Variability in Older Forest Structure in Western Oregon

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By Nathan J. Poage
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By Nathan J. Poage[1]

Abstract

The goal of this report is to assist Federal land managers in developing realistic structural targets for young forests for which the development of late-successional and old-growth (LSOG) characteristics is a long-term management objective (*i.e.*, in Late-Successional Reserves established under the Northwest Forest Plan). A unique LSOG structural database was created using complete inventories, or censuses (*i.e.*, 100% timber cruise records), of *all* conifer trees ≥ 1 ft diameter from 586 recently harvested older forests on five Bureau of Land Management (BLM) districts in western Oregon. The average area of each of the 586 inventoried older forests, 28.1 ac, clearly reflected the spatial scales typical of forest management units on Federal lands covered by the Northwest Forest Plan. All told, the LSOG database contains conifer tree census data for over 16,400 ac of LSOG forests. Ecoregion-level variability in LSOG forest structure was compared and contrasted for sites contained in the LSOG database. The spatial variability of trees and snags at 14 LSOG sites was characterized using structural data collected along one or more long (396-2178 ft) belt transects at each site.

Introduction

Late-successional forest habitat is considered critical for old-growth dependent species such as the northern spotted owl (*Strix occidentalis* var. *caurina*) and the marbled murrelet (*Brachyramphus marmoratus*). Regional concerns about 1) the loss of critical older forest habitat due to timber harvesting within the range of the northern spotted owl and 2) the need to produce timber and other forest products led to the formal adoption of the Northwest Forest Plan in 1994 by the USDI Bureau of Land Management (BLM) and USDA Forest Service (FS) (Record of Decision 1994, Regional Ecosystem Office 2005). The area covered by the Northwest Forest Plan, approximately 24.5 million acres in western Washington, western Oregon, and northwestern California, falls within the range of the northern spotted owl (Regional Ecosystem Office 2005). Within the 7.4 million acre network of Late-Successional Reserves (one of seven Federal land-use allocations designated under the Northwest Forest Plan) forest managers may silviculturally treat young forests if the "purpose of these silvicultural treatments is to be beneficial to the creation and maintenance of late-successional forest conditions" (FSEIS 1994).

Creating and maintaining late-successional and old-growth (LSOG) forest conditions requires an operational description of the forest structure desired in the future (*i.e.*, the structural target). In theory, tree species and size distributions derived from actual old-growth forests can provide managers with realistic and easily communicated structural targets for young forests where accelerating the development of late-successional forest characteristics is a management objective. In practice, however, defining realistic old-growth forest structural targets is challenging for at least three reasons.

First, LSOG structural targets should reflect the local variability found within regionally defined forest types. For example, although Douglas-fir - western hemlock (*Pseudotsuga menziesii* [Mirb.] Franco - *Tsuga heterophylla* [Raf.] Sarg.) forests occur in both the Oregon Coast Range and Cascades, these forests exhibit a great deal of structural variation between the two geographic areas (Poage and Tappeiner 2005). Might it not be realistic to establish different structural targets for older Douglas-fir - western hemlock forests in the Oregon Coast Range and Cascades? Characterizing the structure of LSOG forests by ecoregion is a straightforward means of reflecting local variation in LSOG structural targets. Ecoregions, or ecological regions, are areas identified by "the patterns and the composition of biotic and abiotic phenomena [e.g., geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology] that reflect differences in ecosystem quality and integrity…" (Pater *et al*. 1998).

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Ecoregions are hierarchical in nature. Lower-level, finer-scale ecoregions are nested within higher-level, coarser-scale ecoregions. In Oregon and Washington, for example, the level IV Coastal Uplands (1b) ecoregion is nested with eight other level IV ecoregions within the coarser-scale, level III Coast Range (1) ecoregion. Western Oregon and Washington are divided into 7 level III ecoregions, whereas North America is divided into 15 level I ecoregions (Pater *et al*. 1998).

Second, LSOG structural targets should reflect appropriate scales of management. Although forest management units on Federal lands covered by the Northwest Forest Plan are typically ≥ 25 ac, almost all studies of old-growth forests in the Pacific Northwest have characterized tree species and size structure using a limited number of small (e.g., 0.25 ac) plots at multiple sites or somewhat larger plots (e.g., 1.25-8.25 ac) at one or two sites (Juday 1977, Means 1982, Spies and Franklin 1991, Hershey 1995, Poage 1995, Tappeiner *et al*. 1997, Poage and Tappeiner 2002, Goslin 1997, Winter *et al*. 2002a,b). Scaling up research findings from finer plot-level scales (e.g., 0.25-8.25 ac) to the coarser scales (e.g., ≥ 25 ac) typical of forest management activities in the Pacific Northwest may prove misleading if only the closed-canopy portions of old-growth forests have been sampled using small plots (Poage and Tappeiner 2005).

Third, and finally, LSOG structural targets should reflect the spatial variability in tree species and sizes present horizontally within older forests. With few exceptions (e.g., Kuiper 1988, Spies *et al*. 1990, Bradshaw and Spies 1992, Poage 1995, Goslin 1997, Franklin *et al*. 2002, Zenner 2004), most old-growth studies in the Pacific Northwest have not described horizontal spatial variability in older forests. Studies that have characterized spatial variability indicate that trees and snags are not uniformly distributed in LSOG forests. Lack of detailed information can make it difficult for managers to know, for example, how often large-diameter Douglas-fir and small-diameter non-Douglas-fir conifers (e.g., western hemlock) overlap spatially at fine scales when both are found in the same old-growth forest. As a result, managers may face difficulties establishing realistic spacing guidelines for young forests where the development of late-successional forest characteristics is a management objective.

The goal of this report is to assist Federal land managers in developing realistic structural targets for young forests for which the development of LSOG characteristics is a management objective (*i.e*., in Late-Successional Reserves). As such, this report has three specific objectives which collectively address the above-noted challenges associated with defining realistic old-growth forest structural targets. Objective 1 is to create a BLM LSOG conifer database of the conifer tree structure of 586 LSOG forests on the Coos Bay, Eugene, Medford, Roseburg, and Salem BLM districts in western Oregon. This was done using inventory data from harvest units of recent BLM old-growth timber sales. Objective 2 is to compare and contrast ecoregion-level variability in LSOG forest structure for BLM lands in western Oregon. Specifically, the conifer components of LSOG forest structure contained the BLM LSOG conifer database (Objective 1) were characterized and compared by level III and IV ecoregions (Pater *et al*. 1998). Objective 3 is to characterize the spatial variability of trees and snags at 14 different LSOG sites on BLM land in western Oregon. This was done using structural data collected along one or more long (≥ 330 ft) belt transects at each site.

Methods

Objective 1. Create the BLM LSOG conifer database

The BLM LSOG conifer database was created using complete inventories, or censuses (*i.e*., 100% timber cruise records), of *all* conifer trees ≥ 1 ft diameter at breast height (or dbh, measured at 4.5 ft above the ground) from 586 recently harvested late-successional and old-growth (LSOG) forests on the Coos Bay, Eugene, Medford, Roseburg, and Salem BLM districts of the USDI Bureau of in western Oregon. All BLM timber sales terminated during the period 1990-1993 on these five BLM districts and stored at the National Archives and Records Administration in Seattle, Washington, were systematically examined to identify 100% timber cruise records of older forests. Timber sales terminated during the period 1990-1993 through the Tillamook office of the Salem BLM were not archived in Seattle but were, instead, stored in Tillamook; these timber sales were similarly examined at the Tillamook office. Each timber sale comprised one or more separate harvest units. These harvest units are also referred to as sites throughout this report.

Useable, 100% timber cruise records were identified for a total of 586 spatially distinct older forest sites. All 586 of these timber cruise records were used to construct the BLM LSOG conifer database. (No record was kept of the total number of timber cruise records examined, useable or otherwise.) To be considered useable, a 100% timber cruise record had to include:

1. a complete electronic inventory data file containing:
    a. tree counts by four-inch dbh classes, sorted by sub-sale (each sub-sale in a timber sale corresponded to a unique harvest unit and species combination), and
    b. the automated data processing (ADP) number used to link the electronic inventory data file with the archived hardcopy information (item 2), below;
2. archived hardcopy information, namely:
    a. the list of sub-sales identifying the harvest units and species within each timber sale,

b. the timber sale contract map (*i.e.*, the Exhibit A), used to identify the acreage and location (to the nearest quarter-quarter section) of each harvest unit; and

c. the timber sale summary, which contained the ADP number used to link the archived hardcopy information with the electronic inventory data file (item 1), above; and

3. the presence of at least one Douglas-fir tree with a dbh ≥ 40 inches on each harvest unit.

The electronic inventory data files (item 1) were obtained from the BLM Oregon State Office in Portland, Oregon. The archived hardcopy information (item 2) was obtained from the National Archives and Records Administration in Seattle, Washington and the Tillamook office of the Salem BLM in Tillamook, Oregon.

Data extracted from the archived hardcopy information were entered into a Microsoft Access 2000 database. Custom software was developed and used to merge the Access database with the electronic inventory data files. The merged data were imported into SAS 9.1 (SAS Institute 2003). In SAS, the trees inventoried at each site were assigned to 1-foot diameter classes: 1-foot (1 ft ≤ dbh < 2 ft), 2-foot (2 ft ≤ dbh < 3 ft), and so forth to 9-foot and larger (dbh ≥ 9 ft). Trees were then grouped by species and diameter class into species-diameter classes (SDCs). For example, western hemlock (WH) with diameters at breast height falling in the 2-foot diameter class (*i.e.*, 2 ft ≤ dbh < 3 ft) were assigned to the WH_2 species-diameter class (SDC). In addition to Douglas-fir and western hemlock, SDCs were created for the following 11 species of conifers: grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), incense-cedar (*Calocedrus decurrens* Torr.), noble fir (*Abies procera* Rehd.), Port Orford cedar (*Chamaecyparis lawsoniana* (A. Murr.) Parl.), ponderosa pine (*Pinus ponderosa* Laws.), Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), sugar pine (*Pinus lambertiana* Dougl.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.), white fir (*Abies concolor* (Gord. and Glendl.) Lindl. ex Hildebr.), western red cedar (*Thuja plicata* Donn), and western white pine (*Pinus monticola* Dougl. ex D. Don).

Although all coniferous species present at each site were included in the electronic inventory data, the Coos Bay, Eugene, Medford, Roseburg and Salem BLM districts differed in terms of which (if any) of the hardwood species present at a given site were included in the electronic inventory data for that site. Inclusion in the electronic inventories of trees with dbh < 12 in and snags of all sizes was similarly variable among the five BLM districts in western Oregon. To ensure consistency across the five BLM districts, hardwood species, trees with dbh < 12 in, and snags were dropped from the merged dataset in SAS. For this reason, the BLM LSOG conifer database contains only data for live conifer trees with dbh ≥ 12 in.

The final steps in constructing the BLM LSOG conifer database were:

1. calculate the number of trees/ac (TPA) and basal area (BA, ft^2/ac) in each species-diameter class (SDC) at each site using SAS;

2. use the ArcView 3.3 (ESRI 2002) and ArcGIS 8.3 (ESRI 2003) geographic information systems (GIS) to:

   a. assign latitudes and longitudes in decimal degrees to each site based on the estimated center of each harvest unit,

   b. create a point coverage of the sites using the assigned latitudes and longitudes, and

   c. assign level III and level IV ecoregions to each site using the point coverage of the sites and the ecoregion coverage (Pater *et al*. 1998) obtained from the Oregon Geospatial Data Clearinghouse (*www.gis.state.or.us/data/alphalist.html*);

4. merge the output from steps 1 and 2 with the archived hardcopy data for each site (previously imported from Access into SAS) and save the resulting data file as a permanent SAS dataset; and

5. export the permanent SAS dataset (step 4) to BLM_LSOG_conifer_data.xls, the master Microsoft Excel 2002 workbook.

