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Coarse woody debris in chronosequences of forests on southern Vancouver Island

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R.W. Wells and J.A. Trofymow

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Forest Ecosystem Processes Network

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Coarse woody debris in chronosequences of forests on southern Vancouver Island

R.W. Wells and[1] J.A. Trofymow[2]

[1] Centre for Applied Conservation Biology
University of British Columbia
270–2357 Main Mall
Vancouver, B.C. V6T 1Z4

[2] Canadian Forest Service
506 West Burnside Road
Victoria, B.C. V8Z 1M5

Pacific Forestry Centre
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Canadian Forest Service
Pacific Forestry Centre
506 West Burnside Road
Victoria, British Columbia
V8Z 1M5

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Abstract

We examined trends of coarse woody debris (CWD) abundance in chronosequence plots established by the Canadian Forest Service on the drier east side (CWHxm subzone) and the wetter west side (CWHvm subzone) of southern Vancouver Island. Overall, total biomass of CWD on the east side was substantially (and significantly) lower than on the west side. Mean total biomass in the chronosequences ranged from 17 Mg/ha to 38 Mg/ha on the east side and 65 Mg/ha to 191 Mg/ha on the west side.

We found that total biomass of CWD followed a U-shaped curve over the chronosequence in three of four sites on the west side (CWHvm), while no overall trend was detectable for total biomass in the east side (CWHxm). Further, in both subzones, CWD was skewed to lower decay classes in younger stands, and more normally distributed in older stands. On the east side, CWD in young stands was biased to small size class CWD, and more uniformly distributed in older stands. Conversely, on the west side, CWD tended to be biased to larger size classes in all age classes. Finally, on the east side, Douglas-fir was the most common species among classified CWD; on the west side, western hemlock and western redcedar were most common.

On both the east side (CWHxm) and west side (CWHvm), variance in CWD loadings among plots was substantial. This may have limited our ability to detect some trends, and suggests that other factors besides those examined in this study influence CWD abundance. Finally, it is possible that the regenerating, immature and most mature stands examined in this study are not following the same developmental trajectory as old stands because they were initiated after harvesting while old stands were initiated after natural disturbances. Further studies comparing CWD characteristics in harvested and naturally disturbed stands would improve understanding of the differences in CWD dynamics that result from different disturbance types.

Résumé

Nous avons étudié les tendances que présentait l'abondance des débris ligneux grossiers (DLG) dans les placettes établies par le Service canadien des forêts dans des chronoséquences situées du côté est, plus sec, de l'île de Vancouver (sous-zone CWHxm) et du côté ouest, plus humide, de l'île (sous-zone CWHvm). Dans l'ensemble, la biomasse totale des DLG était en grande partie (et considérablement) plus réduite sur le côté est que sur le côté ouest de l'île. La biomasse totale moyenne des chronoséquences variait de 17 à 38 mg/ha sur le côté est de l'île, et de 65 à 191 mg/ha sur le côté ouest.

Nous avons constaté que la biomasse totale des DLG présentait une courbe en U dans les chronoséquences de trois des quatre stations du côté ouest (CWHvm), tandis que nous n'avons décelé aucune tendance générale du côté est (CWHxm). De plus, la distribution des DLG des deux sous-zones s'étalait vers les classes inférieures de décomposition dans les peuplements plus jeunes et était plus normale dans les peuplements plus âgés. Du côté est de l'île, la distribution des DLG était biaisée vers la classe de DLG de petites dimensions dans les jeunes peuplements et était plus uniforme dans les peuplements plus âgés. Du côté ouest de l'île, elle avait au contraire tendance à être biaisée vers les classes de plus grandes dimensions, dans toutes les classes d'âge. Enfin, le douglas vert était l'essence la plus répandue dans tous les DLG classés dans l'est de l'île, tandis que la pruche de l'Ouest et le thuya géant venaient au premier rang dans l'ouest de l'île.

Tant du côté est (CWHxm) que du côté ouest (CWHvm), nous avons observé une variance importante de la quantité de DLG entre les parcelles. Cette variance nous a peut-être empêchés de déceler certaines tendances et nous permet de supposer que d'autres facteurs que ceux examinés dans le cadre de cette étude influent sur l'abondance des DLG. Enfin, il se peut que les peuplements en voie de régénération, jeunes et presque mûrs étudiés n'aient pas le même profil de développement que les vieux peuplements. En effet, les premiers se sont développés après une coupe et les seconds sont issus de perturbations naturelles. La réalisation d'autres études comparant les caractéristiques des DLG dans les peuplements exploités et dans les peuplements issus de perturbations naturelles permettrait de mieux comprendre les différences que présente la dynamique des DLG résultant de types de perturbations variés.

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1 Introduction

Coarse woody debris (CWD) plays a significant role in the structural dynamics of coastal forests of northwestern North America. Accumulations of over 400 Mg/ha have been recorded in very old stands in these forests and accumulations of over 60 Mg/ha are not uncommon throughout all stages of stand development (reviewed in Harmon *et al.* 1986 and Caza 1993). Moreover, accumulations of CWD are dynamic: substantial change occurs to the structural characteristics of CWD through forest succession (e.g., Spies *et al.* 1988). The dynamics of CWD in turn significantly influence the structural heterogeneity of the forest floor (e.g. Christy and Mack 1984) and the morphology of forest streams (e.g., Franklin *et al.* 1981).

The many ecological functions of CWD at all stages of succession emphasize the important role it plays in forests. For example, CWD provides a substrate for tree seedling establishment in many forest types (Harmon and Franklin 1989; Hofgaard 1993). Vertebrates use CWD for a variety of purposes including feeding, reproduction and cover (Harmon *et al.* 1986); Bunnell and Kremsater (1990) point to the importance of CWD for sustaining populations of terrestrial vertebrates in managed landscapes. CWD also supports diverse and abundant populations of invertebrates (Parsons *et al.* 1991) and fungi (Amaranthus *et al.* 1994). CWD plays an important role in nutrient cycling, particularly in the Pacific Northwest where it can occupy as much as 25% of the forest floor (Harmon *et al.* 1986). More recently, CWD has received attention because of the potential impact on the global carbon cycle of the substantial quantities of carbon stored by CWD in forests (Harmon *et al.* 1990; Kurz *et al.* 1992; Krankina and Harmon 1995; Fleming 1996; Kurz *et al.* 1996).

Although the ecological significance of CWD has been demonstrated in many forest types, few studies have investigated the structural dynamics of CWD during stand development. Spies and Franklin (1988) proposed a general U-shaped pattern of accumulation for CWD during stand development in Douglas-fir stands in Washington and Oregon. They suggested that, after a catastrophic disturbance such as fire, the amount of CWD is high because remnants from the previous stand were able to bridge the disturbance and contribute to the CWD pool of the new stand. As well, there is input of CWD as a result of the disturbance itself which maintains high amounts of CWD in the young stand. As the new stand matures, these “biological legacies” from the previous stand (Franklin and Hemstrom 1981) reach advanced decay states and decrease in density while there is little input of CWD from the maturing forest. Any CWD added is of smaller diameter because competition and suppression are the main sources of tree mortality and competition and suppression kill the smaller, less vigorous trees. This small-diameter CWD decomposes quickly, so there are no net gains in the volume or mass of CWD in the maturing stand. However, in aging forests, CWD accumulates again as large-diameter trees reach their maximum age and die, contributing a much greater proportion of volume and biomass to the CWD than smaller trees. Spies and Franklin (1988) expected that there would be some variance surrounding this general pattern of accumulation depending on the disturbance history of the stand and the decay rates of the tree species present.

There have been few studies investigating the general pattern of CWD accumulation through a forest’s development, but those that did found evidence supporting a U-shaped developmental trajectory. For example, dead above ground biomass was observed to follow the U-shaped accumulation pattern in the Douglas-fir–western hemlock forests in Washington and Oregon (Spies *et al.* 1988; Agee and Huff 1987) and the hardwood forests of the central Appalachians (McCarthy and Bailey 1994). Lee *et al.* (1995) found that the density of CWD in aspen mixed woody boreal forest in Alberta also followed the U-shaped pattern of accumulation with the greatest densities found in young and old forests compared with smaller densities in mature stands.

Little work has been conducted to date on the structural dynamics of coarse woody debris in the forests of coastal British Columbia. So, while studies support the U-shaped accumulation pattern for CWD in three very different forest types, it is difficult to know if this developmental pattern applies here. Further, basic information about the distribution of decay classes, size and species of CWD are currently lacking for coastal forests of British Columbia.

An opportunity to study CWD dynamics in the coastal forests of British Columbia was created with the establishment of chronosequence plots on southern Vancouver Island by the Canadian Forest Service in 1992. The chronosequence plots were established to study changes in carbon and nutrients resulting from conversion of coastal old growth to second-growth forests (Pollard and Trofymow 1993; Trofymow *et al.* 1997) and CWD was sampled along with many other attributes. In this study, we use the chronosequence data to examine trends of CWD abundance across chronosequence plots on the drier east side (CWHxm subzone; see Meidinger and Pojar 1991 for an explanation of biogeoclimatic classification) and the wetter west side (CWHvm subzone) of southern Vancouver Island.

2 Methods

Chronosequence plots were established in 1992 at eight sites on southern Vancouver Island, four on the dry leeward east side of Vancouver Island, all in the CWHxm subzone (Victoria Watershed South, Victoria Watershed North, Koksilah and Nanaimo River) and four on the wet windward west side of the island, in the CWHvm subzone (Renfrew, Red/Granite Creek, Nitinat and Klanawa). Sites were selected from paper map and GIS-based searches of forest cover maps and interviews with local foresters for locations containing old and successional stands in close proximity and with similar edaphic conditions within a site. In this way the four sites within a subzone could be treated as blocks for statistical analysis (Trofymow *et al.* 1997).

Four plots were established at each site in stands representing four different stages of development: *regeneration, immature, mature* and *old* (Trofymow *et al.* 1997). A total of 32 plots were established. All regeneration, immature and mature plots originated after harvesting, with the exception of mature plots on the Koksilah and Klanawa sites which originated after natural fires destroyed the previous stands. All old plots were of natural origin. In each plot ecosystem descriptions were prepared and overstory trees and snags, understory vegetation, coarse woody debris, forest floor materials and soils were measured and sampled as part of the C and nutrient distribution study. Basic plot descriptions are provided in Appendix 1; further details can be found in the establishment report for the experiment (Trofymow *et al.* 1997).

From a benchmark in each plot, three 30-m lines were run, 120° apart, the endpoints defining three subplot centres. These subplot centres define vertices of an equilateral triangle, 51 m on each side. Coarse woody debris were sampled along three 50-m transects which form the boundary of the triangle following the methods of Trowbridge *et al.* (1989) and modified by Blackwell *et al.* (1992). The total transect length for each plot was 150 m.

Woody debris in the largest size category (> 12 cm diameter) was identified to species, where possible, and assigned a decay class in the field according to the system of Sollins (1982):

class 1– logs freshly fallen, bark and all wood sound, current-year twigs attached;

class 2 – sapwood decayed but present, bark and heartwood mainly sound, twigs absent;

class 3 – logs still support own weight, sapwood decayed but still structurally sound;

class 4 – logs do not support own weight, sapwood and bark mainly absent, heartwood not structurally sound, branch stubs can be removed;

class 5 – heartwood mainly fragmented, forming ill-defined elongate mounds on the forest floor sometimes invisible from surface.

Samples which could not be identified as to species were all in decay classes 4 and 5.

Three samples of each size class were collected from each plot as pieces 5 to 15 cm long, except for logs more than 12 cm in diameter, from which 5-cm disks were cut. Slabs of class logs were cut and volumes were measured in the field. Samples were stored at 2°C until they could be processed. Specific gravities of wood were determined on six randomly chosen samples in each plot for each of four small diameter class materials (1.1–3.0, 3.1–5.0, 5.1–7.0, and 7.1–12.0 cm in diameter). Specific gravities of pieces more than 12 cm in diameter were determined on up to three samples of each decay class of each species encountered on each plot. (Trofymow and Blackwell 1993).

We estimated plot CWD mass using the following formula (Van Wagner 1968):

$$\text{Mass of CWD} = \frac{[\pi^2 \times G \times L]}{80} \times \sum D^2$$

where

G = specific gravity

L = transect length (m)

D = diameter (cm)

Mass of the pieces that were less than 12 cm in diameter was calculated using the average specific gravities in each plot for each of the four small diameter class materials. For pieces more than 12 cm in diameter, we used specific gravities for each decay class of the different species encountered on a given plot to calculate mass estimates. Volumes were calculated by using a specific gravity of 1.

We analyzed results using four size classes (SC) (SC1 = 1.1–11.9 cm diameter; SC2 = 12.0–29.9 cm diameter; SC3 = 30.0–59.9 cm diameter; SC4 ≥ 60 cm diameter) and the five decay classes described previously. For some analyses, we examined the distribution of CWD by species of origin. We report results for common species, but species that occurred in small amounts and on few plots we included in the “unclassified” species category. Amabilis fir (*Abies amabilis*) and western white pine (*Pinus monticola*) are included in this category. Unless otherwise noted, analyses and references to total biomass exclude size class 1 (1.1–11.9 cm diameter). Differences in size class 1 are described in sections discussing size classes.

We determined summary statistics and analysis of variance (ANOVA) results using Systat (Wilkinson *et al.* 1992). The effect of subzone, age class, decay class and size class on total biomass of CWD were tested using two, three-factor ANOVA tests. Because of the blocked layout of plots within a subzone, the effect of age class and site on biomass of CWD, for total and individual decay classes and size classes were also examined using several single-factor ANOVA tests for east and west side plots separately. Significant results are noted in the text and all results of the ANOVA tests are presented in Tables 1 and 2. The nonparametric Kruskal-Wallis test for comparing multiple means (Wilkinson *et al.* 1992) was used in some cases where high heteroscedasticity in variance precluded the use of an ANOVA test. We used $\alpha \leq 0.05$ for significance for all statistical tests. Statistical power was calculated for some tests using statistical power analysis software (Borenstein and Cohen 1988). In this report, we discuss results by biomass; equivalent results by volume are presented in Appendices 2–5.

3 Results

3.1 Characteristics of CWD in the Two Coastal Western Hemlock Subzones

We examined the effects of subzone (CWHxm vs. CWHvm), age class, decay class and size class on total biomass of CWD. Overall, we found that subzone had a significant influence on total biomass of CWD (Table 1). On average, east side plots (CWHxm) had substantially less CWD than did west side plots (CWHvm): total mean biomass of all east side plots was 25.8 Mg/ha (SE 5.3) compared to 133.9 Mg/ha (SE 27.2) for west side plots. This difference was significant (separate variances t-test; n = 16, 16; $P = 0.001$).

