, ***and may not be reflected in future plot data since the contractors were instructed to avoid the plots(?)***. As expected, the treatments resulted in large increases in the density of snags in decay class 1, and declines in the density of snags in more-decayed classes (Figure 6).

Seedling densities (trees < 1.4 m tall) increased in response to treatment in all landscape areas and stand types, while sapling densities (trees $1.4 m tall and <5 cm DBH) were temporarily reduced (Table 12). Variation was quite high, however, because of the relatively small plot size used to sample seedlings and saplings. Several species were represented in the seedling pool in all landscape areas, including conifers (ABAM, PIMO3, PSME, THPL, TSHE) and hardwoods (ACMA3, CHCH7, CONU4).

Volume and mass of woody debris declined with treatment in mature stands in both landscape areas, but increased in the LA2 old-growth stands (Tables 13a, 13b). Declines tended to occur across all decay classes (data not shown).

Understory vegetation cover was reduced by treatments, but began recovering quickly (Table 14). There was little change in cover of graminoids, and although herb cover increased since treatment, it only exceeded pre-treatment levels in LA2 old-growth stands in year 2. Shrub cover increased rather quickly in all areas. Species composition was most greatly affected by treatments in the herbs (Table 15). Although many of the species that dominated in the pre-treatment stand were still important after treatment, several early-seral herb species were important in all landscape areas, including ANMA, CIAR, CIVU, EPAN, PTAQ , and SESY. For the shrubs, ACCI appeared to be slower in establishing cover than the other common species. For trees, sprouting hardwoods like ACMA3, CHCH7, and CONU4 were important, but conifers were also found, including PIMO3, most of which was probably planted.

Riparian Plots

There were three vegetation plots measured in each landscape area by stream treatment type combination. The treatments have been fully implemented in LA1 and in the LA2 buffer treatment, but the unit with the LA2 streamside retention treatment was dropped from the timber sale and has not been treated. The LA2 control stream was not measured at the same time the year 0 measurement took place for the LA2 buffer (delayed to coincide with the LA2 streamside retention), but was measured at the same time as the year 2 measurement.

Overstory tree canopy cover over the streams did not appear to be changed by any of the treatments (Figure 7). There were some differences in pre-treatment mean cover among treatments. There seemed to be no significant patterns of canopy cover with distance from stream, and no year-to-year differences in trend, indicating substantial measurement variation over the small range of cover levels found (Figure 8).

Live tree density and basal area declined slightly in the LA1 streamside retention treatments, but otherwise remained similar or increased slightly across the other treatments and landscape areas after treatment (Tables 16 and 17). Note that the streamside retention treatments were the only ones where harvest might have occurred within the plot footprint; all streams were excluded from prescribed burns by within-unit firelines.. Most of the decline in tree density in LA1 occurred in trees 25-75 cm DBH (Figure 9). There was little apparent treatment effect on quadratic mean diameter (Table 18). The sizeable increases in basal area in a short time period (e.g., LA2 buffer) were usually within the standard error of the mean for the previous sample, suggesting that some of the changes within a treatment over time may be a result of sample error (i.e., different trees being recorded as in or out of the plots at different times) rather than actual changes due to harvest, growth, or mortality. For the LA1 buffer plots, there was also the mistaken location of one of the plots in 2005 which caused some of the variation. It might be possible to compare tree lists for the same plot over time and exclude some of the largest trees that were not sampled consistently from year-to-year and affect the basal area, but that was not done for this report.

Tree species composition in the riparian plots was more variable and less consistently dominated by Douglas-fir than in the upland plots (Figure 10). However, stands in these small-order streams were consistently dominated by conifers, with few hardwoods found. Composition varied little over time, primarily due to sample error (data not shown). Changes in live tree volume and biomass are shown in Tables 19a-d.

Estimated seedling (trees < 1.4 m tall) and sapling (trees $1.4 m tall and <5 cm DBH) densities fluctuated over time with little discernable pattern (Table 20). Declines in seedling density were apparent in some of the stand types, and tended to occur in the smallest seedling size classes. There was a mix of hardwood and conifer species, but TSHE was the most abundant in LA1 and LA2, while THPL was the most abundant in LA3.

Few changes in the cover of understory vegetation with time were evident in the riparian plots, although it appeared that the streamside retention treatment in LA1 did reduce understory tree and shrub cover (Table 21). Few graminoids were recorded in any of the streams, and it appears that bryophytes were not recorded in the first year of sampling (pre-treatment in LA1 and LA2). The dominant understory species and their mean cover did not change much over time in any of the landscape areas or treatments (Table 22). A few weedy species not found in the control were recorded in the streamside retention treatment (CABU2, CIRSI), but only in Year 0 with very low cover.

Discussion

Although the time since treatment is still relatively short and not all the units in the first round of the BRLS have been treated yet, the responses detected by the vegetation monitoring plots appear to be in line with the intent of the prescriptions. Canopy cover and tree density on upland plots was lower than the overall target for the prescriptions, but the upland areas were intended to have lower tree density than riparian areas in the units. Indeed, very little tree removal and no reduction in canopy cover was detected in the streamside retention riparian plots in LA1. So far the monitoring has been able to describe the implementation of the prescriptions on trees and snags. Besides the usual immediate effects of harvesting and burning on down wood, ground cover, and understory vegetation, we have not yet seen a strong effect of residual tree density on vegetation.

The overall objective for the upland vegetation monitoring was to “document changes of upland vegetation following timber harvest”. The monitoring employed a stratified random sample design, with the target strata defined as: 1) interior areas of harvest units (>50 m from unit boundaries, and excluding mapped unharvested patches within units) that are 2) areas not influenced by riparian zones and are in 3) plant association groups that are common in the harvest units within a landscape area. Although the third criteria would exclude some upland areas from monitoring, it is a sensible approach to control costs and variation while still being able to describe the predominant conditions in a landscape area. The rationale for the first criteria is not stated, but it might have been intended to avoid effects from neighboring stands. However, this may have introduced a bias against sampling upland areas with higher retention levels; many of the prescriptions for the units called for leaving higher tree densities in lower slope positions and stand boundaries (Anonymous 1997). The cross-unit canopy cover measurements taken by Jim Mayo indicate that prescription targets were met, and that overall tree density in the units was higher than that found on the plots. The 50 m buffers end up excluding a significant portion of each unit from sampling. For example, a 50 m buffer on a square 40 ac unit takes up 17.4 ac (44%); the proportion increases with irregular shapes and smaller units. Since the interior upland zones were sketched on logging unit maps, the strata that the plots sampled are defined geographically, so further characterization of the strata is possible (e.g., with aerial photography or canopy cover measurements).

The current design could be used for implementation monitoring (i.e., “did we do what we said we were going to do?”) if the prescriptions for the interior upland areas were specified. Although there is quite a bit of guidance on placement of residual tree patches and gaps, there do not seem to have been specific prescriptions stated for the strata sampled by the plots. If the interior upland areas of units are an important consideration for management, prescriptions could be specified for them. Alternatively, plots could be placed randomly within units, without regard to proximity to stand boundaries or riparian areas. Plots would then be representative of the units (including any edge effects and riparian areas), and of the landscape areas as a whole. This would increase the variation among plots and the standard errors of the means. Another option would be to rely on a separate sampling system (e.g., of canopy cover across the units) for implementation monitoring instead of the plots.

The treatments in the BRLS are designed to create a high degree of spatial variation in stand structure. It is difficult to describe that variation without intensive measurements of the units. The plots will reflect the variation across units, but only at the scale of 0.1 ha (e.g. some plots may fall entirely within a gap, or a residual patch, or straddle two conditions). Transects can be a useful sampling option for capturing spatial variability, and could be used for simple measurements of canopy cover, or more comprehensive measurements of vegetation and trees (i.e., using strip transects). It might also be possible to use high-resolution imagery of the units to describe the spatial variation of canopy trees.

The upland vegetation monitoring is suitable for describing vegetation response to the different treatments in interior upland areas of the BRLS and for answering the evaluation monitoring questions posed at the beginning of this report. Comparisons of response among landscape areas will be primarily qualitative, because we will never be sure if any differences in response are due to the treatments or the inherent differences in site characteristics and stand history. Statistics comparing landscape areas could be calculated using patches as the experimental units, as long as differences are not attributed to treatments alone. The similarity in plant associations in the LA1 and LA2 mature stands could provide some basis for treatment comparison between those areas, although the difference in pre-treatment tree growth rates suggest the areas are not that similar.

As Acker (2000a) pointed out, the lack of measurements in control areas in each landscape area makes it difficult to attribute responses to treatment effects. For many attributes (e.g., stand composition and density) the comparison with controls may be trite and not of interest. For other attributes, like mortality rates and understory plant composition, it will be harder to determine treatment effects. Although not ideal, it may be possible to identify “similar” stands in the regional strategic inventory datasets that have not been treated and use those for some comparisons.

The riparian monitoring does employ controls, and should be better able to detect treatment effects, to the extent there are any. This study has been compromised by the inability to implement the streamside retention treatment in LA2. Although several people have examined other riparian areas in already-harvested units in LA2, no suitable substitute was found. It might be possible to designate another unit for the streamside retention treatment and take pre-treatment measurements (of vegetation as well as the other monitoring components). The difference in timing of implementation could reduce the ability to infer treatment effects for some attributes (e.g., differences in precipitation among years could confound any stream temperature effects), but it is an option worth discussing. In some respects, the plots in the buffer treatments are almost another set of controls, since the plot areas did not receive any direct treatment. However, plots in buffers should be able to detect indirect effects that could potentially occur from the surrounding treatments (e.g. change in flooding regime or increased input of weedy plant seeds). With the recent tagging of trees in the riparian plots, we should be able to detect any changes in growth or mortality rates as well.

There are several changes in the field protocols that can improve the quality of the data. The transition from plot installation to plot remeasurement coincided with the transition from the original PI to the current one (A. Gray), and a lapse in data entry and analysis. We should record more information on tree locations (azimuth and perhaps distance) when plots are installed to allow better tracking of trees between pre- and post-treatment when tags are melted by fire. We should synthesize and make clearly available to crews all existing information on plot location (navigation to plots, markers, coordinates, and reference trees) to avoid mistakes and reduce redundancy in data collection. We will also revamp protocols and data sheets to include previous data that will ensure collection of necessary attributes for each time period and checking for errors (e.g., previous DBH, transect length), and add new codes to unequivocally characterize change (e.g. tree status). These changes could make some measurements at some visits unnecessary (e.g. DBH on remeasured trees in Year 2).

Other improvements to the data collected which could increase the utility of results might be considered. The plot-based sampling of coarse woody debris (CWD) is useful and robust for characterizing wood volume. However, it does not allow assessments of wood density or distribution by log size (length or diameter), which are often used for wildlife assessments. Line-intercept sampling is often used to collect data on log length and end diameters (in addition to species and decay class), and is being considered in other Cascade Center studies (e.g., the Uneven-Aged Management Project and Young Stand Study). Using the existing parallel transects within upland plots (28 m/plot), or sampling perpendicular lines that span the plots and cross in the center (71 m/plot) are options. Since the same crews tend to sample the UAMP, YSS, and BRLS studies, it would be beneficial to coordinate the development of any new CWD protocols.

Augmented sampling of tree seedlings and saplings may be desirable. The use of six 1 m^2 quadrats per upland plot led to very high standard errors for estimates of density (Table 11). If characterizing regeneration more precisely before it attains the 10 cm DBH size (when it would be sampled on the full plot) is important, augmented sampling might be desirable (e.g., with quadrats along the full length of each transect, or ~28 m^2 per plot). The riparian plots sampled seedlings and saplings were sampled on 40 m^2 per plot, and standard errors were somewhat lower than for the upland plots (Table 19), even though for most cells they were calculated across fewer plots (e.g., three instead of nine).

Changes to sampling designs should never be undertaken lightly, as it complicates the ability to compare among areas and over time. Nevertheless, enough data has been collected in the BRLS to facilitate a discussion among managers and researchers about our ability to answer the highest-priority questions in the study. Potential changes that could be considered to the upland monitoring include:

design:
* Random plot placement in new BRLS units with no pre-stratification to characterize landscape areas as a whole.
* Canopy cover sampling on relocatable transects across all units to characterize units as a whole and spatial variation in cover.
* Intensive strip transect sampling in selected areas to characterize variation in stand structure.

data collection:
* Coarse woody debris measurements on line transects to allow assessment of wildlife habitat.
* Seedling and sapling measurements on a greater sample area to improve precision of estimates for trees less than 10 cm DBH.
* Canopy cover measurements on the original grid of 12 points per plot to improve precision of cover estimates.
* Improved data protocols: tracking of individual tree identity, measurements, and status; complete plot location and navigation information; and clear rules about when each attribute is measured or re-measured.

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Table 1a: Upland vegetation monitoring: units and patches within landscape areas initially selected for sampling. Plant associations were determined from pre-treatment plot data; codes follow McCain and Diaz (2002).

LA	Seral stage	SALE	BLOCK	Sale unit(s)	Patch	Plant association	Treatment year	N plots	
1	Mature	NFQ	2	2A	2A	TSHE/RHMA3-GASH	2001	3	*
1	Mature	NFQ	2	2B	2B	TSHE/RHMA3-GASH	2001	3	
1	Mature	NFQ	8	8A+8C	8	TSHE/ACCI-GASH/POMU	2001	3	**
1	Mature	NFQ	9	9	9	TSHE/MANE2	2001	3	
2	Mature	BRF	4	4A	4A	TSHE/MANE2-GASH	2003	3	
2	Mature	BRF	7	7B	7B	TSHE/RHMA3-MANE2	2003	3	
2	Mature	BRF	7	7C	7C	TSHE/RHMA3-MANE2	2003	3	
2	Old-growth	BRF	3	3X	3X	TSHE/LIBO3		2	
2	Old-growth	BRF	3	3Y	3Y	TSHE/MANE2-GASH		3	***
2	Old-growth	BRF	5	5A	5A	TSHE/RHMA3/LIBO3		2	
2	Old-growth	BRF	5	5B	5B	TSHE/RHMA3-GASH	2003	4	
2	Old-growth	BRF	5	5C	5C	TSHE/RHMA3-GASH	2005	2	
2	Old-growth	BRF	5	5D	5D	TSHE/MANE2-GASH		4	***
2	Old-growth	BRF	5	5E	5E	TSHE/MANE2	2005	1	
3	Mature	WF	21	21-1+21-2	21	ABAM/TITR		3	
3	Mature	WF	26	26	26	ABAM/MANE2		3	
3	Mature	WF	40	40-1	40	TSHE/MANE2		4	
3	Mature	WF	71	71	71	TSHE/LIBO3		2	

* This set of plots was installed to monitor an area of "unsuitable soils"
** 1 plot was dropped after treatment because that portion of unit was not logged
*** Units dropped from study because of difficulty implementing timber sale

Table 1b: Riparian vegetation monitoring: units and patches within landscape areas with treatment streams initially selected for sampling.