Objective 2. Compare and contrast ecoregion-level variability in LSOG forest structure

Comparisons of LSOG forest structure among ecoregions were made using two complimentary approaches. In the first approach, the species composition characteristic of each level IV ecoregion was determined and compared with the other level IV ecoregions. For each species, the proportion of sites containing the species was calculated for each of the level IV ecoregions containing 10 or more sites. A total of 10 level IV ecoregions met this criterion; 566 of 586 sites fell within these 10 level IV ecoregions (Table 1). In all, 13 species proportions were calculated for each of these 10 level IV (*i.e.*, a total of 130 species proportions were calculated).

In the second approach, LSOG structural comparisons among ecoregions was made for each SDC combination of the 13 conifer species and 5 diameter classes (1 ft ≤ dbh < 2 ft, 2 ft ≤ dbh < 3 ft, 3 ft ≤ dbh < 4 ft, 4 ft ≤ dbh < 5 ft, and dbh ≥ 5 ft). The BAs were calculated for each SDC combination (65 total) and each level IV ecoregion containing 10 or more sites (10 total), for a total of 650 mean BAs. The 10 mean BAs (one for each level IV ecoregion) for each SDC were used to calculate a 99% confidence interval for the grand mean BA of the SDC. An SDC was considered to be significantly associated with a particular level IV ecoregion if the mean BA of the SDC for the level IV ecoregion was significantly larger than

Level III Ecoregion	Level IV Ecoregion	Physiography	Potential Natural Vegetation
1. Coast Range	1b. Coastal Uplands (n = 14)	Coastal headlands and upland terraces with medium to high gradient, black-water streams.	Sitka spruce, western hemlock, western red cedar
	1d. Volcanics (n = 64)	Steeply sloping mountains. High gradient, cascading streams and rivers occur and have stable summer flow.	Western hemlock, western red cedar, Douglas-fir
	1g. Mid-Coastal Sedimentary (n = 197)	Moderately sloping, dissected mountains with medium to high gradient, sinuous streams.	Western hemlock, western red cedar, Douglas-fir
	1h. Southern Oregon Coasal Mountains (n = 13)	Dissected mountains with high gradient, sinuous streams and rivers. This ecoregion is part of the Siskiyou Mountains.	Tanoak, Douglas-fir, western hemlock, Port Orford cedar
3. Willamette Valley	3d Valley Foothills (n = 30)	Rolling foothills with medium gradient, sinuous streams.	Oregon white oak and (drier sites), Douglas-fir (moister sites); some western red cedar
4. Cascades	4a. Western Cascades Lowlands and Valleys (n = 53)	Westerly trending ridges and valleys with reservoirs and medium gradient rivers and streams. U-shaped, glaciated valleys in the east.	Western hemlock, western red cedar, Douglas-fir
	4b. Western Cascades Montane Highlands (n = 11)	Steep, glaciated, dissected mountains and ridges with high to medium gradient streams and glacial rock-basin lakes.	Pacific silver fir, western hemlock, mountain hemlock, Douglas-fir; some noble fir
	4f. Umpqua Cascades (n = 49)	Highly dissected mountains with a few small lakes and high to medium gradient streams and rivers.	Grand fir, white fir, western hemlock, Pacific silver fir, Douglas-fir; some Shasta red fir, mountain hemlock
78. Klamath Mountains	78b. Siskiyou Foothills (n = 20)	Moderately sloping mountain foothills with reservoirs and perennial and intermittent streams and rivers.	Ponderosa pine, Douglas-fir, Oregon white oak, California black oak, madrone
	78e. Inland Siskiyous (n = 115)	Highly dissected mountains with permanent and intermittent streams. A few small lakes at higher elevations.	Douglas-fir, ponderosa pine, Oregon white oak, incense cedar, grand fir

Table 1. Ecoregion descriptions of level IV ecoregions containing 10 or more of the late-successional and old-growth (LSOG) sites summarized in the Bureau of Land Management LSOG conifer database (described in the text of this report). Ecoregions, or ecological regions, are hierarchical in nature. Lower-level, finer-scale ecoregions are nested within higher-level, coarser-scale ecoregions. For example, North America is divided into 15 level I ecoregions; western Oregon and Washington are divided into 7 level III ecoregions. All data presented in Table 1 were quoted from the Ecoregions of Western Oregon and Washington (Pater *et al.* 1998).

the grand mean BA of the SDC for all 10 level IV ecoregions (i.e., the mean BA of the SDC for the level IV ecoregion fell outside of and above the 99% confidence interval for the grand mean BA of the SDC for all 10 level IV ecoregions).

To provide readers with a further level of detail, TPA and BA were summarized for each level IV ecoregion using two broad species groups of conifers (Douglas-fir and non-Douglas-fir) and the five diameter classes noted in the previous paragraph. For each combination of species group and diameter class, pair-wise comparisons of mean TPA and mean BA were made for all pairs of the 10 level IV ecoregions. Additional pair-wise comparisons of mean TPA and mean BA were made among level IV ecoregions for 1) the combination of all Douglas-fir diameter classes, 2) the combination of all other (*i.e.*, non-Douglas-fir) conifer diameter classes, and 3) the combination all Douglas-fir and other conifer diameter classes. Whether the mean TPAs or mean BAs of two level IV ecoregions differed significantly from one another was assessed for each combination of species group and diameter class using Tukey's Honest Significance Difference (HSD) method of multiple comparisons with an experiment-wise error rate of $\alpha = 0.05$ (SAS Institute 2003, PROC GLM). Although not discussed further in detail, the TPA and BA summary tables and results of Tukey's HSD multiple comparisons are included for readers as Appendices 1-4.

Objective 3. Characterize the spatial variability of trees and snags in 14 LSOG forests

Long belt transects were used to characterize the spatial variability of standing trees and snags at 14 different LSOG forest sites on BLM land in western Oregon. Both within- and between-SDC spatial patterns were described. Three sites were selected on each of the following BLM districts: Salem, Eugene, Roseburg, and Medford. Two sites were selected on the Coos Bay District. Sites were selected by consulting with BLM personnel and/or examining air photos of areas containing recent timber sales for which complete pre-sale inventories of trees existed. A range of species mixtures was selected, although all forests sampled were dominated by Douglas-fir.

One or more belt transects ≥ 330 ft were established at each site (Table 2). At 13 of 14 sites with clearly sloping terrain, transects were oriented to run from ridge top to valley bottom (or vice-versa). The single transect at the one flat site was oriented to continuously sample the longest cross-section of forest possible. Although the general starting location of each transect was determined using air photos, the exact starting point of each transect was randomized.

Trees and snags ≥ 36 in dbh were tallied along each transect using pairs of 0.10 ac, square (66 ft × 66 ft) plots located contiguously on the left and right sides of the transect center line. Data from each pair of 0.10 ac, square plots were pooled into a single 0.20 ac, rectangular (66 ft × 132 ft) plot extending 66 ft along the transect line and 66 ft on either side of the transect line. (Recall that 66 ft = 1 chain and that the area defined by 1 chain × 1 chain = 0.10 ac.) Trees and snags < 36 in dbh (but with heights ≥ 4.5 ft) were sampled using circular, 0.05 ac plots centered at 66 ft intervals along the transect line. The centers of the circular, 0.05 ac plots were located at 0 ft, 66 ft, 132 ft, and so on along each transect; the 0.20 ac, rectangular plots were centered at 33 ft, 99 ft, 165 ft, and so on along each transect. Consequently, with the exception of the circular, 0.05 ac plots located at the start and end point of each transect, the two halves of each circular, 0.05 ac plot fell within two different (but contiguous) 0.20 ac, rectangular plots.

Trees and snags with one-half or more of their basal area falling within the appropriately sized plot were tallied by diameter class: 0 in < dbh < 3 in, 3 in ≤ dbh < 6 in, 6 in ≤ dbh < 12 in, 12 in ≤ dbh < 24 in, 24 in ≤ dbh < 36 in, and so forth by 12-inch diameter class to dbh ≥ 96 in. The species of each tree and the decay class of each snag was recorded. Decay classes ranged from 1 (least decayed) to 5 (most decayed). A complete description of the characteristics associated with each decay class is found in Maser *et al*. (1988).

Prior to analysis, the tree and snags data were summarized in five general diameter classes: 0 in < dbh < 3 in, 3 in ≤ dbh < 12 in, 12 in ≤ dbh < 36 in, 36 in ≤ dbh < 60 in, and dbh ≥ 60 in. Trees were separated into three species groups: Douglas-fir, other conifer species, and hardwood species. Snags were separated into two species groups based on decay classes: decay classes 1-2 and decay classes 3-5. Taken together, the 5 tree and snag species groups and 5 diameter classes formed 25 species-diameter classes, or SDCs. (Note that SDC is defined somewhat differently for Objective 3 than for Objectives 1 and 2.) The number of trees/ac or snags/ac was calculated for each SDC for each 0.20 ac, rectangular plot (trees and snags ≥ 36 in dbh) or 0.05 ac, circular plot (trees and snags < 36 in dbh). Because the centers of the circular, 0.05 ac plots and 0.20 ac, rectangular plots were offset from each other by 33 ft along each transect, an average number of trees/ac or snags/ac was calculated for each SDC < 36 in dbh for each successive pair of 0.05 ac, circular plots. These average values were used for all subsequent spatial analyses involving SDCs originally sampled using 0.05 ac, circular plots.

The spatial variability of the 25 SDCs was characterized in terms of both within-SDC spatial patterns and between-SDC spatial patterns. Within-SDC spatial patterns were described in terms of mean patch length and patch density (*i.e.*, number of trees or snags/ac) of a single SDC along transect, as well as the mean gap length between patches of the same SDC. For example, casual field observations in LSOG forests suggest that Douglas-fir 36-60 in dbh might be expected to occur in patches with average lengths of 132-264 ft and average densities of 7-13 trees/ac. Similarly, prior observations suggest that the average gap lengths between patches of Douglas-fir 36-60 in dbh might fall between 66 and 198 ft. Patch and gap lengths along each transect were measured in multiples of 66 ft. Means, standard deviations, minima, and maxima of patch length, patch density, and gap

District	Site Name	Transect	Length (ft)	Azimuth (deg)	Elevation Range (ft)	Township-Range-Section (¼, ¼¼)
Salem	North Prairie	1	660	224	2700-2825	T15S-R07W-07 (NW, SE)
		2	528	360	2650-2800	T15S-R07W-07 (NW, SE)
		3	594	354	2600-2800	T15S-R07W-07 (NW, SE)
	Lobster South Fork	1	660	45	1200-1650	T15S-R08W-36 (NW, SE)
		2	594	45	1175-1600	T15S-R08W-36 (NW, SE)
	South Fork Skyline II	1	924	240	2200-2625	T11S-R03E-14 (SW, SW)
		2	990	240	2250-2625	T11S-R03E-14 (SW, SW)
Eugene	Johnson Creek	1	924	360	875-1200	T19S-R07W-33 (NE, SW)
		2	462	90	790-900	T19S-R07W-33 (NE, SW)
		3	990	180	925-1335	T19S-R07W-33 (NE, SW)
	Penn Again	1	1980	360	775-825	T18S-R07W-01 (SE, SW)
	Mill Pond	1	924	110	1550-1725	T15S-R07W-25 (NW, SE)
Roseburg	Pebble Creek	1	1254	260	2625-3475	T25S-R02W-01 (NE, SE)
		2	792	290	2725-3260	T25S-R02W-01 (NE, SE)
	Indian Crest	1	726	240	2950-3360	T31S-R04W-29 (SW, SW)
		2	594	60	3010-3300	T31S-R04W-29 (SW, SW)
	Wolf Bate	1	528	165	675-725	T25S-R08W-09 (NE, NE)
		2	396	345	660-675	T25S-R08W-09 (NE, NE)
Medford	Hoxie	1	2178	290	4860-4880	T38S-R04E-29 (SE, SW)
	Tin Cup	1	1782	210	5425-5450	T38S-R03E-33 (SE, NW)
		2	396	30	5425-5500	T38S-R03E-33 (SE, NW)
	Whiskey Creek	1	1320	190	2925-3285	T33S-R08W-20 (SE, SE)
Coos Bay	Morgan Ridge	1	1782	120	825-925	T26S-R12W-01 (NE, SW)
	Faerial Aerial	2	1914	90	980-1585	T26S-R10W-04 (NW, SE)

Table 2. Description of the transects used to characterize the spatial variability of trees and snags at 14 late-successional and old-growth sites located in five Bureau of Land Management districts in western Oregon. Township-Range-Section (¼, ¼¼) contains the legal description of the quarter-quarter (¼¼) section within which the majority of each transect was located.

length were calculated for each SDC using data pooled from all sites where the SDC occurred.