We further found that decay class and size class all had a significant influence on total biomass of CWD (Table 1). We were not able to detect any differences in total biomass among age classes with subzones combined (Table 1). There were, however, significant interactions between subzone and decay class as well as subzone and size class (Table 1). Because decay class and size class vary differently depending on subzone, we further analyzed variance among different size classes and decay classes for the east side (CWHxm) and west side (CWHvm) separately (Sections 3.2 and 3.3, respectively).

3.2 Characteristics of CWD on East Side (CWHxm) Sites

Among age classes, on the east side (CWHxm), mean total biomass of CWD (> 12 cm diameter) ranged from a low of 17.0 Mg/ha (in the immature age class) to a high of 38.1 Mg/ha (in the mature age class; Table 3). However, the apparent trend (low total biomass in regeneration and immature plots, high biomass in mature and old plots; Table 3; Figures 1–3) was not significant (Tables 1 and 2). At individual sites, it was also difficult to discern trends in CWD abundance with age. On two sites (Victoria Watershed North and Koksilah), the highest biomass of CWD was found on regeneration plots (Figures 4a and 5a). Alternatively, on the remaining two sites (Victoria Watershed South and Nanaimo River) the greatest abundance of CWD was found in mature or old-growth plots (Figures 4a and 5a). Finally, we were unable to detect any trends for total biomass among sites on the east side (Tables 2a and 2b).

3.2.1 Differences among decay classes

Most CWD in regeneration plots on the east side (CWHxm) was of decay class 2 or less (Table 3; Figures 1 and 2). On average, there was significantly more decay class 2 material in regeneration plots than decay classes 4 and 5 (Tukey's HSD; $P \leq 0.036$). Decay class 2 CWD was the most abundant class in every regeneration plot sampled on the east side (Figure 4a). In older age classes (immature, mature and old growth), CWD was more evenly distributed among decay classes (Table 3; Figures 1 and 2). No significant differences were detected among decay classes for mature and old-growth plots (Table 2a). In most older age class plots, CWD of decay class 3 or 4 was more abundant than CWD in the other three decay classes (Figures 4a and 5a).

3.2.2 Differences among size classes

In regeneration plots on the east side (CWHxm), CWD biomass was not equally distributed among size classes (Table 2c; Table 4; Figures 2 and 3). In three of four regeneration plots, material of size class 1 was the most abundant of all size classes (Figure 6a). Note that size class 1 (1.1–11.9 cm diameter) is a smaller size class than many studies define as coarse woody debris (Caza 1993). Also in three of four regeneration plots, size class 2 is the most or second most abundant size class of CWD (Figure 6a). CWD biomass was also not equally distributed among size classes in immature plots (Table 2c; Table 4; Figures 2 and 3). In immature plots, size class 2 was significantly more abundant than size class 4 (Tukey's HSD; $P = 0.05$). In the remaining age classes CWD was distributed more evenly among size classes. No significant differences were detected among size classes for mature and old growth plots (Table 2c; Table 4; Figures 2 and 3). Nonetheless, pieces in the largest size class (size class 4; > 60 cm diameter) were uncommon. This size class was not found in regeneration or immature plots, only in some mature and old plots (Table 4; Figures 3 and 6a).

3.2.3 Differences among species

On the east side (CWHxm), CWD biomass was dominated by Douglas-fir (*Pseudotsuga menziesii*) in essentially all size and decay classes for all age classes among classified logs (Table 5; Figures 1, 3, 4, and 6). Coarse woody debris of western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*) and red alder (*Alnus rubra*) origin was also present on some sites, but not abundant on any (Table 5; Figures 1, 3, 4, and 6).

3.3 Characteristics of CWD on West Side (CWHvm) Sites

As noted previously, the west side (CWHvm) had substantially more CWD than did the east side. Mean total biomass of CWD on the west side ranged from 64.6 Mg/ha in mature plots to 190.7 Mg/ha on old-growth plots (Table 3; Figure 1). In spite of the wide range of biomass among age classes, differences in total biomass were not significant (Table 1; Table 2a and 2b). We did discern patterns on individual sites: on three of four sites, CWD abundance was highest on the regeneration, immature, and old plots and lowest on mature plots (Figure 4b). We were unable to detect any differences in total biomass among sites on the west side (Table 2a and 2b).

3.3.1 Differences among decay classes

Biomass of CWD was not evenly distributed among decay classes on regeneration plots on the west side (CWHvm) (Table 3; Figures 1 and 2; Kruskal-Wallis test, df = 4, $H = 10.38$, $P = 0.035$). Almost all material on these plots was decay class 2 or 3, mostly due to the presence of large amounts of decay class 2 CWD found on the Klanawa regeneration plot. Differences among age classes were also significant for the remaining three age classes (Kruskal-Wallis tests, df = 4, $H \geq 10.52$, $P \leq 0.033$), but here, most CWD was decay class 3 or 4 on nearly all plots (Figure 4b). Decay class 1 material was rarely present in plots, and where it was observed it was found in low amounts (Table 3; Figure 4b). We observed a site effect for decay class 1 and 5 CWD (Table 2a). As noted, decay class 1 material was only present on few sites; both plots where this decay class was observed were on the Klanawa site, but only very small amounts of this material were found (Figure 4b). Klanawa also had more decay class 5 CWD than any other site (Figure 4b).

3.3.2 Differences among size classes

On the west side (CWHxm), biomass of CWD was most abundant in size class 4 in all age classes but mature, where most coarse woody debris was found in size class 3 (Table 4; Figures 3 and 6b). In the immature age class, there was significantly more size class 4 material than size class 1 and 2 material (Tukey's HSD, $P \leq 0.04$). In the mature age class, there was significantly more size class 3 material than size class 1 material (Tukey's HSD, $P = 0.05$). Finally, in the old age class, as in the intermediate age class, there was significantly more size class 4 material than size class 1 and 2 material (Tukey's HSD, $P \leq 0.01$). In regeneration plots there was a very high mean biomass of size class 4 CWD compared to smaller size classes; however, these differences were not significant (Table 2c). The high mean and standard error for size class 4 in this age class is mostly due to the large quantity of size class 4 found in the Klanawa regeneration plot (Figure 6b), which is likely the reason for the non-significant ANOVA result.

The biomass of size class 4 CWD varied with age class (Kruskal-Wallis test, df = 4, $H \geq 7.65$, $P = 0.05$). Biomass was high in regeneration and old-growth plots, and low in immature and mature plots (Table 4; Figures 3 and 6b) suggesting a U-shaped curve of CWD abundance for this size class across age classes. We were unable to detect a trend for size class 3 CWD (Table 2b; Table 4; Figures 2 and 3); material in this size class was fairly abundant for all age classes (Table 5, Figure 3). Biomass of size class 1 and 2 CWD varied with age class (Table 2b). The quantities of size class 1 and 2 CWD were highest on regeneration plots (Table 4; Figures 3 and 6b). Unlike the east side, size class 1 represented only a small amount of the coarse woody debris in all age classes on the west side (Table 4; Figures 3 and 6b). Generally, no site effects were observed, except for a significant site effect for size class 3 material (Table 2b). This size class material appears to increase with latitude among west side sites.

3.3.3 Differences among species

Western hemlock and western redcedar were the dominant tree species among classified CWD on the west side (CWHvm) (Table 5; Figures 3, 4b and 6b). Western hemlock was abundant in all age classes and most plots on the west side while western redcedar was found primarily in regeneration and old-growth plots (Table 5; Figures 1, 3, 4b and 6b). Surprisingly, almost no western redcedar was observed in any mature plots on west side sites (Figures 1b, 3, 5, and 6b). Conversely, western redcedar was the most abundant CWD biomass on three of four old-growth plots (Figures 1b and 6b).

4 Discussion

4.1 Overall Trends in CWD Abundance on the Chronosequence Plots

Mean total biomass, across the chronosequence, ranged from 17 Mg/ha to 38 Mg/ha on the east side (CWHxm) compared to 65 Mg/ha to 191 Mg/ha on the west side (CWHvm). Thus, on west side plots total CWD is substantially (and significantly) more abundant than on east side plots. The low level of CWD on the east side is somewhat surprising (see Section 4.2.2), but the difference between the two subzones is expected, given differences in climate and disturbance history. The drier climate and higher temperatures on the east side likely result in higher decay rates than in the cooler and wetter west side. Further, on the east side, fire is much more frequent, while on the west side, windthrow and individual tree mortality is much more common. Thus, CWD is more likely to accumulate on the west side, while infrequent surface fire likely reduces CWD loading on the east side.

4.2 Coarse Woody Debris on the East Side (CWHxm)

4.2.1 Trends of development

We were unable to detect a U-shaped trend, as predicted by Spies and Franklin (1988), for total CWD biomass on the east side (CWHxm). Quantities of CWD varied independently of age class among plots (Table 1). Some trends were noted, however. On east side sites, the peak in CWD abundance shifted from lower decay classes and smaller size classes on regeneration plots to a more even decay class distribution and larger size classes in the older age classes of the chronosequences. Thus, CWD in older plots may have more habitat value than that in the regeneration plots because of the wider range of decay and size classes (e.g., Harmon *et al.* 1986). Further, the small size class CWD found in regeneration plots is subject to higher decay rates than larger pieces (Harmon *et al.* 1986). Thus, as the regeneration plots age, it is possible that CWD will decline to lower amounts than those observed in the older plots in this study.

Generally no trends were detected for CWD among study sites on the east side. Trends related to site location may exist (for example, one might predict that loadings of CWD could increase as one moved north or to higher elevations, due to reduced decay rates resulting from lower mean annual temperatures). However, it is unlikely that trends related to site location would be detected in this study because low sample size and high variance (due partly to the substantial age difference among plots at a given site) limits statistical power.

4.2.2 Comparisons with similar forest types

The range of 17 Mg/ha to 38 Mg/ha, (55.3 m^3/ha to 149.3 m^3/ha) found in the forests on the drier east side of Vancouver Island (Table 3) were among the lowest CWD accumulations recorded for this forest type, regardless of age class (Caza 1993). Low mass and volume of CWD have been observed in some young and mature forests in Washington and Oregon. For example, Spies *et al.* (1988) observed amounts as low as 14 Mg/ha in young stands and 25 Mg/ha in mature stands. However, the low accumulation of CWD on the old-growth plots in this study has not been observed in similar forest types in Washington and Oregon. Reported biomass in old-growth forests (>200 years of age) ranges from 66 Mg/ha to 490 Mg/ha in Douglas-fir–hemlock forests of Washington and Oregon, and volumes range from 313 m^3/ha to 1421 m^3/ha (Caza 1993). The amounts found on the chronosequence plots are more comparable to drier interior conifer forests and hardwood forests in eastern North America. In interior conifer forests, biomass ranged from 5 Mg/ha to 154 Mg/ha (but was typically under 100 Mg/ha) and reported volumes ranged from 7 m^3/ha to 430 m^3/ha (Caza 1993). The biomass of CWD in deciduous forests ranged from 5 Mg/ha to 55 Mg/ha; reported volumes ranged from 46 m^3/ha to 132 m^3/ha (Harmon *et al.* 1986; McCarthy and Bailey 1994; Lee *et al.* 1995).

The low amounts of CWD observed in this study on the east side plots (CWHxm) is somewhat surprising, given the high values observed in Douglas-fir forests in Washington and Oregon. It may be that the old-growth plots in this study were established in less productive stands than is typically the case on the east side (because productive sites in the CWHxm on southern Vancouver Island have been subject to more harvesting than less productive sites), yielding lower than typical CWD loadings. All but 2 of the 16 plots were classified to site series 01 (Trofymow *et al.* 1997) which is the typical zonal norm for the east side (CWHxm) (Green and Klinka 1994), but total soil nitrogen was substantially lower on east side (CWHxm) sites than on west side (CWHvm) sites (Trofymow *et al.* 1997). Decay rates, which can be high on dry sites (Harmon *et al.* 1986), combined with lower growth rates of trees, could result in lower than typical CWD loadings on unproductive sites.

4.3 Coarse Woody Debris on the West Side (CWHvm)

4.3.1 Trends of development

In general, on the west side (CWHvm), regeneration and old plots contained the most CWD, while immature and mature plots contained the least. This suggests a U-shaped curve for total biomass of CWD across age classes, as predicted by Spies and Franklin (1988). Further, as on east side plots, the most uniform distribution of debris by decay class was observed in old plots. Unlike the east side plots, there tended to be a higher proportion debris in larger size classes in all age classes. A disproportionate amount of the larger CWD was western redcedar, which may persist as a biological legacy in the younger stands due to lower decay rates. Finally, CWD was substantially more abundant on west side plots than on east side plots.

Generally, few trends were detected for CWD among study sites on the west side. Those that were detected are either of little interest (the very low amounts of decay class 1 material found on the Klanawa site, for example) or difficult to explain (the apparent trend with latitude in size class 3 material). However, the high levels of decay class 5 material found on the Klanawa site might result from reduced decay rates on this site relative to the other three west side sites. Decay rates could be reduced by increased soil moisture (this site had the lowest slopes and wettest site series; Appendix 1; Trofymow *et al.* 1997) and lower temperature (Klawana was the most northerly of west side sites; Trofymow *et al.* 1997). In general, as with east side sites, it is unlikely that trends related to location would be detected in this study because of limited statistical power.

4.3.2 Comparisons with similar forest types

As noted earlier, reported biomass in old-growth forests (>200 years of age) ranges from 66 Mg/ha to 490 Mg/ha (313 m^3/ha to 1421 m^3/ha) in Douglas-fir–hemlock forests of the Pacific Northwest (Caza 1993). Mass and volume in younger forests generally fall within this range as well, although both might be lower in immature forests (50–130 years) where accumulations as low as 20 Mg/ha or 148 m^3/ha have been recorded (Caza 1993). Therefore, the range of 64 Mg/ha to 190 Mg/ha of biomass (307 m^3/ha to 636 m^3/ha) found in the mature and old-growth sites of this study (Table 3) may be considered typical of this forest type. Keenan *et al.* (1993) observed mean biomass values of 166 Mg/ha and 134 Mg/ha of downed CWD in cedar–hemlock and hemlock–amabilis fir forests on northern Vancouver Island, which is comparable to the accumulations observed in this study on the west side of the Island.

