Return to Part A

(Healey and others 2005) and tasseled cap transformations (Crist and Cicone 1984, Kauth and Thomas 1976). Cohen and Fiorella (1998) and Cohen and others (1998) found tasseled-cap-transformed data to be nearly equivalent to aerial photography for identifying stand-replacing disturbance. Postprocessing involved passing a majority 3- by 3-pixel filter over the image and automatically eliminating patches of less than 5 ac to remove false change caused by image misregistration. Some manual cleanup was also employed, and disturbances owing to fire were distinguished from those owing to harvest by using rules based on size and shape of disturbance. Other disturbance agents (landslide, rivercourse change) were explicitly excluded from the map by using hand editing.

Change detection in California—
Changes to older forests within the Plan area in California were mapped as part of the California Land Cover Mapping and Monitoring Program (Levien and others 1998, http://frap.cdf.ca.gov/projects/land_cover/index.html). We used information from three portions of this program in our trend analysis. These were the Cascade Northeast project area, mapped between 1994 and 1999 (Levien and others 2003a), the North Coast project area, mapped between 1994 and 1998 (Levien and others, 2003b), and the combination of these project areas mapped through 2003 (table 10). Data from these three projects were combined and clipped to the Plan boundary in California for analysis (fig. 9).

The California change-detection project used Landsat TM imagery to classify vegetation change. Briefly, the methodology followed these main steps: registration of images from times 1 and 2; radiometric correction to remove differences in atmospheric conditions; analysis of tasseled cap differences between the two dates; classifying the magnitude and direction of change into several categories, from large decreases in vegetation to large increases in vegetation; and labeling the cause of change. A more detailed description of the change-detection procedures can be found in Levien and others (1998, 1999, 2003a, 2003b).

In California, vegetation change was mapped in categorical decrease and increase classes. We used only the class labeled as "large decrease" (71 to 100 percent decrease in canopy cover) in our monitoring assessment. This class paralleled the stand-replacing disturbance class mapped in Oregon and Washington project areas (that is, disturbances that result in more or less full removal of the existing tree canopy). In the California change map, we eliminated mapped changed patches less than 5 ac, to be consistent with the mapping resolution in Washington and Oregon.

Disturbance map accuracy assessment—
In California, Forest Inventory and Analysis plots were used as reference values to assess the accuracy of the disturbance maps. Error matrices summarizing absolute and fuzzy accuracies were constructed, similar to the methods described for assessing the CALVEG maps (app. 4). In Washington and Oregon, quality of the disturbance maps was assessed by using visual pixel-level interpretation of the original Landsat imagery, as described in detail by Cohen and others (1998, 2002).

Stand-replacing disturbances are typically large, demarcated events that are readily detected with remote sensing. This is reflected in high overall accuracy values. Accuracies range from about 78 percent to greater than 90 percent in mapping stand-replacing disturbances (Cohen and others 1998, 2002; Healey and others in press; Levien and others 2003a, 2003b). The results are summarized in appendix 5.

Trend Analysis: Remeasured Plot Data Methods

The analysis of older forest change with inventory plots as the data source complemented the analysis of change that used remote-sensing change-detection maps. Remeasured plots were used to assess net change, including vegetation decreases from partial disturbance such as surface fires or thinning harvest, as well as increases resulting from regrowth following stand disturbance and recruitment into older forest classes from younger classes. Change estimates made from plot data have the disadvantage that they are nonspatial data, and thus gain and loss estimates from them cannot be displayed easily on a map. Plots representing approximately 47 percent of inventoried area had been

sampled a second time by the time this change analysis was conducted (table 9). The remeasurement period (number of years between the first and second measurements) averaged 4.08 years across the Plan area.

We used the remeasured plot data to estimate rates of change in forest vegetation classes in the following manner. Each remeasured sample was assigned to one of two size classes (<20 in or 20 in) at each measurement occasion. The 20-in class is equivalent to our "medium and large" older forest class. Then a matrix was constructed summarizing transitions between classes. Values in the matrix were acres annualized by dividing by the length of the interval between remeasurements, in years. We calculated the percentage of samples moving between size classes as an annual rate of change, R, weighted by acres sampled, by using the formula,

$$R = 100\left(\frac{\sum_{i=1}^{n}\delta_i\left(\frac{A_i}{P_i}\right)}{\sum_{i=1}^{n}\frac{A_i}{P_i}}\right),$$

where

n is the number of remeasured sample plots,

A_i is the sampling weight in acres for plot *i*,

P_i is the length of the remeasurement period in years for plot *i*,

$$\delta_i \begin{cases} 1 & \text{if } S_{T_1} < 20 \text{ in and } S_{T_2} \geq 20 \text{ in} \\ -1 & \text{if } S_{T_1} \geq 20 \text{ in and } S_{T_2} < 20 \text{ in} \\ 0 & \text{otherwise} \end{cases},$$

S_{T_1} and S_{T_2} are size class at measurement times 1 and 2, respectively.

The net transition rate was then applied to the baseline estimate (that is, at time 1) of "medium and large older forest" and extrapolated to a 10-year basis to estimate the magnitude of acres transitioning into or out of "medium and large older forest" between 1994 and 2003. This approach assumes that average rate of change is constant over the 10-year period. The estimate from the remeasured plot approach represents net change resulting after losses from fire and harvest and gains from growth.

Fire Regime Analysis

We analyzed the older forest baseline amounts against coarse-scale information about fire regimes. In particular, we were interested in the general distribution of older for-ests mapped at the baseline within fire regimes. At one ex-treme, historical fire regimes in the Plan area are characterized by long fire-return intervals and stand-replacing fires (such as in the Washington Olympic Peninsula province). At the other extreme are provinces where historically, fre-quent fires burned with low intensity (such as the Klamath provinces). To analyze the distribution of baseline older forests with respect to fire regimes, we grouped older for-ests into broad climatic areas and fire regime classes based on physiographic province and potential natural vegetation zone. Oregon Coast Range, California Coast Range, Washington Olympic Peninsula, Oregon Willamette Valley, and Washington Western Lowlands were placed in the Coast climatic area, Washington Western Cascades and Oregon Western Cascades in the West Cascades, Washington Eastern Cascades, Oregon Eastern Cascades, and California Cascades in the East Cascades, and Oregon Klamath and California Klamath in the Klamath climatic area. Vegetation zone groups were classed according to the degree to which they represent naturally fire-adapted ecosystems (that is, vegetation types that have evolved in concert with frequent, low-severity fires). Interior Douglas-fir, dry firs, dry/mixed conifers, oaks, pines, and tanoak/Douglas-fir vegetation zone groups were categorized as "fire adapted," and all other vegetation zone groups were categorized as "not fire adapted." Then we calculated fire-adapted acres of older forests by climatic area to broadly assess older forest risk to wildfire.

We also intersected the older forest data with a map showing the relationship between historical and current fire regime (frequency and severity). Fire regimes and condition classes for the Northwest Forest Plan area are displayed in fig. 10 (Hardy and others 2001, Schmidt and others 2002).

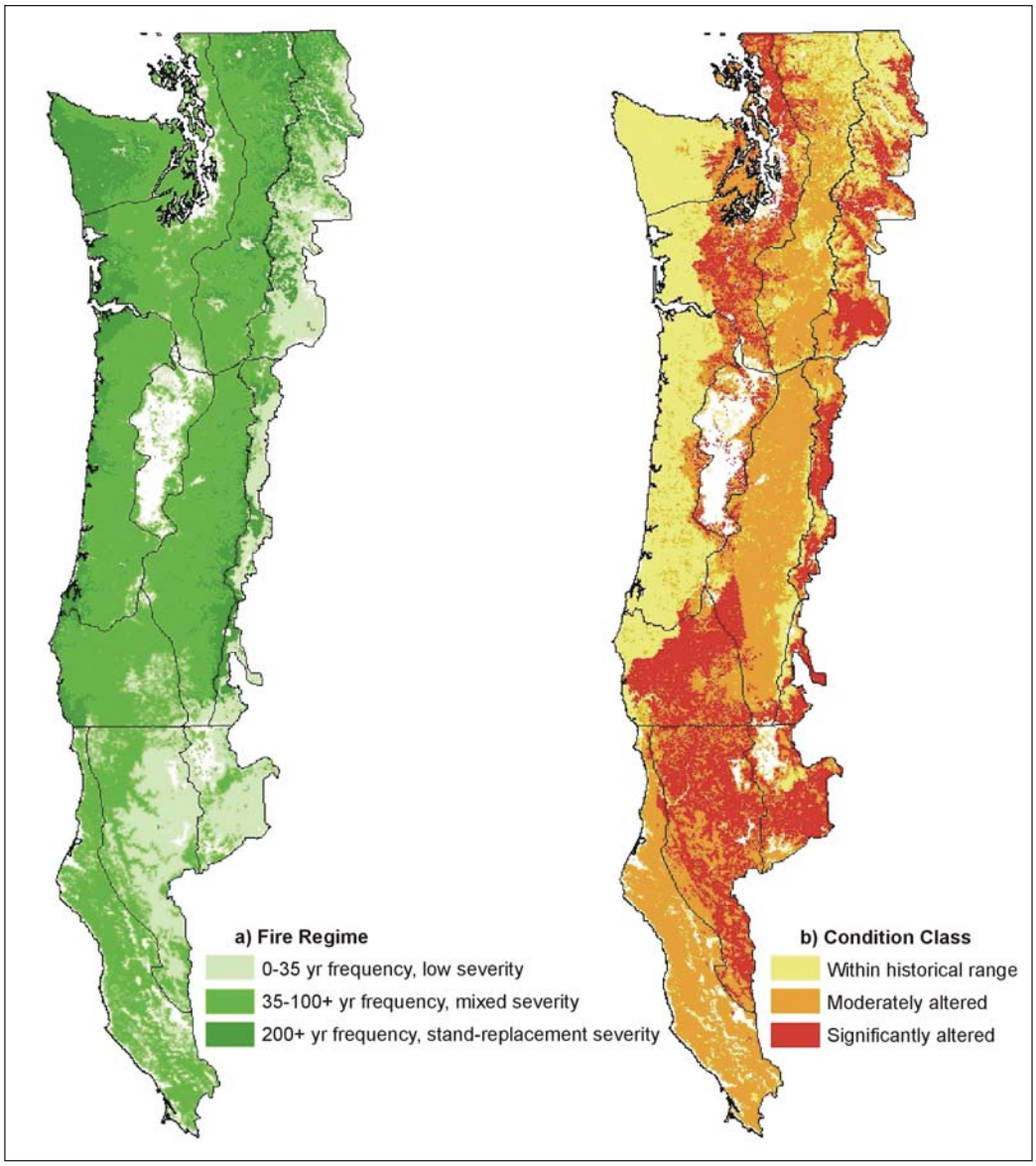


Figure 10—Fire regime and condition class mapped for the Northwest Forest Plan area by Hardy and others (2001) (http://www.fs.fed.us/fire/fuelman). See sidebar 4 for explanation of classes. There is considerable controversy over the appropriateness of using the national classification for forests of the Pacific Northwest. (See text for more discussion.)

The map, developed at the national scale, represents a coarse-level view (1-km^2) (0.386-mi^2) of the degree of departure of current vegetation conditions from an historical fire regime. Fire regime is the characteristic mix of fire frequency and severity for a landscape of interest and is heavily influenced by climate, soils, topography, and vegetation (Schmidt and others 2002). Condition class is a measure of departure from the historical range of seral stages, fire frequency, and fire severity and can be described as both a continuous and categorical variable. For ease of communication, fire regimes and condition class are usually expressed categorically. Condition class 1 areas are functioning within the historical range. Condition class 2 and 3 areas are moderately or significantly altered from the historical range, respectively.

Sidebar 4—Interpreting Fire Regime Condition Classes

Fire regime condition classes measure the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components (from Hardy and others 2001)

Historical Natural Fire Regime–fire frequency and severity

Fire frequency is the average number of years between fires.