LA	Treatment	SALE	BLOCK	Sale unit(s	Patch	Plant association*	Treatment year	N plots	
1	Stream Ret.	NFQ	2	2B	2B	TSHE/MANE2-GASH	2001	3	
1	Buffer	NFQ	2	2E	2E	TSHE/MANE2/POMU	2001	3	
1	Control	NFQ	2	CON	2CON	TSHE/ACCI-GASH/POMU		3	
2	Stream Ret.	BRF	5	5D	5D	TSHE/MANE2/POMU		3	**
2	Buffer	BRF	5	5B	5B	TSHE/GASH	2003	3	
2	Control	BRF	5	CON	5CON	TSHE/RHMA3-GASH		3	
3	Stream Ret.	WF	20	A	20A	TSHE/OPHO/MAST4		3	
3	Buffer	WF	20	B	20B	TSHE/MANE2/ACTR		3	
3	Control	WF	20	CON	20CON	TSHE/ACTR		3	

* Note: riparian plant data did not fit in published plant associations very well
** Unit dropped from study because of difficulty implementing timber sale

Table 2: Parameters for equations used to estimate tree height from DBH, by species. Equations for TABR2 and CHCH7 were reported in Hanus et al. (1999).

Species code	α0	α1	α2	N trees	MSE	R2
TSHE	8.4003	-7.6338	-0.2375	250	11.54	0.963
THPL	6.4501	-6.2617	-0.389	130	9.16	0.973
PSME/ABPR/PIMO3	6.0888	-5.9076	-0.5038	380	24.2	0.968
ABAM/ABGR	-4.6097	6.2532	0.1314	20	4.48	0.983
CONU4	3.0248	-35.3901	-5.7446	9	19.21	0.925
ACMA3	4.2479	-14.4566	-2.0337	9	18.22	0.968
TABR2	5.1071	-3.2864	-0.2402			
CHCH7	9.2252	-7.6531	-0.1548			
ALRU2	5.7154	-3.7876	-0.3635	515	35.5	0.944

Table 3: Number of plots sampled at each time period in the Blue River Landscape study by landscape area and stand. Numbers apply to all results unless otherwise noted.

Landscape Area	Stand type	Pre-treatment	Year 0	Year 2	Year 4
1	Mature	11	11	11	11
2	Mature	9	9	9	
2	Old-growth	11	7	4	
3	Mature	12			

Table 4: Canopy cover after logging, from moosehorn measurements on cross-unit transects with at least 200 points/unit sampled (Jim Mayo, personal communication). Includes data from units not monitored with plots.

Landscape area	Seral stage	Sale	Patch	Timing	Canopy cover (%)
1	Mature	NFQ	2A	after burn	56
1	Mature	NFQ	2B	after burn	64
1	Mature	NFQ	2C	after burn	52
1	Mature	NFQ	2D	after burn	37
1	Mature	NFQ	2E	after burn	54
1	Mature	NFQ	2F	after burn	55
1	Mature	NFQ	9	after burn	41
Average LA1:					51
2	Mature	BRF	4A	before burn	33
2	Mature	BRF	7B	before burn	40
2	Mature	BRF	7C	before burn	45
2	Old-growth	BRF	5B	before burn	38
2	?	BRF	6B *	before burn	43
Average LA2:					40

* No record of this unit found on sale unit maps

Table 5: Estimated density (trees per hectare) of live trees (>=5 cm DBH) and standing dead trees ("snags" >=10 cm DBH) in the Blue River Landscape study by landscape area and stand type, as means of plot-level means.

Landscape Area	Stand type	Pre-treatment TPH	Pre-treatment SE	Year 0 TPH	Year 0 SE	Year 2 TPH	Year 2 SE	Year 4 TPH	Year 4 SE
Live trees									
1	Mature	485.5	69.3	133.6	23.7	137.3	31.9	133.6	31.6
2	Mature	357.8	55.7	101.1	20.6	74.4	14.6		
2	Old-growth	514.5	52.2	64.3	18.2	35.0	8.7		
3	Mature	458.3	27.8						
Snags									
1	Mature	94.5	16.4	125.5	43.7	133.6	47.7	126.4	46.0
2	Mature	35.6	11.7	21.1	5.6	40.0	10.8		
2	Old-growth	80.0	14.3	28.6	20.4	65.0	32.3		
3	Mature	72.5	13.8						

Table 6: Estimated basal area (per hectare) of live trees (>=5 cm DBH) and standing dead trees ("snags" >=10 cm DBH) in the Blue River Landscape study by landscape area and stand type, as means of plot-level means.

Landscape Area	Stand type	Pre-treatment BAHA (m2/ha)	Pre-treatment SE	Year 0 BAHA (m2/ha)	Year 0 SE	Year 2 BAHA (m2/ha)	Year 2 SE	Year 4 BAHA (m2/ha)	Year 4 SE
Live trees									
1	Mature	60.8	4.9	31.3	4.8	31.5	5.8	32.1	5.9
2	Mature	45.6	3.5	23.7	3.7	23.3	4.1		
2	Old-growth	82.7	9.8	39.7	14.1	20.1	4.6		
3	Mature	87.3	9.5						
Snags									
1	Mature	9.7	2.5	8.6	3.2	8.9	3.3	8.8	3.3
2	Mature	9.5	4.1	1.4	0.7	2.5	1.0		
2	Old-growth	17.8	2.9	7.1	4.5	15.0	7.0		
3	Mature	12.0	3.4						

Table 7: Survival and mean DBH of live trees with different amounts of fire scorch from year 0 to 2 after treatment.

Fire Scorch	Live after 2 yrs DBH (cm)	Live after 2 yrs Ntrees	Dead after 2 yrs DBH (cm)	Dead after 2 yrs Ntrees
None	25.9	49		
<3 m up bole	28.6	31	9.9	4
>3 m up bole	78.2	41	41.8	6
Crown scorched	63.3	55	29.3	15
Crown consumed	28.1	3	32.6	11

Note: crown consumed and alive included 2 ACMA3 and 1 THPL

Table 8: Estimated quadratic mean diameter (cm) of live trees in the Blue River Landscape study by landscape area and stand type, as means of plot-level means.

Landscape Area	Stand type	Pre-treatment QMD (cm)	Pre-treatment SE	Year 0 QMD (cm)	Year 0 SE	Year 2 QMD (cm)	Year 2 SE	Year 4 QMD (cm)	Year 4 SE
1	Mature	42.0	2.9	58.8	5.8	62.1	6.6	63.5	6.7
2	Mature	42.5	3.4	60.5	6.0	66.8	5.3		
2	Old-growth	45.7	3.2	91.3	8.2	94.7	20.0		
3	Mature	49.4	3.3						

Table 9: Estimated height of the tallest measured live trees in the Blue River Landscape study by landscape area and stand type, as means of plot-level means of three trees.

Landscape Area	Stand type	Pre-treatment Height (m)	Pre-treatment SE
1	Mature	43.7	2.3
2	Mature	49.2	3.3
2	Old-growth	49.2	3.3
3	Mature	53.9	2.9

Table 10a: Estimated merchantable volume (12" stump to 4" top) for live trees >=5" DBH in the Blue River Landscape study by landscape area and stand type, as means of plot-level sums.

Landscape Area	Stand type	Variable	Pre-treatment	Year 0	Year 2	Year 4
1	Mature	VOL (m3/ha)	762.9	421.6	423.5	434.0
		SE	85.4	67.4	81.4	82.8
		N	11	11	11	11
2	Mature	VOL (m3/ha)	634.6	347.6	349.6	
		SE	56.0	55.2	60.7	
		N	9	9	9	
2	Old-growth	VOL (m3/ha)	1,047.4	565.7	285.7	
		SE	143.1	218.8	72.0	
		N	11	7	4	
3	Mature	VOL (m3/ha)	1,275.1			
		SE	157.5			
		N	12			

* Note: Tree status (live or dead) for most of the trees measured on two of the plots in Landscape area 1 during the first remeasurement was not recorded; those trees were not included in this analysis

Table 10b: Estimated merchantable volume (12" stump to 4" top) for live trees >=5" DBH in the Blue River Landscape study by landscape area and stand type, as means of plot-level sums

Landscape Area	Stand type	Variable	Pre-treatment	Year 0	Year 2	Year 4
1	Mature	VOL (ft3/ac)	66,570	36,783	36,955	37,866
		SE	7,455	5,881	7,100	7,221
		N	11	11	11	11
2	Mature	VOL (ft3/ac)	55,370	30,329	30,508	
		SE	4,889	4,818	5,293	
		N	9	9	9	
2	Old-growth	VOL (ft3/ac)	91,389	49,356	24,931	
		SE	12,487	19,093	6,285	
		N	11	7	4	
3	Mature	VOL (ft3/ac)	111,254			
		SE	13,739			
		N	12			

* Note: Tree status (live or dead) for most of the trees measured on two of the plots in Landscape area 1 during the first remeasurement was not recorded; those trees were not included in this analysis

Table 10c: Estimated sawtimber volume for conifers >=9" DBH and hardwoods >=11" DBH in the Blue River Landscape study by landscape area and stand type, as means of plot-level sums.

Landscape Area	Stand type	Variable	Pre-treatment	Year 0	Year 2	Year 4
1	Mature	VOL (bdft2/ac)	329,635	194,363	196,365	201,718
		SE	44,723	32,849	39,383	40,227
		N	11	11	11	11
2	Mature	VOL (bdft2/ac)	296,008	170,753	173,373	
		SE	27,744	27,864	30,553	
		N	9	9	9	
2	Old-growth	VOL (bdft2/ac)	477,615	284,841	140,048	
		SE	73,953	114,661	38,250	
		N	11	7	4	
3	Mature	VOL (bdft2/ac)	620,410			
		SE	86,182			
		N	12			

* Note: Tree status (live or dead) for most of the trees measured on two of the plots in Landscape area 1 during the first remeasurement was not recorded; those trees were not included in this analysis

Table 10d: Estimated total stem biomass for live trees in the Blue River Landscape study by landscape area and stand type, as means of plot-level sums.

Landscape Area	Stand type	Variable	Pre-treatment	Year 0	Year 2	Year 4
1	Mature	BIOM (kg/ha)	364,829	200,144	201,054	205,733
		SE	40,995	32,152	38,772	39,444
		N	11	11	11	11
2	Mature	BIOM (kg/ha)	302,043	165,379	166,351	
		SE	26,893	26,240	28,819	
		N	9	9	9	
2	Old-growth	BIOM (kg/ha)	470,824	259,352	129,766	
		SE	66,609	102,293	36,280	
		N	11	7	4	
3	Mature	BIOM (kg/ha)	594,583			
		SE	74,168			
		N	12			

* Note: Tree status (live or dead) for most of the trees measured on two of the plots in Landscape area 1 during the first remeasurement was not recorded; those trees were not included in this analysis

Table 11: Mean annual basal area growth for live trees in the Blue River Landscape study by landscape area, stand type, species, and diameter class, as means of plot-level means of individual trees.

Landscape Area	Stand type	Species	Diameter class (cm)	Variable	PTM	Year 2	Year 4
1	Mature	PSME	50-75	BAG (m2/yr)	27.5	35.9	43.2
				SE	2.0	10.8	11.4
				N	11	9	9
2	Mature	PSME	50-75	BAG (m2/yr)	38.5	40.3	
				SE	1.3	28.9	
				N	9	3	
2	Old-growth	PSME	50-75	BAG (m2/yr)	43.7	42.8	
				SE	7.4	0.0	
				N	8	1	
1	Mature	PSME	75-100	BAG (m2/yr)	38.3	82.7	55.9
				SE	5.3	36.3	17.7
				N	9	9	9
2	Mature	PSME	75-100	BAG (m2/yr)	56.0	55.6	
				SE	4.6	28.8	
				N	8	8	
1	Mature	PSME	100-150	BAG (m2/yr)	33.2	181.1	26.7
				SE	2.6	88.5	44.4
				N	5	4	4
2	Mature	PSME	100-150	BAG (m2/yr)	59.4	424.5	
				SE	10.7	142.0	
				N	2	2	
2	Old-growth	PSME	100-150	BAG (m2/yr)	44.1	193.5	
				SE	5.1	0.0	
				N	8	1	
1	Mature	TSHE	10-25	BAG (m2/yr)	6.2	7.4	10.2
				SE	0.6	2.0	3.3
				N	7	4	4
2	Mature	TSHE	10-25	BAG (m2/yr)	10.7	8.7	
				SE	1.0	0.9	
				N	9	2	
1	Mature	TSHE	25-50	BAG (m2/yr)	22.7	19.2	22.8
				SE	0.7	1.0	3.4
				N	2	2	2
2	Mature	TSHE	25-50	BAG (m2/yr)	21.4	40.2	
				SE	2.0	0.0	
				N	7	1	

Table 12: The density of seedlings and saplings in the Blue River Landscape study by landscape area, and stand type, as means of plot-level sums.