4.4 Limitations of the Study

4.4.1 Statistical inference

Plots were selected to maintain similar edaphic conditions within a site (Appendix 1; Trofymow *et al.* 1997). Statistical inference is therefore limited to sites with similar characteristics. Nonetheless, variation in CWD abundance among plots, regardless of age class, is clearly a distinguishing characteristic of CWD dynamics in the CWHvm (west side) and CWHxm (east side) subzones. However, this high level of variation, combined with small sample sizes (four sites per subzone, four plots per site) limited statistical power, hindering detection of trends in this study. Thus, while we did not detect significant differences in total biomass of CWD among age classes on the east side or the west side plots, β equaled 0.922, and 0.917 in the east and west sides, respectively. Therefore, statistical power, or the probability of detecting a real effect, is only 0.078 and 0.083 on the east and west sides, respectively, making it very unlikely that real differences among age classes would be detected in this study. This was particularly relevant to west side (CWHvm) results, where similar trends in total biomass with stand age were apparent on all sites, yet these trends were not significant. In general, power was low for many of the statistical tests in this study; in many cases trends in biomass of CWD may exist, but are unlikely to be detected in this study.

4.4.2 Inferring developmental trends from chronosequence plots

It was not an explicit objective of this study to infer developmental trends from the chronosequence plots, and caution is advised in doing so. The old-growth stands in this study began their development at least 250 years ago and in some cases substantially earlier. Thus, it is possible that older plots are on different developmental trajectories than younger ones, as climatic conditions have changed significantly over that length of time (see, for example, Lertzman 1995). Past climate conditions could have influenced CWD dynamics by influencing disturbance history and decay rates, and by favouring some tree species over others. For example, changes in tree species composition could influence CWD recruitment and decay rates. Further, we expect that changes in fire frequency would influence CWD recruitment, especially in east side sites, and changes to temperature and precipitation would influence decay rates.

Disturbance history has also varied among the chronosequence plots. All of the old-growth stands are of natural origin, whereas most mature stands and all the regeneration and immature stands were initiated after harvesting. The amounts of CWD that result from a natural disturbance are expected to be substantially larger than those expected after harvesting (Spies *et al.* 1988); thus, it is likely the quantities of CWD observed in regeneration and immature chronosequence plots are lower than those that would be observed after natural disturbances such as fire or windthrow. Further, the old-growth stands that develop after harvesting may have different CWD loadings than the old-growth plots in this study. Sampling in young and mature stands initiated after natural disturbances would allow comparisons between disturbance types (natural vs. harvesting); CWD loadings in old growth stands that develop after harvesting can only be inferred by modeling CWD recruitment and decay rates.

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Table 1. Three factor ANOVA results for (a) decay class and (b) size class. Note that significant results are the same for (b) when size class 1 (<12 cm diameter) material is included.

df = degrees of freedom; MSE = mean square error; F = F-ratio

(a)

Dependent Variable: Total Biomass		**Multiple R^2: 0.447**		
Source	**df**	**MSE**	**F**	***P***
Subzone	1	18722.7	16.421	**< 0.001**[a]
Age Class	3	1446.2	1.268	0.288
Decay Class	4	5415.6	4.750	**0.001**
Subzone × Age Class	3	1814.1	1.591	0.195
Subzone × Decay Class	4	3090.3	2.710	**0.033**
Age Class × Decay Class	12	2289.4	2.008	**0.029**
Subzone × Age Class × Decay Class	12	1729.9	1.517	0.127
Error	120	1140.1		

(b)

Dependent Variable: Total Biomass		**Multiple R^2: 0.472**		
Source	**df**	**MSE**	**F**	***P***
Subzone	1	25617.7	22.846	**< 0.001**
Age Class	3	2255.1	1.765	0.162
Size Class	2	5527.8	3.638	**0.031**
Subzone × Age Class	3	2270.5	2.213	0.094
Subzone × Size Class	2	7080.6	5.658	**0.005**
Age Class × Size Class	6	1158.6	1.062	0.394
Subzone × Age Class × Size Class	6	958.3	0.771	0.596
Error	96	1030.97		

[a] bold face numbers highlight f tests in which $p \leq 0.05$.

Table 2. Single factor ANOVA results for age class and site effects within a subzone for (a) CWD decay classes and biomass totals (size class 1 excluded) (b) CWD size classes and biomass totals (size class 1 included). Single factor ANOVA results for size class and decay class effects (c) on CWD within age classes.

(a)

		Decay Class 1		Decay Class 2		Decay Class 3		Decay Class 4		Decay Class 5		Total (excl. SC1)[a]	
Source	**df**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**
						East Side (CWHxm)							
Age Class	3,12	0.552	0.657	1.620	0.237	0.687	0.577	1.434	0.281	0.747	0.545	0.712	0.563
Site	3,12	1.157	0.366	0.059	0.980	1.588	0.244	2.312	0.128	1.494	0.266	0.883	0.477
						West Side (CWHvm)							
Age Class	3,12	0.774	0.531	0.979	0.435	6.998	0.006	2.439	0.115	0.775	0.531	1.483	0.269
Site	3,12	7.051	**0.005**[b]	0.986	0.432	0.397	0.758	1.747	0.211	5.399	**0.014**	2.061	0.159

(b)

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total (incl. SC1)[a]	
Source	**df**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**
						East Side (CWHxm)					
Age Class	3,12	8.245	**0.003**	0.414	0.746	1.018	0.419	1.013	0.421	0.818	0.508
Site	3,12	0.315	0.814	0.396	0.758	1.364	0.301	0.500	0.689	0.694	0.573
						West Side (CWHvm)					
Age Class	3,12	8.400	**0.003**	13.409	**0.000**	0.591	0.633	1.321	0.313	1.570	0.248
Site	3,12	0.451	0.721	0.120	0.947	5.041	**0.017**	1.756	0.209	1.824	0.196

(c)

		Regeneration		Immature		Mature		Old growth	
Source	**df**	**f**	**p**	**f**	**p**	**f**	**p**	**f**	**p**
						East Side (CWHxm)			
Decay Class	4,15	4.303	**0.016**	1.764	0.189	1.001	0.438	0.751	0.573
Size Class	3,12	3.524	**0.049**	3.637	**0.045**	1.036	0.412	0.379	0.770
						West Side (CWHvm)			
Decay Class	4,15	1.323	0.306	1.819	0.178	1.811	0.179	9.745	**0.000**
Size Class	3,12	0.950	0.447	4.731	**0.021**	3.583	**0.047**	7.659	**0.004**

[a] SC = size class: SC1 = 1.1–11.9 cm, SC2 = 12.0–29.9 cm, SC3 = 30.0–59.9 cm, SC4 ≥ 60 cm diameter.
[b] Bold face numbers highlight f tests in which P ≤ 0.05.

Table 3. Mean mass and volumes of CWD by decay class and age class for east and west side chronosequences. Size Class 1 is not included. For all means, n = 4.

East Side (CWHxm) CWD						West Side (CWHvm) CWD					
Mass (Mg/ha)						Mass (Mg/ha)					
Decay Class	Age Class[a] R	I	M	O		Decay Class	Age Class[a] R	I	M	O	
1	0.71	0.30	1.89	0.25	**Mean**	1	0.27	0.00	0.19	0.15	**Mean**
	0.71	0.30	1.89	0.25	**SE**		0.27	0.00	0.19	0.15	**SE**
2	16.89	0.16	11.36	5.13	**Mean**	2	106.10	17.85	3.66	19.38	**Mean**
	7.62	0.16	8.03	2.92	**SE**		91.71	17.85	3.31	13.98	**SE**
3	2.16	8.01	12.40	10.00	**Mean**	3	69.57	22.63	21.11	116.09	**Mean**
	0.92	5.28	5.76	6.97	**SE**		20.03	7.12	6.72	25.86	**SE**
4	0.90	5.47	10.32	7.05	**Mean**	4	4.05	45.19	22.48	51.56	**Mean**
	0.52	1.24	5.65	3.02	**SE**		2.28	18.73	10.11	17.88	**SE**
5	0.00	3.03	2.10	4.87	**Mean**	5	4.11	10.57	17.18	3.57	**Mean**
	0.00	1.70	0.96	4.26	**SE**		4.11	7.60	11.61	1.44	**SE**
Total	20.68	16.96	38.07	27.29	**Mean**	**Total**	184.10	96.25	64.61	190.74	**Mean**
	9.01	6.33	15.47	11.01	**SE**		94.37	17.40	14.97	36.46	**SE**

Volume (m^3/ha)						Volume (m^3/ha)					
Decay Class	Age Class[a] R	I	M	O		Decay Class	Age Class[a] R	I	M	O	
1	1.91	0.67	4.11	0.89	**Mean**	1	1.14	0.00	0.45	0.31	**Mean**
	1.91	0.67	4.11	0.89	**SE**		1.14	0.00	0.45	0.31	**SE**
2	42.14	0.38	23.75	13.56	**Mean**	2	431.60	57.52	12.44	53.59	**Mean**
	18.83	0.38	16.74	7.54	**SE**		385.10	57.52	11.02	38.96	**SE**
3	7.14	26.28	45.43	36.79	**Mean**	3	227.24	86.38	75.16	362.71	**Mean**
	2.97	17.00	24.70	25.18	**SE**		62.20	20.92	27.74	68.72	**SE**
4	4.14	29.32	63.49	35.30	**Mean**	4	17.57	220.49	102.19	196.84	**Mean**
	2.45	6.32	34.35	15.52	**SE**		9.93	94.55	45.93	66.30	**SE**
5	0.00	18.20	12.52	22.12	**Mean**	5	20.56	60.09	116.96	22.98	**Mean**
	0.00	10.79	6.14	18.29	**SE**		20.56	36.83	88.94	9.68	**SE**
Total	55.33	74.84	149.29	108.65	**Mean**	**Total**	698.10	424.47	307.20	636.42	**Mean**
	22.58	25.02	59.59	39.47	**SE**		397.98	94.58	82.25	122.73	**SE**

[a] Age classes: R = Regeneration, I = Immature, M = Mature and O = Old

Table 4. Mean mass and volumes of CWD by size class and age class for east and west side chronosequences. For all means, n=4.

	East (CWHxm) CWD						West Side (CWHvm) CWD				
	Mass (Mg/ha)						Mass (Mg/ha)				
Size Class[b]	Age Class[a] R	I	M	O		Size Class[b]	Age Class[a] R	I	M	O	
1	17.23	1.87	6.43	4.35	**Mean**	1	24.17	9.85	9.63	6.25	**Mean**
	4.26	0.78	1.77	0.61	**SE**		4.25	2.58	1.44	1.85	**SE**
2	13.50	10.11	9.94	7.44	**Mean**	2	30.65	9.78	12.05	14.05	**Mean**
	4.97	4.28	3.87	1.33	**SE**		4.23	1.48	1.54	2.13	**SE**
3	7.19	6.85	21.82	10.09	**Mean**	3	46.59	36.03	37.55	59.43	**Mean**
	4.69	2.12	12.21	9.76	**SE**		16.38	11.42	11.04	16.18	**SE**
4	0.00	0.00	6.32	9.76	**Mean**	4	106.86	50.45	15.03	117.26	**Mean**
	0.00	0.00	6.32	7.28	**SE**		75.40	14.32	7.61	33.03	**SE**
Total	37.92	18.83	44.50	31.64	**Mean**	**Total**	208.27	106.09	74.24	196.99	**Mean**
(SC1 incl.)	12.99	7.07	15.89	10.65	**SE**	(SC1 incl.)	97.17	17.67	14.25	35.58	SE
Total	20.68	16.96	38.07	27.29	**Mean**	**Total**	184.10	96.25	64.61	190.74	**Mean**
(SC1 excl.)	9.01	6.33	15.47	11.01	**SE**	(SC1 excl.)	94.37	17.40	14.97	36.46	**SE**

	Volume (m^3/ha)						Volume (m^3/ha)				
Size Class[b]	Age Class[a] R	I	M	O		Size Class[b]	Age Class[a] R	I	M	O	
1	35.50	4.53	14.67	10.81	**Mean**	1	45.27	24.84	26.03	13.39	**Mean**
	7.33	1.59	3.65	2.38	**SE**		7.07	6.45	6.16	4.05	**SE**
2	37.00	44.65	45.50	28.65	**Mean**	2	110.88	45.89	51.35	54.06	**Mean**
	12.84	19.66	13.95	5.58	**SE**		22.70	7.53	8.85	8.22	**SE**
3	18.33	30.20	90.63	46.52	**Mean**	3	174.22	175.51	188.10	213.54	**Mean**
	11.55	6.25	56.31	18.22	**SE**		71.75	56.84	70.53	46.52	**SE**
4	0.00	0.00	13.16	33.49	**Mean**	4	413.01	203.07	67.75	368.83	**Mean**
	0.00	0.00	13.16	23.14	**SE**		307.94	60.61	31.09	113.76	**SE**
Total	90.83	79.36	163.95	119.46	**Mean**	**Total**	743.38	449.31	333.23	649.80	**Mean**
(SC1 incl.)	29.29	26.59	59.01	38.02	**SE**	(SC1 incl.)	402.18	93.68	77.66	120.57	**SE**
Total	55.33	74.84	149.29	108.65	**Mean**	**Total**	698.10	424.47	307.20	636.42	**Mean**
(SC1 excl.)	22.58	25.02	59.59	39.47	**SE**	(SC1 excl.)	397.98	94.58	82.25	122.73	**SE**

[a] Age classes: R = Regeneration, I = Immature, M = Mature and O = Old
[b] Size classes (SC): 1 = 1.1 to 11.9 cm diameter; 2 = 12.0 to 29.9 cm diameter; 3 = 30.0–59.9 cm diameter; 4 ≥ 60 cm diameter.

Table 5. Mean mass and volumes of CWD by species and age class for east and west side chronosequences. Size class 1 is not included. For all means, n = 4.