Severity is the effect of the fire on the dominant overstory vegetation. Low-severity fires are fires in which >70 percent of the basal area and >90 percent of the canopy cover survives. Mixed-severity: moderate effects on the overstory, mixed mortality. Stand-replacement fires consume or kill >80 percent of basal area or >90 percent of overstory canopy cover.

Code	Description of historical natural fire regime
1	0-35-yr frequency, low severity
2	0-35-yr frequency, stand-replacement severity
3	35-100+ yr frequency, mixed severity
4	35-100+ yr frequency, stand-replacement severity
5	200+ yr frequency, stand-replacement severity

Interpretation:

1: Found in forests that experience frequent, low-severity, nonlethal surface fires.

2: Found primarily in grass and shrublands.

3, 4, 5: Can occur in any vegetation type.

Condition class measures the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components

Code	Description of condition class
1	Fire regimes within or near historical range; risk of losing key ecosystem components is low.
2	Fire regimes moderately altered from historical range; risk of losing key ecosystem components is moderate.
3	Fire regimes significantly altered from historical range; risk of losing key ecosystem components is high.
0	Fire regimes unknown because of 1-km mapping resolution.

Interpretation:

1: Species composition and structure are intact and functioning within historical range. Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire use.

2: Areas are moderately departed from historical conditions, often having missed at least one fire-return interval (or in some ecosystems, experiencing fires more frequently than occurred historically). Fuels are often accumulating to high levels in these areas. May need moderate levels of restoration treatments to be restored to historical regime.

3: Areas are greatly departed from historical conditions, often having missed two or more fire-return intervals, with associated buildup of fuel. May need high levels of restoration treatments to be restored to historical regime. The amount of effort to restore areas generally increases with condition class; for example, restoring condition class 3 to 2 will be more expensive and time-consuming than restoring from condition class 2 to 1.

The analysis using the national fire regime condition class map should be viewed only as a rough first approximation of the fire situation for older forests at the start of the Plan. The map was based on a 1-km^2 (0.386-mi^2) resolution map prepared for a quick national "snapshot" of conditions in 2000. Perhaps more importantly, this map shows fire regimes influenced by all disturbances (not only fire), including human-caused urban development, logging, and agriculture. Areas with condition class 2 and 3 in western Washington and northwest Oregon often result from patterns of these human-caused disturbances, rather than from fire suppression. Also, the national map is missing a moderate- or mixed-severity fire regime class considered prevalent in parts of the Plan area, especially in the Cascades Range where the fire regimes are a complex mixture of stand-replacing and low-severity fires (Agee 1993, 2003; Spies, in press). A later section in this report touches on work in progress to improve fire regime and condition class maps for the Pacific Northwest.

Results—Older Forests at the Start of the Northwest Forest Plan

We mapped existing vegetation and older forest at the beginning of the Plan from the satellite data. The distribution of forested land mapped by average topstory tree size, canopy layering, and life form classes (table 1) is displayed for the entire Plan area (all ownerships) in figure 11. Three maps corresponding to the "medium and large older forest," "large, multistoried older forest," and "older forest with size indexed to potential natural vegetation zone" definitions are displayed in figure 12. The older forest maps are accessible online for readers wishing to view them with additional resolution (http://www.reo.gov/monitoring/).

Older Forest Distribution

Estimates derived from the older forest maps showed that the proportion of the federally managed land area occupied by older forests at the start of the Plan ranged from 30 per--cent of forest-capable area (7.04 million ac ± 1.93 million ac) by the "older forest with size indexed to potential natural vegetation zone" definition, to 34 percent of forest-capable area (7.87 million ac ± 1.96 million ac) by the "medium and large older forest" definition (table 11). Twelve percent of federal forest-capable land was occupied by "large, multistoried older forest" (2.72 million ac ± 0.35 million ac). The estimates of prediction error placed around the acres for each older forest definition were based on within-province overall map accuracies (table 6) by using the standard formula for the variance of stratified sampling for proportions (Cochran 1977).

Distributions of "medium and large older forest" and "older forest with size indexed to potential natural vegetation zone" were quite different (table 11). In general, applying the "medium and large" definition predicted relatively more area occupied by older forests in the provinces west of the Cascade crest, and relatively less area in the eastern Cascades provinces when compared with predictions made applying the "older forest with size indexed to potential natural vegetation zone" definition. This was because the constant average-tree-size criterion used in the "medium and large older forest" definition (minimum 20 in) tended to predict relatively lower amounts of older forest in potential natural vegetation zones where forest productivity is naturally low (for example, in the dry forests of the eastern Cascades and at higher elevations), and relatively higher amounts in very productive forests (for example, in moist coastal forests). Areas predicted as occupied by "large, multistoried older forest," which is a subset of "medium and large older forest," were concentrated in the Oregon and California Coast Range, Washington Olympic Peninsula, Washington and Oregon Western Cascades, and Oregon and California Klamath provinces.

Of the total amount of older forest in the Plan area, about three-quarters was in the provinces of the Western Cascades (Washington Western Cascades and Oregon Western Cascades) and Klamath Mountains (Oregon Klamath and California Klamath), by any of the definitions (fig. 13). The Coastal provinces (Washington Olympic Peninsula, Oregon Coast Range, and California Coast Range) contained 24 percent of the total "large, multistoried older forest" in the Plan area, 17 percent of total "medium and large older forest," and 14 percent of total "older forest

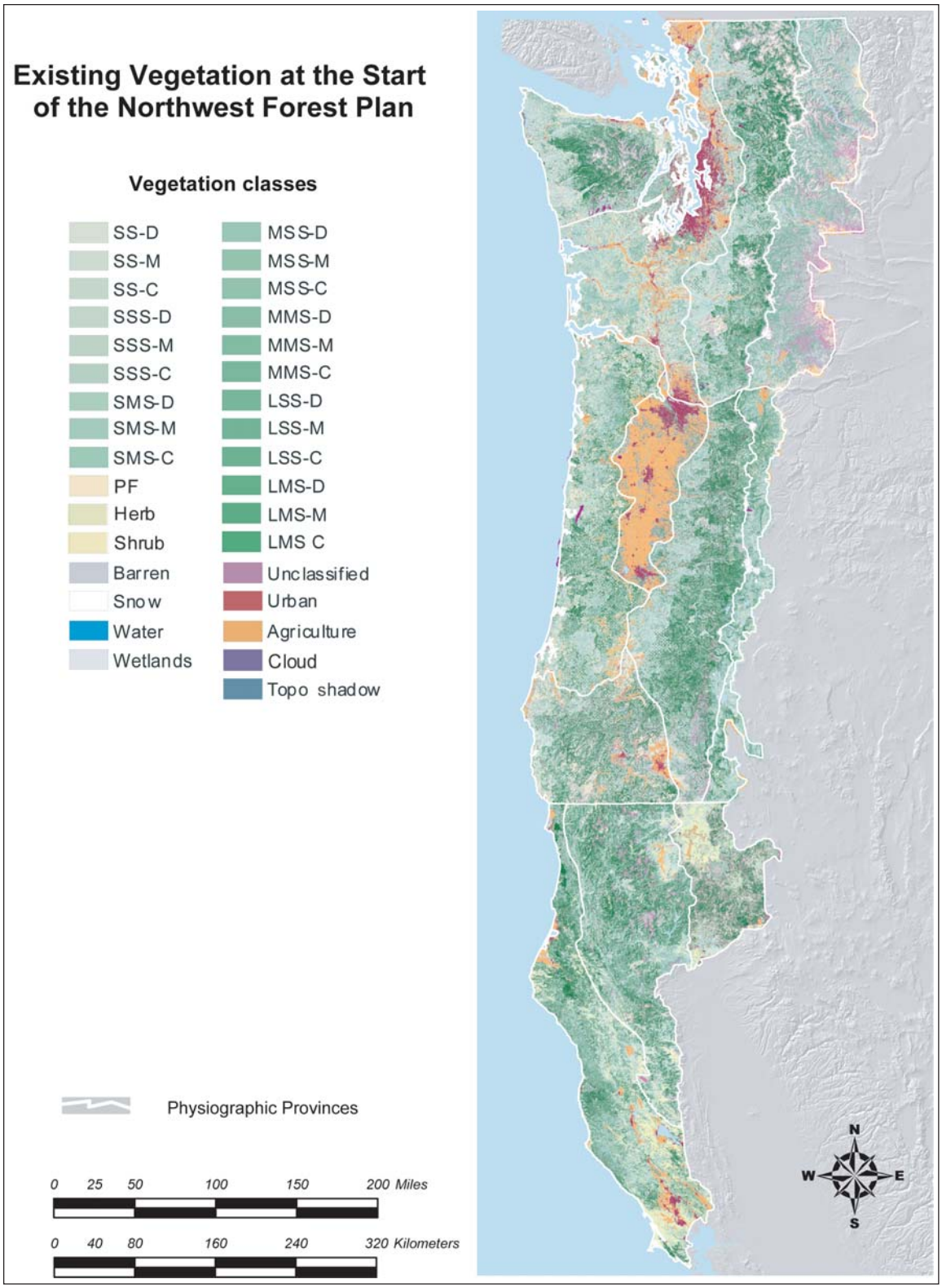


Figure 11—Existing vegetation at the start of the Northwest Forest Plan. Classes are mapped from IVMP and CALVEG based on average tree size, canopy closure, canopy layering, and life form (see table 1 for code definitions).

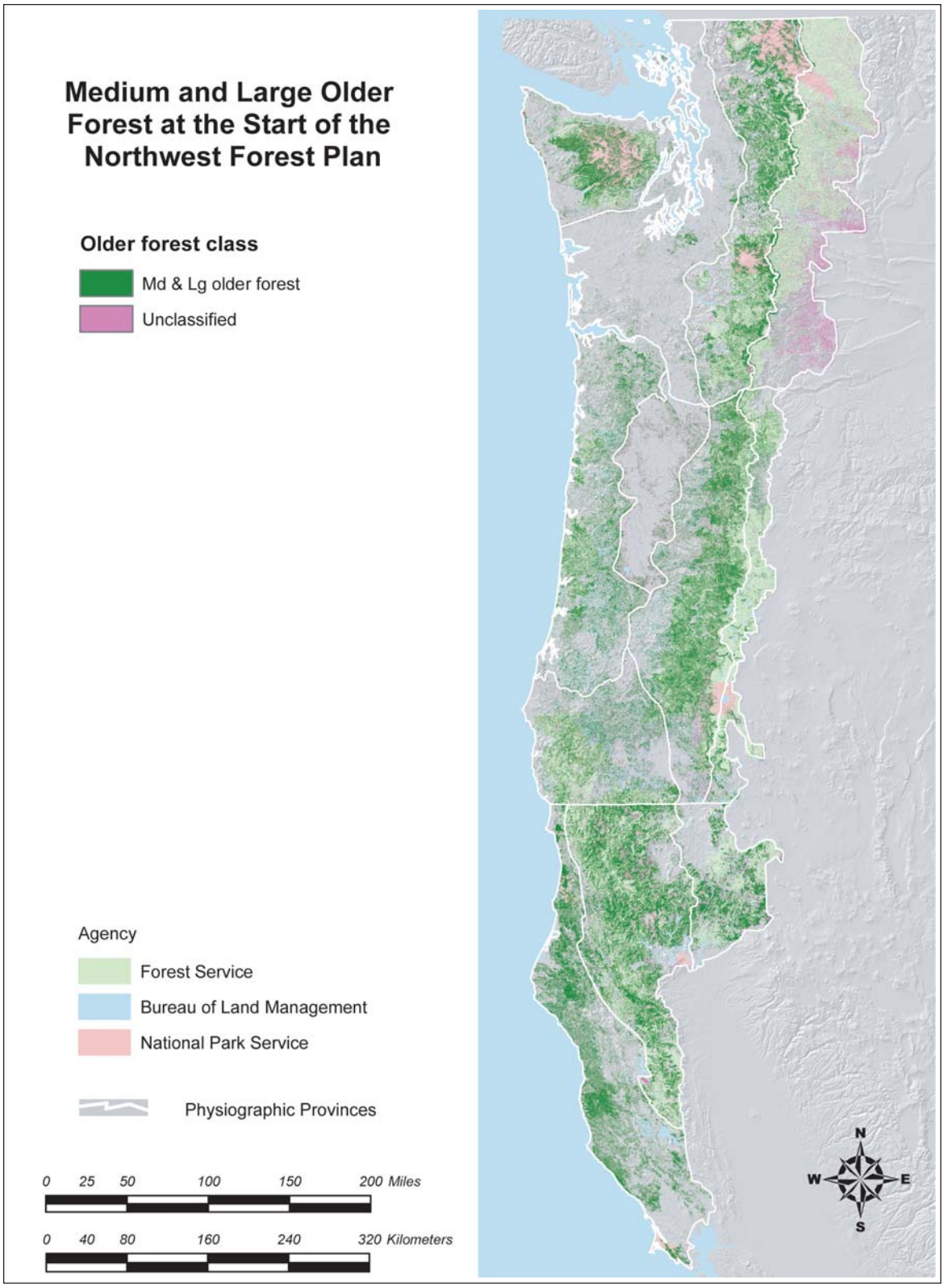


Figure 12a—Older forests at the start of the Northwest Forest Plan mapped in accordance with the "medium and large older forest" definition (minimum 10-percent canopy cover, average tree size ≥20 in, single- or multistoried canopies—classes 11-22 in table 1). Based on IVMP and CALVEG data.