Tree size	Landscape Area	Stand type	Variable	PTM	Year 0	Year 2	Year 4
Seedlings	1	Mature	TPH	2,273	5,000	15,000	4,545
			SE	1,656	2,762	8,364	1,441
	2	Mature	TPH	2,778	16,296	5,000	
			SE	1,416	16,089	3,203	
	2	Old-growth	TPH	1,970	476	3,333	
			SE	1,185	307	680	
	3	Mature	TPH	15,278			
			SE	7,790			
Saplings	1	Mature	TPH	303	0	303	152
			SE	203	0	203	152
	2	Mature	TPH	5,000	0	0	
			SE	3,093	0	0	
	2	Old-growth	TPH	606	0	0	
			SE	339	0	0	
	3	Mature	TPH	278			
			SE	187			

Table 13a: Estimated volume (m3 per hectare) of coarse woody debris (>=10 cm Dia) in the Blue River Landscape study by landscape area and stand type, as means of plot-level means.

Landscape Area	Stand type	Variable	Pre-treatment	First remeasurement
1	Mature	VOL (m3/ha)	93.6	83.9
		SE	30.5	16.2
		N	11	9
2	Mature	VOL (m3/ha)	106.4	93.8
		SE	34.2	20.8
		N	9	9
2	Old-growth	VOL (m3/ha)	269.2	311.7
		SE	38.8	64.3
		N	11	7
3	Mature	VOL (m3/ha)	242.8	
		SE	69.5	
		N	12	

Table 13b: Estimated mass (Mg per hectare) of coarse woody debris (>=10 cm Dia) in the Blue River Landscape study by landscape area and stand type, as means of plot-level means.

Landscape Area	Stand type	Variable	Pre-treatment	Year 0
1	Mature	Mass (Mg/ha)	251.4	215.5
		SE	72.7	29.8
		N	11	9
2	Mature	Mass (Mg/ha)	382.2	250.7
		SE	153.7	51.5
		N	9	9
2	Old-growth	Mass (Mg/ha)	723.2	892.7
		SE	109.5	192.2
		N	11	7
3	Mature	Mass (Mg/ha)	761.5	
		SE	221.3	
		N	12	

Table 14: Summed cover of understory vegetation types in the Blue River Landscape study by landscape area, and stand type, as means of plot-level sums of species' cover.

Vegetation type	Landscape Area	Stand type	PTM Cover	PTM SE	Year 0 Cover	Year 0 SE	Year 2 Cover	Year 2 SE	Year 4 Cover	Year 4 SE
Tree	1	Mature	2.0	1.0	1.8	1.0	1.5	0.9	3.3	1.7
	2	Mature	15.4	7.2	0.1	0.1	0.6	0.5		
	2	Old-growth	15.7	3.4	0.4	0.3	2.6	2.6		
	3	Mature	6.7	2.5						
Shrub	1	Mature	98.5	17.3	12.6	4.4	21.1	5.2	30.7	4.1
	2	Mature	96.6	16.3	6.5	2.2	34.7	7.1		
	2	Old-growth	38.8	11.6	2.8	1.1	24.6	2.5		
	3	Mature	34.5	8.0						
Herb	1	Mature	9.5	2.8	1.5	0.5	4.9	2.1	8.2	2.3
	2	Mature	26.9	13.7	6.2	4.3	18.2	10.7		
	2	Old-growth	6.9	2.0	1.3	0.5	13.0	4.6		
	3	Mature	15.2	4.2						
Graminoid	1	Mature	0.1	0.1	0.0	0.0	0.3	0.2	0.7	0.4
	2	Mature	3.6	3.5	4.2	4.1	2.9	1.6		
	2	Old-growth	0.0	0.0	0.0	0.0	0.3	0.3		
	3	Mature	0.3	0.1						
Bryophyte	1	Mature	4.8	3.2	2.0	1.1	1.2	0.8	3.1	1.4
	2	Mature	19.6	6.8	2.3	2.1	6.5	6.0		
	2	Old-growth	23.0	8.5	5.0	3.8	1.6	1.6		
	3	Mature	0.1	0.0						

Table 15: The four most abundant understory species by lifeform in the Blue River Landscape study by landscape area, and stand type, as means of plot-level means of species' cover.

Vegetation type	Landscape Area	Stand type	Rank	Pretreatment Species	Pretreatment Cover	Pretreatment SE	Year 0 Species	Year 0 Cover	Year 0 SE	Year 2 Species	Year 2 Cover	Year 2 SE	Year 4 Species	Year 4 Cover	Year 4 SE
Herb	1	Mature	1	POMU	3.24	1.68	XETE	0.70	0.44	CIAR4	1.24	0.90	XETE	1.45	0.96
Herb			2	XETE	2.21	1.10	CIVU	0.30	0.21	ANMA	0.61	0.57	CIAR4	1.24	0.80
Herb			3	LIBO3	2.03	1.06	PTAQ	0.09	0.09	XETE	0.58	0.30	PTAQ	0.95	0.64
Herb			4	VISE3	1.00	0.69	CIAR4	0.09	0.08	CIVU	0.47	0.26	POMU	0.56	0.37
Herb	2	Mature	1	ATFI	6.52	6.52	ATFI	2.13	2.13	ATFI	6.76	6.76			
Herb			2	POMU	5.41	3.08	PTAQ	1.20	1.01	PTAQ	2.56	1.94			
Herb			3	PTAQ	3.72	2.72	GATR3	0.43	0.29	POMU	1.28	0.97			
Herb			4	LIBO3	2.37	0.71	ADBI	0.35	0.31	CHAN9	1.00	0.60			
Herb	2	Old-growth	1	LIBO3	3.82	1.50	LIBO3	0.38	0.19	LIBO3	3.83	2.53			
Herb			2	COLA3	1.06	0.44	XETE	0.33	0.24	CHAN9	3.13	0.74			
Herb			3	POMU	0.55	0.45	VISE3	0.19	0.08	SESY	1.67	0.99			
Herb			4	VISE3	0.53	0.17	TRBO2	0.07	0.05	TITR	1.13	1.13			
Herb	3	Mature	1	ACTR	2.68	0.95									
Herb			2	VAHE	2.63	1.24									
Herb			3	LIBO3	2.38	1.14									
Herb			4	VISE3	1.35	0.26									
Shrub	1	Mature	1	ACCI	38.70	7.68	ACCI	3.97	1.77	RHMA3	7.33	2.83	MANE2	7.83	2.09
Shrub			2	RHMA3	21.18	8.47	RHMA3	3.74	1.87	ACCI	4.47	1.99	RHMA3	7.31	2.94
Shrub			3	GASH	19.29	5.26	MANE2	2.48	0.74	MANE2	4.21	1.03	GASH	7.06	1.23
Shrub			4	MANE2	15.35	4.42	GASH	2.06	0.77	GASH	3.64	0.82	ACCI	4.58	1.82
Shrub	2	Mature	1	MANE2	24.13	5.21	RUUR	2.11	1.14	MANE2	10.06	2.45			
Shrub			2	ACCI	23.64	11.31	MANE2	1.76	0.53	RUUR	9.33	2.99			
Shrub			3	GASH	23.40	5.15	GASH	1.04	0.41	GASH	5.07	1.28			
Shrub			4	RHMA3	16.65	8.57	ACCI	1.03	0.73	ACCI	4.56	2.90			
Shrub	2	Old-growth	1	RHMA3	21.13	8.41	GASH	1.02	0.47	RHMA3	5.69	2.64			
Shrub			2	GASH	7.18	2.59	MANE2	0.95	0.35	WHMO	5.29	1.63			
Shrub			3	MANE2	4.42	1.71	RUUR	0.43	0.22	GASH	4.75	3.82			
Shrub			4	VAPA	2.55	0.68	COCA13	0.21	0.21	MANE2	4.33	1.71			
Shrub	3	Mature	1	ACCI	7.81	4.05									
Shrub			2	MANE2	7.14	1.84									
Shrub			3	RHMA3	6.84	5.20									
Shrub			4	VAME	2.63	2.22									

Vegetation type	Landscape Area	Stand type	Rank	Pretreatment Species	Pretreatment Cover	Pretreatment SE	Year 0 Species	Year 0 Cover	Year 0 SE	Year 2 Species	Year 2 Cover	Year 2 SE	Year 4 Species	Year 4 Cover	Year 4 SE
Tree	1	Mature	1	TSHE	1.20	0.94	TSHE	1.77	0.95	TSHE	1.43	0.88	TSHE	2.05	1.45
Tree			2	PSME	0.76	0.51				PIMO3	0.07	0.07	CHCH7	1.13	1.13
Tree			3	CHCH7	0.02	0.02				ACMA3	0.02	0.02	PIMO3	0.09	0.09
Tree			4												
Tree	2	Mature	1	PSME	8.78	6.87	CONU4	0.06	0.06	CONU4	0.48	0.48			
Tree			2	CONU4	4.53	2.58				PSME	0.13	0.13			
Tree			3	TSHE	1.67	1.67									
Tree			4	ABPR	0.27	0.27									
Tree	2	Old-growth	1	THPL	9.81	3.80	CHCH7	0.34	0.34	CHCH7	2.61	2.61			
Tree			2	TSHE	5.01	1.63	ACMA3	0.07	0.07						
Tree			3	CHCH7	0.85	0.74									
Tree			4												
Tree	3	Mature	1	TSHE	3.03	1.28									
Tree			2	ABAM	2.67	2.02									
Tree			3	CHCH7	0.93	0.89									
Tree			4	ABGR	0.08	0.08									

Table 16a: Estimated density (trees per ha) of live trees (>=5 cm DBH) in riparian areas the Blue River Landscape study by landscape area and treatment, as means of plot-level means (N=3).

		PTM		Year 0		Year 2		Year 4	
Landscape Area	Treatment	TPH	SE	TPH	SE	TPH	SE	TPH	SE
1	Streamside retention	380.0	65.6	340.0	66.6	330.0	45.8	303.3	21.9
1	Buffer	340.0	17.3	293.3	8.8	270.0	58.6	283.3	44.1
1	Control	583.3	46.3	586.7	83.3	576.7	49.1	593.3	64.9
2	Streamside retention	573.3	92.1						
2	Buffer	616.7	29.1	686.7	57.0	746.7	98.2		
2	Control	740.0	28.9			730.0	62.4		
3	Streamside retention	393.3	49.8						
3	Buffer	416.7	68.9						
3	Control	490.0	30.6						

Table 16b: Estimated density (trees per ha) of standing dead trees (>=10 cm DBH) in riparian areas the Blue River Landscape study by landscape area and treatment, as means of plot-level means (N=3).

		PTM		Year 0		Year 2		Year 4	
Landscape Area	Treatment	TPH	SE	TPH	SE	TPH	SE	TPH	SE
1	Streamside retention	40.0	17.3	25.0	5.0	30.0	10.0	33.3	3.3
1	Buffer	56.7	13.3	56.7	26.0	60.0	28.9	30.0	11.5
1	Control	30.0	10.0	23.3	8.8	23.3	8.8	23.3	3.3
2	Streamside retention	73.3	23.3						
2	Buffer	126.7	3.3	133.3	6.7	123.3	6.7		
2	Control	30.0	5.8			23.3	3.3		
3	Streamside retention	63.3	26.0						
3	Buffer	96.7	8.8						
3	Control	36.7	17.6						

Table 17a: Estimated basal area of live trees (>=5 cm DBH) in riparian areas the Blue River Landscape study by landscape area and treatment, as means of plot-level means (N=3).

Landscape Area	Treatment	PTM BAHA (m2/ha)	PTM SE	Year 0 BAHA (m2/ha)	Year 0 SE	Year 2 BAHA (m2/ha)	Year 2 SE	Year 4 BAHA (m2/ha)	Year 4 SE
1	Streamside retention	63.4	5.3	49.1	3.9	50.6	5.5	48.5	6.5
1	Buffer	45.5	4.8	49.3	4.5	48.0	7.0	50.6	3.6
1	Control	63.6	3.9	53.8	7.2	58.8	5.8	63.6	2.6
2	Streamside retention	79.8	20.2						
2	Buffer	81.2	10.2	87.4	9.2	89.7	11.8		
2	Control	51.8	5.7			66.9	9.7		
3	Streamside retention	68.4	15.9						
3	Buffer	54.4	4.3						
3	Control	39.5	12.0						

Table 17b: Estimated basal area of standing dead trees (>=10 cm DBH) in riparian areas the Blue River Landscape study by landscape area and treatment, as means of plot-level means (N=3).

Landscape Area	Treatment	PTM BAHA (m2/ha)	PTM SE	Year 0 BAHA (m2/ha)	Year 0 SE	Year 2 BAHA (m2/ha)	Year 2 SE	Year 4 BAHA (m2/ha)	Year 4 SE
1	Streamside retention	4.2	2.5	1.8	0.2	1.9	0.1	3.7	1.3
1	Buffer	5.0	1.8	7.1	3.3	7.2	3.3	5.0	2.7
1	Control	8.7	0.7	4.4	2.1	4.4	2.1	5.3	2.5
2	Streamside retention	11.3	4.2						
2	Buffer	11.9	1.1	12.0	1.1	13.0	2.7		
2	Control	6.5	2.5			6.1	1.1		
3	Streamside retention	6.0	2.8						
3	Buffer	8.7	0.9						
3	Control	4.4	3.7						

Table 18: Estimated meand diameter (QMD, cm) of live trees (>=5 cm DBH) in riparian areas the Blue River Landscape study by landscape area and treatment, as means of plot-level means (N=3).

		PTM		Year 0		Year 2		Year 4	
Landscape Area	Treatment	QMD (cm)	SE	QMD (cm)	SE	QMD (cm)	SE	QMD (cm)	SE
1	Streamside retention	47.0	3.5	43.7	2.8	44.4	1.0	44.9	1.7
1	Buffer	41.2	2.5	46.2	2.7	48.6	4.5	48.5	3.6
1	Control	37.3	0.9	34.9	5.0	36.2	3.0	37.2	1.8
2	Streamside retention	41.6	3.8						
2	Buffer	40.8	2.4	40.3	2.6	39.3	3.1		
2	Control	29.8	1.8			34.3	3.2		
3	Streamside retention	47.0	5.5						
3	Buffer	41.4	2.1						
3	Control	31.0	4.4						

Table 19a: Estimated merchantable volume (12" stump to 4" top) for live trees >=5" DBH in riparian treatments in the Blue River Landscape study by landscape area and stand, as means of plot-level sums.