	East Side (CWHxm) CWD						West Side (CWHvm) CWD				
	Mass (Mg/ha)						Mass (Mg/ha)				
	Age Class[a]						Age Class[a]				
Species[b]	**R**	**I**	**M**	**O**		**Species[b]**	**R**	**I**	**M**	**O**	
FD	16.74	11.01	27.25	15.38	**Mean**	FD	0.00	0.00	0.00	4.88	**Mean**
	8.41	7.23	12.52	5.14	**SE**		0.00	0.00	0.00	4.88	**SE**
HW	1.12	0.68	0.75	1.93	**Mean**	HW	35.63	50.81	35.10	51.59	**Mean**
	1.12	0.68	0.75	1.93	**SE**		23.78	33.42	20.70	26.45	**SE**
CW	2.55	1.54	0.00	1.19	**Mean**	CW	44.31	19.87	0.18	121.28	**Mean**
	1.65	0.92	0.00	0.71	**SE**		25.44	18.61	0.18	48.37	**SE**
UN	0.27	3.74	10.09	8.68	**Mean**	UN	104.16	25.58	29.35	12.99	**Mean**
	0.18	3.09	5.50	6.14	**SE**		92.70	17.37	15.82	4.33	**SE**
Total	20.68	16.96	38.07	27.29	**Mean**	**Total**	184.10	96.25	64.61	190.74	**Mean**
	9.01	6.33	15.47	11.01	**SE**		94.37	17.40	14.97	36.46	**SE**

	Volume (m^3/ha)						Volume (m^3/ha)				
	Age Class[a]						Age Class[a]				
Species[b]	**R**	**I**	**M**	**O**		**Species[b]**	**R**	**I**	**M**	**O**	
FD	42.56	42.08	87.20	53.14	**Mean**	FD	0.00	0.00	0.00	12.20	**Mean**
	20.70	27.23	35.00	18.35	**SE**		0.00	0.00	0.00	12.20	**SE**
HW	3.73	1.89	2.20	5.22	**Mean**	HW	113.88	226.52	136.46	167.80	**Mean**
	3.73	1.89	2.20	5.22	**SE**		76.99	161.44	88.84	82.51	**SE**
CW	7.99	6.98	0.00	4.71	**Mean**	CW	150.23	68.58	0.76	385.93	**Mean**
	5.24	4.03	0.00	2.80	**SE**		86.01	63.06	0.76	152.22	**SE**
UN	1.41	23.91	59.90	45.09	**Mean**	UN	433.99	129.38	169.96	70.50	**Mean**
	0.97	20.00	35.57	30.28	**SE**		386.24	88.46	102.60	26.78	**SE**
Total	55.33	74.84	149.29	108.65	**Mean**	**Total**	698.10	424.47	307.20	636.42	**Mean**
	22.58	25.02	59.59	39.47	**SE**		397.98	94.58	82.25	122.73	**SE**

[a] Age classes: R = Regeneration, I = Immature, M = Mature and O = Old

[b] Species: FD = Douglas-fir, HW = western hemlock, CW = western redcedar, and UN = unclassified.

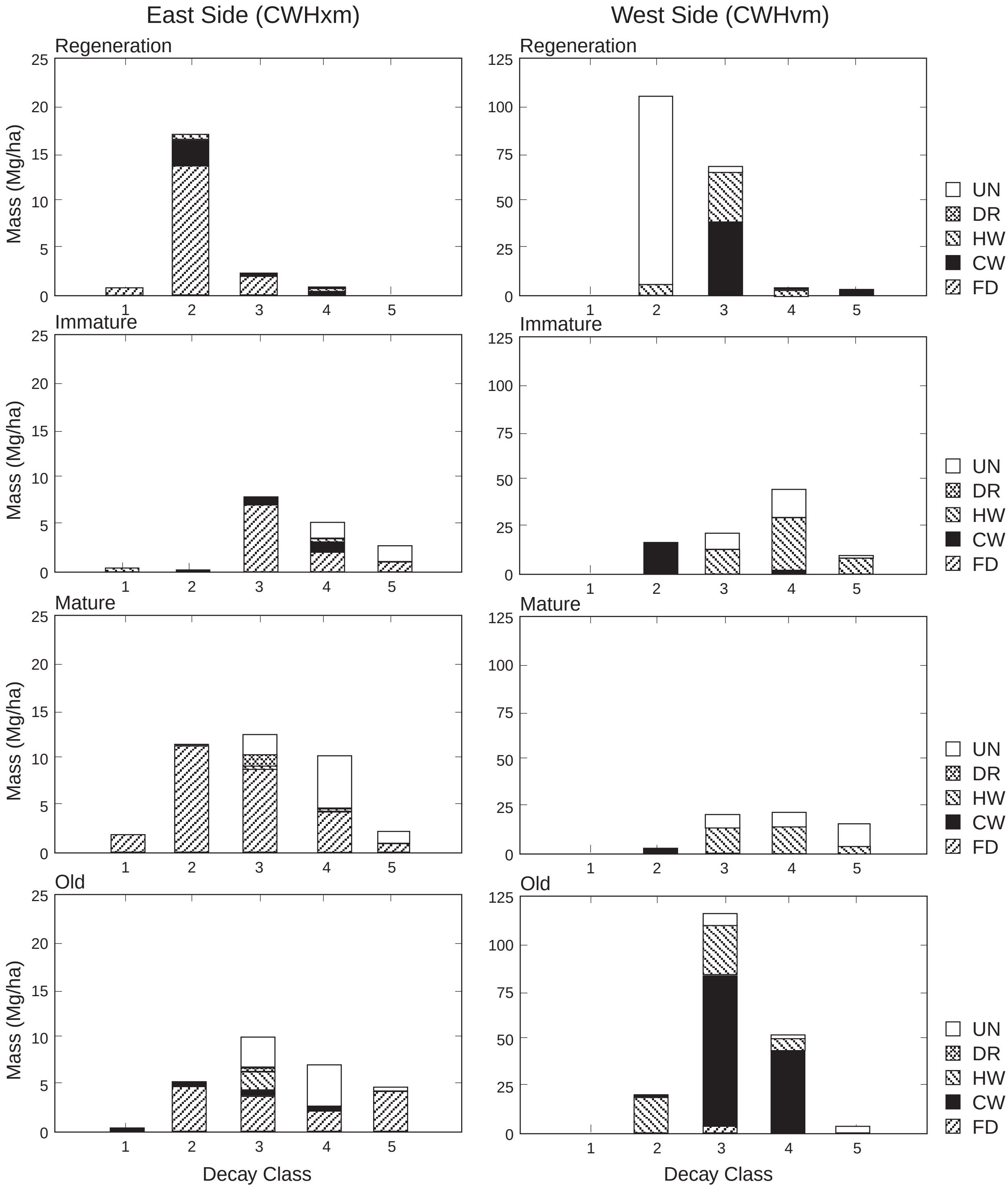


Figure 1. **Mean CWD mass by species and decay class for east and west side chronosequences. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified.) Note change in scale between east and west side plots. Size Class 1 is not included.**

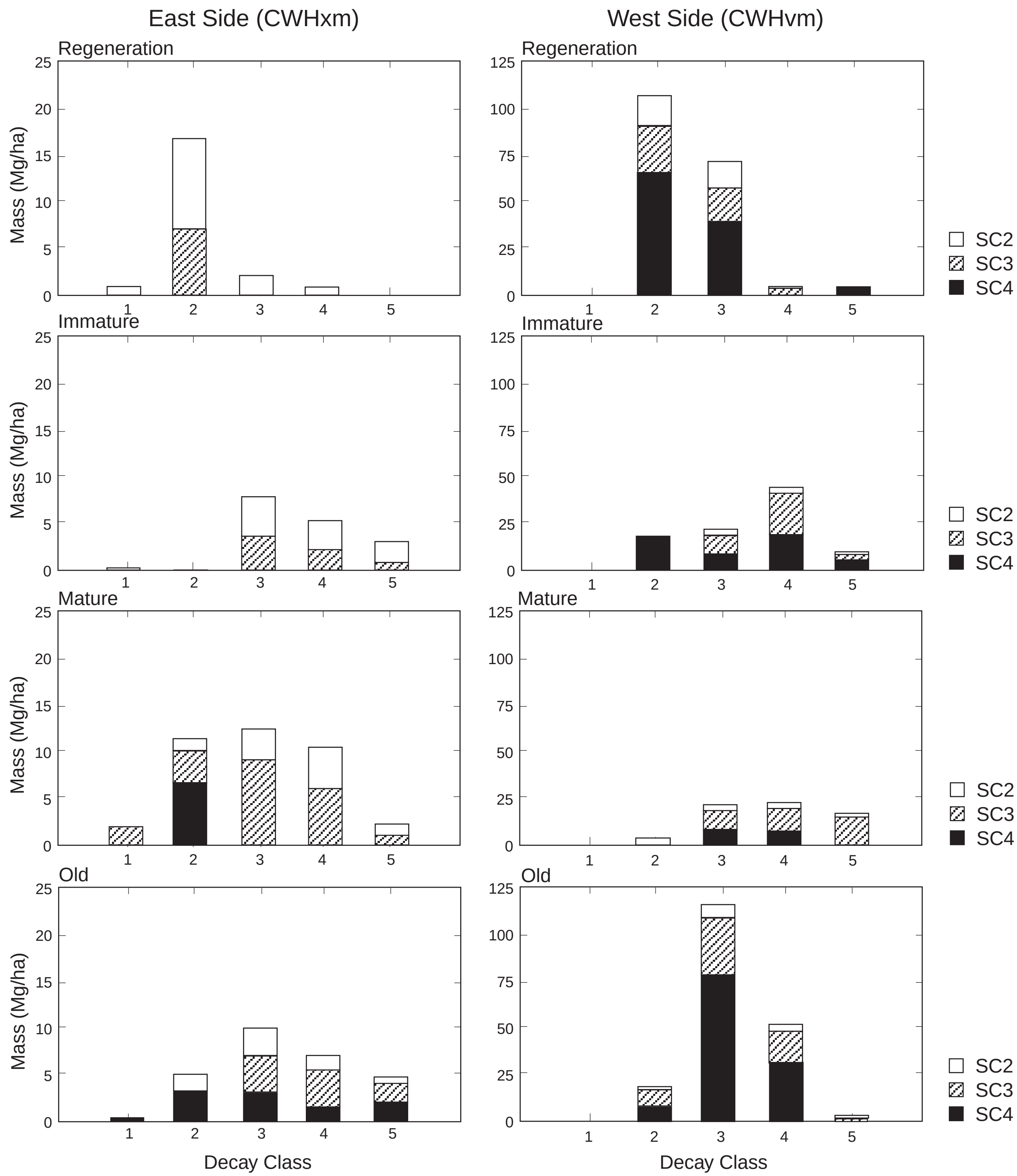


Figure 2. **Mean CWD mass by size and decay class for east and west side chronosequences. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.**

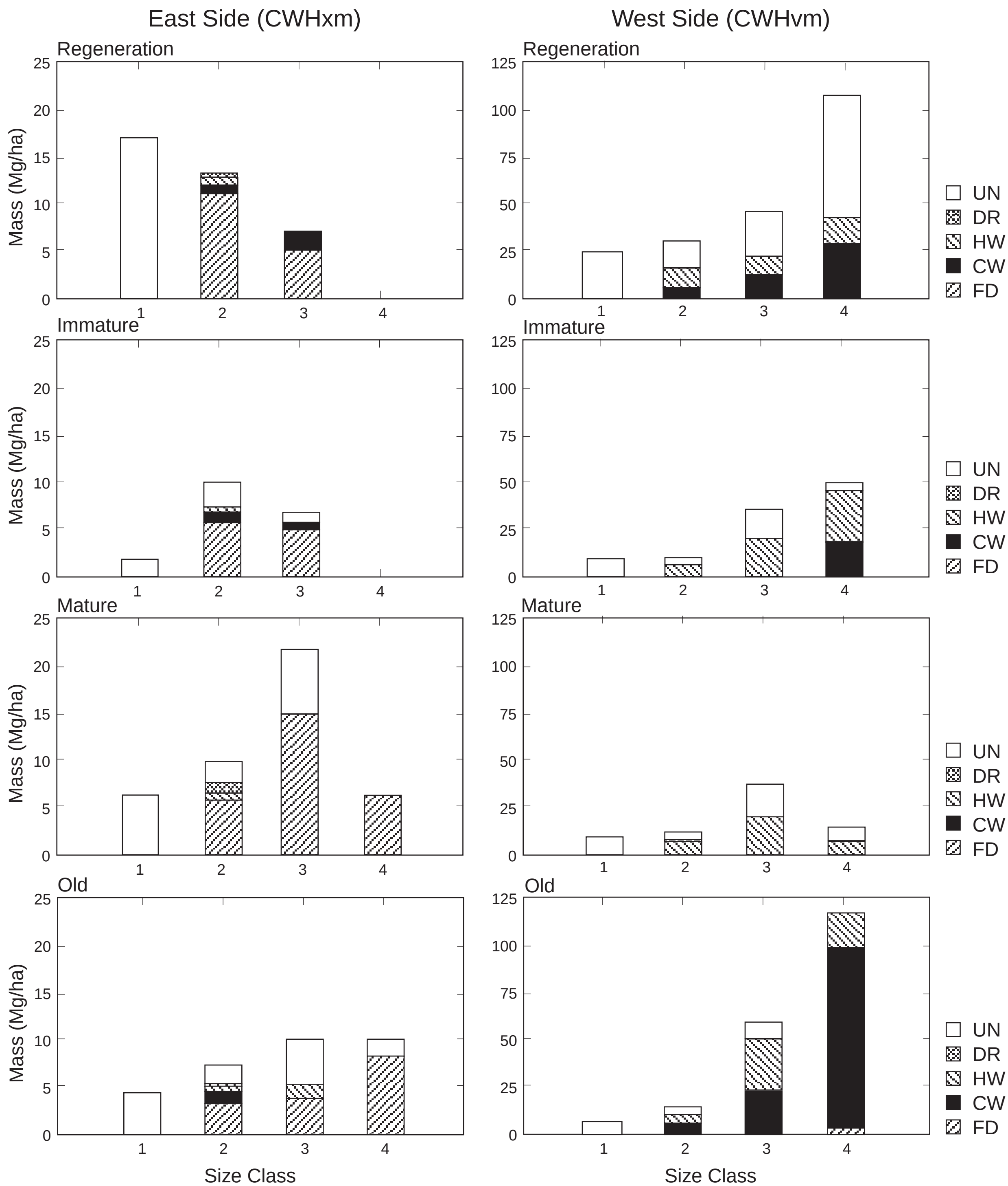


Figure 3. **Mean CWD mass by species and size class for east and west side chronosequences. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified.)**