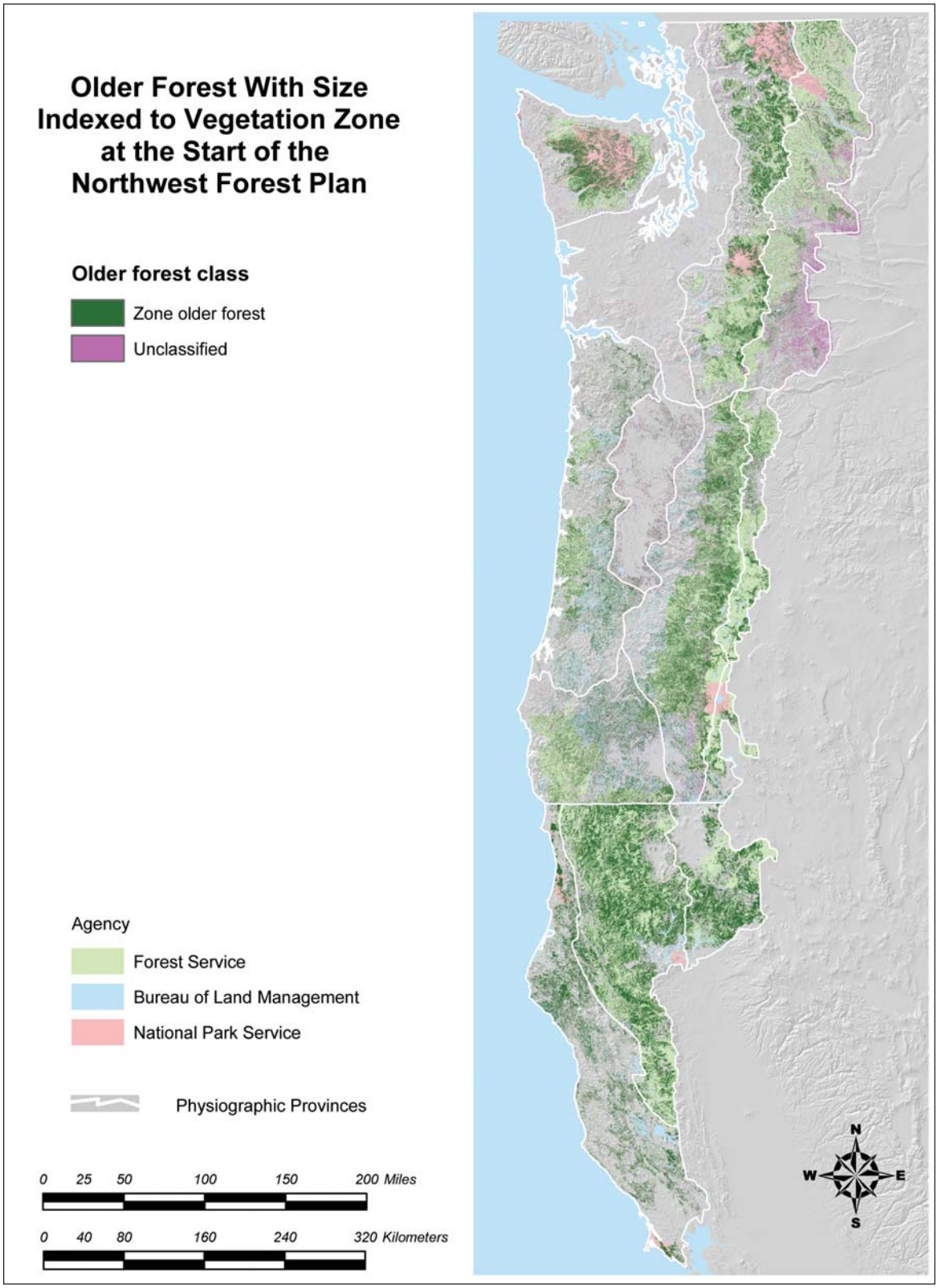


Figure 12b—Older forests at the start of the Northwest Forest Plan mapped in accordance with the "older forest with size indexed to vegetation zone" definition (minimum 10-percent canopy cover, average tree size varies by vegetation zone—see table 3, single- or multistoried canopies). Based on IVMP and CALVEG data.

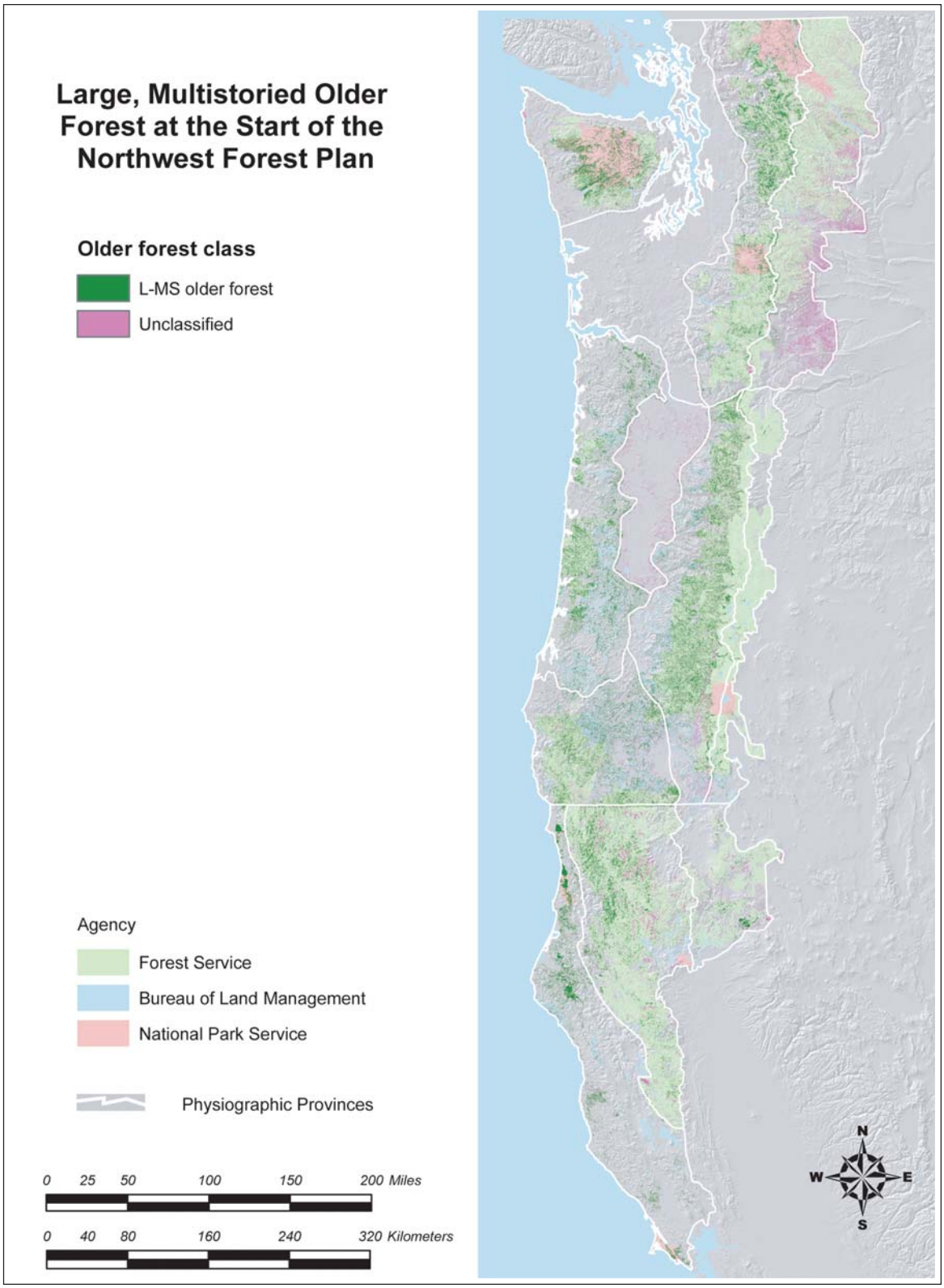


Figure 12c—Older forests at the start of the Northwest Forest Plan mapped in accordance with the "large, multistoried older forest" definition (minimum 10-percent canopy cover, average tree size ≥30 in, multistoried canopy—classes 20-22 in table 1). Based on IVMP and CALVEG data.

Table 11—Percentage of forest-capable areas[a] on federally managed land from map of older forest by definition

Province	M&L definition		Zone definition		LMS definition	
	Total older forest	Blocks >1,000 acres	Total older forest	Blocks >1,000 acres	Total older forest	Blocks >1,000 acres
			Percent			
California						
Cascades	36	23	37	26	2	0
Coast Range	47	29	41	26	21	13
Klamath	43	33	43	34	9	0
Total	42	31	42	32	9	1
Oregon						
Coast Range	37	12	25	4	21	3
Eastern Cascades	15	4	19	9	2	0
Klamath	34	11	26	5	18	1
Western Cascades	44	33	35	24	17	2
Willamette Valley	25	0	15	0	0	0
Total	36	20	29	14	15	1
Washington						
Eastern Cascades	5	0	12	3	0	0
Olympic Peninsula	43	31	33	23	20	6
Western Cascades	38	29	32	23	15	3
Western Lowlands	5	0	1	0	0	0
Total	26	18	24	15	10	2
Northwest Forest Plan	34	22	30	19	12	2
Older forest area	7,867,900 acres		7,038,300 acres		2,722,500 acres	
(± map prediction error)[b]	(5,908,800 9,827,000)		(5,110,300 8,967,600)		(2,374,000 3,070,900)	

Note: M& L = medium and large older forest–minimum 10-percent canopy cover, minimum average tree size 20 in (quadratic mean diameter), single- or multistoried canopies.

Zone = older forest with size indexed to vegetation zone–minimum 10-percent canopy cover, minimum average tree size varies by vegetation zone.

L-MS = large, multistoried older forest–minimum 10-percent canopy cover, minimum average tree size 30 in, multistoried canopy.

[a] Total forest-capable acres given in table 4.

[b] Based on map accuracy in table 6.