		PTM		Year 0		Year 2		Year 4	
LA	Treatment	VOL (m3/ha)	SE	VOL (m3/ha)	SE	VOL (m3/ha)	SE	VOL (m3/ha)	SE
1	Streamside retention	854.0	78.3	677.7	47.3	684.5	81.9	663.1	94.5
1	Buffer	612.1	81.1	675.4	79.1	691.7	137.8	716.1	54.0
1	Control	859.7	48.8	697.1	130.2	779.4	94.4	839.2	28.7
2	Streamside retention	983.8	291.1						
2	Buffer	1,039.5	145.2	1,121.4	132.9	1,141.2	171.4		
2	Control	544.0	78.6			764.9	139.1		
3	Streamside retention	1,015.3	288.3						
3	Buffer	768.0	80.2						
3	Control	430.3	154.9						

Table 19b: Estimated merchantable volume (12" stump to 4" top) for live trees >=5" DBH in riparian treatments in the Blue River Landscape study by landscape area and stand, as means of plot-level sums.

		PTM		Year 0		Year 2		Year 4	
LA	Treatment	VOL (ft3/ac)	SE	VOL (ft3/ac)	SE	VOL (ft3/ac)	SE	VOL (ft3/ac)	SE
1	Streamside retention	74,513	6,829	59,129	4,124	59,727	7,148	57,859	8,244
1	Buffer	53,405	7,077	58,935	6,901	60,352	12,024	62,483	4,709
1	Control	75,017	4,262	60,823	11,360	68,004	8,235	73,228	2,506
2	Streamside retention	85,838	25,397						
2	Buffer	90,700	12,666	97,852	11,595	99,575	14,958		
2	Control	47,465	6,856			66,745	12,133		
3	Streamside retention	88,592	25,154						
3	Buffer	67,014	6,998						
3	Control	37,544	13,513						

Table 19c: Estimated sawtimber volume for conifers >=9" DBH and hardwoods >=11" DBH in riparian treatments in the Blue River Landscape study by landscape area and stand, as means of plot-level sums.

		PTM		Year 0		Year 2		Year 4	
LA	Treatment	VOL (Scribner bd-ft/ac)	SE	VOL (Scribner bd-ft/ac)	SE	VOL (Scribner bd-ft/ac)	SE	VOL (Scribner bd-ft/ac)	SE
1	Streamside retention	415,210	38,795	330,587	22,289	334,134	40,932	325,287	46,395
1	Buffer	279,095	44,213	313,378	42,489	330,546	77,135	339,820	27,439
1	Control	409,607	23,609	326,977	70,953	370,456	50,895	396,610	16,415
2	Streamside retention	445,977	148,329						
2	Buffer	465,322	70,087	503,487	66,105	507,887	85,598		
2	Control	219,885	33,268			328,958	67,637		
3	Streamside retention	484,290	157,752						
3	Buffer	348,203	44,548						
3	Control	172,860	71,179						

Table 19d: Estimated total stem biomass for live trees in riparian treatments in the Blue River Landscape study by landscape area and stand, as means of plot-level sums.

		PTM		Year 0		Year 2		Year 4	
LA	Treatment	BIOM (kg/ha)	SE	VOL (Scribner bd-ft/ac)	SE	VOL (Scribner bd-ft/ac)	SE	VOL (Scribner bd-ft/ac)	SE
1	Streamside retention	405,320	38,006	322,819	22,585	325,448	38,490	315,686	44,742
1	Buffer	274,551	38,375	307,578	36,939	308,862	57,636	323,163	23,856
1	Control	391,520	22,579	318,336	61,807	351,406	44,561	383,109	13,839
2	Streamside retention	412,407	131,886						
2	Buffer	466,477	68,751	503,014	63,172	513,272	81,274		
2	Control	217,169	34,404			298,869	42,968		
3	Streamside retention	464,939	128,255						
3	Buffer	353,596	33,913						
3	Control	182,987	65,196						

Table 20: The density of seedlings and saplings in riparian treatments in the Blue River Landscape study by landscape area, as means of plot-level sums.

			PTM		Year 0		Year 2		Year 4	
Tree size	**LA**	**Treatment**	**TPH**	**SE**	**TPH**	**SE**	**TPH**	**SE**	**TPH**	**SE**
Seedlings	1	Streamside retention	1,833	333	1,000	289	1,333	583	3,000	2,255
		Buffer	1,083	846	1,583	1,228	2,000	1,639	1,750	878
		Control	8,667	5,304	6,250	3,253	4,917	2,171	2,250	577
	2	Streamside retention	2,417	2,171						
		Buffer	6,333	2,522	7,500	3,041	4,583	583		
		Control	4,583	1,014			1,667	928		
	3	Streamside retention	417	167						
		Buffer	4,917	2,945						
		Control	6,750	1,283						
Saplings	1	Streamside retention	0	0	0	0	0	0	0	0
		Buffer	0	0	167	167	167	167	83	83
		Control	333	333	417	300	167	83	750	629
	2	Streamside retention	250	250						
		Buffer	250	144	250	144	333	167		
		Control	1,083	300			167	83		
	3	Streamside retention	83	83						
		Buffer	167	83						
		Control	667	83						

Table 21: Summed cover of understory vegetation types in riparian treatments in the Blue River Landscape study by landscape area, as means of plot-level sums of species' cover.

Vegetation type	LA	Treatment	PTM Cover	PTM SE	Year 0 Cover	Year 0 SE	Year 2 Cover	Year 2 SE	Year 4 Cover	Year 4 SE
Tree	1	Streamside retention	14.3	10.2	6.1	2.3	5.8	3.4	6.2	5.2
		Buffer	4.5	4.5	5.9	4.2	5.5	3.5	4.4	2.5
		Control	13.6	5.9	17.3	7.0	12.3	2.8	9.1	4.9
	2	Streamside retention	18.0	12.6						
		Buffer	3.8	0.4	7.2	1.8	9.5	0.8		
		Control	35.3	8.3			13.2	7.1		
	3	Streamside retention	5.0	2.2						
		Buffer	5.7	3.5						
		Control	28.4	10.5						
Shrub	1	Streamside retention	65.9	15.2	49.6	6.9	56.4	10.0	53.6	4.0
		Buffer	9.3	3.4	10.0	2.2	11.7	1.8	12.7	2.5
		Control	29.4	9.7	36.9	8.7	30.1	7.5	19.0	2.6
	2	Streamside retention	32.9	15.7						
		Buffer	32.6	16.3	33.6	14.2	36.3	15.6		
		Control	28.5	7.7			20.3	12.9		
	3	Streamside retention	33.2	13.1						
		Buffer	16.0	5.5						
		Control	21.6	4.9						
Herb	1	Streamside retention	24.3	4.7	21.2	5.1	17.6	3.3	20.8	1.9
		Buffer	15.0	1.4	14.4	3.0	14.8	2.1	18.6	3.5
		Control	16.9	0.7	16.5	2.3	13.2	1.0	21.3	3.1
	2	Streamside retention	16.9	7.8						
		Buffer	12.5	3.2	12.0	4.0	11.8	4.4		
		Control	16.1	7.0			19.3	8.3		
	3	Streamside retention	29.0	9.3						
		Buffer	24.8	5.5						
		Control	21.9	10.4						

Vegetation type	LA	Treatment	PTM Cover	PTM SE	Year 0 Cover	Year 0 SE	Year 2 Cover	Year 2 SE	Year 4 Cover	Year 4 SE
Graminoid	1	Streamside retention	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0
		Buffer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Control	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0
	2	Streamside retention	0.0	0.0						
		Buffer	0.1	0.1	0.1	0.1	0.1	0.1		
		Control	0.0	0.0			0.0	0.0		
	3	Streamside retention	0.1	0.0						
		Buffer	0.1	0.0						
		Control	0.2	0.1						
Bryophyte	1	Streamside retention	0.0	0.0	15.7	3.2	12.9	2.3	23.8	6.1
		Buffer	0.0	0.0	18.6	3.4	21.3	3.9	29.2	1.0
		Control	0.0	0.0	38.7	6.7	39.8	4.2	56.5	7.1
	2	Streamside retention	0.0	0.0						
		Buffer	0.0	0.0	47.9	5.7	51.4	5.2		
		Control	0.0	0.0			51.1	8.9		
	3	Streamside retention	0.0	0.0						
		Buffer	0.0	0.0						
		Control	12.7	3.6						

Table 22: The four most abundant understory species by lifeform in riparian areas in the Blue River Landscape study by landscape area, as means of plot-level means of species' cover.

				Pretreatment			Year 0			Year 2			Year 4		
Type	LA	Stand type	Rank	Spp	Cover	SE	Spp	Cover	SE	Spp	Cover	SE	Spp	Cover	SE
Herb	1	Streamside retention	1	POMU	17.8	4.0	POMU	12.8	3.6	POMU	10.4	3.2	POMU	14.3	1.1
Herb			2	ARCA2	2.4	1.7	ARCA2	5.1	2.9	ARCA2	2.6	1.2	ARCA2	2.1	1.5
Herb			3	LIBO3	0.8	0.2	LIBO3	0.7	0.3	VAHE	1.1	0.3	VAHE	1.0	0.2
Herb			4	VAHE	0.7	0.2	VAHE	0.6	0.1	LIBO3	0.9	0.5	LIBO3	0.6	0.2
Herb		Buffer	1	BLSP	8.8	1.0	BLSP	7.7	0.9	BLSP	7.5	0.4	BLSP	10.9	1.5
Herb			2	POMU	4.9	1.5	POMU	4.7	1.6	POMU	4.0	1.3	POMU	5.2	1.7
Herb			3	OXOR	0.8	0.0	OXOR	1.2	0.3	OXOR	2.2	0.4	OXOR	1.6	0.5
Herb			4	LIBO3	0.3	0.1	LIBO3	0.3	0.1	LIBO3	0.8	0.2	LIBO3	0.5	0.2
Herb		Control	1	POMU	8.7	1.9	POMU	7.0	1.9	POMU	7.8	1.8	POMU	11.7	2.8
Herb			2	ARCA2	1.9	0.6	ARCA2	3.6	1.4	ARCA2	1.7	0.7	ARCA2	2.5	0.9
Herb			3	LIBO3	1.1	0.3	LIBO3	1.3	0.6	COLA3	0.9	0.3	COLA3	2.0	1.1
Herb			4	COLA3	1.1	0.4	OXOR	1.2	0.6	LIBO3	0.8	0.2	OXOR	1.2	0.7
Herb	2	Streamside retention	1	POMU	5.0	2.2									
Herb			2	LIBO3	2.5	1.4									
Herb			3	ATFI	2.0	2.0									
Herb			4	TITR	1.4	1.0									
Herb		Buffer	1	LIBO3	3.7	1.0	LIBO3	3.0	1.2	LIBO3	3.4	1.2			
Herb			2	ATFI	2.2	1.7	ATFI	2.1	1.6	COLA3	1.8	0.9			
Herb			3	BOOC2	1.6	1.1	COLA3	1.7	0.6	ATFI	1.4	1.3			
Herb			4	COLA3	1.2	0.4	TITR	1.4	0.7	BOOC2	1.3	0.9			
Herb		Control	1	BLSP	9.6	6.2				BLSP	11.4	6.9			
Herb			2	POMU	3.9	0.4				POMU	4.9	1.3			
Herb			3	COLA3	0.5	0.1				COLA3	1.0	0.1			
Herb			4	LIBO3	0.5	0.2				OXOR	0.5	0.1			
Herb	3	Streamside retention	1	ATFI	7.7	3.7									
Herb			2	VAHE	6.9	2.2									
Herb			3	POMU	3.0	1.7									
Herb			4	TITR	1.5	0.2									
Herb		Buffer	1	ATFI	9.7	1.9									
Herb			2	VAHE	3.6	1.9									
Herb			3	LIBO3	2.2	0.9									
Herb			4	VISE3	1.1	0.1									
Herb		Control	1	ADPE	6.3	5.0									
Herb			2	ATFI	3.1	1.0									
Herb			3	VAHE	2.5	1.8									
Herb			4	POMU	1.6	1.1									