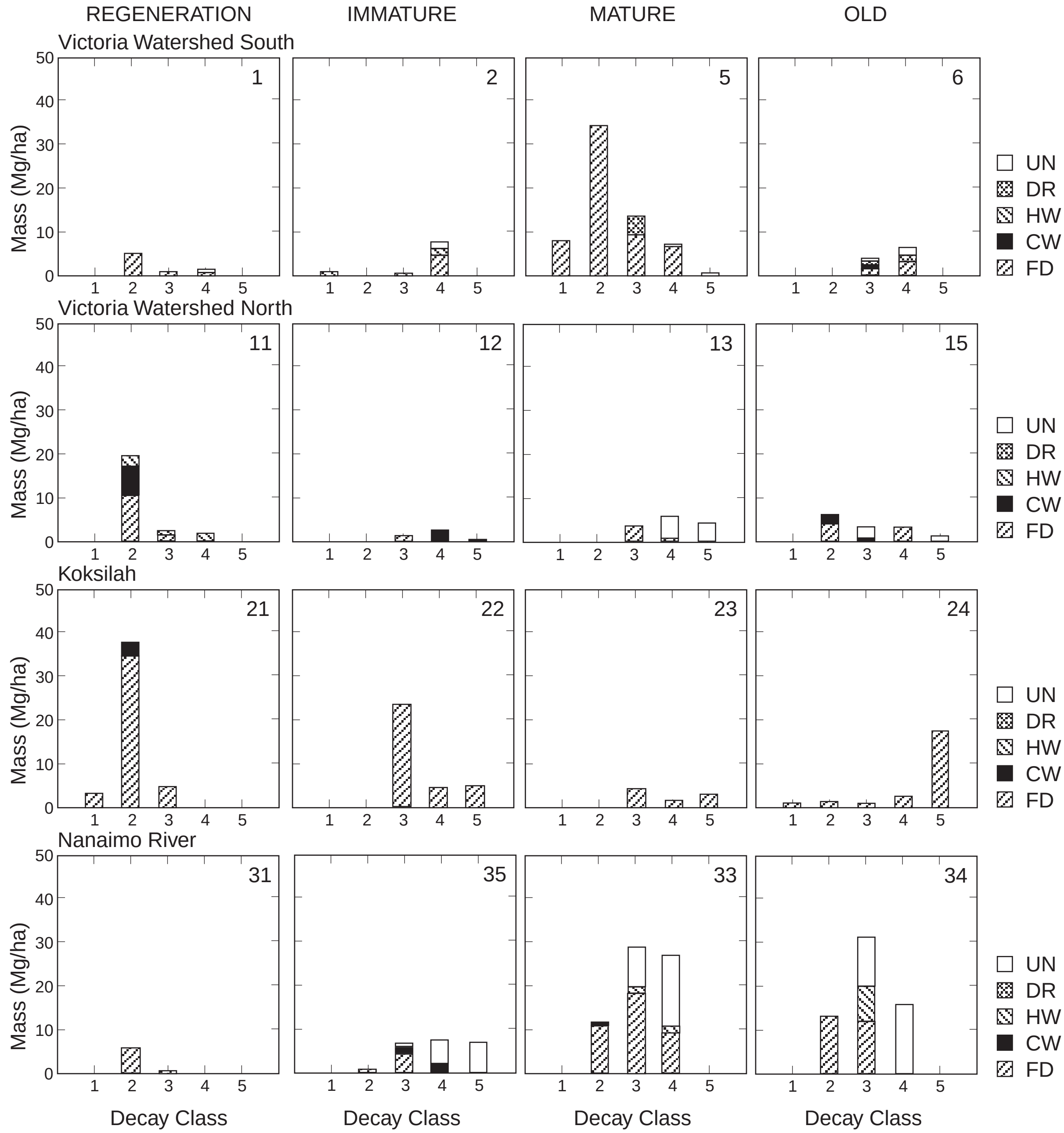


Figure 4a. **CWD mass by species and decay class for east side (CWHxm) plots. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified.) Note change in scale between east and west side plots. Size Class 1 is not included.**

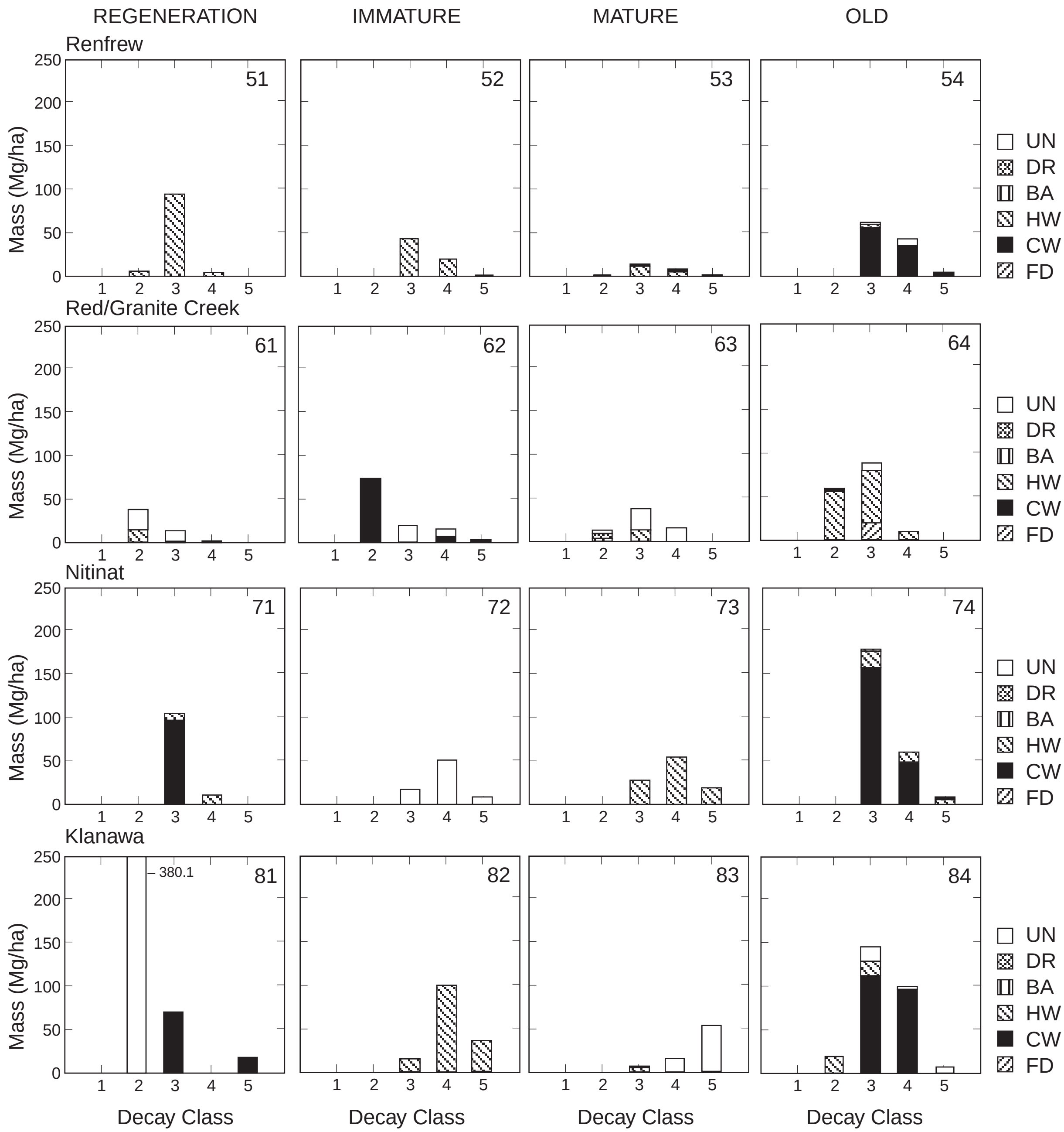


Figure 4b. CWD mass by species and decay class for west side (CWHvm) plots. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; BA = amabilis fir; UN = unclassified.) Note change in scale between east and west side plots. Size Class 1 is not included.

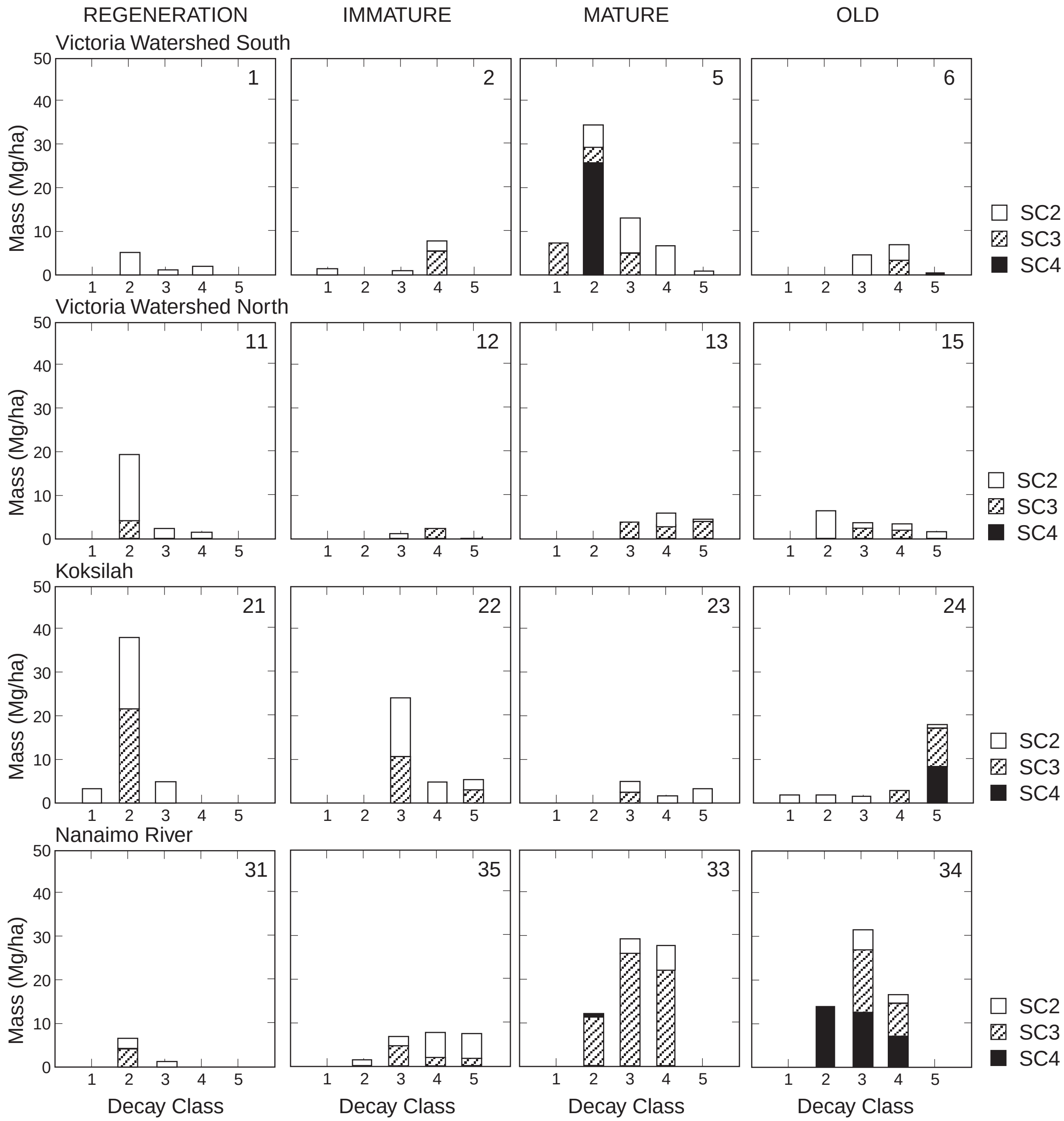


Figure 5a. CWD mass by size and decay class for east side (CWHxm) plots. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.

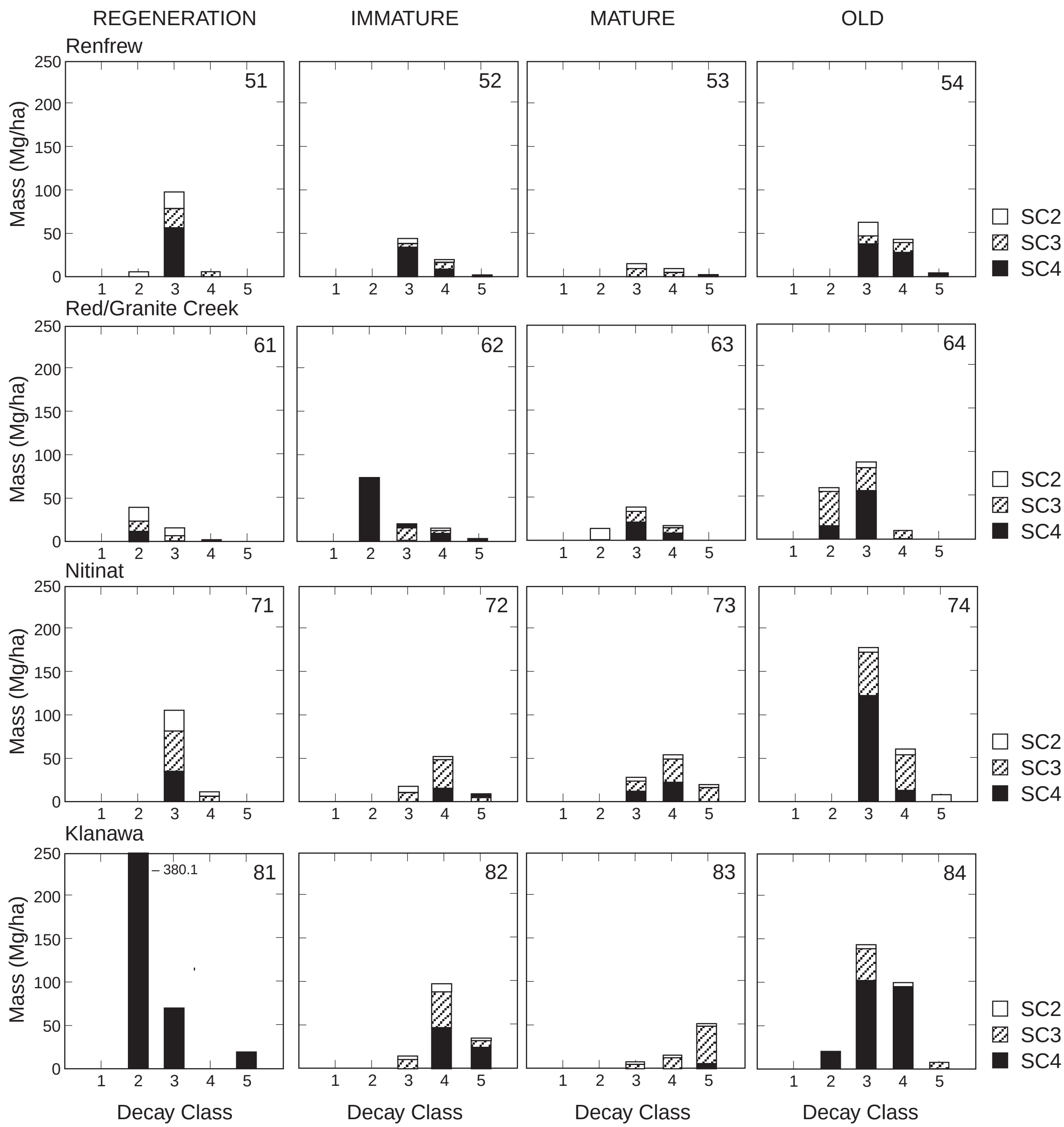


Figure 5b. **CWD mass by size and decay class for west side (CWHvm) plots. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.**