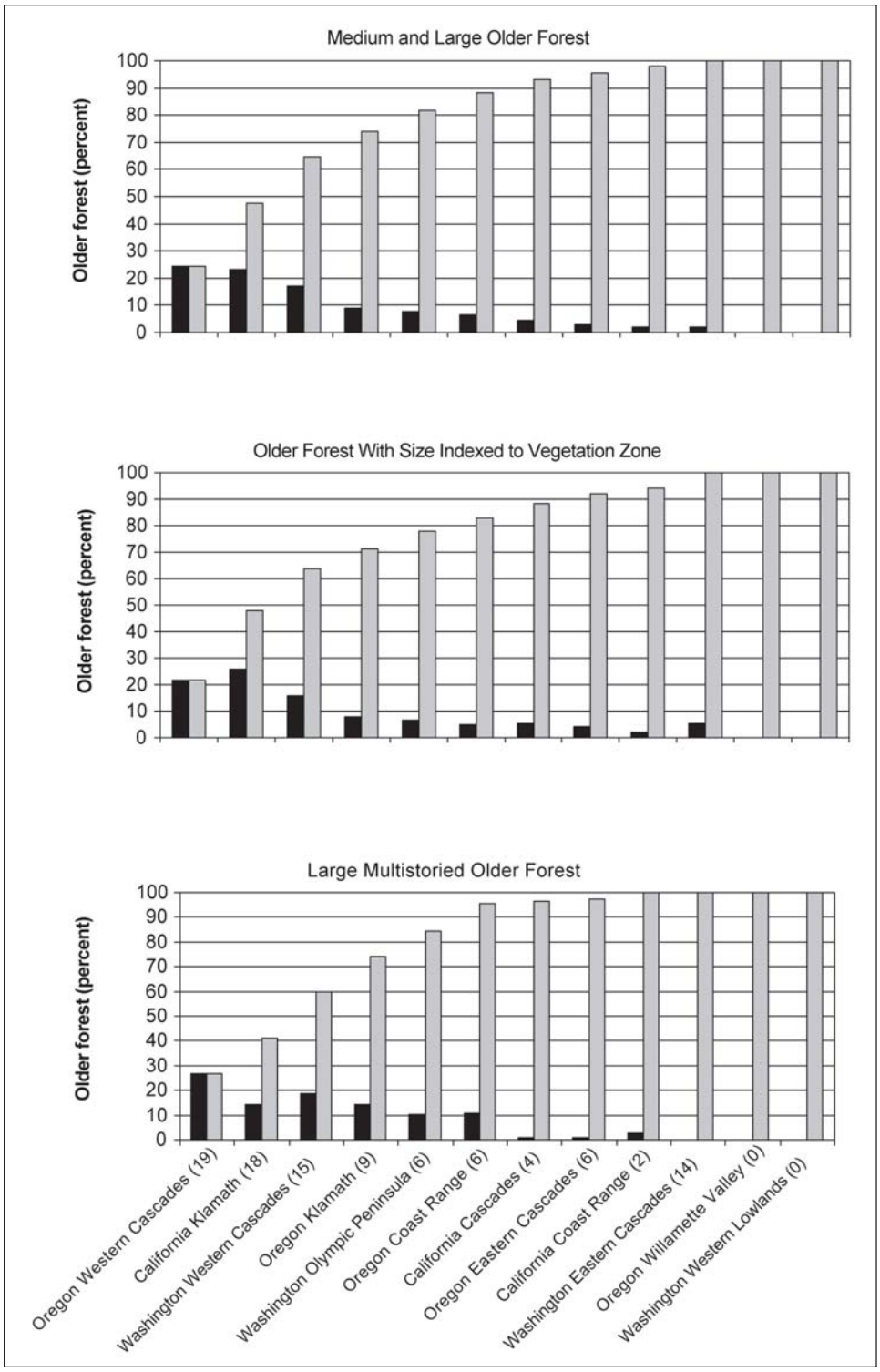


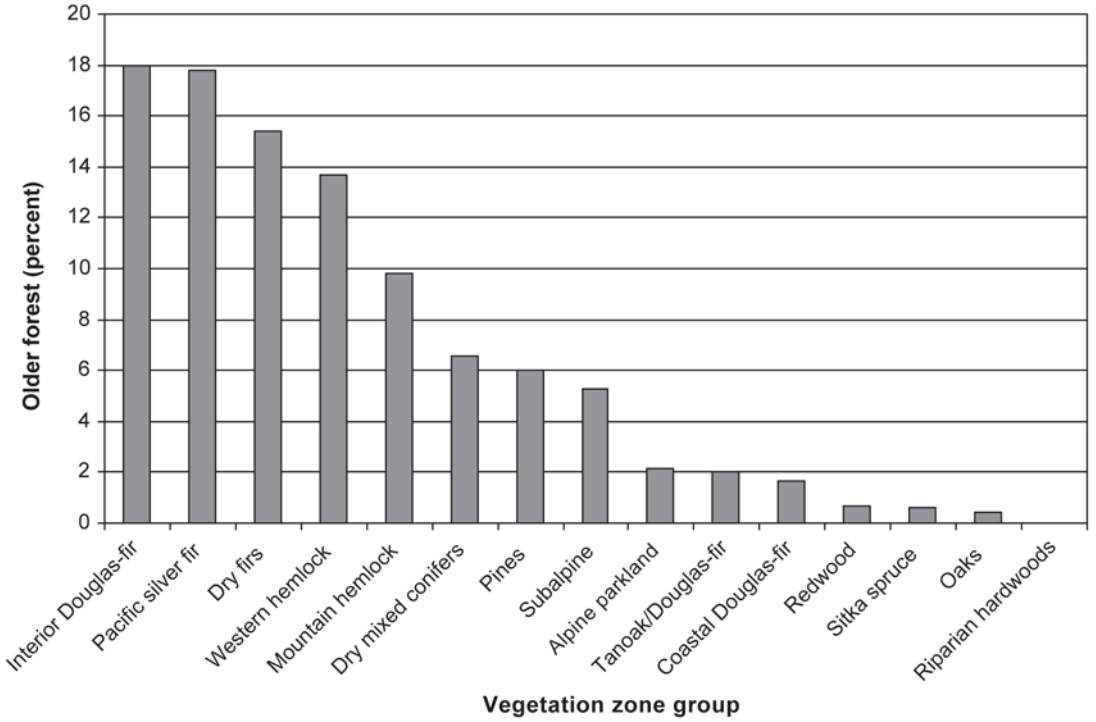
Figure 13—Older forest on federally managed lands at the start of the Northwest Forest Plan. Each chart shows the percentage of total older forest contained within each province (black bars) and cumulative percentage (grey bars). Numbers in parentheses are the percentage of the total federal forest-capable area accounted for by the province. Values were estimated from the map data.

with size indexed to potential natural vegetation zone." The eastern Cascades provinces (Washington Eastern Cascades, Oregon Eastern Cascades, and California Cascades) contained 15 percent of total "older forest with size indexed to potential natural vegetation zone," 9 percent of total "medium and large older forest," and only 2 percent of total "large, multistoried older forest." Of the total older forest acres, there was relatively more "older forest with size indexed to potential natural vegetation zone" than "medium and large older forest" in the Eastern Cascades, and relatively less in the provinces along the Pacific coast and west of the Cascade crest. There was very little federal older forest land in either the Oregon Willamette Valley or ashington Western Lowlands provinces, and thus very little of the total older forest was accounted for in these provinces.

We also examined the distribution across vegetation zone groups (see fig. 4) of total area mapped according to the "older forest with size indexed to potential natural vegetation zone" definition. Interior Douglas-fir and Pacific silver fir zones had the highest proportion of older forests (each with 18 percent of the total) (fig. 14). Older forest in the Douglas-fir zone occurred in every physiographic province but was concentrated in the Klamath provinces, Western Cascades of Oregon, and Coastal California and Oregon (fig. 15). Older forest in the Pacific silver fir zone occurred predominantly in the Western Cascades and Olympic provinces, and to a lesser degree in the Eastern Cascades. The next highest proportions occurred in the dry fir group (grand fir [*Abies grandis* (Dougl. Ex D. Don) Lindl.], white fir [*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.], California red fir [*Abies magnifica* A. Murr.], or Shasta fir [*Abies magnifica* A. Murr. var. *shastensis* Lemm.]), and western hemlock zone, each making up about 15 percent of the total older forest (fig. 14). The western hemlock zone was limited in geographic extent to Washington and Oregon. In those states, older forest occupied large portions of the lowland western hemlock zone in the Oregon Coast and Olympic provinces. Older forest was also extensive in the upland western hemlock zone in the Western Cascades, and in the Eastern Cascades to a smaller extent. Older forest composed a major portion of forest in dry fir types in the Oregon and California Cascades (especially white fir and grand fir) and Klamath (especially white fir and the red firs) provinces. Older forest occupied 10 percent of forests in the mountain hemlock zone, concentrated in the Cascades and Olympic provinces. Older forest occupied less than 10 percent of forest in the remaining vegetation zones.

The relative occurrence of older forest within land use allocation groups (compare table 5) also differed with definition type (fig. 16). There was 29 percent of the total "medium and large older forest" in the matrix group (which, remember, does include an unknown proportion of riparian reserve), and only 24 percent of the total "large, multistoried older forest" in the matrix group. Thus, older forest according to the more restrictive definition ("large, multistoried") occurred in greater proportions in the late-successional reserve land allocations than in the matrix group. There was very little difference between types in the administratively withdrawn/congressionally reserved group. The distribution of older forest with "size indexed to potential natural vegetation zone" was very similar to that for "medium and large" older forest, and is not shown in fig. 16. Planwide, every size and structure class composing "medium and large older forest" occupied a higher proportion of land in reserve allocations than in nonreserve allocations (fig. 17). Conversely, younger forests occupied a greater proportion in nonreserved land than in reserved land allocations.

Within-province older forest map results are summarized in a common set of figures (fig. 18). A key to the format of these figures is included prior to the province results. Each set of charts summarizes the distribution of forest size and structure classes for the province as a whole and by land use allocation group. The four right-hand bars in fig. 18 (labeled M-SS, M-MS, L-SS and L-MS) equate to classes 11-22 in table 1, and the sum of their percentages equals the total percentage of "medium and large" older forest in the province. The rightmost bar (L-MS) equates to classes 20-22 in table 1 and is equivalent to the percentage of "large, multistoried" older forest. Percentage of "older forest with size indexed to potential natural vegetation



Vegetation zone group	Fire-prone	Vegetation zones in group
Interior Douglas-fir	Yes	Douglas-fir (in Klamath and Cascades provinces)
Pacific silver fir	No	Pacific silver fir
Dry firs	Yes	Grand fir, White fir, California red fir, Shasta red fir
Western hemlock	No	Western hemlock
Mountain hemlock	No	Mountain hemlock
Dry mixed conifers	Yes	Shrub-steppe, Mixed conifer, Western juniper
Pines	Yes	Ponderosa pine, Pacific ponderosa pine, interior ponderosa pine, Pacific ponderosa pine/Douglas-fir, Jeffrey pine, lodgepole pine, knobcone pine, western white pine
Subalpine	No	Subalpine fir, California mixed subalpine, whitebark pine
Alpine parkland	No	Parkland-mountain hemlock, parkland-subalpine larch, alpine open
Tanoak/Douglas-fir	Yes	Tanoak, Tanoak/Douglas-fir/Pacific madrone
Coastal Douglas-fir	No	Douglas-fir, Pacific Douglas-fir (in coastal provinces)
Redwood	No	Redwood
Sitka spruce	No	Sitka spruce
Oaks	Yes	California black oak, California coast live oak, canyon live oak, Oregon white oak, gray pine/blue oak
Riparian hardwoods	No	Cottonwood/willow, red alder

Figure 14— Distribution by vegetation zone group of "older forest with size indexed to vegetation zone" on federally managed lands at the start of the Northwest Forest Plan. Values were estimated from the map data.