Between-SDC spatial patterns were characterized in terms of the degree of spatial overlap occurring between two SDCs along each 66 ft of transect length. Specifically, the proportion of times SDC 1 overlapped with SDC 2 was calculated using data pooled from all sites where both SDC 1 and SDC 2 were present. For example, when both Douglas-fir 36-60 in dbh (SDC 1) and other (non-Douglas-fir) conifers 12-36 in dbh (SDC 2) occur in the same LSOG forest, it might be expected that the larger Douglas-fir (SDC 1) will overlap spatially one-half of the time with the smaller, other conifers (SDC 2). A total of 25 × 24 = 600 between-SDC spatial patterns were characterized for the 25 SDCs.

Results and Discussion

Objective 1. Create the BLM LSOG conifer database

The BLM LSOG conifer database created contains estimates of the number of trees/ac (TPA) and basal area (BA, ft^2/ac) for 13 tree species and 9 diameter classes at 586 late-successional and old-growth (LSOG) sites on BLM lands in western Oregon. The combination of 13 species and 9 diameter classes represents 117 species-diameter classes (SDCs). The following are also included in the database for each of the 586 sites: BLM district, timber sale and unit, sale year, unit acreage, legal coordinates (*i.e.*, nearest township, range, section, quarter section, and quarter-quarter section) and geographic coordinates (*i.e.*, longitude and latitude in decimal degrees) of the estimated unit center, and the level III and IV ecoregions within which the majority of the unit fell. As of the date of publication of this report, the BLM LSOG conifer database may be downloaded from the USGS Forest and Rangeland Ecosystem Science Center website (*http://fresc.usgs.gov/ArcIMS/Website/lsog*).

The BLM LSOG conifer database is absolutely unique for three reasons. First, the database contains structural data for a particularly large number—586—of LSOG forests inventoried over a wide geographic area (Figure 1). Second, the structural data—the number of trees/ac and basal area in different species and diameter classes—are based on complete censuses of **all** conifer trees ≥ 1 ft diameter at breast height found at each of the 586 inventoried older forests. Third, the average area of each of the 586 inventoried older forests, 28.1 ac, clearly reflects the spatial scales typical of forest management units on Federal lands covered by the Northwest Forest Plan. All told, the BLM LSOG conifer database contains conifer tree census data for a staggering 16,470 ac, or 25.7 mi^2, of late-successional and old-growth forests on five BLM districts in western Oregon. As such, the BLM LSOG conifer database represents one of the largest collections of detailed data ever assembled on older forest structure.

Objective 2. Compare and contrast ecoregion-level variability in LSOG forest structure

The presence and absence of species identified coarse ecoregion-level differences in LSOG forest structure. Certain species were relatively consistent among the level III and level IV ecoregions, whereas other species exhibited a high degree of variability among ecoregions. For example, western hemlock (WH) was present at ≥ 0.50 of all sites in the level III Coast Range (1), Willamette Valley (3), and Cascades (4) ecoregions (Table 3). Similarly, six out of eight level IV ecoregions in these three level III ecoregions had western red cedar (WRC) present at ≥ 0.50 of sites. In contrast, WH and WRC were far less common at sites in the level III Klamath Mountains (78) ecoregion. Indeed, WH and WRC were entirely absent at sites in the level IV Siskiyou Foothills (78b) ecoregion.

Viewing species differences by diameter class (*i.e.*, by SDC) and density (e.g., BA) in each SDC highlighted more subtle structural differences among ecoregions. For example, WH and WRC occurred in both the Coastal Uplands (1b) and Western Cascades Montane Highlands (4b) level IV ecoregions (Table 3). Clear differences in the densities of WH and WRC existed between the two ecoregions in terms of diameter classes, however. The highest mean density of WRC observed in each of the five diameter classes occurred in the Coastal Uplands (1b), whereas the highest mean densities of WH all occurred in the Western Cascades Montane Highlands (4b) (Figure 2, Table 4).

The following narrative descriptions of LSOG forest structure by level IV ecoregion were drawn from the data summaries in Table 3, Figure 2, and Table 4. The Coastal Uplands (1b) were characterized by WRC in all diameter classes (as noted above), the largest Douglas-fir (DF), and mid-sized Sitka spruce (SS). DF and SS were also characteristic of the Coastal Volcanics (1d) ecoregion, but for different diameter classes (DF 1-3 ft, SS 1-3 ft, and SS ≥ 5 ft) than for the Coastal Uplands (1b). The densities of WH and WRC were considerably lower in the Coastal Volcanics (1d) ecoregion than in the Coastal Uplands (1b).

In contrast to the Coastal Uplands (1b) and Coastal Volcanics (1d), SS was almost entirely absent from the Mid-Coastal Sedimentary (1g) and Southern Oregon Coastal Mountains (1h). The Mid-Coastal Sedimentary (1g) and Southern Oregon Coastal Mountains (1h) were the only level IV ecoregions with sites containing Port Orford Cedar (POC). POC was present at a higher proportion of the Southern Oregon Coastal Mountains (1h) sites than of the Mid-Coastal Sedimentary (1g) sites. Grand fir (GF) was present in both the Mid-Coastal Sedimentary (1g) and Southern Oregon Coastal Mountains (1h) ecoregions, but occurred more frequently and with higher mean densities at sites in the Southern Oregon

Level III Ecoregion	Level IV Ecoregion	DF	GF	IC	NF	POC	PP	PSF	SP	SS	WF	WH	WRC	WWP
1. Coast Range	1b. Coastal Uplands (n = 14)	**1.00**	.	.	.	.	.	.	.	0.36	.	**1.00**	**1.00**	.
	1d. Volcanics (n = 64)	**1.00**	*0.03*	.	.	.	.	.	.	*0.20*	.	**0.90**	0.48	.
	1g. Mid-Coastal Sedimentary (n = 197)	**1.00**	0.35	*0.07*	.	0.29	.	.	*0.01*	*0.01*	*0.01*	**0.90**	**0.73**	.
	1h. Southern Oregon Coasal Mountains (n = 13)	**1.00**	**0.85**	.	.	**0.77**	.	.	.	.	.	**0.69**	0.39	.
3. Willamette Valley	3d Valley Foothills (n = 30)	**1.00**	**0.67**	**0.70**	.	.	.	.	.	.	.	**0.50**	**0.53**	.
4. Cascades	4a. Western Cascades Lowlands and Valleys (n = 53)	**1.00**	0.26	*0.15*	*0.08*	.	.	*0.02*	*0.04*	.	.	**0.96**	**0.72**	*0.08*
	4b. Western Cascades Montane Highlands (n = 11)	**1.00**	.	.	0.46	.	.	0.46	.	.	.	**1.00**	0.27	*0.09*
	4f. Umpqua Cascades (n = 49)	**1.00**	0.41	**0.86**	.	.	.	.	**0.90**	.	.	**0.94**	**0.76**	*0.22*
78. Klamath Mountains	78b. Siskiyou Foothills (n = 20)	**1.00**	.	**0.65**	.	.	**0.65**	.	**0.60**	.	0.35	.	.	.
	78e. Inland Siskiyous (n = 115)	**1.00**	*0.05*	**0.62**	.	.	0.37	.	**0.70**	.	0.39	0.30	*0.02*	.

Table 3. Ecoregion-level differences in late-successional and old-growth (LSOG) forest structure in terms of species presence. The degree to which a species is characteristic of a level IV ecoregion is indicated by the proportion of LSOG sites containing the species within the level IV ecoregion. For example, the proportion of sites in the level IV Coastal Uplands (1b) ecoregion containing Sitka spruce (column SS) was 0.36. Proportions $\geq$ 0.50 appear in **bold**; proportions < 0.25 are *italicized*. The coded column headings indicate the common names for the following species: DF = Douglas-fir, GF = grand fir, IC = incense-cedar, NF = noble fir, POC = Port Orford cedar, PP = ponderosa pine, PSF = Pacific silver fir, SP = sugar pine, SS = Sitka spruce, WH = white fir, WH = western hemlock, WRC = western red cedar, and WWP = western white pine (see text for scientific names). See Table 1 for descriptions of the level IV ecoregions.