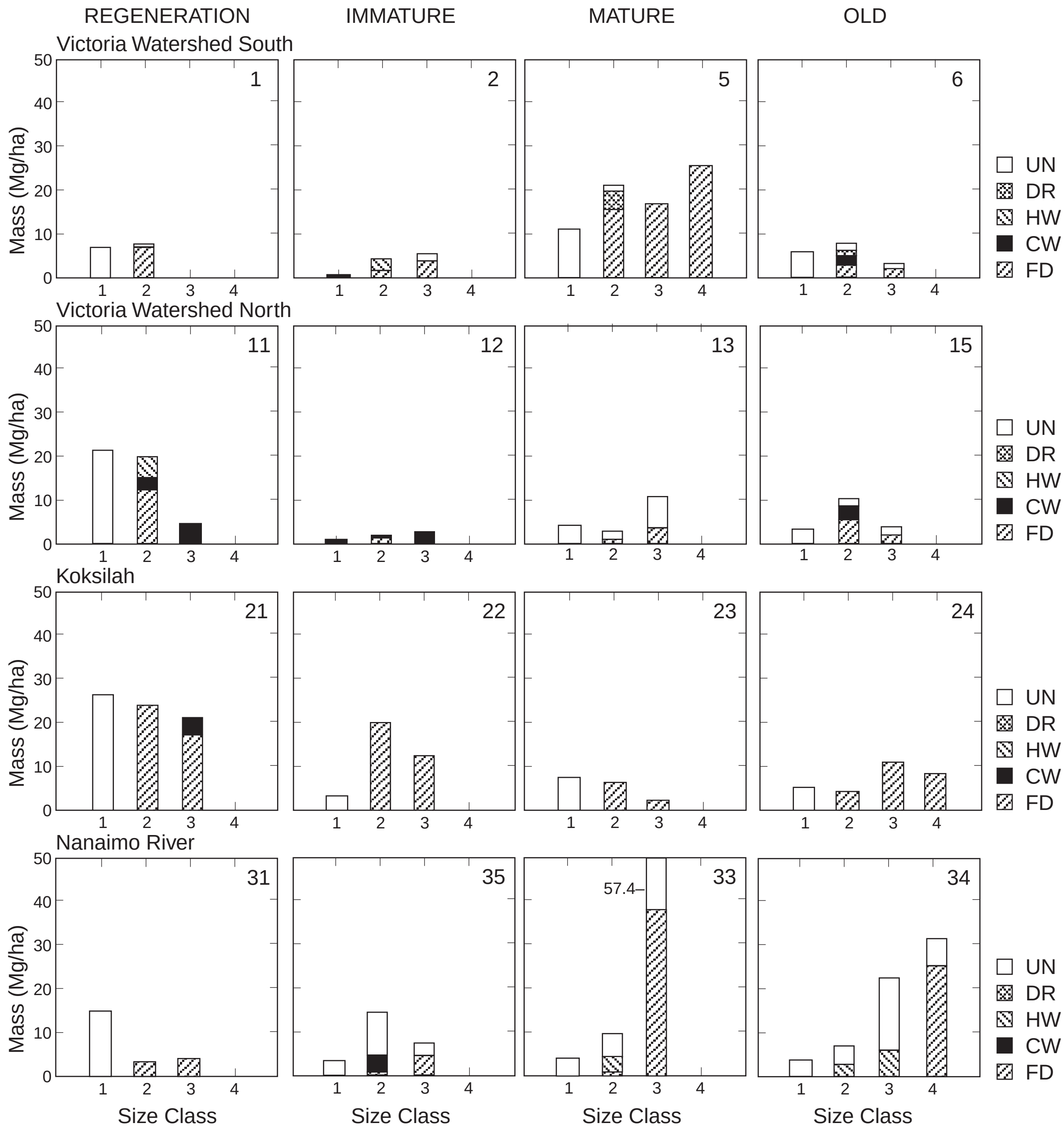


Figure 6a. CWD mass by species and size class for east side (CWHxm) plots. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified). Note change in scale between east and west side plots.

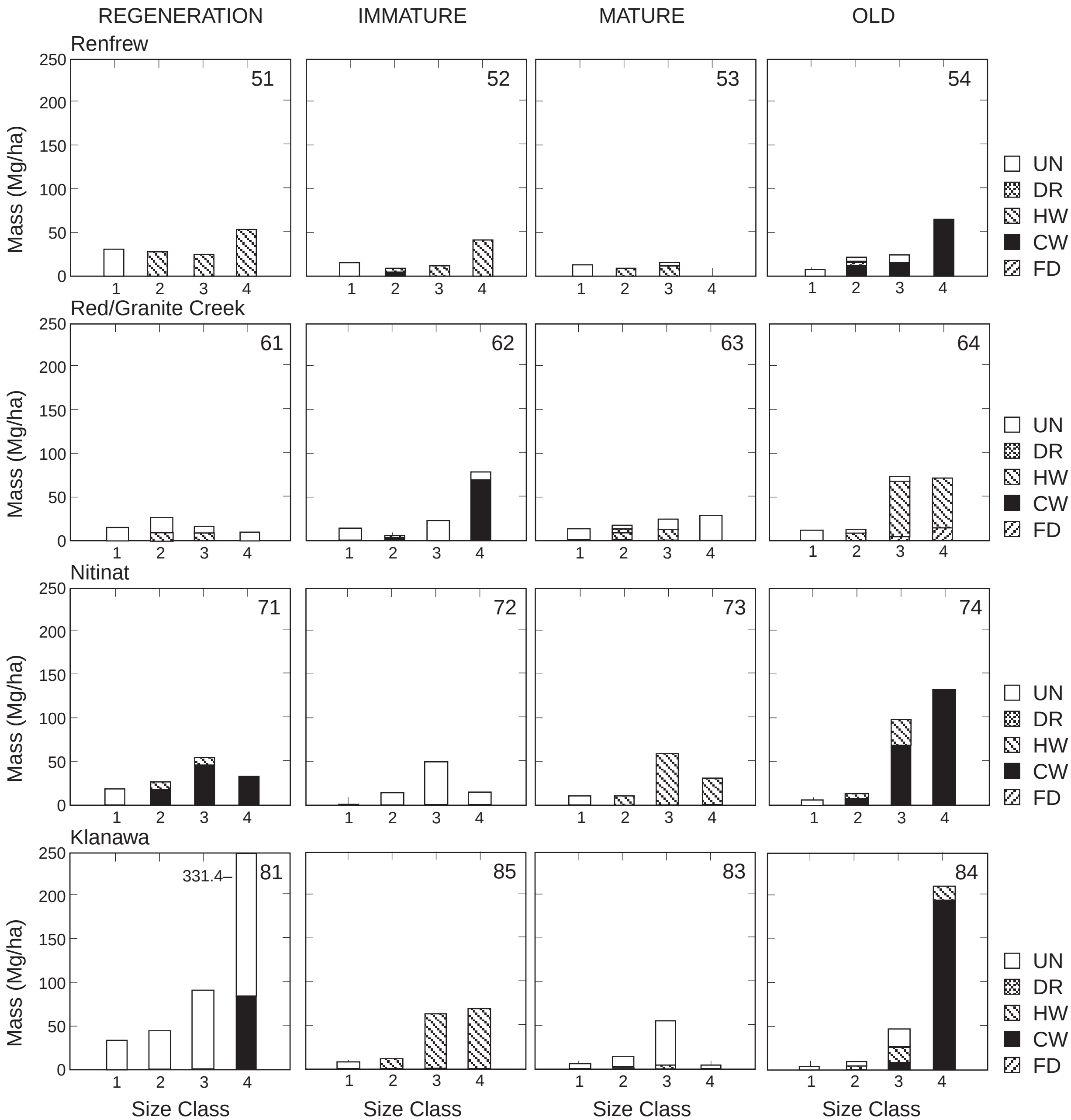


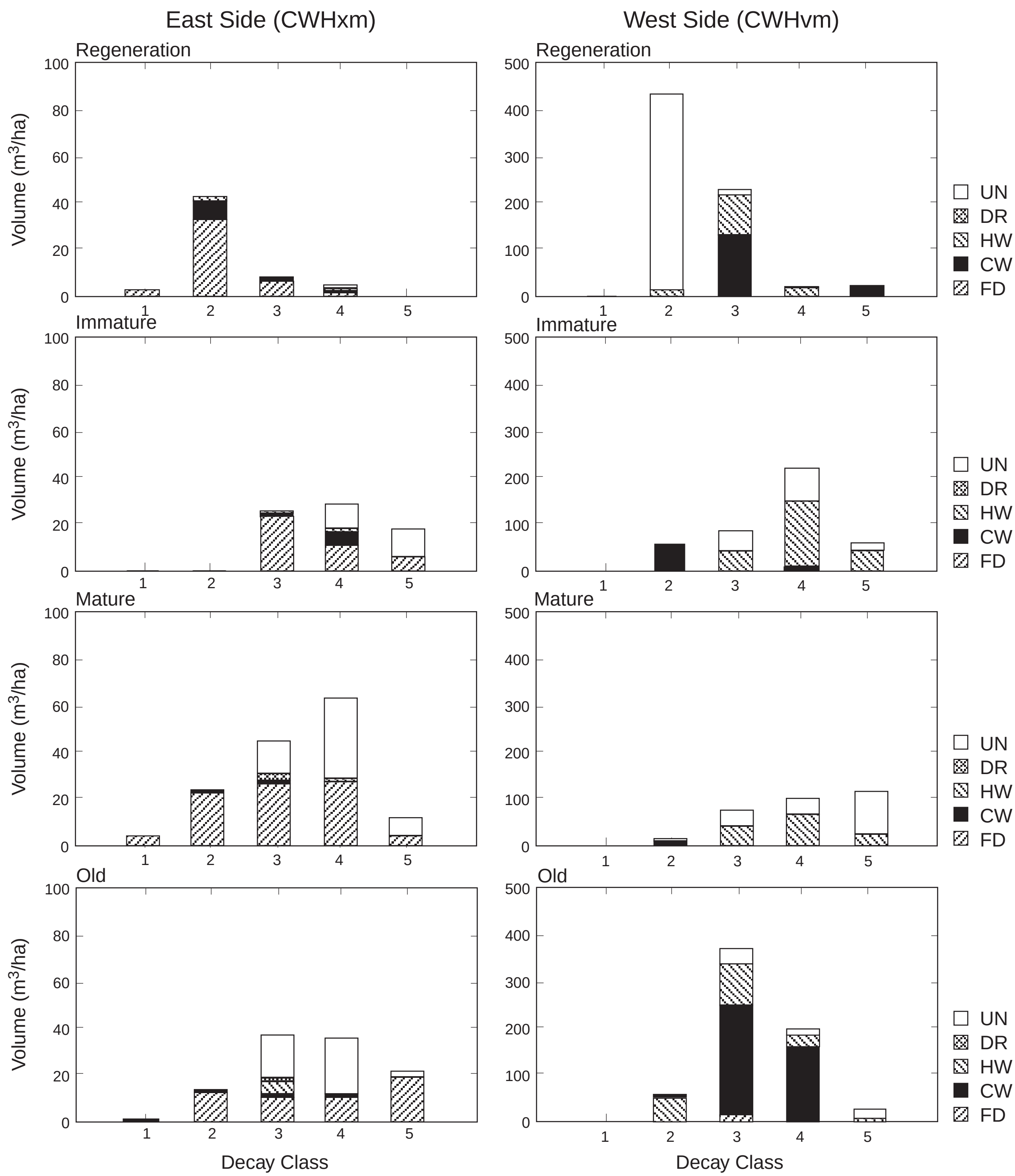
Figure 6b. CWD mass by species and size class for west side (CWHvm) plots. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; BA = amabilis fir; UN = unclassified). Note change in scale between east and west side plots.

Appendix 1: Summary site characteristics of plots (from Trofymow *et al.* 1997). Species 1 and 2 refer to dominant overstory species by basal area; basal area and density refer to live overstory stems.