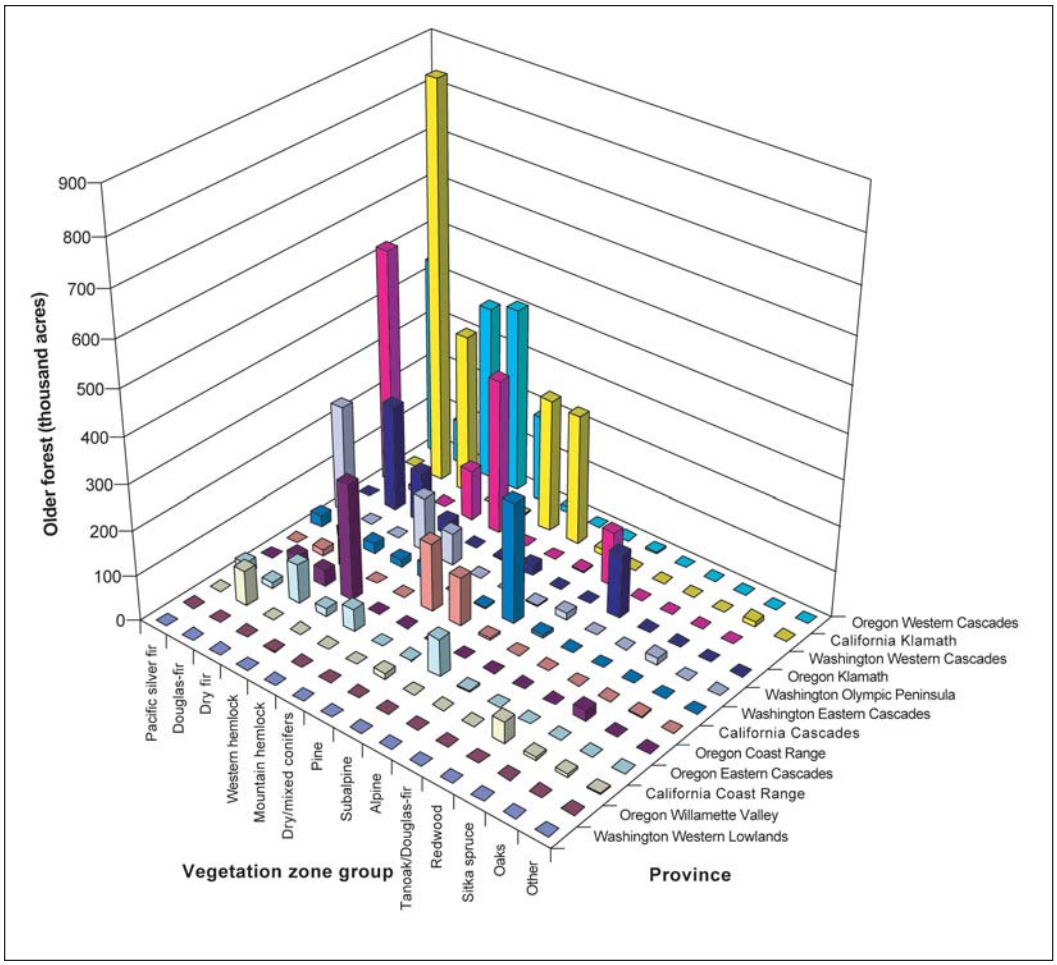


Figure 15—Area of "older forest with size indexed to vegetation zone" at the start of the Northwest Forest Plan. Values were estimated from the map data.

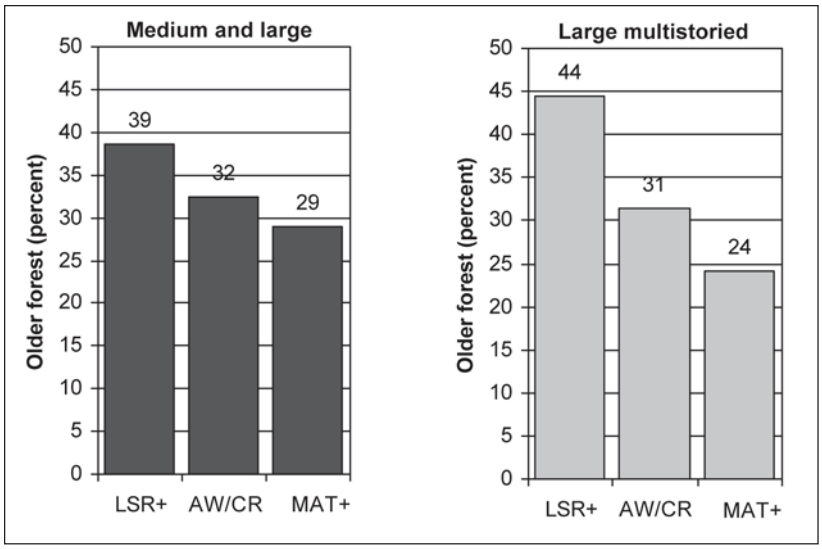


Figure 16—Distribution of total older forest within land allocation groups at the start of the Northwest Forest Plan for "medium and large" and "large, multistoried" older forest. Land allocation group definitions: late-successional reserve group (LSR+); administratively withdrawn/congressionally reserved group (AW/CR), and matrix group (MAT+). See table 5 for individual land use allocations included in groups. Values were estimated from the map data.

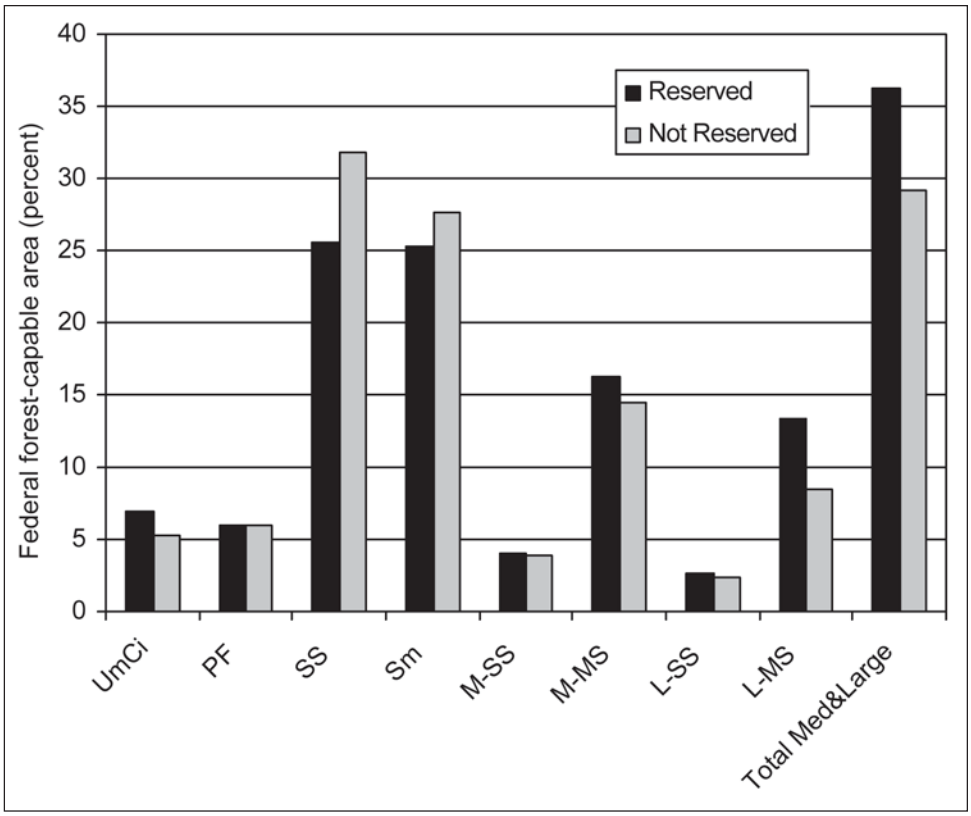


Figure 17—Distribution of federal forest-capable land in the Northwest Forest Plan area by size and structure classes in reserved and nonreserved allocations (table 5). UnCl = unclassified; PF = potential forest (canopy closure <10 percent); SS = seedling/sapling (average tree size <10 in); Sm = small (10≤ average tree size <20 in); M-SS = medium, single-storied (20≤ average tree size <30 in); M-MS = medium, multistoried; L-SS = Large, single-storied (average tree size ≥30 in); L-MS = large, multistoried; Total Med&Large = (M-SS + M-MS + L-SS + L-MS).

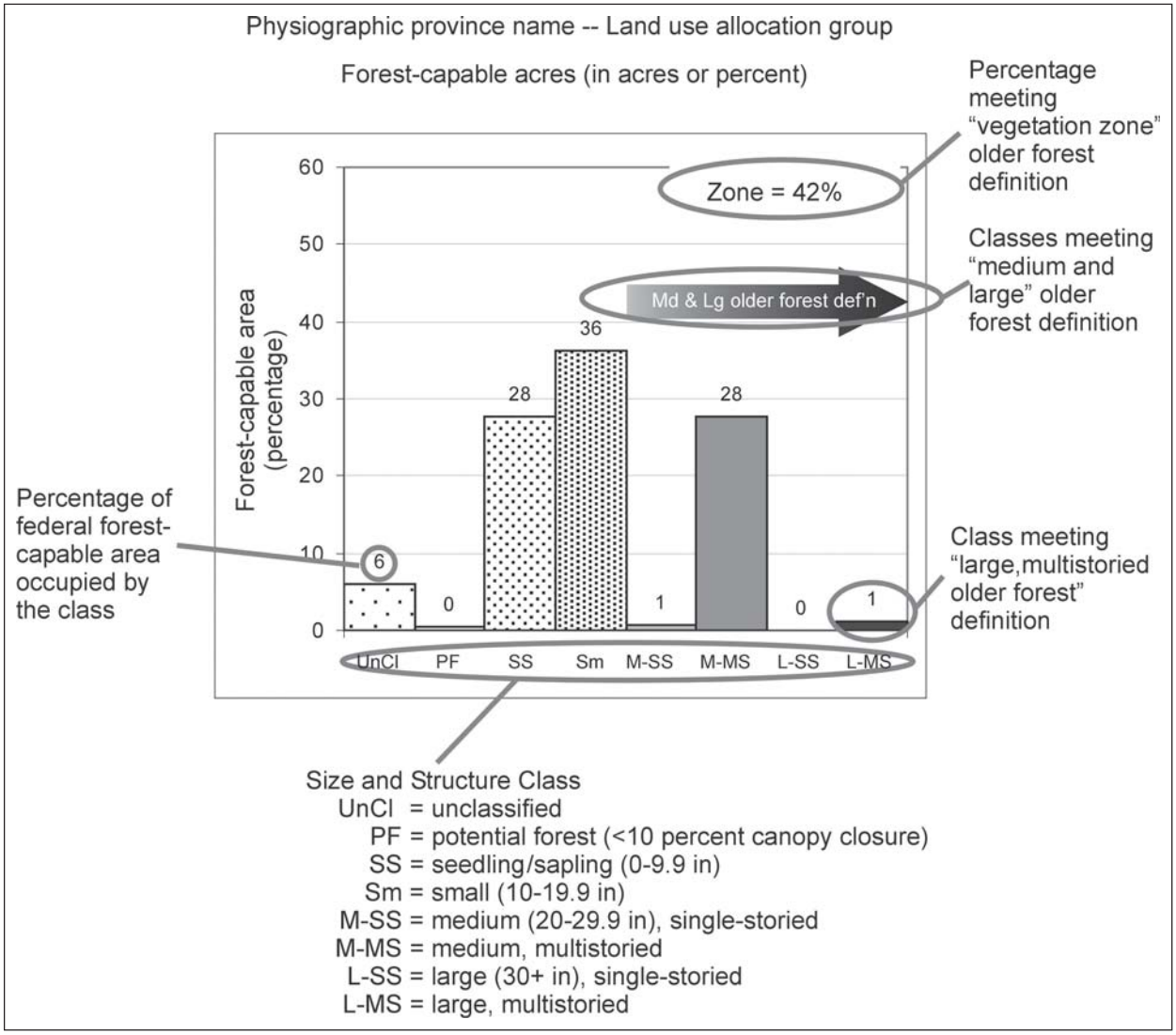


Figure 18a—Key to graphs of percentage of federal forest-capable area occupied by vegetation size and structure classes within physiographic province at the start of the Northwest Forest Plan. Values are estimated from the map data. See table 5 for individual land use allocations included in groups.