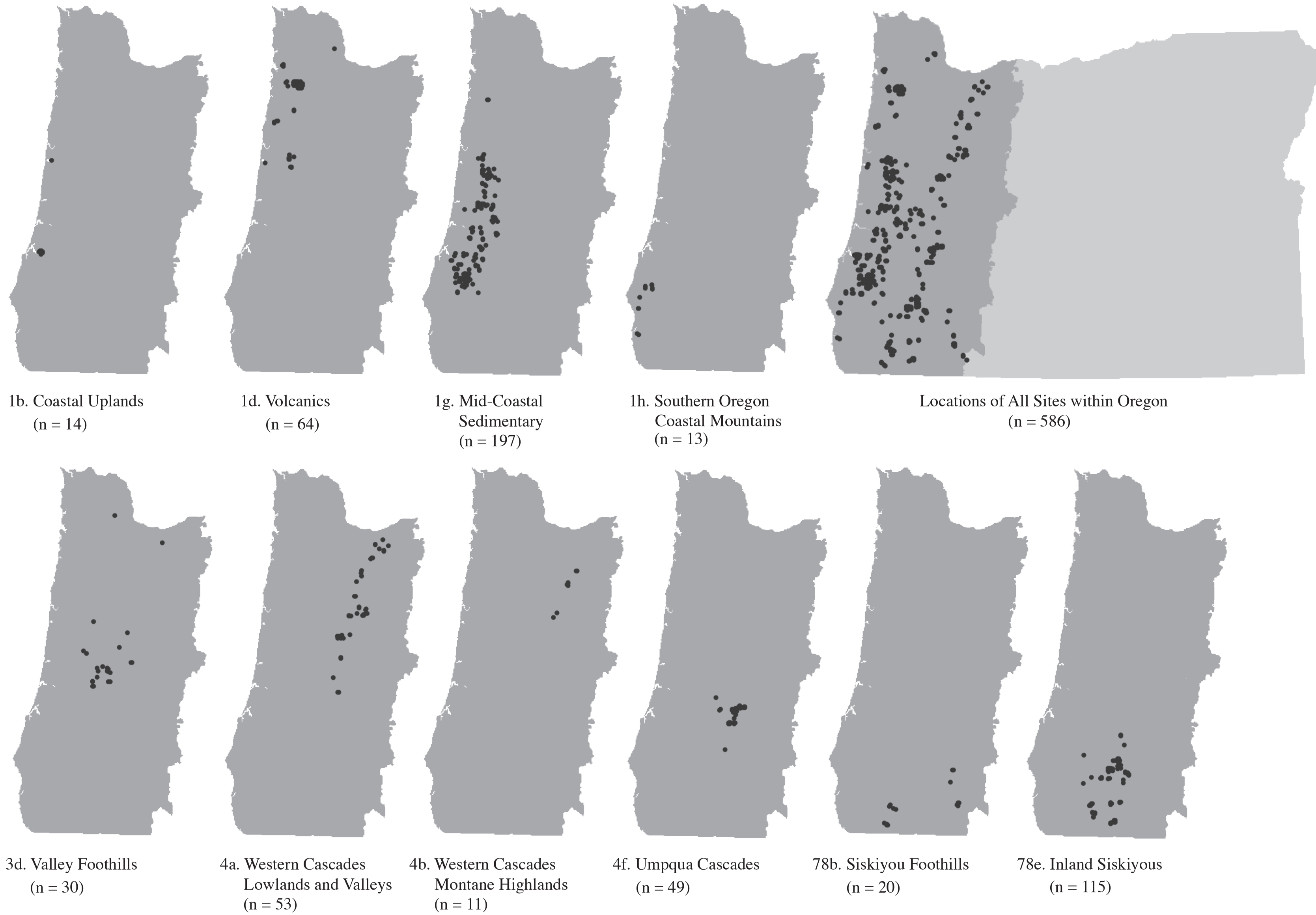

Figure 1. Locations of late-successional and old-growth (LSOG) sites summarized in the Bureau of Land Management LSOG conifer database (described in the text of this report). Sites are shown by level IV ecoregion. The level IV ecoregions shown contain ≥ 10 LSOG sites. The numbers in parentheses below each level IV ecoregion name indicate the number of LSOG sites within that level IV ecoregion.

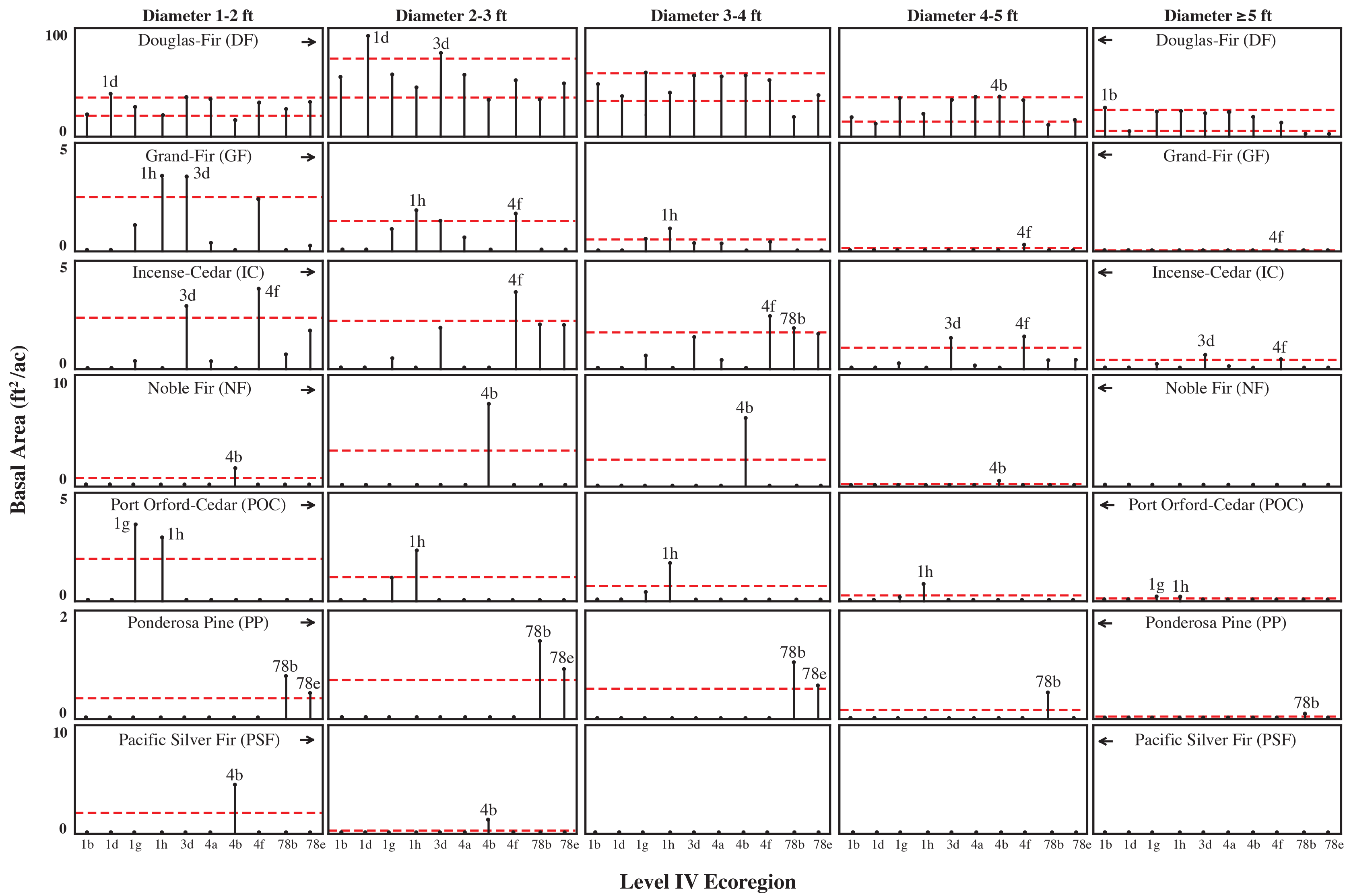

Figure 2. Species-diameter classes (SDCs) characteristic of level IV ecoregions. (Figure 2 should be viewed with Table 4.) Mean basal areas (BA, ft²/ac) are shown for all combinations of level IV ecoregion and SDC. For each SDC, the dashed lines indicate the 99% confidence interval for the grand mean BA of the SDC for all 10 level IV ecoregions. An SDC was considered to be significantly associated with a particular level IV ecoregion if the mean BA of the SDC for the level IV ecoregion fell outside of and above the 99% confidence interval for the grand mean BA of the SDC for all 10 level IV ecoregions. For example, Douglas-fir in the 2-3 ft diameter class was characteristic of both the Volcanics (1d) and Valley Foothills (3d) level IV ecoregions. See Table 1 for descriptions of the level IV ecoregions.

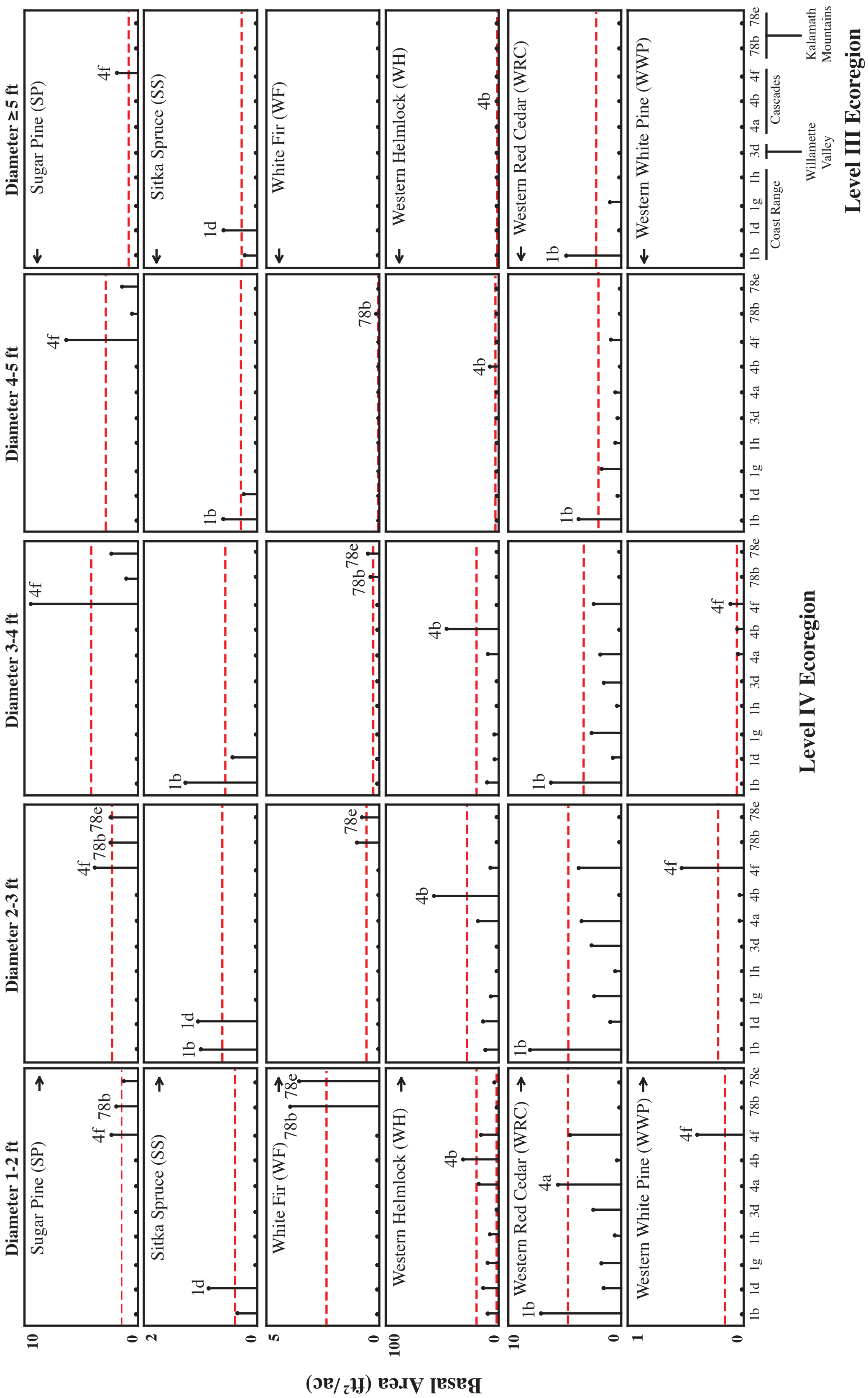

Figure 2.—continued

Level III Ecoregion	Level IV Ecoregion	DF	GF	IC	NF	POC	PP	PSF	SP	SS	WF	WH	WRC	WWP
1. Coast Range	11b. Coastal Uplands (n = 14)	____5	.	.	.	.	.	.	.	_234_	.	.	12345	.
	1d. Volcanics (n = 64)	12___	.	.	.	.	.	.	.	12__5	.	.	.	.
	1g. Mid-Coastal Sedimentary (n = 197)	.	.	.	.	1___5	.	.	.	.	.	.	.	.
	1h. Southern Oregon Coasal Mountains (n = 13)	.	123__	.	.	12345	.	.	.	.	.	.	.	.
3. Willamette Valley	3d Valley Foothills (n = 30)	_2___	1____	1__45	.	.	.	.	.	.	.	.	.	.
4. Cascades	4a. Western Cascades Lowlands and Valleys (n = 53)	.	.	.	.	.	.	.	.	.	.	.	1____	.
	4b. Western Cascades Montane Highlands (n = 11)	___4_	.	.	1234_	.	.	12___	.	.	.	12345	.	.
	4f. Umpqua Cascades (n = 49)	.	_2_45	12345	.	.	.	.	12345	.	.	.	.	123__
78. Klamath Mountains	78b. Siskiyou Foothills (n = 20)	.	.	__3__	.	.	12345	.	12___	.	1234_	.	.	.
	78e. Inland Siskiyous (n = 115)	.	.	.	.	.	123__	.	_2___	.	123__	.	.	.