				Pretreatment			Year 0			Year 2			Year 4		
Type	**LA**	**Stand type**	**Rank**	**Spp**	**Cover**	**SE**	**Spp**	**Cover**	**SE**	**Spp**	**Cover**	**SE**	**Spp**	**Cover**	**SE**
Shrub	1	Streamside retention	1	ACCI	47.3	6.0	ACCI	38.1	2.5	ACCI	40.4	2.3	ACCI	38.7	3.1
Shrub			2	MANE2	6.8	1.5	GASH	5.0	3.7	GASH	6.1	3.9	GASH	6.4	3.7
Shrub			3	GASH	6.3	4.2	MANE2	4.0	1.9	MANE2	5.7	1.4	MANE2	5.5	1.7
Shrub			4	VAPA	4.5	3.0	VAPA	1.9	1.1	VAPA	2.9	2.5	VAPA	2.4	1.5
Shrub		Buffer	1	MANE2	5.4	2.7	MANE2	5.3	2.4	MANE2	4.8	1.2	MANE2	6.4	2.0
Shrub			2	VAPA	2.7	1.1	VAPA	3.9	1.4	VAPA	4.3	0.4	VAPA	4.1	0.6
Shrub			3	GASH	1.0	1.0	GASH	0.5	0.4	ACCI	1.2	1.0	GASH	0.9	0.9
Shrub			4	RUUR	0.1	0.1	ACCI	0.1	0.1	GASH	1.0	0.8	VAME	0.7	0.7
Shrub		Control	1	ACCI	17.9	6.1	ACCI	22.6	7.0	ACCI	17.0	8.2	ACCI	9.2	1.6
Shrub			2	VAPA	5.8	2.9	VAPA	8.5	2.7	VAPA	8.6	4.6	MANE2	3.6	3.1
Shrub			3	GASH	3.2	2.2	GASH	2.6	1.7	MANE2	2.0	1.8	GASH	3.1	2.4
Shrub			4	MANE2	2.0	1.5	MANE2	2.6	2.2	GASH	1.8	1.1	VAPA	2.6	1.9
Shrub	2	Streamside retention	1	VAPA	13.0	5.7									
Shrub			2	ACCI	10.8	6.6									
Shrub			3	MANE2	4.3	1.0									
Shrub			4	GASH	2.6	1.4									
Shrub		Buffer	1	GASH	15.4	9.7	GASH	14.3	7.6	GASH	16.2	8.7			
Shrub			2	VAPA	9.9	3.7	VAPA	12.2	3.2	VAPA	13.2	4.6			
Shrub			3	MANE2	3.0	1.5	ACCI	3.4	3.4	MANE2	3.0	2.2			
Shrub			4	ACCI	2.9	2.9	MANE2	3.1	1.8	ACCI	2.9	2.9			
Shrub		Control	1	VAPA	13.1	4.7				VAPA	8.0	4.4			
Shrub			2	RHMA3	7.1	3.1				RHMA3	4.7	4.0			
Shrub			3	ACCI	4.0	4.0				GASH	2.7	1.6			
Shrub			4	GASH	2.1	1.1				VAME	2.5	2.4			
Shrub	3	Streamside retention	1	ACCI	14.8	13.7									
Shrub			2	OPHO	6.0	2.1									
Shrub			3	VAPA	3.4	1.8									
Shrub			4	COCA13	2.8	0.2									
Shrub		Buffer	1	COCA13	5.1	2.2									
Shrub			2	VAPA	2.3	1.0									
Shrub			3	ACCI	2.2	1.6									
Shrub			4	MANE2	1.9	1.6									
Shrub		Control	1	ACCI	7.1	5.0									
Shrub			2	VAPA	5.6	2.4									
Shrub			3	RHMA3	3.2	2.7									
Shrub			4	ACGL	2.4	2.4									

Type	LA	Stand type	Rank	Pretreatment Spp	Cover	SE	Year 0 Spp	Cover	SE	Year 2 Spp	Cover	SE	Year 4 Spp	Cover	SE
Tree	1	Streamside retention	1	TSHE	14.1	10.0	TSHE	5.5	2.5	TSHE	5.3	2.9	TSHE	4.9	4.0
Tree			2	CHCH7	0.2	0.2	TABR2	0.6	0.6	CHCH7	0.4	0.4	ACMA3	0.7	0.7
Tree			3	ACMA3	0.0	0.0	FRPU7	0.0	0.0	FRPU7	0.1	0.1	CHCH7	0.5	0.5
Tree			4	ALRU2	0.0	0.0	CHCH7	0.0	0.0	ALRU2	0.0	0.0	FRPU7	0.0	0.0
Tree		Buffer	1	TABR2	4.3	4.3	TABR2	4.6	4.6	TABR2	3.9	3.9	TABR2	2.7	2.7
Tree			2	TSHE	0.2	0.2	TSHE	1.3	1.3	TSHE	1.7	1.5	TSHE	1.8	1.5
Tree			3												
Tree			4												
Tree		Control	1	TSHE	10.3	5.9	TSHE	7.5	2.1	TSHE	9.7	3.0	TSHE	8.3	5.3
Tree			2	THPL	3.3	2.6	TABR2	6.1	6.1	THPL	2.6	2.2	THPL	0.8	0.4
Tree			3	TABR2	0.0	0.0	THPL	3.7	2.9	TABR2	0.0	0.0	TABR2	0.0	0.0
Tree			4												
Tree	2	Streamside retention	1	TSHE	11.3	9.8									
Tree			2	TABR2	3.7	2.1									
Tree			3	THPL	3.0	1.2									
Tree			4												
Tree		Buffer	1	TSHE	2.0	0.2	TSHE	4.9	1.2	TSHE	7.9	0.4			
Tree			2	TABR2	0.9	0.9	TABR2	1.1	1.1	TABR2	1.1	1.1			
Tree			3	THPL	0.5	0.3	CHCH7	0.6	0.6	PSME	0.3	0.3			
Tree			4	CHCH7	0.3	0.3	THPL	0.6	0.6	CHCH7	0.2	0.2			
Tree		Control	1	TSHE	24.6	9.3				TSHE	9.5	7.1			
Tree			2	TABR2	7.5	4.9				TABR2	1.9	1.1			
Tree			3	THPL	3.2	3.0				THPL	1.8	1.8			
Tree			4												
Tree	3	Streamside retention	1	THPL	2.3	2.3									
Tree			2	TSHE	1.7	1.7									
Tree			3	ABGR	0.8	0.8									
Tree			4	CHCH7	0.2	0.2									
Tree		Buffer	1	TSHE	5.4	3.7									
Tree			2	ABAM	0.4	0.4									
Tree			3												
Tree			4												
Tree		Control	1	THPL	20.3	12.9									
Tree			2	TSHE	6.6	4.3									
Tree			3	TABR2	1.5	1.2									
Tree			4												

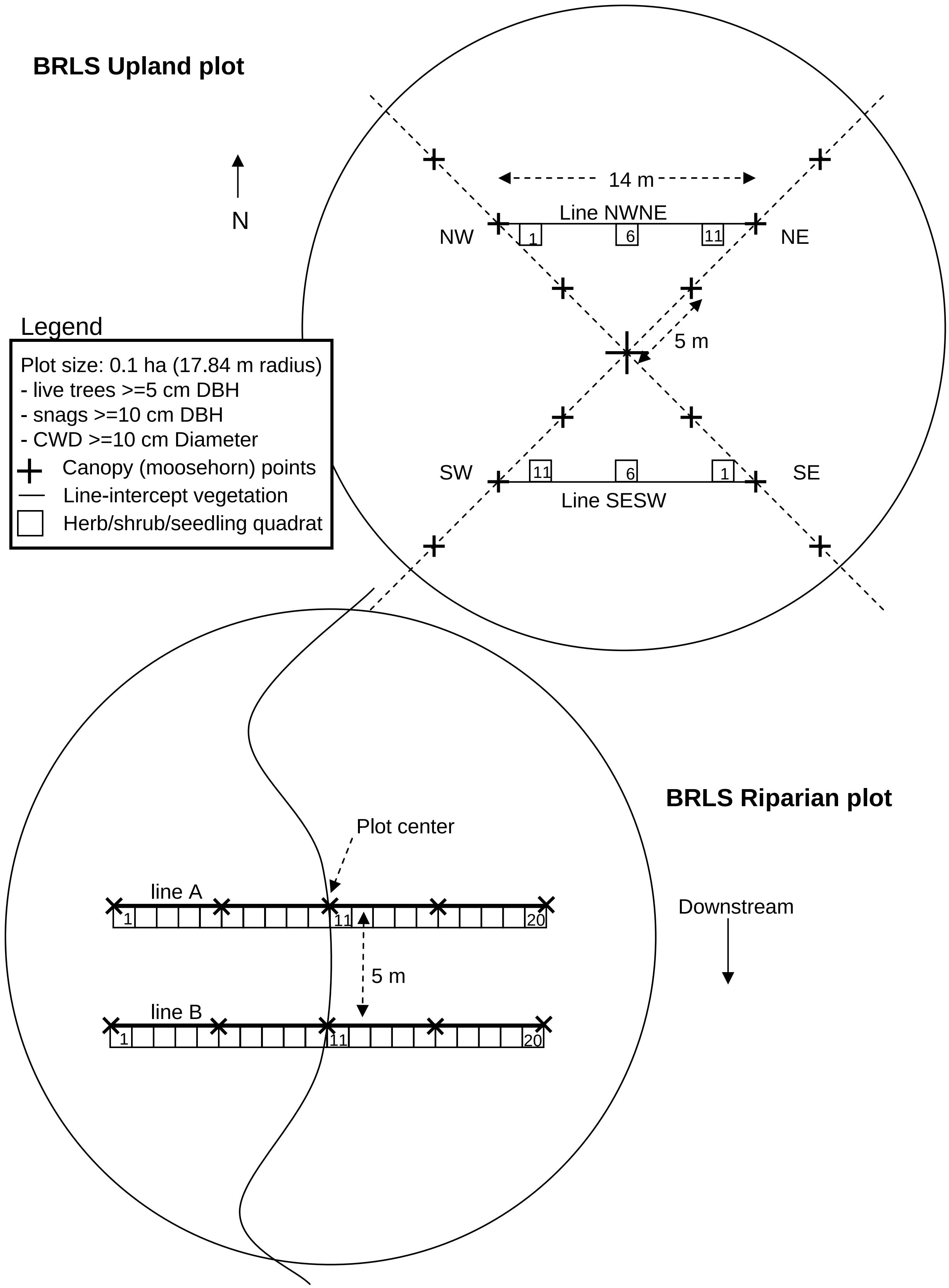

Figure 1: Diagrams for upland and riparian plots, Blue River Landscape study

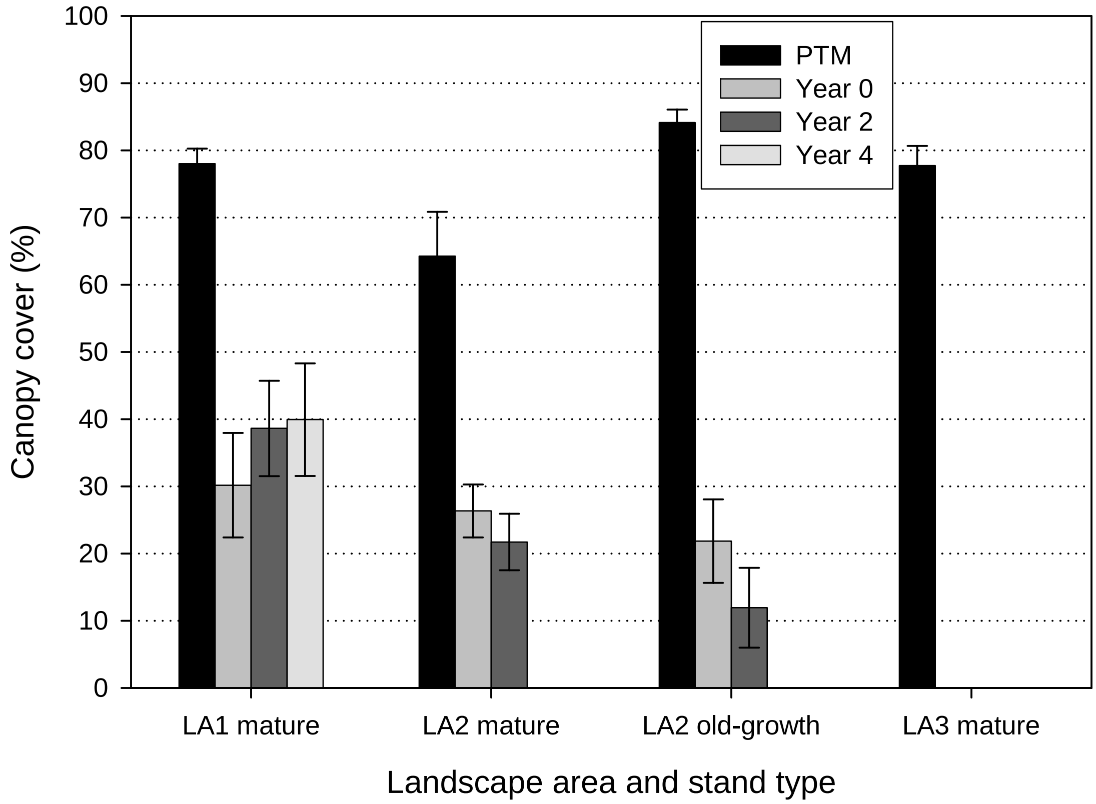

Figure 2: Mean canopy cover over time by landscape area and stand type. Sample sizes are in Table3, except N=9 for LA1 in year0.

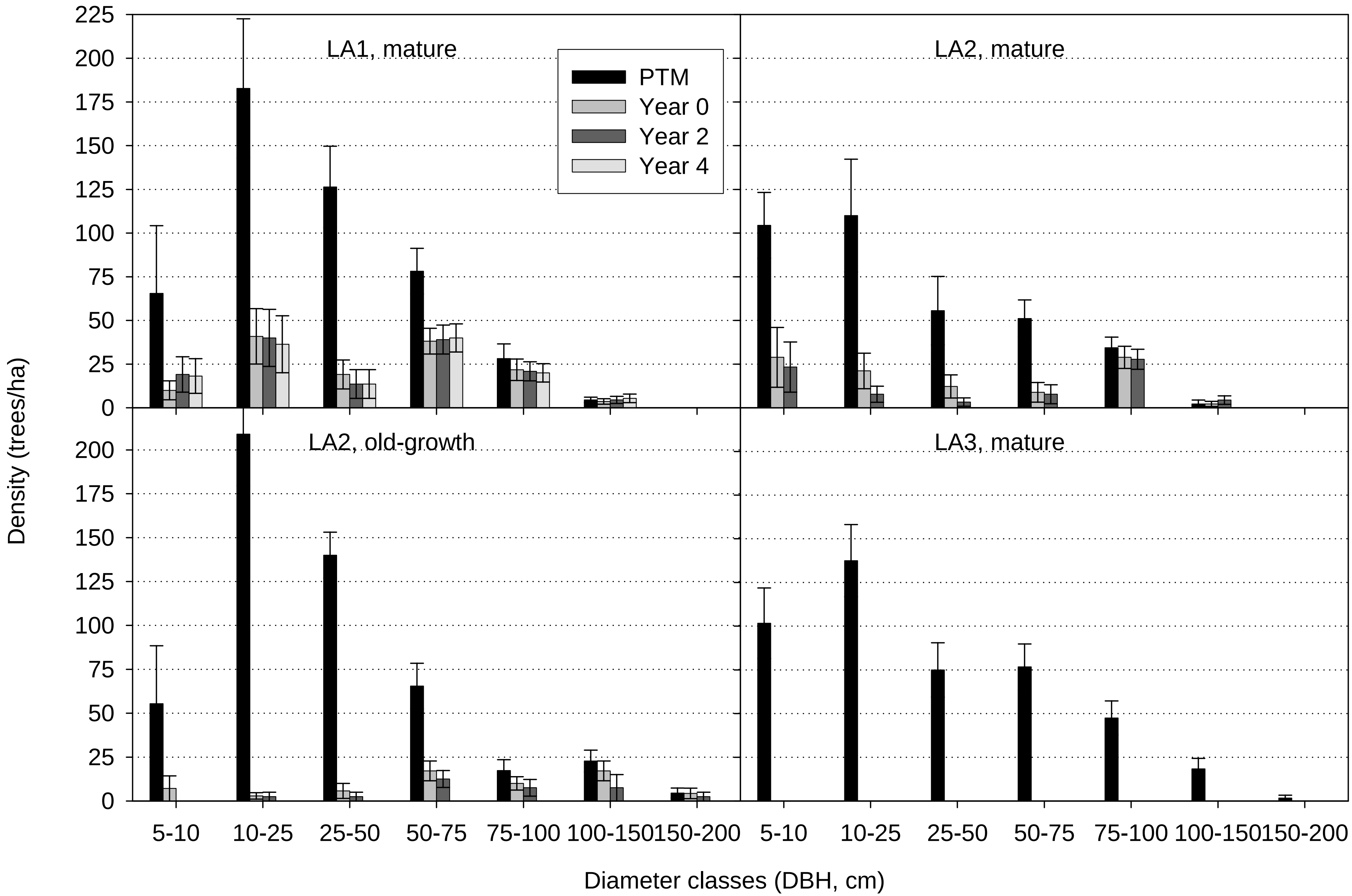

Figure 3: Live tree density by diameter class, landscape area, and seral stage over time in the Blue River Landscape study.