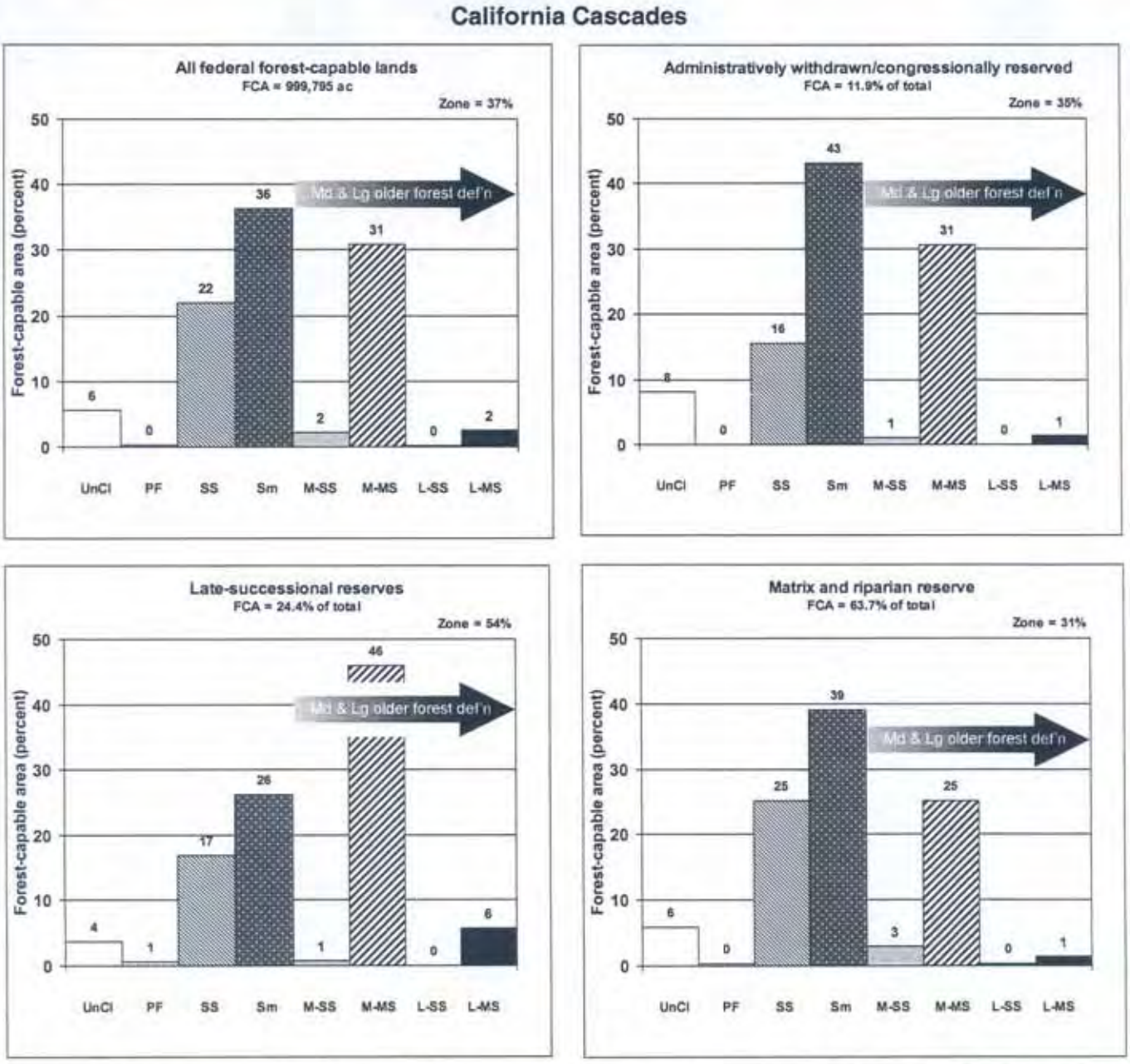


Figure 18b—The percentage of federal forest-capable area occupied by vegetation classes within the California Cascades physiographic province, by land use allocation group. (See fig. 18a for code definitions).

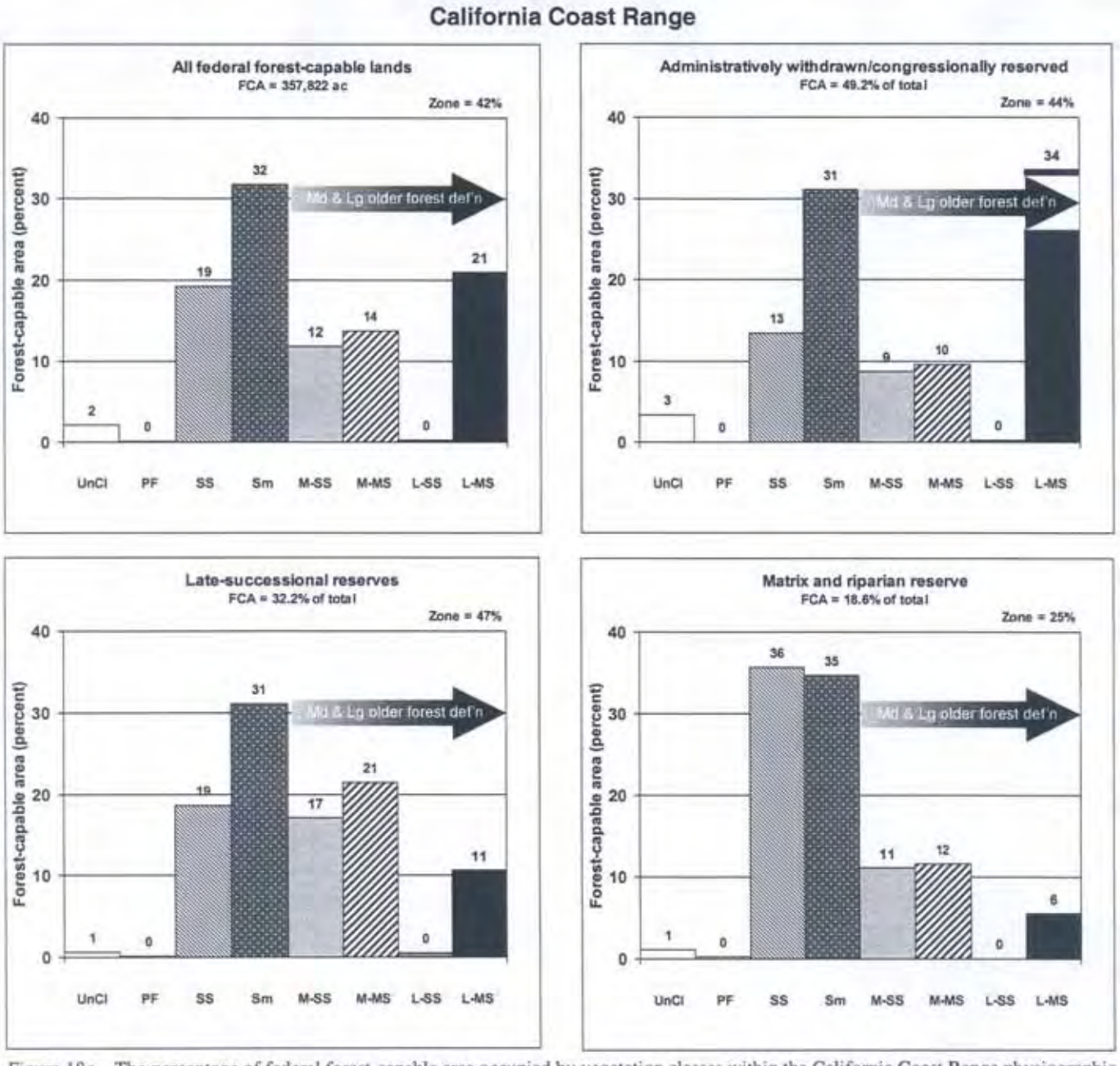


Figure 18c—The percentage of federal forest-capable area occupied by vegetation classes within the California Coast Range physiographic province, by land use allocation group. (See fig. 18a for code definitions).

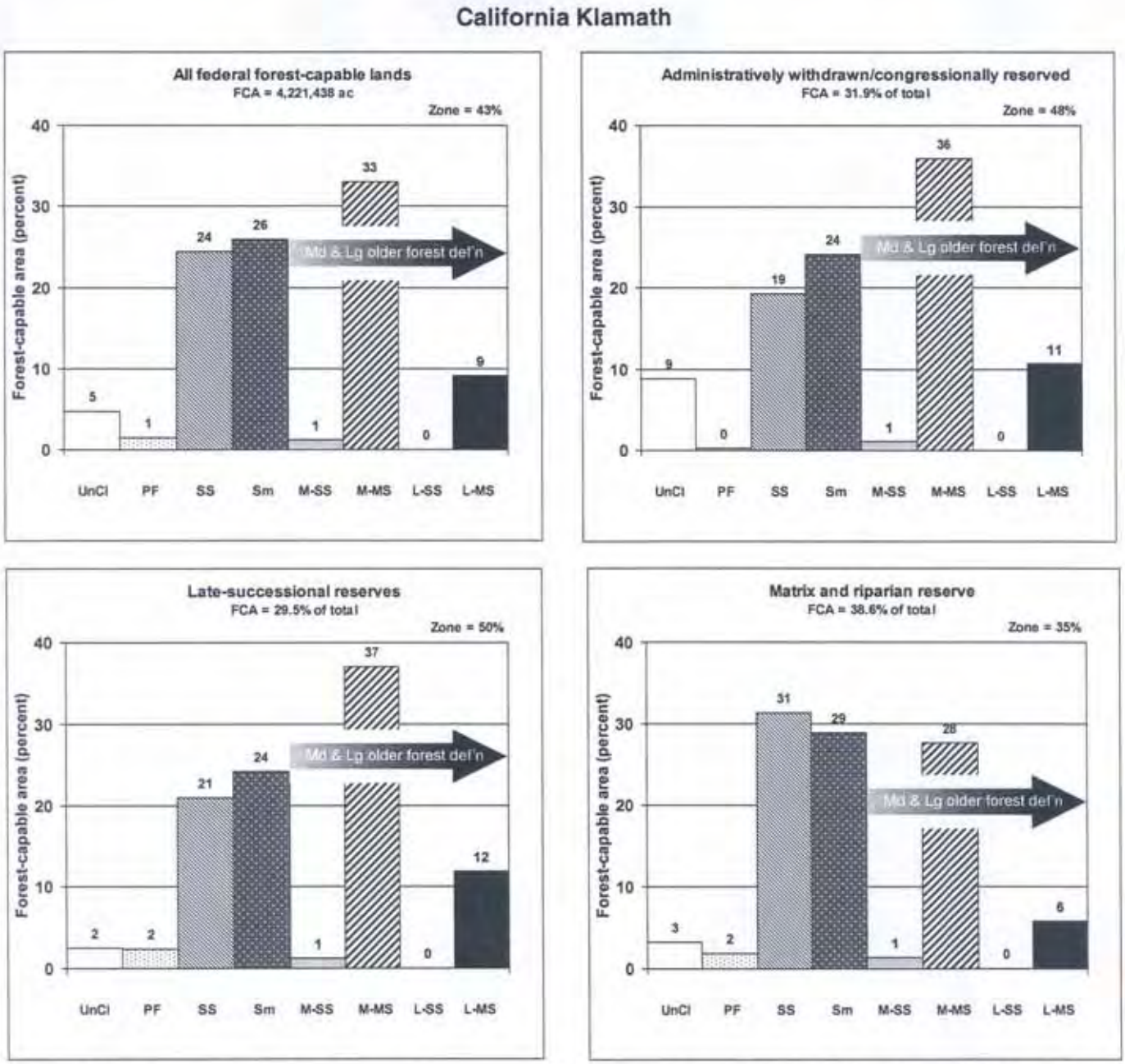


Figure 18d—The percentage of federal forest-capable area occupied by vegetation classes within the California Klamath physiographic province, by land use allocation group. (See fig. 18a for code definitions).