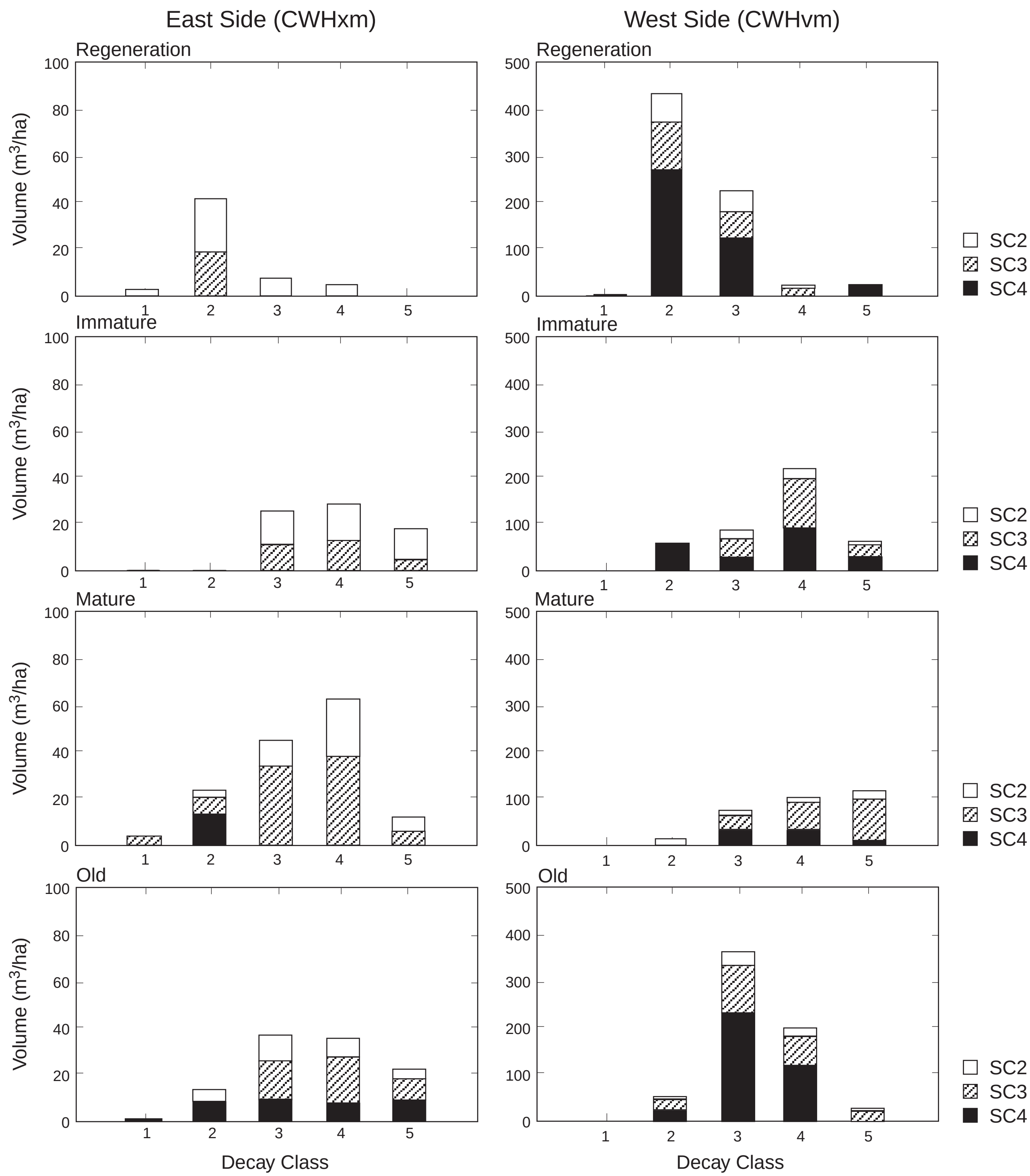
Site name	Plot	Sere	Age (l990)	Elev. (m)	Slope (%)	Aspect	BEC subzone	Site series	Sp. 1[a]	Sp. 2	Basal Area (m^2/ha)	Density (no./ha)
Victoria	1	R	4	280	15	50	CWHxm1	01	Fd	–	0.3	1443
Watershed	2	I	32	305	40	20	CWHxm1	01	Fd	Hw	30.4	2250
South	5	M	99	240	11	315	CWHxm1	01–07	Fd	Cw	88.7	693
VWS	6	O	245	390	40	30	CWHxm1	01	Fd	Hw	83.1	542
Victoria	11	R	6	450	25	260	CHWxm2	01	Fd	–	0.5	1019
Watershed	12	I	42	355	5	360	CHWxm2	01	Fd	–	48.6	2080
North	13	M	93	260	15	55	CHWxm1	01	Fd	Cw	66.7	1337
VWN	15	O	316	465	40	250	CHWxm2	01	Fd	Cw	90.0	711
Koksilah	21	R	5	595	15	170	CHWxm2	01	Fd	–	0.1	764
KOK	22	I	43	710	15	170	CHWxm2	01	Fd	Cw	47.6	3735
	23	M	77	590	35	210	CHWxm2	03	Fd	–	63.0	3353
	24	O	288	630	15	180	CHWxm2	03	Fd	Hw	87.7	478
Nanaimo River	31	R	10	460	20	190	CWHxm1	01	Fd	–	1.5	3565
NAN	35	I	39	440	20	138	CWHxm1	01	Fd	Cw	32.6	1909
	33	M	68	430	20	180	CWHxm1	01	Fd	Hw	95.9	3225
	34	O	330	430	25	220	CWHxm1	01	Fd	Hw	69.0	678
Renfrew	51	R	4	240	50	340	CWHvm1	01	Hw	Cw	0.9	2207
REN	52	I	42	135	45	350	CWHvm1	01	Hw	Ss	45.9	1527
	53	M	66	130	25	340	CWHvm1	01	Hw	Ba	70.6	520
	54	O	255	320	35	270	CWHvm1	06s	Cw	Hw	83.9	608
Red/Granite	61	R	9	300	45	5	CWHvm1	01	Hw	Cw	1.5	1825
Creek	62	I	43	130	35	360	CWHvm1	01	Dr	Hw	53.6	1826
RGC	63	M	76	80	10	85	CWHvm1	05	Hw	–	76.8	891
	64	O	176	180	100	360	CWHvm1	05	Hw	Cw	94.1	499
Nitinat	71	R	9	315	30	240	CWHvm1	01s	Hw	Cw	0.6	1783
NIT	72	I	39	185	45	225	CWHvm1	04	Fd	Hw	66.9	1868
	73	M	70	85	30	280	CWHvm1	05	Hw	–	63.1	456
	74	O	270	325	22	245	CWHvm1	01s	Hw	Cw	83.3	806
Klanawa	81	R	3	120	15	300	CWHvm1	06	Hw	Cw	0.1	2674
KLA	82	I	32	230	35	135	CWHvm1	01	Hw	Ba	61.8	1698
	83	M	69	120	15	330	CWHvm1	06	Hw	Ba	66.0	1571
	84	O	445	150	27	340	CWHvm1	01s	Cw	Hw	250.0	499

[a] Species: Fd = Douglas-fir, Hw = western hemlock, Cw = western redcedar, Ba = Amabilis fir, Ss = Sitka spruce, Dr = red alder

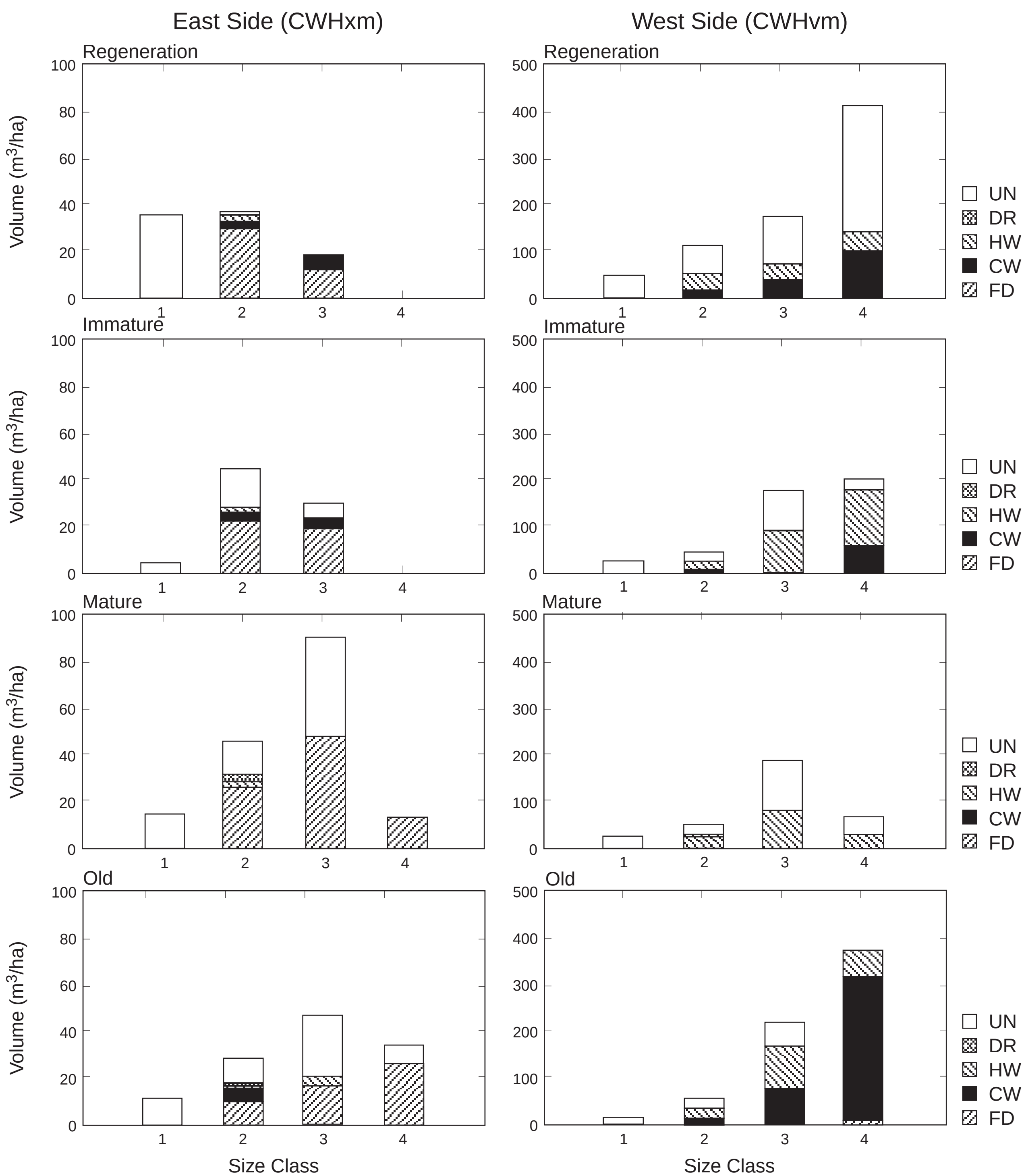
Appendix 2a. Mean CWD volume by species and decay class for east and west side chronosequences. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified). Note change in scale between east and west side plots. Size class 1 is not included.



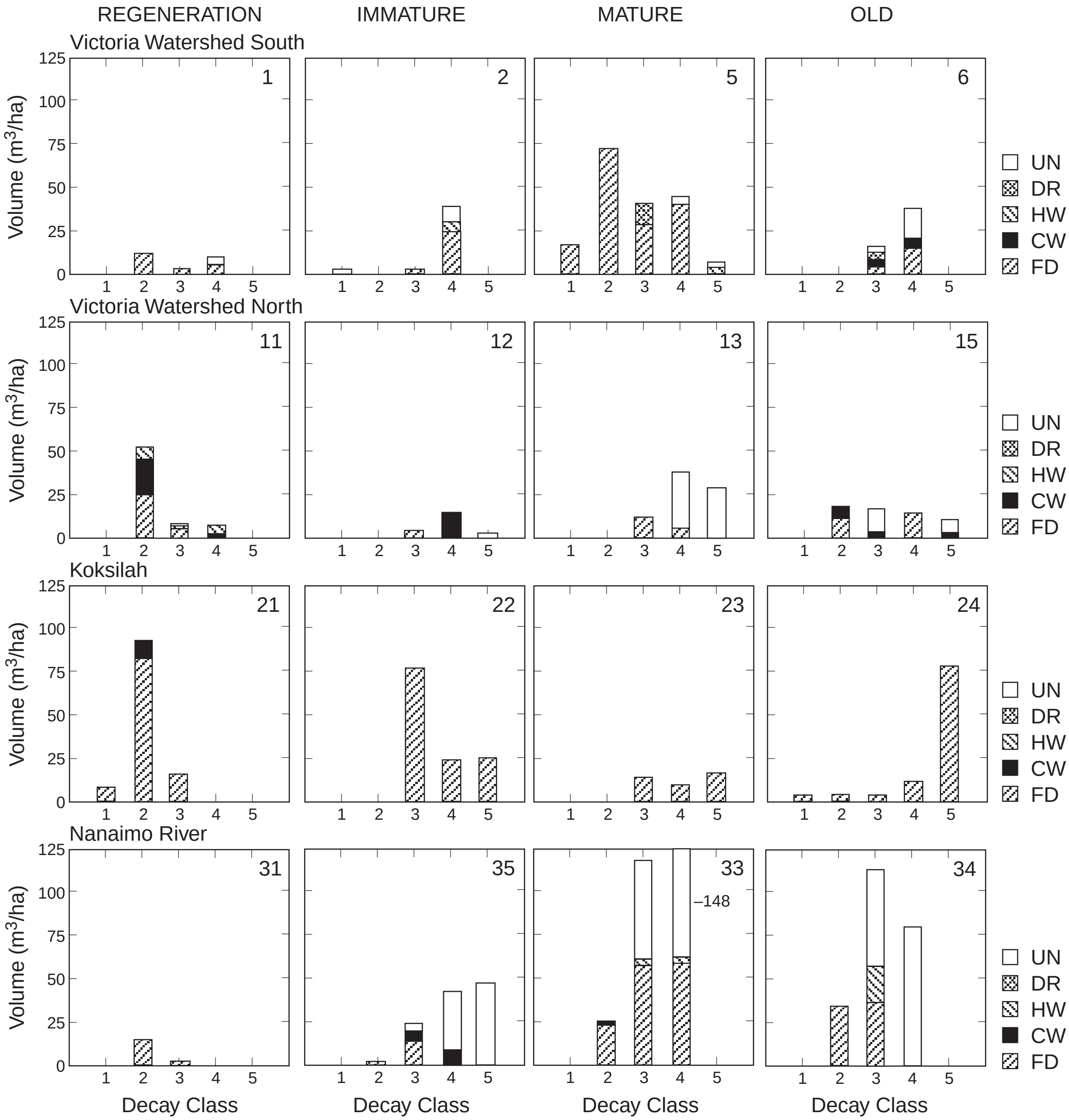
Appendix 2b. Mean CWD volume by size and decay class for east and west side chronosequences. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.



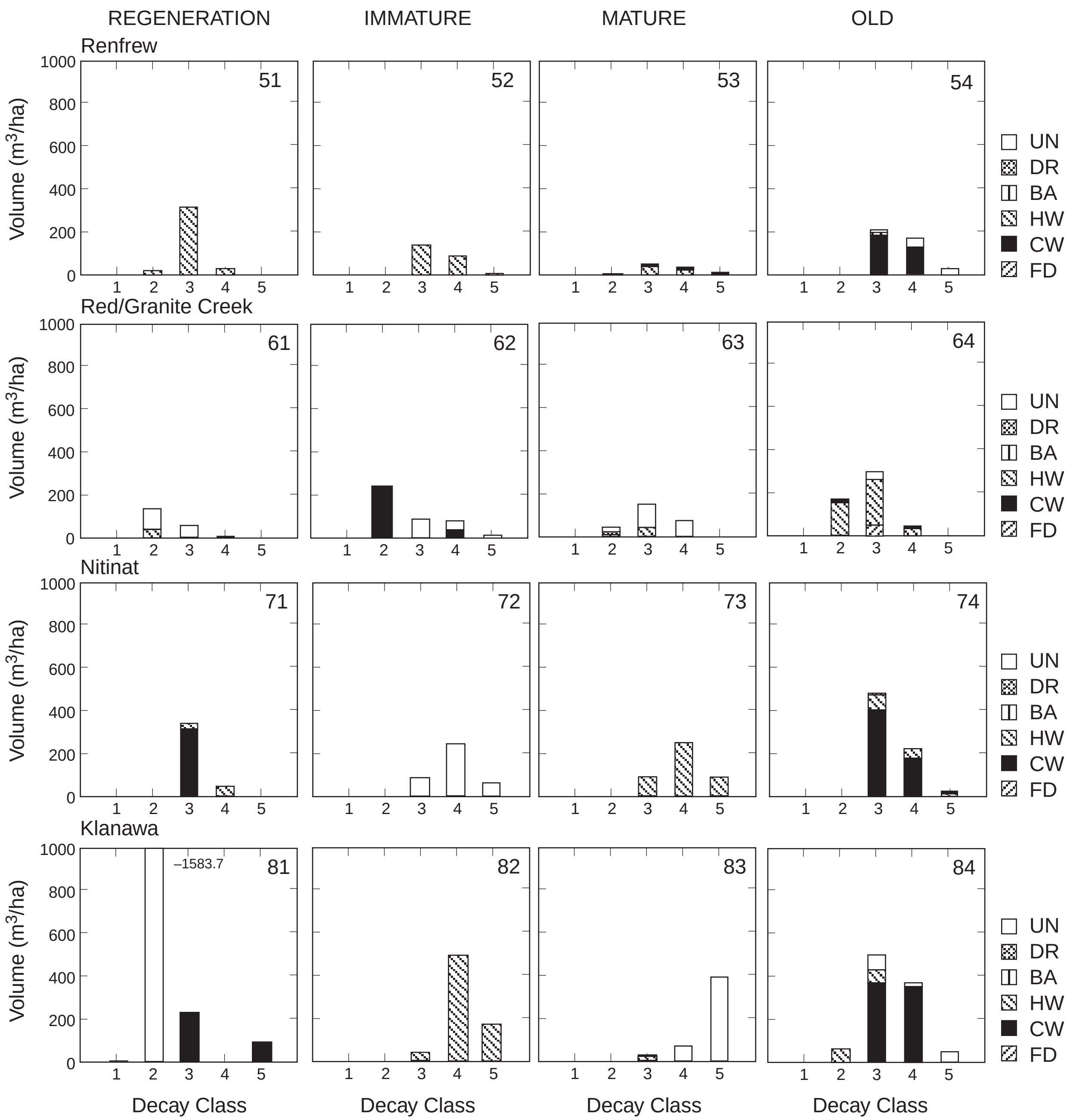
Appendix 2c. Mean CWD volume by species and size class for east and west side chronosequences. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified). Note change in scale between east and west side plots.