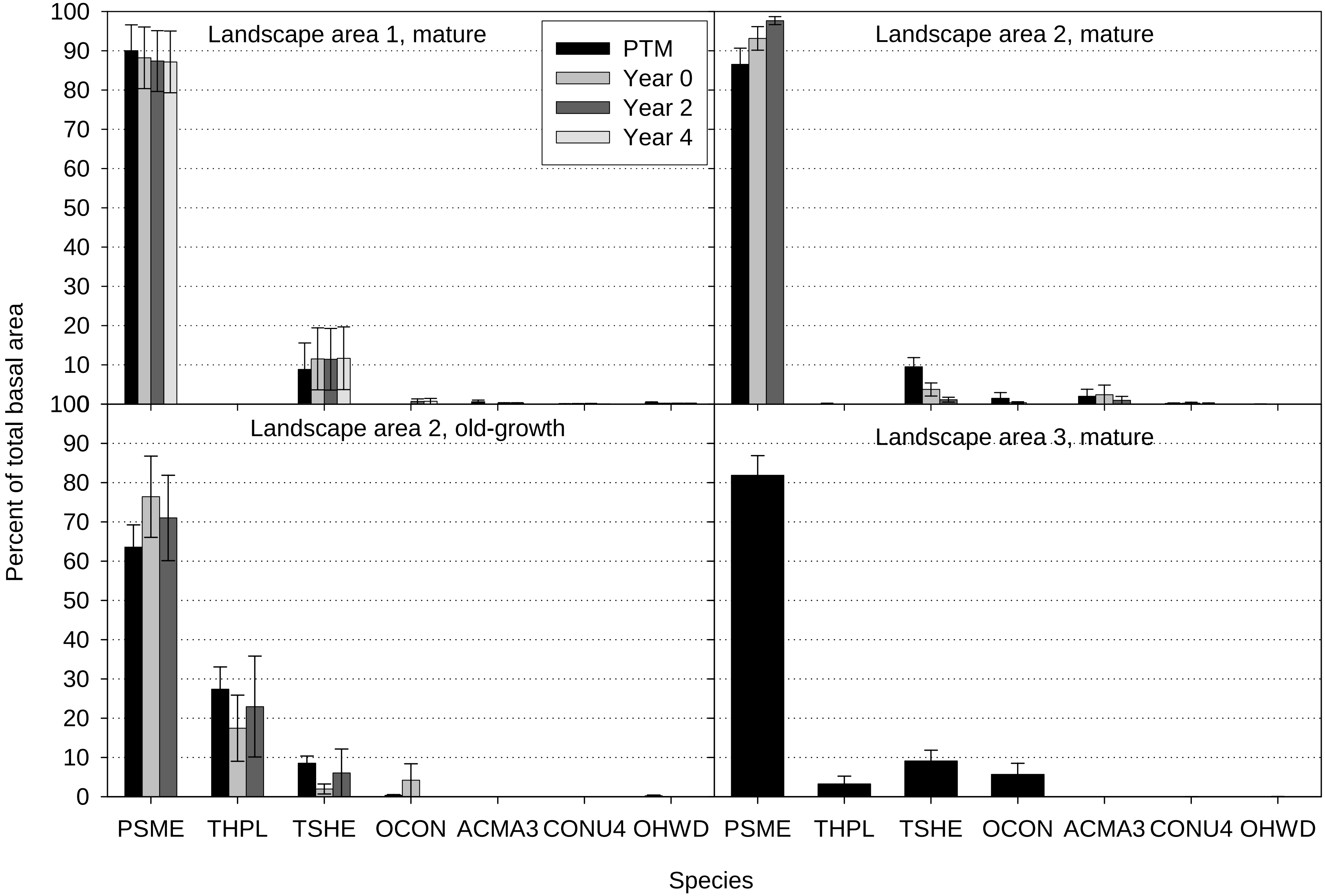

Figure 4: Mean live tree composition as a percent of basal area by landscape area and seral stage over time in the Blue River Landscape study. "OCON" and "OHWD" refer to other conifer and other hardwood, respectively.

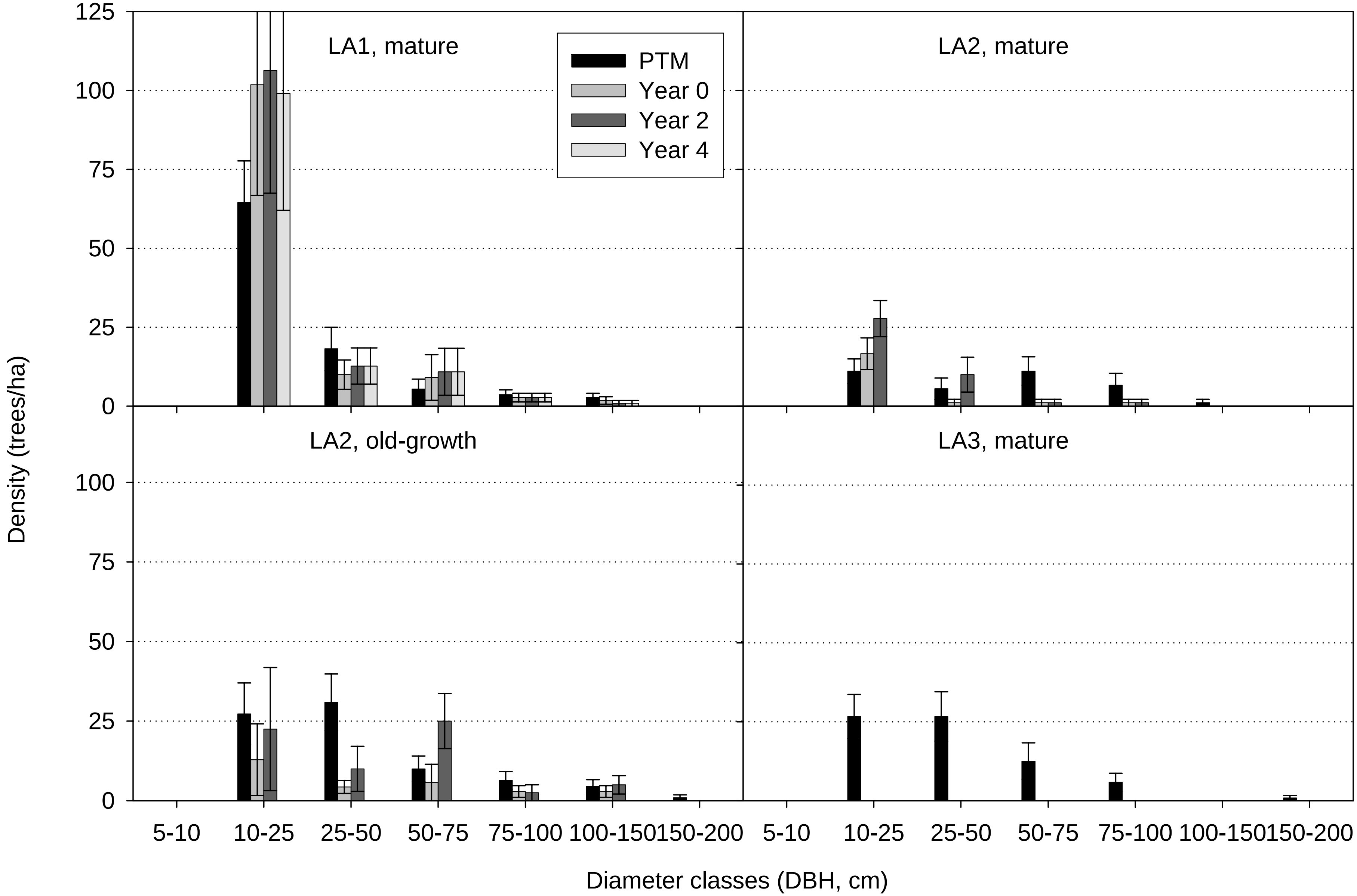

Figure 5: Snag density by diameter class, landscape area, and seral stage over time in the Blue River Landscape study.

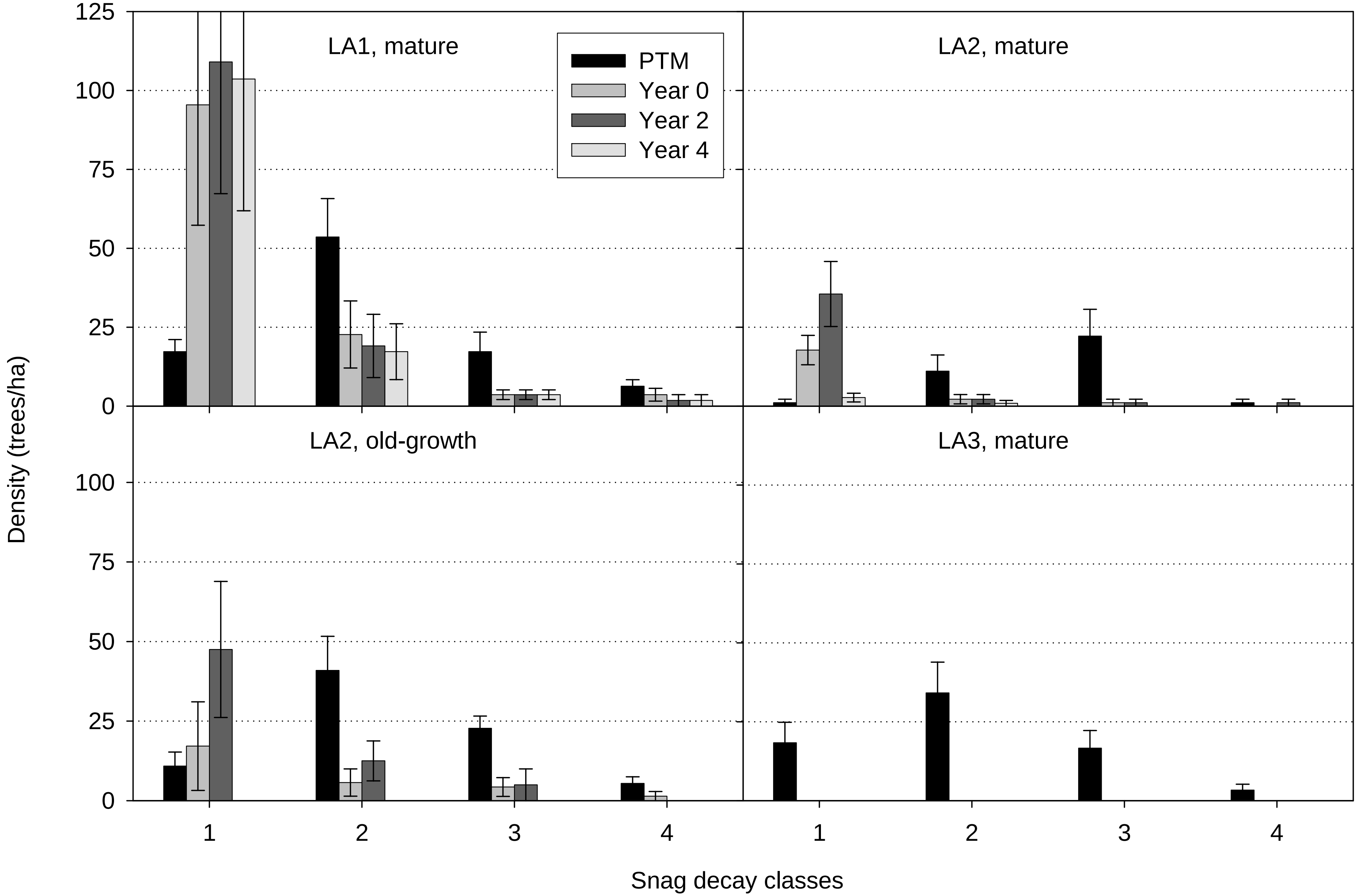

Figure 6: Snag density by decay class, landscape area, and seral stage over time in the Blue River Landscape study.