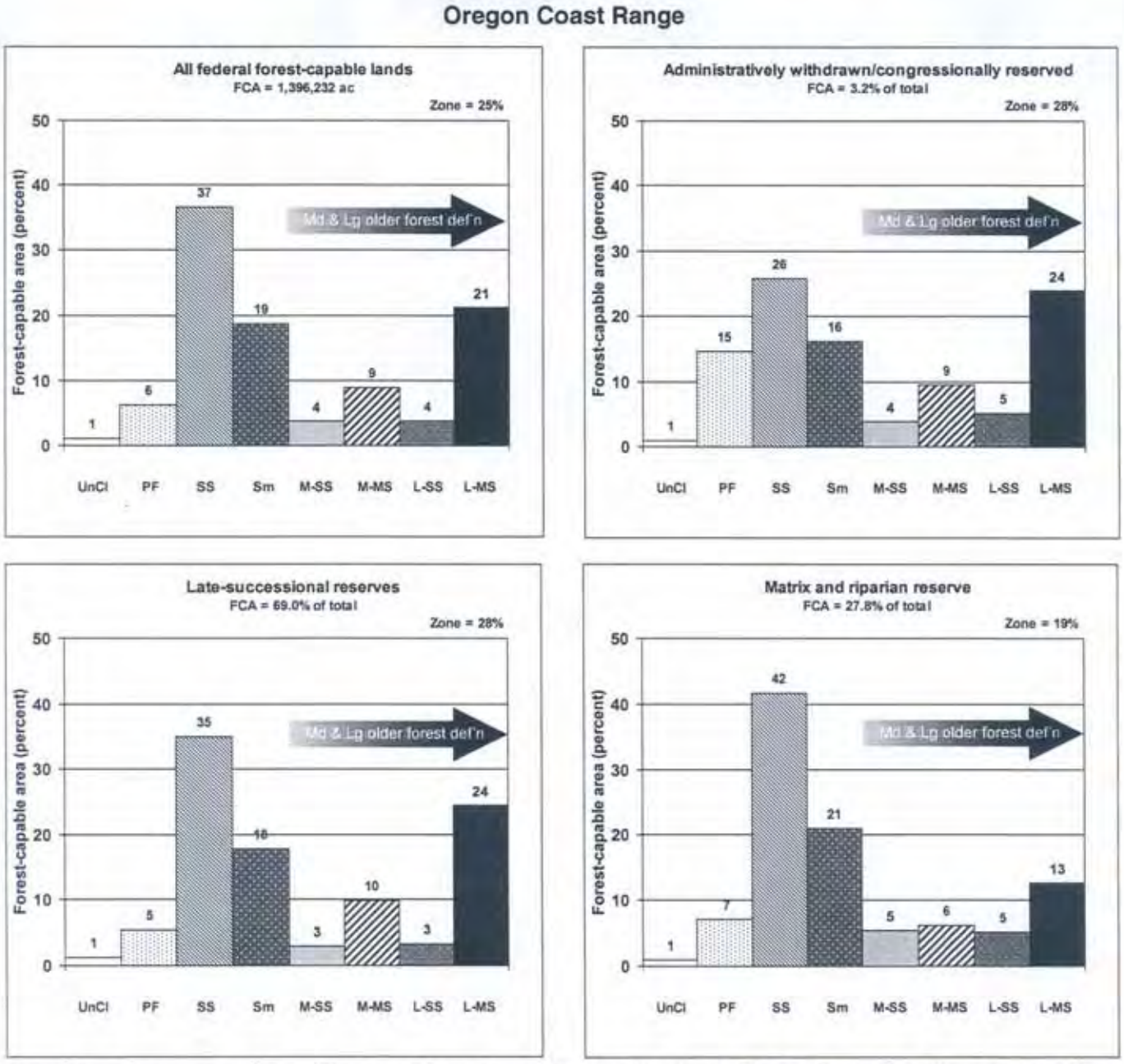


Figure 18e—The percentage of federal forest-capable area occupied by vegetation classes within the Oregon Coast Range physiographic province, by land use allocation group. (See fig. 18a for code definitions).

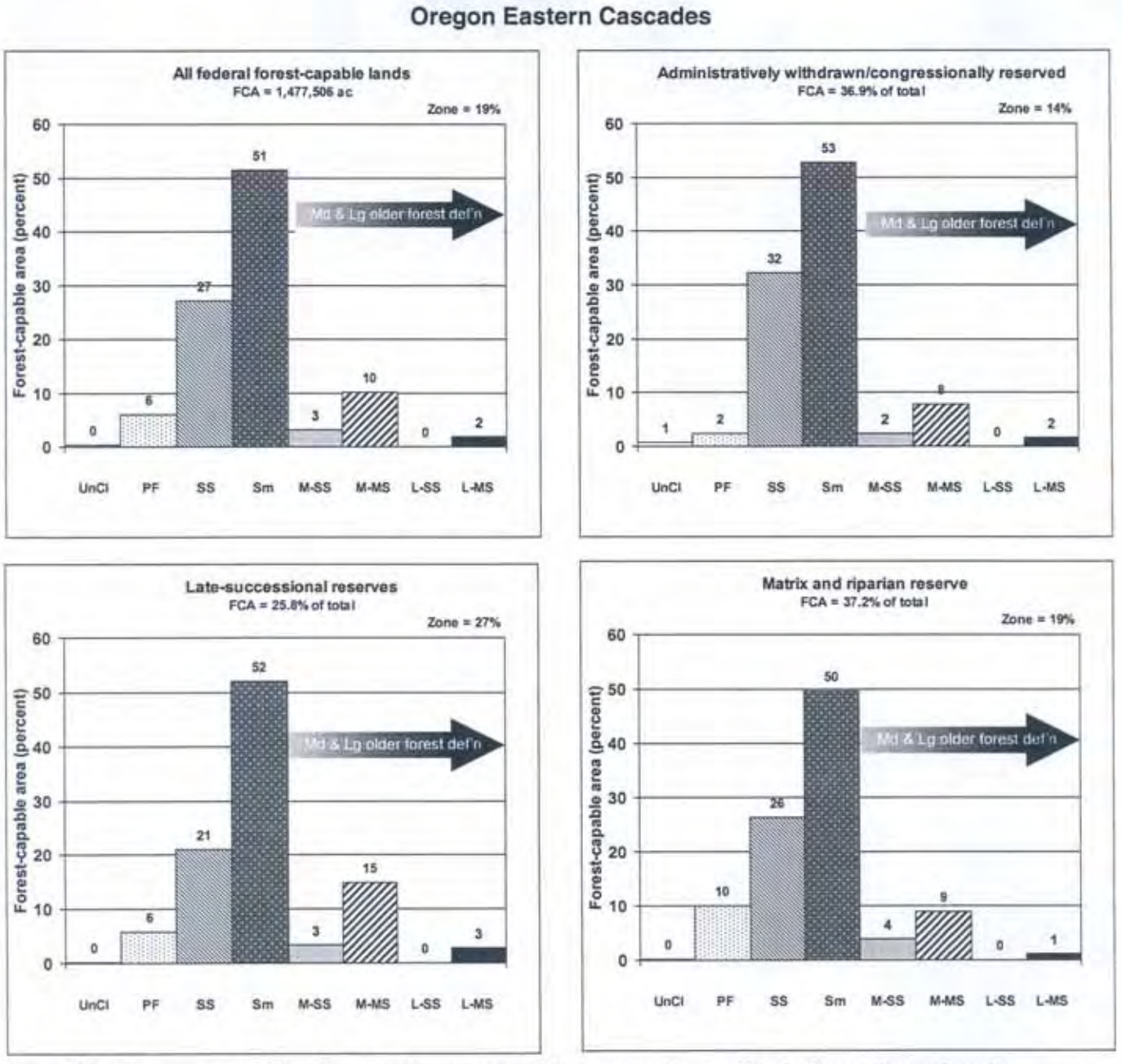


Figure 18f—The percentage of federal forest-capable area occupied by vegetation classes within the Oregon Eastern Cascades physiographic province, by land use allocation group. (See fig. 18a for code definitions).

Oregon Klamath

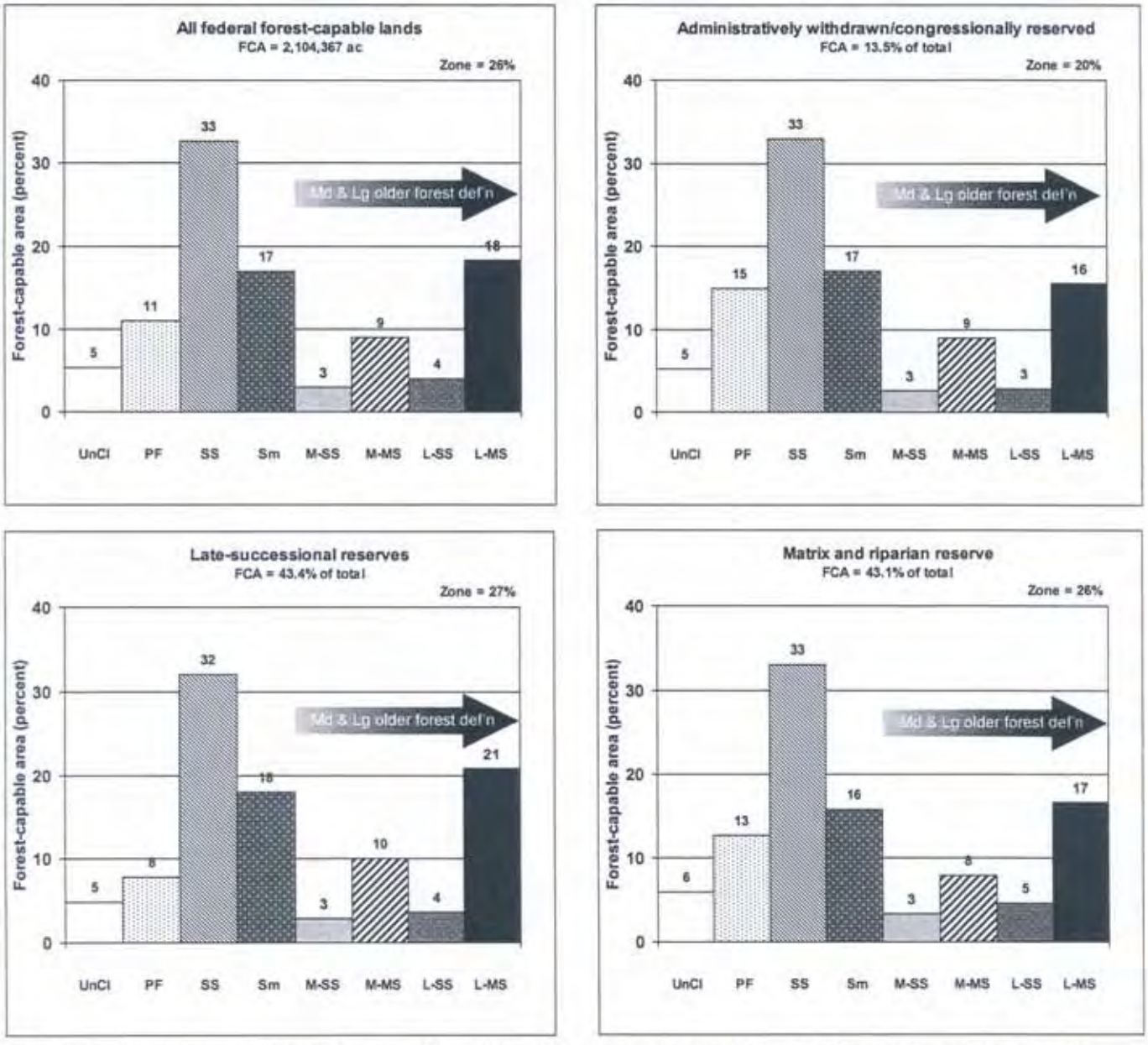


Figure 18g—The percentage of federal forest-capable area occupied by vegetation classes within the Oregon Klamath physiographic province, by land use allocation group. (See fig. 18a for code definitions).