Table 4. Species-diameter classes (SDCs) characteristic of level IV ecoregions. (Table 4 should be viewed with Figure 2.) SDCs characteristic of a level IV ecoregion are indicated by species (columns DF-WWP) and diameter class (1 = 1-2 ft dbh, 2 = 2-3 ft dbh, 3 = 3-4 ft dbh, 4 = 4-5 ft dbh, 5 = $\geq$ 5 ft dbh; dbh = diameter at breast height, measured at 4.5 ft above the ground). For example, the level IV Coastal Uplands (1b) ecoregion was characterized by Douglas-fir (column DF) in the 5 ft diameter class (____5), Sitka spruce (column SS) in the 2-4 ft diameter classes (_234_), and western red cedar (column WRC) in all diameter classes (12345). An SDC was considered to be significantly associated with a particular level IV ecoregion if the mean basal area (BA, ft^2/ac) of the SDC for the level IV ecoregion fell outside of and above the 99% confidence interval for the grand mean BA of the SDC for all 10 level IV ecoregions. The coded column headings indicate the common names for the following species: DF = Douglas-fir, GF = grand fir, IC = incense-cedar, NF = noble fir, POC = Port Orford cedar, PP = ponderosa pine, PSF = Pacific silver fir, SP = sugar pine, SS = Sitka spruce, WH = white fir, WH = western hemlock, WRC = western red cedar, and WWP = western white pine (see text for scientific names). See Table 1 for descriptions of the level IV ecoregions.

Coastal Mountains (1h). GF was also characteristic of sites in the Willamette Valley Foothills (3d). The Willamette Valley Foothills (3d) ecoregion was additionally characterized by DF (2-3 ft) and incense-cedar (IC, 1-2 ft and ≥ 4 ft).

The three level IV Cascade (4) ecoregions were more different from one another than the level IV ecoregions of the Coast Range (1) or Klamath Mountains (78). Although 9 of the 13 conifer species represented in the BLM LSOG conifer database occurred at sites in the Western Cascades Lowlands and Valleys (4a), 5 of these 9 species occurred at 0.15 or fewer of the Western Cascades Lowlands and Valleys (4a) sites. (A similar pattern of high species diversity within an ecoregion and low species consistency across sites was observed for the Mid-Coastal Sedimentary (1g) ecoregion, above.) Consequently, only small WRC was characteristic of the Western Cascades Lowlands and Valleys (4a) ecoregion. The Western Cascades Montane Highlands (4b), in contrast, were characterized by WH in all diameter classes (as noted above), noble fir (NF, 1-4 ft), and Pacific silver fir (PSF, 1-2 ft). The SDCs characterizing the Umpqua Cascades (4f) were GF (2 ft and ≥ 4 ft), IC (all diameter classes), sugar pine (SP, all diameter classes), and western white pine (WWP, 1-3 ft).

The species characteristic of the Umpqua Cascades (4f) were more similar to the species characteristic of the two level IV ecoregions of the Klamath Mountains (78) than the species characteristic of the other two level IV Cascades (4) ecoregions. SP was characteristic of the Umpqua Cascades (4f), the Siskiyou Foothills (78b), and the Inland Siskiyous (78e), and IC characterized both the Umpqua Cascades (4f) and the Siskiyou Foothills (78b). Two other species—ponderosa pine (PP) and white fir (WF)—were almost entirely confined to sites in the Klamath Mountains (78).

Objective 3. Characterize the spatial variability of trees and snags in 14 LSOG forests

The spatial distribution of trees and snags was not uniform at the 14 older forest transect sites in western Oregon. Both within-SDC spatial patterns and between-SDC spatial patterns were highly variable. The mean within-SDC patch length and mean within-SDC patch density (TPA) of individual species groups generally decreased with increasing diameter class (Table 5). For example, the mean patch length of Douglas-fir decreased from 377 ft for the 0-3 in diameter class to 126 ft for the ≥ 60 in diameter class. Similarly, the mean density of Douglas-fir decreased from 43 TPA for the 0-3 in diameter class to 7 TPA for the ≥ 60 in diameter class.

The general trends observed for within-SDC spatial patterns are most likely reflections of the normal processes of tree mortality and snag production and decay within stands. As the trees in a patch increase in size, self-thinning reduces patch density and—by creating gaps within a patch—can divide the original patch into two smaller ones. Similarly, tree growth and mortality lead to fewer but larger snags in a patch. Decay also decreases the patch density of snags and can lead to the formation of gaps within patches of snags. The formation of gaps within patches appears somewhat random, however. Clear patterns for mean gap length between adjacent patches of the same SDC were not as apparent for within-SDC patch length and density (Table 5). For example, the mean gap length between adjacent patches of Douglas-fir ≥ 60 in (273 ft) was larger than that for Douglas-fir 36-60 in (133 ft), but was smaller than that for Douglas-fir 12-36 in (335 ft).

Between-SDC spatial patterns were varied at the scale examined (*i.e.*, 66 ft of transect length). Not surprisingly, more common SDCs occurred less frequently with less common SDCs than vice versa (Table 6). For example, other (*i.e.*, non-Douglas-fir) conifers 0-3 in were far more common than Douglas-fir ≥ 60 in. The more common other conifers 0-3 in overlapped spatially with the less common Douglas-fir ≥ 60 in only 0.29 of the time. In contrast, the probability of Douglas-fir ≥ 60 in co-occurring spatially with other conifers 0-3 in was 0.75. Decay class 3-5 snags 0-3 in always occurred with Douglas-fir and other conifers 3-36 in, but never with hardwoods.

Management implications

An estimated $600,000-$1,200,000 worth of late-successional and old-growth (LSOG) structural data are summarized in the BLM LSOG conifer database (assuming a cost of $1,000-$2,000 to inventory each of the 586 sites). Although these data were collected as part of the BLM's timber sale program, they can prove extremely useful in setting long-term structural goals for young stand where accelerating the development of LSOG structural characteristics is a management objective. Managers can, for example, use the BLM LSOG conifer database to identify LSOG sites that are (were) located close to a young stand they intend to manipulate silviculturally and then use the SDC data from these LSOG sites to help define an LSOG structural target for the young stand. The BLM LSOG conifer database also can be used to establish more regional LSOG structural goals for young forests (e.g., by ecoregion, as described above under Objective 2).

The average area inventoried at each of the 586 sites in the BLM LSOG conifer database was 28.1 ac. Consequently, LSOG structural targets derived from the BLM LSOG conifer database will accurately reflect the scales typical of forest management units on Federal lands in the Pacific Northwest (e.g., ≥ 25 ac). Combining the data in the BLM LSOG conifer database with the within-SDC and between-SDC spatial data (Objective 3) will enable managers to define more realistic LSOG structural targets. This is particularly true if managers are permitted to define LSOG structural goals at the 10- to 25-acre scale rather than establishing structural targets that must be met on each and every acre. Consider, for example, young stands in the level IV Coastal Uplands (1b) ecoregion for which long-term LSOG structural goals are being defined (e.g., Figure 2). For these stands, an LSOG basal area target

Species-Diameter Class		Patch Length (feet)					Patch Density (number / acre)					Gap Length (feet)				
		Mean	S.D.	n	Min	Max	Mean	S.D.	n	Min	Max	Mean	S.D.	n	Min	Max
Douglas-fir	0-3 in	377	332	17	66	1320	43	37	17	10	128	358	364	19	66	1518
	3-12 in	340	335	26	66	1320	35	47	26	10	243	401	429	28	66	1650
	12-36 in	266	306	36	66	1320	25	23	36	10	118	335	313	37	66	1518
	36-60 in	194	193	76	66	792	11	6	76	5	30	133	93	69	66	462
	≥ 60 in	126	79	51	66	330	7	3	51	5	15	273	261	64	66	1188
Other Conifers	0-3 in	416	340	40	66	1584	93	193	40	10	1170	207	176	35	66	660
	3-12 in	514	532	34	66	2178	47	38	34	10	156	256	257	25	66	858
	12-36 in	468	469	36	66	2178	40	29	36	10	110	221	238	26	66	858
	36-60 in	145	107	57	66	594	8	4	57	5	25	215	241	58	66	990
	≥ 60 in	66	0	9	66	66	6	2	9	5	10	424	341	12	66	1254
Hardwoods	0-3 in	206	196	24	66	924	35	50	24	10	250	416	334	26	66	1386
	3-12 in	222	188	33	66	990	27	29	33	10	153	303	177	34	66	594
	12-36 in	210	137	34	66	594	20	15	34	10	87	300	243	35	66	1254
	36-60 in	74	23	8	66	132	6	2	8	5	10	310	194	10	66	594
	≥ 60 in	99	47	2	66	132	5	0	2	5	5	875	359	4	396	1254
Snags, decay 1-2	0-3 in	222	270	22	66	1320	33	31	22	10	111	387	415	31	66	1584
	3-12 in	244	239	37	66	1320	20	16	37	10	90	304	320	41	66	1584
	12-36 in	177	114	40	66	660	14	7	40	10	40	353	291	45	66	1320
	36-60 in	100	55	47	66	264	6	2	47	5	13	263	240	62	66	1122
	≥ 60 in	66	0	9	66	66	6	2	9	5	10	579	464	13	66	1782
Snags, decay 3-5	0-3 in	132	0	1	132	132	10	0	1	10	10	638	550	3	198	1254
	3-12 in	143	38	12	132	264	13	9	12	10	40	452	318	27	66	1518
	12-36 in	155	49	20	66	264	16	8	20	10	40	387	357	35	66	1584
	36-60 in	95	69	50	66	396	6	2	50	5	13	304	267	63	66	1056
	≥ 60 in	66	0	4	66	66	5	0	4	5	5	469	205	9	132	726

Table 5. Within-SDC (species-diameter class) spatial patterns of trees and snags at 14 late-successional and old-growth (LSOG) sites in western Oregon. A complete description of the characteristics associated with each snag decay class is found in Maser *et al.* (1988).