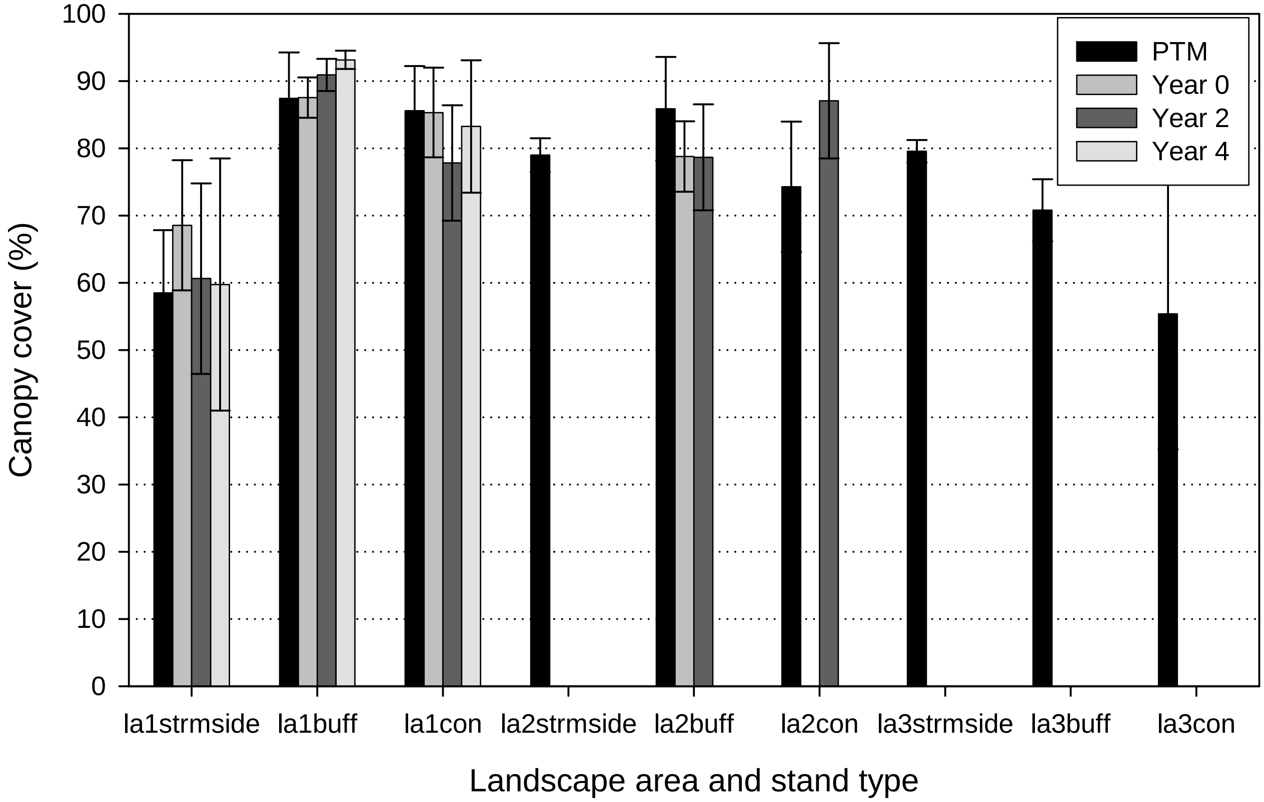

Figure 7: Mean canopy cover over time by landscape area and stream type (N=3).

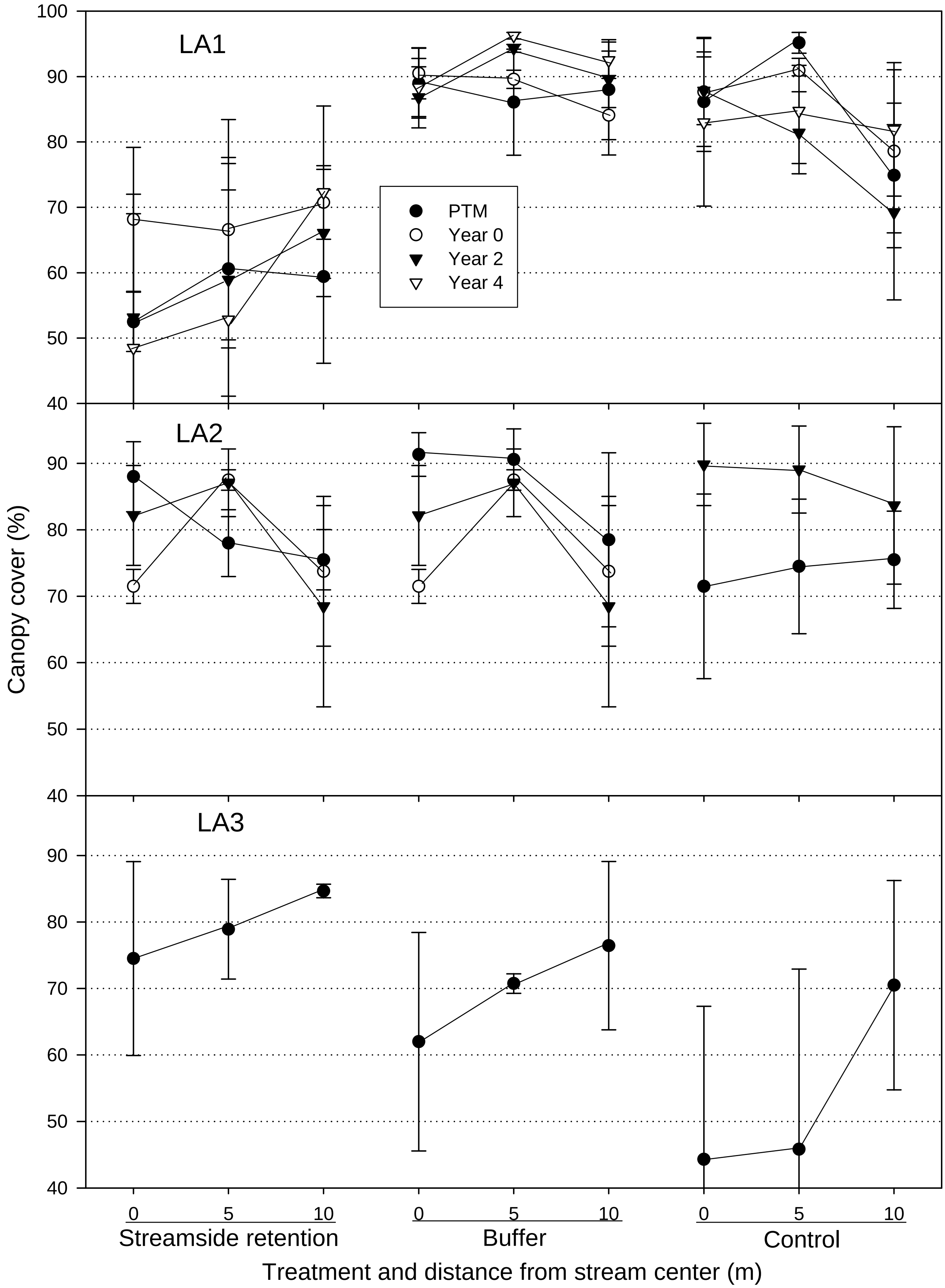

Figure 8: Mean canopy cover over time by landscape area, stream type, and distance from stream (N=3).

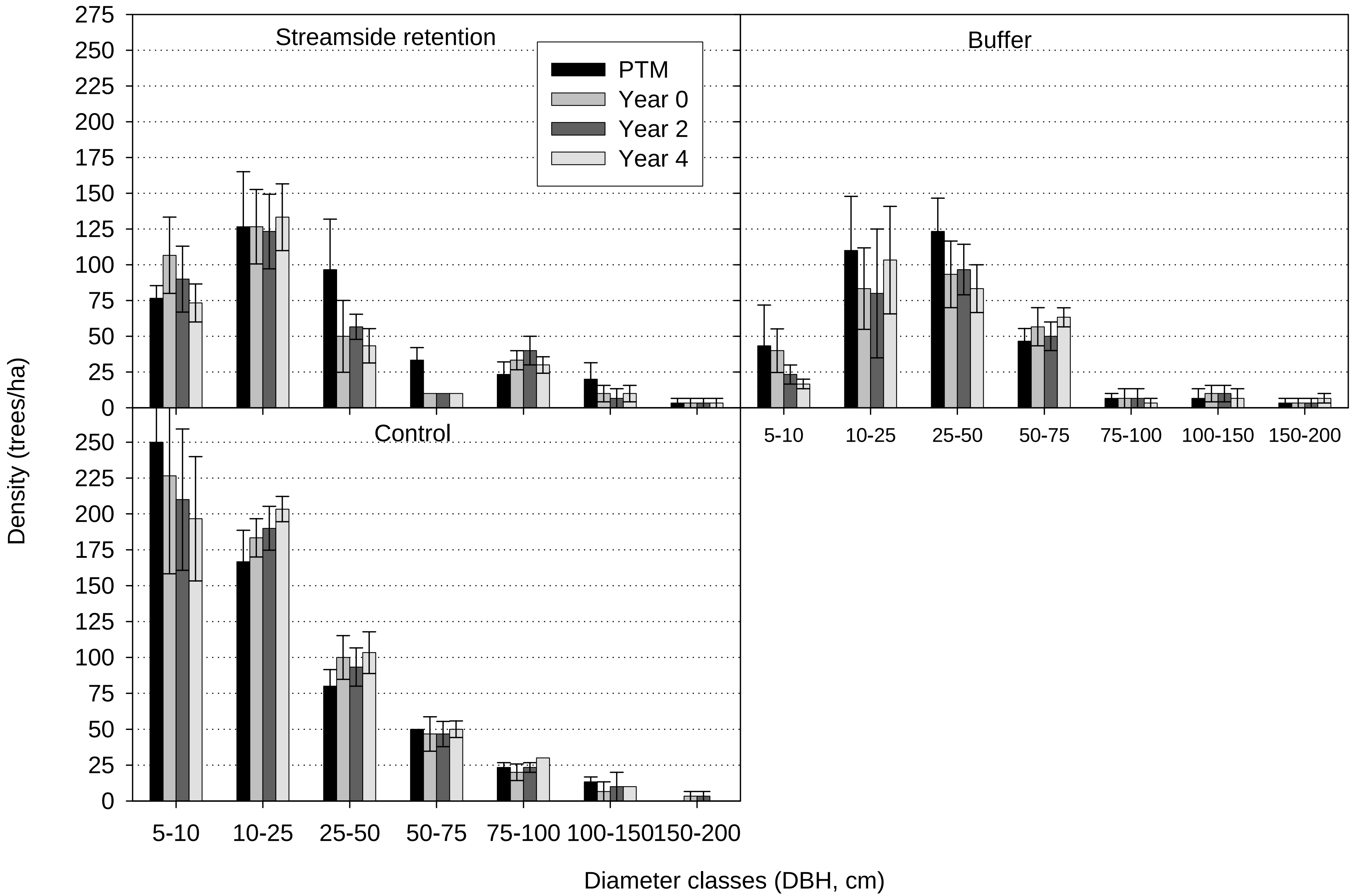

Figure 9: Live tree density in LA1 riparian stands by diameter class over time in the Blue River Landscape study.

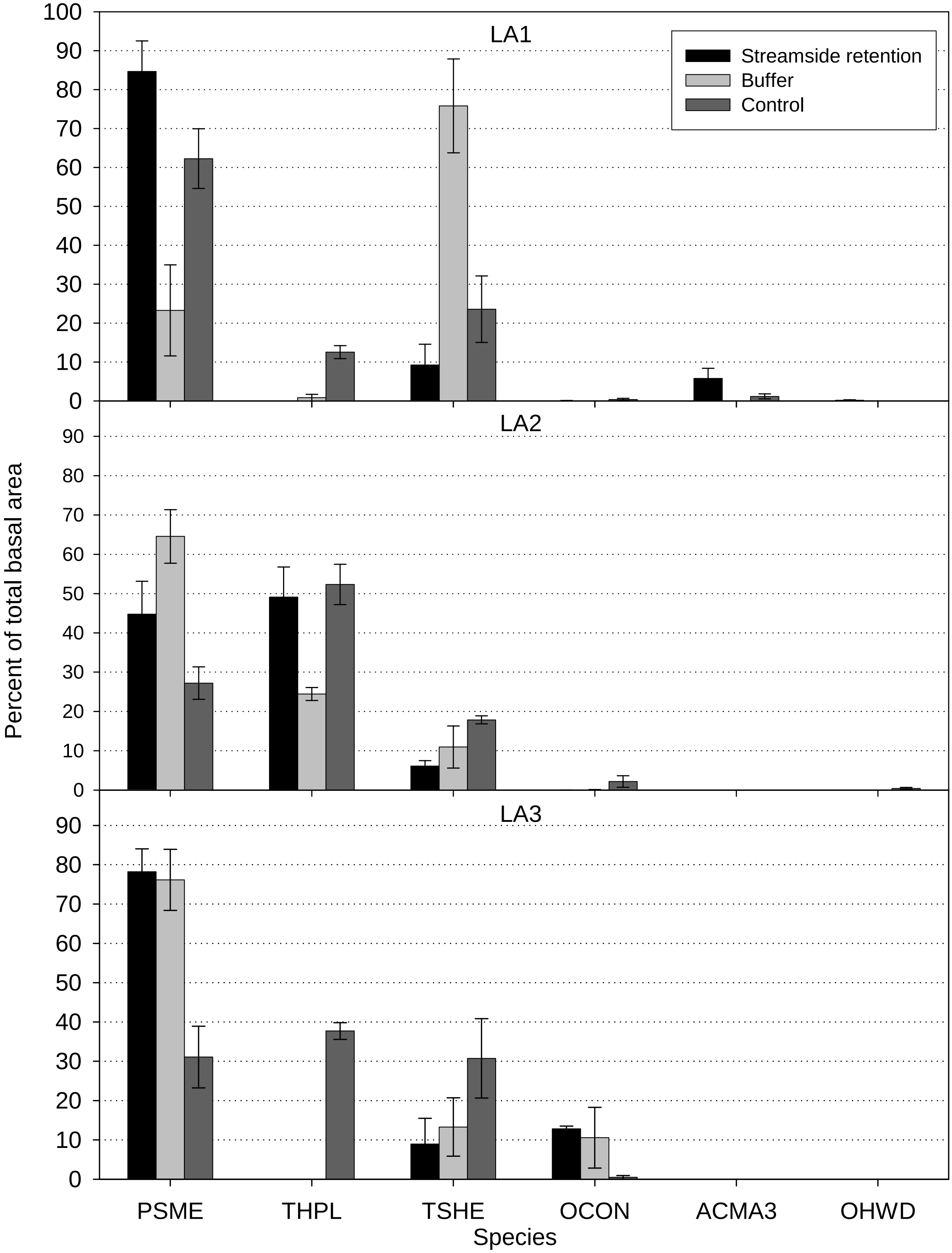

Figure 10: Mean live tree composition as a percent of basal area by landscape area and stream treatment in the Blue River Landscape study, pre-treatment sample period. "OCON" and "OHWD" refer to other conifer and other hardwood, respectively.