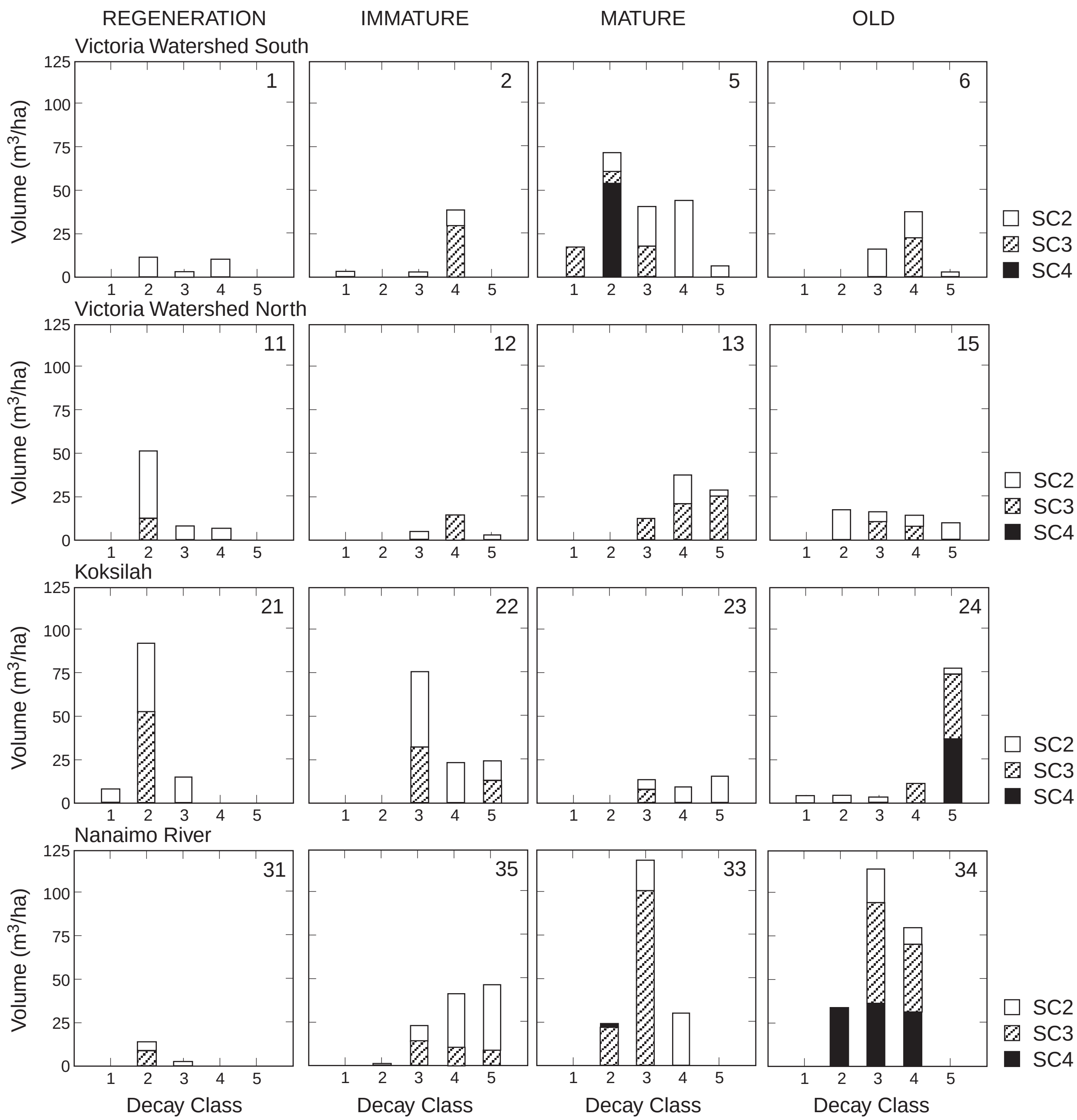
Appendix 3a. CWD volume by species and decay class for east side (CWHxm) plots. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified). Note change in scale between east and west side plots. Size class 1 is not included.



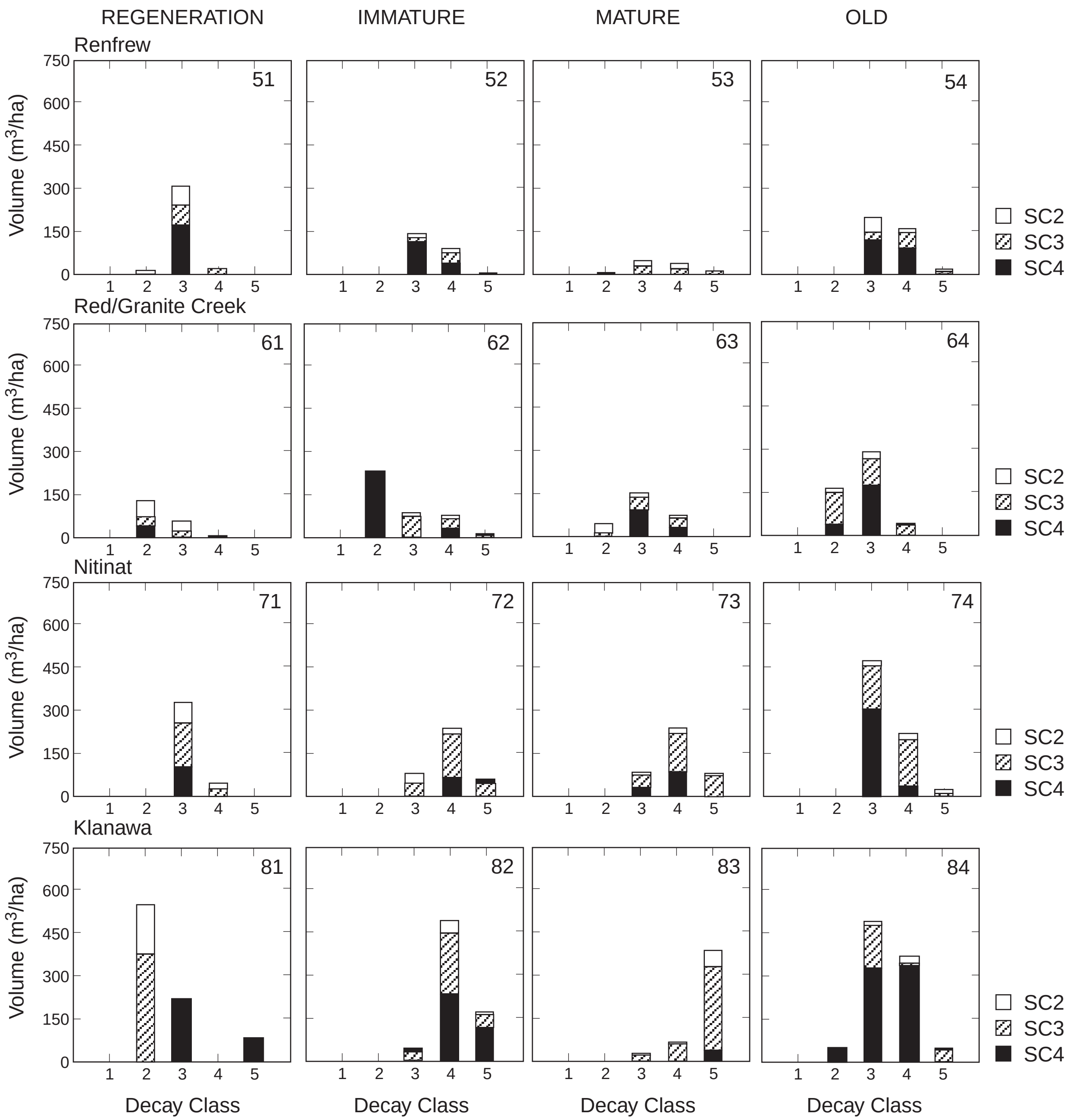
Appendix 3b. CWD volume by species and decay class for west side (CWHvm) plots. (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; BA = amabilis fir; UN = unclassified). Note change in scale between east and west side plots. Size class 1 is not included.



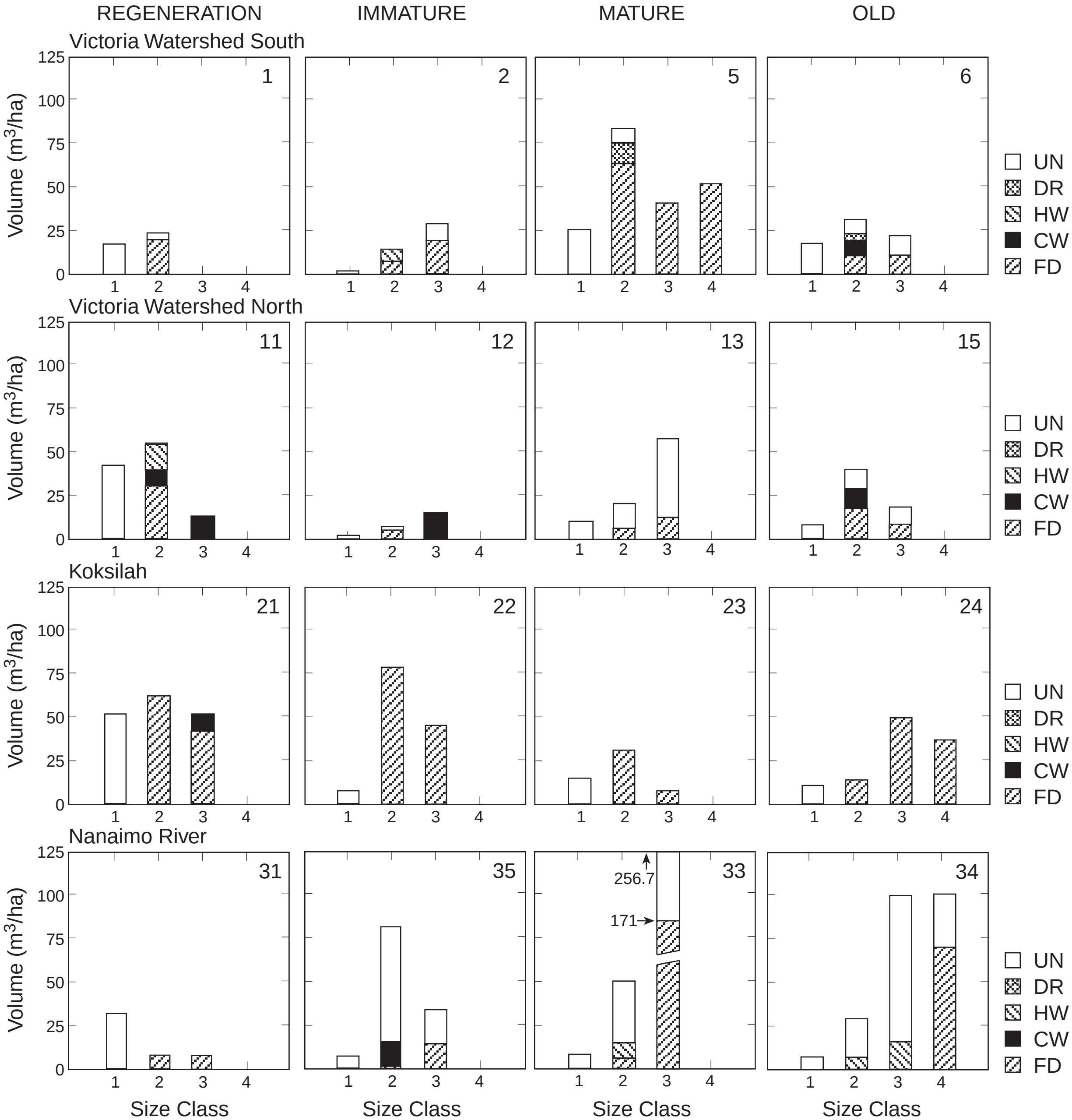
Appendix 4a. CWD volume by size and decay class for east side (CWHxm) plots. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.



Appendix 4b. CWD volume by size and decay class for west side (CWHvm) plots. (SC = size class: 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) Note change in scale between east and west side plots. Size class 1 is not included.



Appendix 5a. CWD volume by species and size class for east side (CWHxm) plots. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; DR = red alder; UN = unclassified). Note change in scale between east and west side plots.



Appendix 5b. **CWD volume by species and size class for west side (CWHvm) plots. (SC = size class: 1 = 1.1–11.9 cm diameter.; 2 = 12.0–29.9 cm diameter.; 3 = 30.0–59.9 cm diameter.; 4 ≥ 60.0 cm diameter.) (FD = Douglas-fir; CW = western redcedar; HW = western hemlock; BA = amabilis fir; UN = unclassified). Note change in scale between east and west side plots.**