Species-Diameter Class		Douglas-fir 0-3 in	Douglas-fir 3-12 in	Douglas-fir 12-36 in	Douglas-fir 36-60 in	Douglas-fir ≥ 60 in	Other Conifers 0-3 in	Other Conifers 3-12 in	Other Conifers 12-36 in	Other Conifers 36-60 in	Other Conifers ≥ 60 in	Hardwoods 0-3 in	Hardwoods 3-12 in	Hardwoods 12-36 in	Hardwoods 36-60 in	Hardwoods ≥ 60 in
Douglas-fir	0-3 in	-	0.92	0.86	0.65	0.10	0.56	0.45	0.46	0.24	.	0.62	0.74	0.63	.	.
	3-12 in	0.76	-	0.87	0.63	0.16	0.58	0.57	0.61	0.28	0	0.57	0.64	0.57	0.33	0
	12-36 in	0.72	0.83	-	0.66	0.17	0.61	0.58	0.60	0.28	0.17	0.52	0.61	0.54	0.17	0.17
	36-60 in	0.47	0.45	0.45	-	0.28	0.67	0.74	0.76	0.32	0.06	0.32	0.42	0.39	0.17	0.04
	≥ 60 in	0.25	0.26	0.31	0.64	-	0.75	0.80	0.81	0.31	0.05	0.24	0.33	0.31	0.20	0.04
Other Conifers	0-3 in	0.43	0.38	0.38	0.60	0.29	-	0.88	0.85	0.41	0.11	0.29	0.39	0.38	0.14	0
	3-12 in	0.34	0.35	0.34	0.62	0.29	0.84	-	0.95	0.44	0.08	0.23	0.32	0.34	0.12	0.03
	12-36 in	0.31	0.34	0.33	0.62	0.31	0.83	0.98	-	0.44	0.05	0.22	0.31	0.34	0.13	0.03
	36-60 in	0.38	0.36	0.30	0.46	0.22	0.75	0.82	0.80	-	0.18	0.20	0.24	0.27	0.15	0.04
	≥ 60 in	.	0	0.40	0.22	0.22	0.78	0.56	0.33	0.78	-	0	0.22	0.22	0.25	0.13
Hardwoods	0-3 in	0.79	0.77	0.76	0.64	0.20	0.63	0.47	0.45	0.24	0	-	0.75	0.63	0.50	0
	3-12 in	0.77	0.65	0.68	0.64	0.25	0.62	0.49	0.49	0.19	0.08	0.56	-	0.85	0.14	0.14
	12-36 in	0.72	0.58	0.61	0.61	0.25	0.61	0.54	0.55	0.22	0.07	0.49	0.87	-	0.10	0.20
	36-60 in	.	0.25	0.25	0.44	0.56	0.56	0.44	0.44	0.44	0.22	0.25	0.22	0.11	-	0.22
	≥ 60 in	.	0	0.50	0.33	0.33	0	0.33	0.33	0.33	0.33	0	0.67	0.67	0.67	-
Snags, decay 1-2	0-3 in	0.73	0.67	0.63	0.65	0.28	0.77	0.77	0.74	0.36	0	0.55	0.47	0.36	0	0
	3-12 in	0.53	0.56	0.59	0.64	0.24	0.66	0.72	0.76	0.36	0	0.34	0.43	0.41	0	0
	12-36 in	0.46	0.45	0.50	0.64	0.23	0.68	0.74	0.81	0.34	0.05	0.27	0.41	0.44	0.08	0
	36-60 in	0.33	0.31	0.30	0.61	0.27	0.79	0.85	0.84	0.42	0.09	0.27	0.39	0.28	0.09	0
	≥ 60 in	0.33	0.22	0.44	0.44	0.22	0.89	1.00	0.89	0.33	0	0.17	0.33	0.33	0	0
Snags, decay 3-5	0-3 in	0.50	1.00	1.00	1.00	0	1.00	1.00	1.00	0	.	0	0	0	.	.
	3-12 in	0.40	0.35	0.50	0.62	0.15	0.69	0.88	0.88	0.44	0	0.14	0.31	0.25	0	0
	12-36 in	0.45	0.37	0.34	0.74	0.21	0.70	0.83	0.88	0.42	0	0.14	0.34	0.22	0	0
	36-60 in	0.65	0.34	0.37	0.60	0.32	0.72	0.85	0.82	0.54	0.11	0.31	0.39	0.39	0.21	0
	≥ 60 in	0	0.25	0.25	0.50	0.25	1.00	1.00	1.00	0.67	0	0.33	0.50	0.50	0	0

Table 6. Between-SDC (species-diameter class) spatial patterns of trees and snags at 14 late-successional and old-growth (LSOG) sites in western Oregon. The proportion of times SDC 1 (column 1) overlapped spatially with SDC 2 (columns 2-4 and 6-7) was calculated using data pooled from all sites where both SDC 1 and SDC 2 were present. For example, the proportion of times Douglas-fir in the 0-3 in diameter class (SDC 1) overlapped spatially with hardwoods in the 3-12 in diameter class (SDC 2) was 0.74. Proportions ≥ 0.50 appear in **bold**; proportions < 0.25 are *italicized*. A complete description of the characteristics associated with each snag decay class is found in Maser *et al.* (1988).

Species-Diameter Class		Snags, decay 1-2 0-3 in	3-12 in	12-36 in	36-60 in	> 60 in	Snags, decay 3-5 0-3 in	3-12 in	12-36 in	36-60 in	> 60 in
Douglas-fir	0-3 in	0.54	0.70	0.33	0.15	0.05	0.08	0.08	0.14	0.15	0
	3-12 in	0.48	0.70	0.34	0.14	0.06	0.09	0.09	0.16	0.13	0.11
	12-36 in	0.42	0.66	0.36	0.15	0.11	0.07	0.15	0.17	0.16	0.06
	36-60 in	0.30	0.44	0.32	0.21	0.07	0.07	0.12	0.22	0.19	0.05
	> 60 in	0.27	0.36	0.27	0.25	0.06	0	0.09	0.19	0.24	0.04
Other Conifers	0-3 in	0.31	0.39	0.30	0.26	0.08	0.11	0.12	0.19	0.21	0.07
	3-12 in	0.28	0.39	0.31	0.27	0.08	0.11	0.15	0.20	0.23	0.07
	12-36 in	0.28	0.39	0.33	0.28	0.07	0.13	0.15	0.20	0.23	0.08
	36-60 in	0.28	0.33	0.26	0.25	0.06	0	0.12	0.15	0.28	0.09
	> 60 in	0	0	0.11	0.13	0	.	0	0	0.33	0
Hardwoods	0-3 in	0.58	0.65	0.23	0.17	0.13	0	0.05	0.10	0.20	0.17
	3-12 in	0.36	0.56	0.27	0.19	0.10	0	0.07	0.18	0.19	0.13
	12-36 in	0.27	0.54	0.29	0.16	0.08	0	0.06	0.12	0.19	0.13
	36-60 in	0	0	0.11	0.11	0	.	0	0	0.33	0
	> 60 in	0	0	0	0	0	.	0	0	0	0
Snags, decay 1-2	0-3 in	-	0.73	0.46	0.18	0.04	0.33	0	0.13	0.14	0
	3-12 in	0.44	-	0.65	0.21	0.11	0.04	0.22	0.28	0.16	0.05
	12-36 in	0.37	0.85	-	0.23	0.09	0	0.27	0.28	0.13	0
	36-60 in	0.23	0.37	0.31	-	0.04	0	0.12	0.18	0.21	0
	> 60 in	0.14	0.56	0.44	0.20	-	.	0	0	0.22	0.50
Snags, decay 3-5	0-3 in	1.00	0.50	0	0	.	-	0	.	0	.
	3-12 in	0	0.54	0.65	0.25	0	0	-	0.92	0.38	0
	12-36 in	0.21	0.56	0.48	0.25	0	.	0.58	-	0.26	0.07
	36-60 in	0.20	0.33	0.20	0.27	0.08	0	0.26	0.26	-	0.07
	> 60 in	0	0.25	0	0	0.50	.	0	0.25	0.25	-

Table 6.—continued

of 80 ft^2 per *10* acres for western red cedar 2-3 ft dbh would allow managers to define LSOG structures at scales that are more realistic ecologically and operationally than would a basal area target of 8 ft^2 per *1* acre. Although 80 ft^2 per *10* acres is mathematically equivalent to 8 ft^2 per *1* acre, the former target affords managers more opportunities when working with young forests where accelerating the development of realistic LSOG forest structures is a management goal.

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Appendix 1

Mean number of trees/ac by species-diameter class (SDC) and level IV ecoregion. Standard deviations are shown in parentheses below each mean.

Level III	Level IV	Douglas-fir						Other Conifers						Grand
Ecoregion	Ecoregion	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
1. Coast Range	1b. Coastal Uplands	11.13	10.59	4.85	1.02	0.75	28.34	9.67	4.34	1.66	0.35	0.17	16.20	44.54
	(n = 14)	(7.03)	(7.24)	(2.84)	(0.56)	(1.13)	(15.23)	(6.84)	(3.88)	(1.84)	(0.45)	(0.29)	(11.78)	(16.04)
	1d. Volcanics	21.27	18.65	3.79	0.56	0.17	44.43	8.19	2.95	0.38	0.05	0.02	11.59	56.02
	(n = 64)	(14.45)	(8.61)	(3.06)	(1.00)	(0.41)	(20.02)	(11.48)	(4.47)	(0.72)	(0.15)	(0.13)	(16.28)	(21.01)
	1g. Mid-Coastal Sedimentary	14.77	11.10	5.84	2.05	0.81	34.58	9.02	2.18	0.77	0.18	0.05	12.20	46.78
	(n = 197)	(13.94)	(7.95)	(3.44)	(1.80)	(1.00)	(17.66)	(9.01)	(2.50)	(1.28)	(0.44)	(0.25)	(11.34)	(16.98)
	1h. Southern Oregon Coastal Mountains	10.42	8.89	4.04	1.21	0.82	25.37	6.94	1.12	0.33	0.08	0.01	8.48	33.85
	(n = 13)	(8.98)	(8.42)	(2.83)	(1.04)	(1.04)	(16.75)	(7.20)	(1.44)	(0.46)	(0.10)	(0.02)	(8.34)	(19.40)
3. Willamette Valley	3d. Valley Foothills	19.67	15.39	5.77	2.00	0.67	43.50	6.18	1.57	0.35	0.11	0.03	8.25	51.74
	(n = 30)	(13.04)	(8.30)	(2.78)	(1.15)	(0.58)	(19.55)	(5.81)	(2.07)	(0.55)	(0.18)	(0.07)	(8.17)	(18.20)
4. Cascades	4a. Western Cascades Lowlands and Valleys	18.66	11.35	5.54	2.10	0.79	38.44	13.94	4.17	1.16	0.14	0.01	19.43	57.86
	(n = 53)	(17.78)	(8.91)	(4.30)	(1.70)	(0.99)	(23.08)	(12.49)	(4.61)	(1.69)	(0.23)	(0.04)	(16.48)	(23.36)
	4b. Western Cascades Montane Highlands	6.84	6.53	5.79	2.24	0.65	22.05	20.91	13.14	5.28	0.58	0.02	39.93	61.98
	(n = 11)	(19.37)	(7.56)	(3.20)	(1.48)	(0.57)	(21.38)	(13.90)	(4.33)	(2.18)	(0.43)	(0.02)	(11.69)	(30.50)
	4f. Umpqua Cascades	16.52	9.81	5.21	1.96	0.41	33.91	16.37	3.85	1.66	0.57	0.09	22.55	56.45
	(n = 49)	(10.47)	(5.32)	(2.90)	(1.50)	(0.51)	(15.15)	(10.40)	(2.31)	(3.13)	(1.22)	(0.20)	(12.48)	(14.31)
78. Klamath Mountains	78b. Siskiyou Foothills	13.83	6.82	1.68	0.51	0.09	22.93	3.78	1.33	0.39	0.08	0.01	5.58	28.51
	(n = 20)	(20.11)	(3.65)	(1.13)	(0.76)	(0.16)	(23.32)	(3.86)	(1.52)	(0.60)	(0.10)	(0.02)	(4.55)	(24.96)
	78e. Inland Siskiyous	16.61	9.63	3.61	0.79	0.10	30.74	5.14	1.33	0.48	0.10	0.01	7.06	37.80
	(n = 115)	(12.33)	(6.02)	(2.86)	(1.01)	(0.20)	(16.79)	(6.68)	(1.63)	(0.58)	(0.17)	(0.03)	(8.06)	(19.56)
	All Units Combined	16.28	11.34	4.80	1.50	0.50	34.42	9.14	2.63	0.84	0.18	0.04	12.82	47.24
	(n = 586)	(14.32)	(7.95)	(3.45)	(1.59)	(0.80)	(19.27)	(9.88)	(3.40)	(1.57)	(0.48)	(0.17)	(13.20)	(20.71)

Appendix 2

Pair-wise differences between level IV ecoregions in terms of mean number of trees/ac (TPA), by species-diameter class (SDC). The values shown, the pair-wise differences between level IV ecoregion mean TPAs, are all significantly different than 0. For example, the Volcanics (1d) level IV ecoregion had an average of 6.49 TPA more Douglas-fir in the 1-2 ft diameter class than did the Mid-Coastal Sedimentary (1g) ecoregion. Empty cells indicate that the difference between means was not significantly different than 0. Significance was assessed for each combination of species group and diameter class using Tukey's Honest Significance Difference (HSD) method of multiple comparisons with an experiment-wise error rate of $\alpha = 0.05$. See Appendix 1 for the mean TPAs by species-diameter class (SDC) and level IV ecoregion.