Appendix A: List of species and codes recorded in the Blue River Landscape Study

Type	CODE	Scientific name	Common name
Tree	ABAM	Abies amabilis	Pacific silver fir
Tree	ABGR	Abies grandis	grand fir
Tree	ABPR	Abies procera	noble fir
Tree	ACMA3	Acer macrophyllum	bigleaf maple
Tree	ALRU2	Alnus rubra	red alder
Tree	ARME	Arbutus menziesii	Pacific madrone
Tree	CADE27	Calocedrus decurrens	incense cedar
Tree	CHCH7	Chrysolepis chrysophylla	giant chinquapin
Tree	CONU4	Cornus nuttallii	Pacific dogwood
Tree	FRPU7	Frangula purshiana	Pursh's buckthorn
Tree	PILA	Pinus lambertiana	sugar pine
Tree	PIMO3	Pinus monticola	western white pine
Tree	PREM	Prunus emarginata	bitter cherry
Tree	PSME	Pseudotsuga menziesii	Douglas-fir
Tree	TABR2	Taxus brevifolia	Pacific yew
Tree	THPL	Thuja plicata	western red cedar
Tree	TSHE	Tsuga heterophylla	western hemlock
Tall shrub	ACCI	Acer circinatum	vine maple
Tall shrub	ACGL	Acer glabrum	Rocky Mountain maple
Tall shrub	AMAL2	Amelanchier alnifolia	Saskatoon serviceberry
Tall shrub	ARCO3	Arctostaphylos columbiana	hairy manzanita
Tall shrub	CEIN3	Ceanothus integerrimus	deerbrush
Tall shrub	CESA	Ceanothus sanguineus	redstem ceanothus
Tall shrub	CEVE	Ceanothus velutinus	snowbrush ceanothus
Tall shrub	COCO6	Corylus cornuta	beaked hazelnut
Tall shrub	COSE16	Cornus sericea	redosier dogwood
Tall shrub	HODI	Holodiscus discolor	oceanspray
Tall shrub	MAAQ2	Mahonia aquifolium	hollyleaved barberry
Tall shrub	OPHO	Oplopanax horridus	devil's club
Tall shrub	RHMA3	Rhododendron macrophyllum	Pacific rhododendron
Tall shrub	RILA	Ribes lacustre	prickly currant
Tall shrub	RISA	Ribes sanguineum	redflower currant
Tall shrub	ROGY	Rosa gymnocarpa	dwarf rose
Tall shrub	RULE	Rubus leucodermis	whitebark raspberry
Tall shrub	RUPA	Rubus parviflorus	thimbleberry
Tall shrub	RUSP	Rubus spectabilis	salmonberry
Tall shrub	SALIX	Salix	willow species
Tall shrub	SARA2	Sambucus racemosa	red elderberry
Tall shrub	SORBU	Sorbus	mountain ash species
Tall shrub	SOSI2	Sorbus sitchensis	western mountain ash
Tall shrub	SYAL	Symphoricarpos albus	common snowberry
Tall shrub	TODI	Toxicodendron diversilobum	Pacific poison oak
Tall shrub	VACCI	Vaccinium	huckleberry species
Tall shrub	VAME	Vaccinium membranaceum	thinleaf huckleberry
Tall shrub	VAOV	Vaccinium ovalifolium	oval-leaf blueberry
Tall shrub	VAPA	Vaccinium parvifolium	red huckleberry

Type	CODE	Scientific name	Common name
Low shrub	CHME	Chimaphila menziesii	little prince's pine
Low shrub	CHUM	Chimaphila umbellata	pipsissewa
Low shrub	COCA13	Cornus canadensis	bunchberry dogwood
Low shrub	GAOV2	Gaultheria ovatifolia	western teaberry
Low shrub	GASH	Gaultheria shallon	salal
Low shrub	LIBO3	Linnaea borealis	twinflower
Low shrub	LONIC	Lonicera	honeysuckle species
Low shrub	MANE2	Mahonia nervosa	Cascade barberry
Low shrub	PAMY	Paxistima myrsinites	Oregon boxleaf
Low shrub	RULA2	Rubus lasiococcus	roughfruit berry
Low shrub	RUNI2	Rubus nivalis	snow raspberry
Low shrub	RUUR	Rubus ursinus	California blackberry
Low shrub	SYMO	Symphoricarpos mollis	creeping snowberry
Low shrub	WHMO	Whipplea modesta	common whipplea
Forb	ACTR	Achlys triphylla	sweet after death
Forb	ACRU2	Actaea rubra	red baneberry
Forb	ADBI	Adenocaulon bicolor	American trailplant
Forb	ADPE	Adiantum pedatum	northern maidenhair
Forb	ALVI2	Allotropa virgata	sugarstick
Forb	ANMA	Anaphalis margaritacea	western pearly everlasting
Forb	ANEMO	Anemone	Anemone species
Forb	ANDE3	Anemone deltoidea	Columbian windflower
Forb	ANLY	Anemone lyallii	Little Mountain thimbleweed
Forb	ANAR3	Angelica arguta	Lyall's angelica
Forb	ANAR5	Antennaria argentea	silver pussytoes
Forb	APOCY	Apocynum	dogbane
Forb	APAN2	Apocynum androsaemifolium	spreading dogbane
Forb	ARCA2	Aralia californica	California spikenard
Forb	ARNU2	Aralia nudicaulis	wild sarsaparilla
Forb	ARLA8	Arnica latifolia	broadleaf arnica
Forb	ARDI8	Aruncus dioicus	bride's feathers
Forb	ASCA2	Asarum caudatum	British Columbia wildginger
Forb	ASTR10	Asplenium trichomanes-ramosum	brightgreen spleenwort
Forb	ATFI	Athyrium filix-femina	common ladyfern
Forb	BLSP	Blechnum spicant	deer fern
Forb	BOOC2	Boykinia occidentalis	coastal brookfoam
Forb	BRASS	Brassica	Brassica species
Forb	CASC7	Campanula scouleri	pale bellflower
Forb	CABU2	Capsella bursa-pastoris	shepherd's purse
Forb	CEFO2	Cerastium fontanum	big chickweed
Forb	CHAN9	Chamerion angustifolium	fireweed
Forb	CIAL	Circaea alpina	small enchanter's nightshade
Forb	CIRSI	Cirsium	Cirsium/thistle species
Forb	CIAR4	Cirsium arvense	Canada thistle
Forb	CIVU	Cirsium vulgare	bull thistle
Forb	CLSI2	Claytonia sibirica	Siberian springbeauty
Forb	CLUN2	Clintonia uniflora	bride's bonnet
Forb	COHE2	Collomia heterophylla	variableleaf collomia
Forb	COAR4	Convolvulus arvensis	field bindweed
Forb	CONYZ	Conyza	Conyza species

Type	CODE	Scientific name	Common name
Forb	COLA3	Coptis laciniata	Oregon goldthread
Forb	COST	Corallorrhiza striata	hooded coralroot
Forb	CRCA3	Crepis capillaris	smooth hawksbeard
Forb	DIFO	Dicentra formosa	Pacific bleeding heart
Forb	DIHO3	Disporum hookeri	drops of gold
Forb	DISM2	Disporum smithii	largeflower fairybells
Forb	EPILO	Epilobium	epilobium species
Forb	EPCI	Epilobium ciliatum	fringed willowherb
Forb	EPMI	Epilobium minutum	chaparral willowherb
Forb	EQUIS	Equisetum	horsetail
Forb	EQAR	Equisetum arvense	field horsetail
Forb	FRVE	Fragaria vesca	woodland strawberry
Forb	FRVI	Fragaria virginiana	Virginia strawberry
Forb	GAAP2	Galium aparine	stickywilly
Forb	GAOR	Galium oreganum	Oregon bedstraw
Forb	GATR3	Galium triflorum	fragrant bedstraw
Forb	GOOB2	Goodyera oblongifolia	western rattlesnake plantain
Forb	HECO6	Hemitomes congestum	coneplant
Forb	HIAL2	Hieracium albiflorum	white hawkweed
Forb	HICY	Hieracium cynoglossoides	houndstongue hawkweed
Forb	HYTE	Hydrophyllum tenuipes	Pacific waterleaf
Forb	HYRA3	Hypochaeris radicata	hairy catsear
Forb	IRIS	Iris	Iris species
Forb	LASE	Lactuca serriola	prickly lettuce
Forb	LILIU	Lilium	Lilly species
Forb	LIBO3	Linnaea borealis	twinflower
Forb	LISTE	Listera	twayblade species
Forb	LICA10	Listera caurina	northwestern twayblade
Forb	LICO6	Listera cordata	heartleaf twayblade
Forb	LICA11	Lithospermum californicum	California stoneseed
Forb	LOMI	Lotus micranthus	desert deervetch
Forb	LUPIN	Lupinus	lupine species
Forb	LUAR	Lupinus arboreus	yellow bush lupine
Forb	LULA4	Lupinus latifolius	broadleaf lupine
Forb	LUPO2	Lupinus polyphyllus	bigleaf lupine
Forb	MASA	Madia sativa	coast tarweed
Forb	MAIAN	Maianthemum	false lilly species
Forb	MARA7	Maianthemum racemosum	feathery false lily of the vally
Forb	MAST4	Maianthemum stellatum	starry false lily of the vally
Forb	MAPA5	Malva parviflora	cheeseweed mallow
Forb	MITEL	Mitella	miterwort species
Forb	MIOV	Mitella ovalis	coastal miterwort
Forb	MIPE	Mitella pentandra	fivestamen miterwort
Forb	MOUN2	Moneses uniflora	single delight
Forb	MOUN3	Monotropa uniflora	Indianpipe
Forb	MOPA2	Montia parvifolia	littleleaf minerslettuce
Forb	MYMU	Mycelis muralis	wall-lettuce
Forb	OESA	Oenanthe sarmentosa	water parsely
Forb	ORSE	Orthilia secunda	sidebells wintergreen
Forb	OSBE	Osmorhiza berteroi	sweetcicely
Forb	OXOR	Oxalis oregana	redwood-sorrel

Type	CODE	Scientific name	Common name
Forb	PABO6	Packera bolanderi	Bolander's ragwort
Forb	PERA	Pedicularis racemosa	sickletop lousewort
Forb	PECA80	Penstemon campanulatus	bellflower beardtongue
Forb	PEFR5	Petasites frigidus	arctic sweet coltsfoot
Forb	PHHA	Phacelia hastata	silverleaf phacelia
Forb	PIUN3	Piperia unalascensis	slender-spire orchid
Forb	PICA9	Pityopus californica	California pinefoot
Forb	POMU	Polystichum munitum	western swordfern
Forb	POGL9	Potentilla glandulosa	sticky cinquefoil
Forb	PSCA11	Pseudognaphalium canescens	Wright's cudweed
Forb	PTAQ	Pteridium aquilinum	western brackenfern
Forb	PTAN2	Pterospora andromedea	woodland pinedrops
Forb	PYAS	Pyrola asarifolia	liverleaf wintergreen
Forb	PYPI2	Pyrola picta	whiteveined wintergreen
Forb	SENEC	Senecio	Senecio species
Forb	SEJA	Senecio jacobaea	stinking willie
Forb	SESY	Senecio sylvaticus	woodland ragwort
Forb	STACH	Stachys	hedgenettle species
Forb	STCH	Stachys chamissonis	coastal hedgenettle
Forb	STELL	Stellaria	Stellaria species
Forb	STAM2	Streptopus amplexifolius	claspleaf twistedstalk
Forb	STLA16	Streptopus lanceolatus	twistedstalk
Forb	SYCA3	Symphyotrichum campestre var.	western meadow aster
Forb	SYRE	Synthyris reniformis	snowqueen
Forb	TAOF	Taraxacum officinale	common dandelion
Forb	TEGR2	Tellima grandiflora	bigflower tellima
Forb	THPR	Thymus praecox	creeping thyme
Forb	TITR	Tiarella trifoliata	threeleaf foamflower
Forb	TOME	Tolmiea menziesii	youth on age
Forb	TRBO2	Trientalis borealis	broadleaf starflower
Forb	TRIFO	Trifolium	clover species
Forb	TROV2	Trillium ovatum	Pacific trillium
Forb	VAHE	Vancouveria hexandra	white insideout flower
Forb	VERON	Veronica	Veronica species
Forb	VEAM2	Veronica americana	American speedwell
Forb	VICIA	Vicia	vetch species
Forb	VIAM	Vicia americana	American vetch
Forb	VIGL	Viola glabella	pioneer violet
Forb	VIOR	Viola orbiculata	darkwoods violet
Forb	VISE3	Viola sempervirens	evergreen violet
Forb	XETE	Xerophyllum tenax	common beargrass
Other	BRVU	Bromus vulgaris	Columbia brome
Other	BRYO	Bryophyte	Bryophyte
Other	CAREX	Carex	Carex/sedge species
Other	CADE8	Carex densa	dense sedge
Other	GRAMI	Graminoid	Graminoid (usually grass)
Other	JUNCU	Juncus	Rush species
Other	JUPA	Juncus parryi	Parry's rush