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
1b - 1d	.	-8.06	.	.	.	.	.	.	.	.	.	.	.
1b - 1g	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 3d	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 4a	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 4b	.	.	.	.	.	.	.	-8.81	-3.62	.	.	-23.74	.
1b - 4f	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 78b	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 78e	.	.	.	.	.	.	.	3.01	.	.	0.16	.	.
1d - 1b	.	8.06	.	.	.	.	.	.	.	.	.	.	.
1d - 1g	6.49	7.54	-2.05	-1.49	-0.64	9.85	.	.	.	.	.	.	9.24
1d - 1h	.	9.75	.	.	.	19.05	.	.	.	.	.	.	22.16
1d - 3d	.	.	.	-1.44	.	.	.	.	.	.	.	.	.
1d - 4a	.	7.30	.	-1.54	-0.62	.	-5.75	.	.	.	.	-7.84	.
1d - 4b	.	12.12	.	-1.69	.	22.38	-12.72	-10.19	-4.91	-0.53	.	-28.34	.
1d - 4f	.	8.84	.	-1.40	.	.	-8.18	.	-1.29	-0.52	.	-10.96	.
1d - 78b	.	11.83	.	.	.	21.49	.	.	.	.	.	.	27.50
1d - 78e	.	9.02	.	.	.	13.68	.	1.62	.	.	.	.	18.21
1g - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
1g - 1d	-6.49	-7.54	2.05	1.49	0.64	-9.85	.	.	.	.	.	.	-9.24
1g - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
1g - 3d	.	.	.	.	.	.	.	.	.	.	.	.	.
1g - 4a	.	.	.	.	.	.	-4.92	-2.00	.	.	.	-7.23	-11.08
1g - 4b	.	.	.	.	.	.	-11.89	-10.96	-4.51	.	.	-27.73	.
1g - 4f	.	.	.	.	0.39	.	-7.35	-1.67	-0.89	-0.39	.	-10.34	.

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
1g - 78b	.	.	4.16	1.54	0.72	.	.	.	.	.	.	.	18.27
1g - 78e	.	.	2.23	1.25	0.71	.	3.88	.	.	.	.	5.14	8.97
1h - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 1d	.	-9.75	.	.	.	-19.05	.	.	.	.	.	.	-22.16
1h - 1g	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 3d	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 4a	.	.	.	.	.	.	.	-3.06	.	.	.	.	-24.01
1h - 4b	.	.	.	.	.	.	-13.97	-12.02	-4.95	.	.	-31.45	-28.12
1h - 4f	.	.	.	.	.	.	-9.44	.	.	-0.49	.	-14.06	-22.60
1h - 78b	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 78e	.	.	.	.	0.71	.	.	.	.	.	.	.	.
3d - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
3d - 1d	.	.	.	1.44	.	.	.	.	.	.	.	.	.
3d - 1g	.	.	.	.	.	.	.	.	.	.	.	.	.
3d - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
3d - 4a	.	.	.	.	.	.	-7.76	-2.61	.	.	.	-11.18	.
3d - 4b	.	8.86	.	.	.	21.45	-14.73	-11.57	-4.93	.	.	-31.68	.
3d - 4f	.	5.58	.	.	.	.	-10.19	-2.28	-1.31	-0.46	.	-14.30	.
3d - 78b	.	8.57	4.09	1.49	.	20.56	.	.	.	.	.	.	23.23
3d - 78e	.	5.76	2.16	1.20	0.57	12.75	.	.	.	.	.	.	13.94
4a - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
4a - 1d	.	-7.30	.	1.54	0.62	.	5.75	.	.	.	.	7.84	.
4a - 1g	.	.	.	.	.	.	4.92	2.00	.	.	.	7.23	11.08
4a - 1h	.	.	.	.	.	.	.	3.06	.	.	.	.	24.01
4a - 3d	.	.	.	.	.	.	7.76	2.61	.	.	.	11.18	.
4a - 4b	.	.	.	.	.	.	.	-8.97	-4.12	.	.	-20.50	.
4a - 4f	.	.	.	.	.	.	.	.	.	-0.43	.	.	.
4a - 78b	.	.	3.86	1.59	0.69	15.50	10.16	2.84	.	.	.	13.85	29.35

Appendix 2—continued

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
4a - 78e	.	.	1.93	1.31	0.68	.	8.80	2.85	.	.	.	12.37	20.06
4b - 1b	.	.	.	.	.	.	.	8.81	3.62	.	.	23.74	.
4b - 1d	.	-12.12	.	1.69	.	-22.38	12.72	10.19	4.91	0.53	.	28.34	.
4b - 1g	.	.	.	.	.	.	11.89	10.96	4.51	.	.	27.73	.
4b - 1h	.	.	.	.	.	.	13.97	12.02	4.95	.	.	31.45	28.12
4b - 3d	.	-8.86	.	.	.	-21.45	14.73	11.57	4.93	.	.	31.68	.
4b - 4a	.	.	.	.	.	.	.	8.97	4.12	.	.	20.50	.
4b - 4f	.	.	.	.	.	.	.	9.30	3.62	.	.	17.39	.
4b - 78b	.	.	4.11	1.73	.	.	17.13	11.81	4.90	.	.	34.35	33.47
4b - 78e	.	.	.	.	.	.	15.77	11.81	4.80	0.48	.	32.87	24.18
4f - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
4f - 1d	.	-8.84	.	1.40	.	.	8.18	.	1.29	0.52	.	10.96	.
4f - 1g	.	.	.	.	-0.39	.	7.35	1.67	0.89	0.39	.	10.34	.
4f - 1h	.	.	.	.	.	.	9.44	.	.	0.49	.	14.06	22.60
4f - 3d	.	-5.58	.	.	.	.	10.19	2.28	1.31	0.46	.	14.30	.
4f - 4a	.	.	.	.	.	.	.	.	.	0.43	.	.	.
4f - 4b	.	.	.	.	.	.	.	-9.30	-3.62	.	.	-17.39	.
4f - 78b	.	.	3.53	1.45	.	.	12.59	2.52	1.28	0.49	.	16.97	27.94
4f - 78e	.	.	.	1.16	.	.	11.24	2.52	1.18	0.47	.	15.49	18.65
78b - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
78b - 1d	.	-11.83	.	.	.	-21.49	.	.	.	.	.	.	-27.50
78b - 1g	.	.	-4.16	-1.54	-0.72	.	.	.	.	.	.	.	-18.27
78b - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
78b - 3d	.	-8.57	-4.09	-1.49	.	-20.56	.	.	.	.	.	.	-23.23
78b - 4a	.	.	-3.86	-1.59	-0.69	-15.50	-10.16	-2.84	.	.	.	-13.85	-29.35
78b - 4b	.	.	-4.11	-1.73	.	.	-17.13	-11.81	-4.90	.	.	-34.35	-33.47
78b - 4f	.	.	-3.53	-1.45	.	.	-12.59	-2.52	-1.28	-0.49	.	-16.97	-27.94

Appendix 2—continued

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
78b - 78e	.	.	.	.	.	.	.	.	.	.	.	.	.
78e - 1b	.	.	.	.	.	.	.	-3.01	.	.	-0.16	.	.
78e - 1d	.	-9.02	.	.	.	-13.68	.	-1.62	.	.	.	.	-18.21
78e - 1g	.	.	-2.23	-1.25	-0.71	.	-3.88	.	.	.	.	-5.14	-8.97
78e - 1h	.	.	.	.	-0.71	.	.	.	.	.	.	.	.
78e - 3d	.	-5.76	-2.16	-1.20	-0.57	-12.75	.	.	.	.	.	.	-13.94
78e - 4a	.	.	-1.93	-1.31	-0.68	.	-8.80	-2.85	.	.	.	-12.37	-20.06
78e - 4b	.	.	.	.	.	.	-15.77	-11.81	-4.80	-0.48	.	-32.87	-24.18
78e - 4f	.	.	.	-1.16	.	.	-11.24	-2.52	-1.18	-0.47	.	-15.49	-18.65
78e - 78b	.	.	.	.	.	.	.	.	.	.	.	.	.

Appendix 2—continued

Appendix 3

Mean basal area (ft^2/ac) by species-diameter class and level IV ecoregion. Standard deviations are shown in parentheses below each mean.

Level III Ecoregion	Level IV Ecoregion	Douglas-fir 1-2 ft	Douglas-fir 2-3 ft	Douglas-fir 3-4 ft	Douglas-fir 4-5 ft	Douglas-fir ≥ 5 ft	Douglas-fir Total	Other Conifers 1-2 ft	Other Conifers 2-3 ft	Other Conifers 3-4 ft	Other Conifers 4-5 ft	Other Conifers ≥ 5 ft	Other Conifers Total	Grand Total
1. Coast Range	1b. Coastal Uplands	19.7	52.0	46.6	16.3	23.6	158.2	17.1	21.3	16.0	5.6	4.9	64.9	223.1
	(n = 14)	(12.4)	(35.6)	(27.3)	(8.9)	(38.9)	(72.4)	(12.1)	(19.1)	(17.7)	(7.2)	(9.1)	(56.8)	(84.8)
	1d. Volcanics	37.6	91.5	36.5	8.8	4.4	178.8	14.5	14.5	3.6	0.8	0.7	34.1	212.9
	(n = 64)	(25.5)	(42.3)	(29.4)	(15.8)	(10.7)	(67.9)	(20.3)	(22.0)	(6.9)	(2.3)	(4.3)	(50.1)	(63.2)
	1g. Mid-Coastal Sedimentary	26.1	54.5	56.2	32.6	21.3	190.7	15.9	10.7	7.5	2.9	1.3	38.2	229.0
	(n = 197)	(24.6)	(39.0)	(33.1)	(28.7)	(26.9)	(63.4)	(15.9)	(12.3)	(12.3)	(7.0)	(6.5)	(40.1)	(67.2)
	1h. Southern Oregon Coastal Mountains	18.4	43.7	38.9	19.2	22.2	142.3	12.3	5.5	3.2	1.3	0.3	22.5	164.8
	(n = 13)	(15.9)	(41.3)	(27.2)	(16.6)	(28.5)	(66.5)	(12.7)	(7.1)	(4.4)	(1.6)	(0.4)	(21.4)	(70.0)
3. Willamette Valley	3d. Valley Foothills	34.8	75.5	55.5	31.7	17.2	214.8	10.9	7.7	3.4	1.8	0.8	24.6	239.4
	(n = 30)	(23.0)	(40.7)	(26.7)	(18.3)	(15.3)	(65.9)	(10.3)	(10.1)	(5.3)	(2.8)	(1.8)	(26.5)	(56.8)
4. Cascades	4a. Western CascadesLowlands and Valleys	33.0	55.7	53.3	33.4	20.7	196.1	24.6	20.5	11.2	2.2	0.3	58.8	254.9
	(n = 53)	(31.4)	(43.7)	(41.3)	(27.1)	(26.5)	(76.0)	(22.1)	(22.6)	(16.2)	(3.7)	(1.0)	(53.8)	(55.3)
	4b. Western Cascades Montane Highlands	12.1	32.0	55.7	35.7	16.5	152.0	36.9	64.5	50.8	9.3	0.4	161.9	313.9
	(n = 11)	(34.2)	(37.1)	(30.8)	(23.5)	(14.6)	(41.8)	(24.6)	(21.3)	(20.9)	(6.9)	(0.5)	(30.4)	(40.2)
	4f. Umpqua Cascades	29.2	48.1	50.1	31.1	10.0	168.6	28.9	18.9	16.0	9.1	2.3	75.2	243.8
	(n = 49)	(18.5)	(26.1)	(27.9)	(23.9)	(12.5)	(66.2)	(18.4)	(11.4)	(30.1)	(19.4)	(4.9)	(55.7)	(60.7)
78. Klamath Mountains	78b. Siskiyou Foothills	24.4	33.5	16.2	8.1	2.2	84.4	6.7	6.5	3.7	1.2	0.2	18.3	102.7
	(n = 20)	(35.5)	(17.9)	(10.9)	(12.1)	(3.8)	(59.1)	(6.8)	(7.4)	(5.8)	(1.6)	(0.6)	(15.7)	(62.2)
	78e. Inland Siskiyous	29.4	47.3	34.7	12.6	2.5	126.5	9.1	6.5	4.6	1.7	0.2	22.1	148.6
	(n = 115)	(21.8)	(29.5)	(27.5)	(16.0)	(4.9)	(64.7)	(11.8)	(8.0)	(5.6)	(2.7)	(0.7)	(22.5)	(70.2)
	All Units Combined	28.8	55.7	46.2	23.8	13.2	167.7	16.1	12.9	8.0	2.8	1.0	40.9	208.6
	(n = 586)	(25.3)	(39.0)	(33.2)	(25.3)	(21.8)	(74.1)	(17.5)	(16.7)	(15.1)	(7.7)	(4.6)	(46.2)	(79.0)

Appendix 4

Pair-wise differences between level IV ecoregions in terms of mean basal area (BA, ft^2/ac), by species-diameter class (SDC). The values shown, the pair-wise differences between level IV ecoregion mean BAs, are all significantly different than 0. For example, the Volcanics (1d) level IV ecoregion had an average of 11.5 more BA in the Douglas-fir 1-2 ft diameter class than did the Mid-Coastal Sedimentary (1g) ecoregion. Empty cells indicate that the difference between means was not significantly different than 0. Significance was assessed for each combination of species group and diameter class using Tukey's Honest Significance Difference method of multiple comparisons with an experiment-wise error rate of $\alpha = 0.05$. See Appendix 3 for the mean BAs by SDC and level IV ecoregion.

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
1b - 1d	.	-39.6	.	.	.	.	.	.	.	.	.	.	.
1b - 1g	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 3d	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 4a	.	.	.	.	.	.	.	.	.	.	4.7	.	.
1b - 4b	.	.	.	.	.	.	.	-43.2	-34.8	.	.	-97.0	-90.8
1b - 4f	.	.	.	.	.	.	.	.	.	.	.	.	.
1b - 78b	.	.	.	.	.	73.7	.	.	.	.	.	46.6	120.3
1b - 78e	.	.	.	.	21.1	.	.	14.8	.	.	4.7	42.8	74.5
1d - 1b	.	39.6	.	.	.	.	.	.	.	.	.	.	.
1d - 1g	11.5	37.0	-19.7	-23.7	-16.9	.	.	.	.	.	.	.	.
1d - 1h	.	47.9	.	.	.	.	.	.	.	.	.	.	.
1d - 3d	.	.	.	-22.9	.	.	.	.	.	.	.	.	.
1d - 4a	.	35.8	.	-24.6	-16.3	.	-10.2	.	.	.	.	-24.7	-42.0
1d - 4b	.	59.5	.	-26.8	.	.	-22.5	-50.0	-47.2	-8.5	.	-127.8	-101.0
1d - 4f	.	43.4	.	-22.3	.	.	-14.5	.	-12.4	-8.3	.	-41.1	.
1d - 78b	.	58.1	.	.	.	94.4	.	.	.	.	.	.	110.2
1d - 78e	.	44.3	.	.	.	52.4	.	8.0	.	.	.	.	64.3
1g - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
1g - 1d	-11.5	-37.0	19.7	23.7	16.9	.	.	.	.	.	.	.	.
1g - 1h	.	.	.	.	.	.	.	.	.	.	.	.	64.1
1g - 3d	.	.	.	.	.	.	.	.	.	.	.	.	.
1g - 4a	.	.	.	.	.	.	-8.7	-9.8	.	.	.	-20.6	.
1g - 4b	.	.	.	.	.	.	-21.0	-53.8	-43.4	.	.	-123.7	-84.9

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
1g - 4f	.	.	.	.	11.3	.	-13.0	-8.2	-8.6	-6.2	.	-36.9	.
1g - 78b	.	.	40.0	24.5	19.1	106.3	.	.	.	.	.	.	126.2
1g - 78e	.	.	21.5	19.9	18.8	64.3	6.9	.	.	.	.	16.1	80.4
1h - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 1d	.	-47.9	.	.	.	.	.	.	.	.	.	.	.
1h - 1g	.	.	.	.	.	.	.	.	.	.	.	.	-64.1
1h - 3d	.	.	.	.	.	-72.5	.	.	.	.	.	.	-74.6
1h - 4a	.	.	.	.	.	.	.	-15.0	.	.	.	.	-90.1
1h - 4b	.	.	.	.	.	.	-24.7	-59.0	-47.6	.	.	-139.4	-149.1
1h - 4f	.	.	.	.	.	.	-16.7	.	.	-7.8	.	-52.6	-79.0
1h - 78b	.	.	.	.	.	.	.	.	.	.	.	.	.
1h - 78e	.	.	.	.	19.7	.	.	.	.	.	.	.	.
3d - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
3d - 1d	.	.	.	22.9	.	.	.	.	.	.	.	.	.
3d - 1g	.	.	.	.	.	.	.	.	.	.	.	.	.
3d - 1h	.	.	.	.	.	72.5	.	.	.	.	.	.	74.6
3d - 4a	.	.	.	.	.	.	-13.7	-12.8	.	.	.	-34.2	.
3d - 4b	.	43.5	.	.	.	.	-26.0	-56.8	-47.4	.	.	-137.3	-74.5
3d - 4f	.	27.4	.	.	.	.	-18.0	-11.2	-12.6	-7.3	.	-50.5	.
3d - 78b	.	42.1	39.3	23.6	.	130.3	.	.	.	.	.	.	136.6
3d - 78e	.	28.3	20.8	19.1	14.7	88.3	.	.	.	.	.	.	90.8
4a - 1b	.	.	.	.	.	.	.	.	.	.	-4.7	.	.
4a - 1d	.	-35.8	.	24.6	16.3	.	10.2	.	.	.	.	24.7	42.0
4a - 1g	.	.	.	.	.	.	8.7	9.8	.	.	.	20.6	.
4a - 1h	.	.	.	.	.	.	.	15.0	.	.	.	.	90.1
4a - 3d	.	.	.	.	.	.	13.7	12.8	.	.	.	34.2	.
4a - 4b	.	.	.	.	.	.	.	-44.0	-39.6	.	.	-103.1	.
4a - 4f	.	.	.	.	.	.	.	.	.	-6.9	.	.	.

Appendix 4—continued

Appendix 4—continued

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
4a - 78b	.	.	37.1	25.3	18.5	111.6	18.0	14.0	.	.	.	40.5	152.2
4a - 78e	.	.	18.6	20.8	18.2	69.6	15.6	14.0	.	.	.	36.7	106.3
4b - 1b	.	.	.	.	.	.	.	43.2	34.8	.	.	97.0	90.8
4b - 1d	.	-59.5	.	26.8	.	.	22.5	50.0	47.2	8.5	.	127.8	101.0
4b - 1g	.	.	.	.	.	.	21.0	53.8	43.4	.	.	123.7	84.9
4b - 1h	.	.	.	.	.	.	24.7	59.0	47.6	.	.	139.4	149.1
4b - 3d	.	-43.5	.	.	.	.	26.0	56.8	47.4	.	.	137.3	74.5
4b - 4a	.	.	.	.	.	.	.	44.0	39.6	.	.	103.1	.
4b - 4f	.	.	.	.	.	.	.	45.6	34.8	.	.	86.8	70.1
4b - 78b	.	.	39.5	27.6	.	.	30.3	58.0	47.1	.	.	143.6	211.2
4b - 78e	.	.	.	.	.	.	27.9	58.0	46.2	7.6	.	139.8	165.3
4f - 1b	.	.	.	.	.	.	.	.	.	.	.	.	.
4f - 1d	.	-43.4	.	22.3	.	.	14.5	.	12.4	8.3	.	41.1	.
4f - 1g	.	.	.	.	-11.3	.	13.0	8.2	8.6	6.2	.	36.9	.
4f - 1h	.	.	.	.	.	.	16.7	.	.	7.8	.	52.6	79.0
4f - 3d	.	-27.4	.	.	.	.	18.0	11.2	12.6	7.3	.	50.5	.
4f - 4a	.	.	.	.	.	.	.	.	.	6.9	.	.	.
4f - 4b	.	.	.	.	.	.	.	-45.6	-34.8	.	.	-86.8	-70.1
4f - 78b	.	.	33.9	23.0	.	84.2	22.3	12.4	12.3	7.9	.	56.9	141.1
4f - 78e	.	.	.	18.5	.	42.2	19.9	12.4	11.4	7.4	.	53.1	95.2
78b - 1b	.	.	.	.	.	-73.7	.	.	.	.	.	-46.6	-120.3
78b - 1d	.	-58.1	.	.	.	-94.4	.	.	.	.	.	.	-110.2
78b - 1g	.	.	-40.0	-24.5	-19.1	-106.3	.	.	.	.	.	.	-126.2
78b - 1h	.	.	.	.	.	.	.	.	.	.	.	.	.
78b - 3d	.	-42.1	-39.3	-23.6	.	-130.3	.	.	.	.	.	.	-136.6
78b - 4a	.	.	-37.1	-25.3	-18.5	-111.6	-18.0	-14.0	.	.	.	-40.5	-152.2
78b - 4b	.	.	-39.5	-27.6	.	.	-30.3	-58.0	-47.1	.	.	-143.6	-211.2
78b - 4f	.	.	-33.9	-23.0	.	-84.2	-22.3	-12.4	-12.3	-7.9	.	-56.9	-141.1

Appendix 4—continued

	Douglas-fir						Other Conifers						Grand
Comparison	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	1-2 ft	2-3 ft	3-4 ft	4-5 ft	≥ 5 ft	Total	Total
78b - 78e	.	.	.	.	.	.	.	.	.	.	.	.	.
78e - 1b	.	.	.	.	-21.1	.	.	-14.8	.	.	-4.7	-42.8	-74.5
78e - 1d	.	-44.3	.	.	.	-52.4	.	-8.0	.	.	.	.	-64.3
78e - 1g	.	.	-21.5	-19.9	-18.8	-64.3	-6.9	.	.	.	.	-16.1	-80.4
78e - 1h	.	.	.	.	-19.7	.	.	.	.	.	.	.	.
78e - 3d	.	-28.3	-20.8	-19.1	-14.7	-88.3	.	.	.	.	.	.	-90.8
78e - 4a	.	.	-18.6	-20.8	-18.2	-69.6	-15.6	-14.0	.	.	.	-36.7	-106.3
78e - 4b	.	.	.	.	.	.	-27.9	-58.0	-46.2	-7.6	.	-139.8	-165.3
78e - 4f	.	.	.	-18.5	.	-42.2	-19.9	-12.4	-11.4	-7.4	.	-53.1	-95.2
78e - 78b	.	.	.	.	.	.	.	.	.	.	.	.	.