Oregon Western Cascades

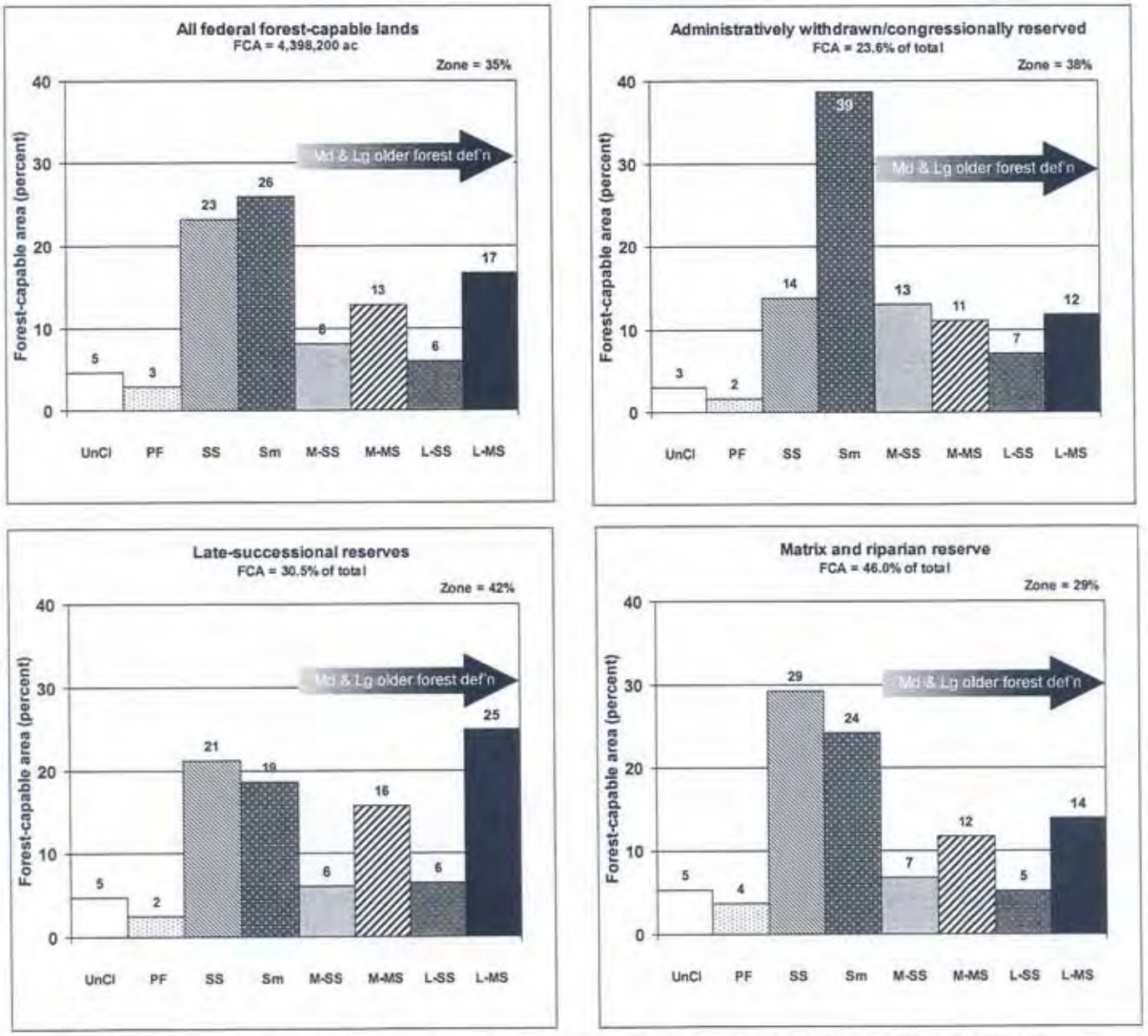


Figure 18h—The percentage of federal forest-capable area occupied by vegetation classes within the Oregon Western Cascades physiographic province, by land use allocation group. (See fig. 18a for code definitions).

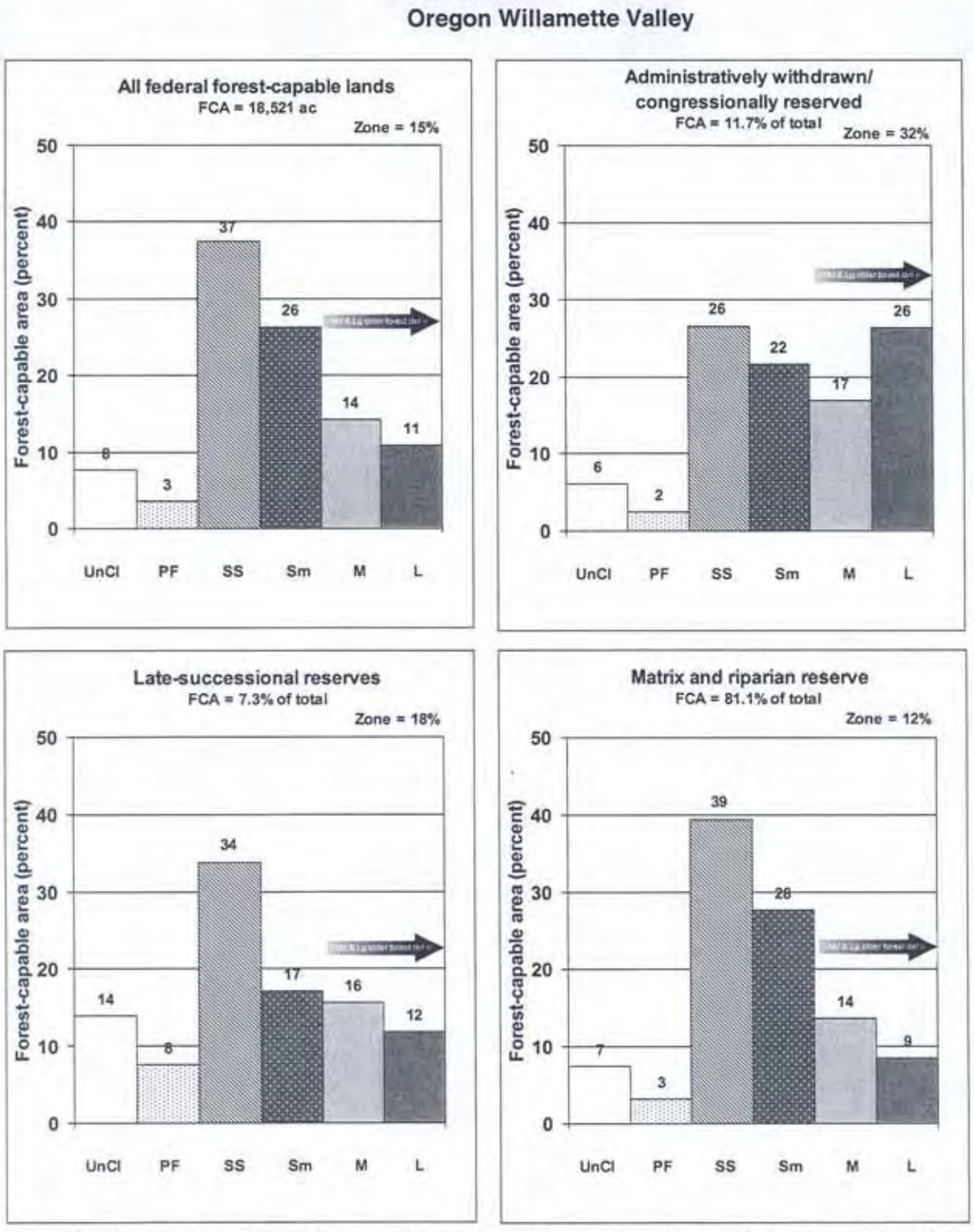


Figure 18i—The percentage of federal forest-capable area occupied by vegetation classes within the Oregon Willamette Valley physiographic province, by land use allocation group. (See fig. 18a for code definitions).

Washington Eastern Cascades

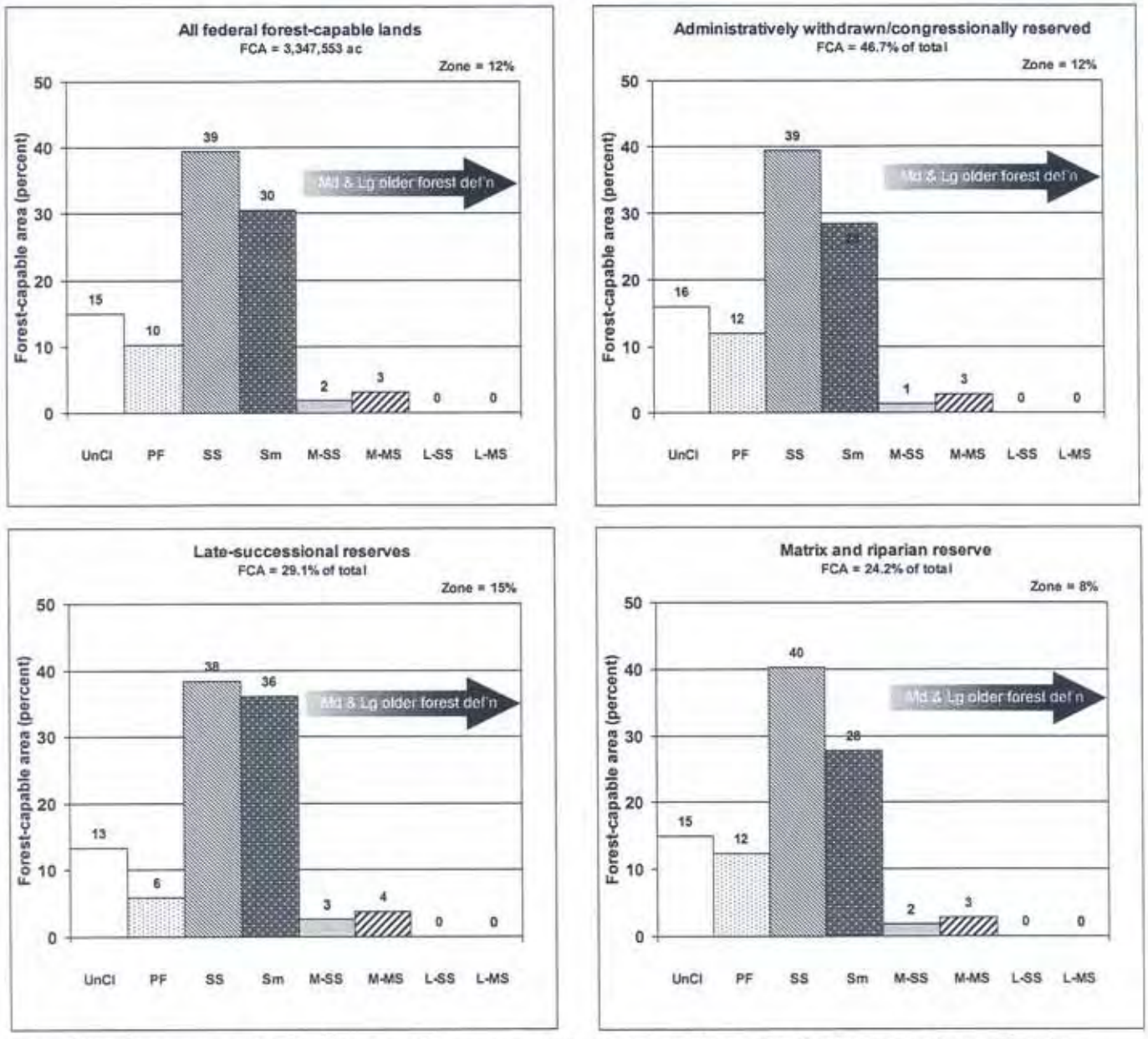


Figure 18j—The percentage of federal forest-capable area occupied by vegetation classes within the Washington Eastern Cascades physiographic province, by land use allocation group. (See fig. 18a for code definitions).

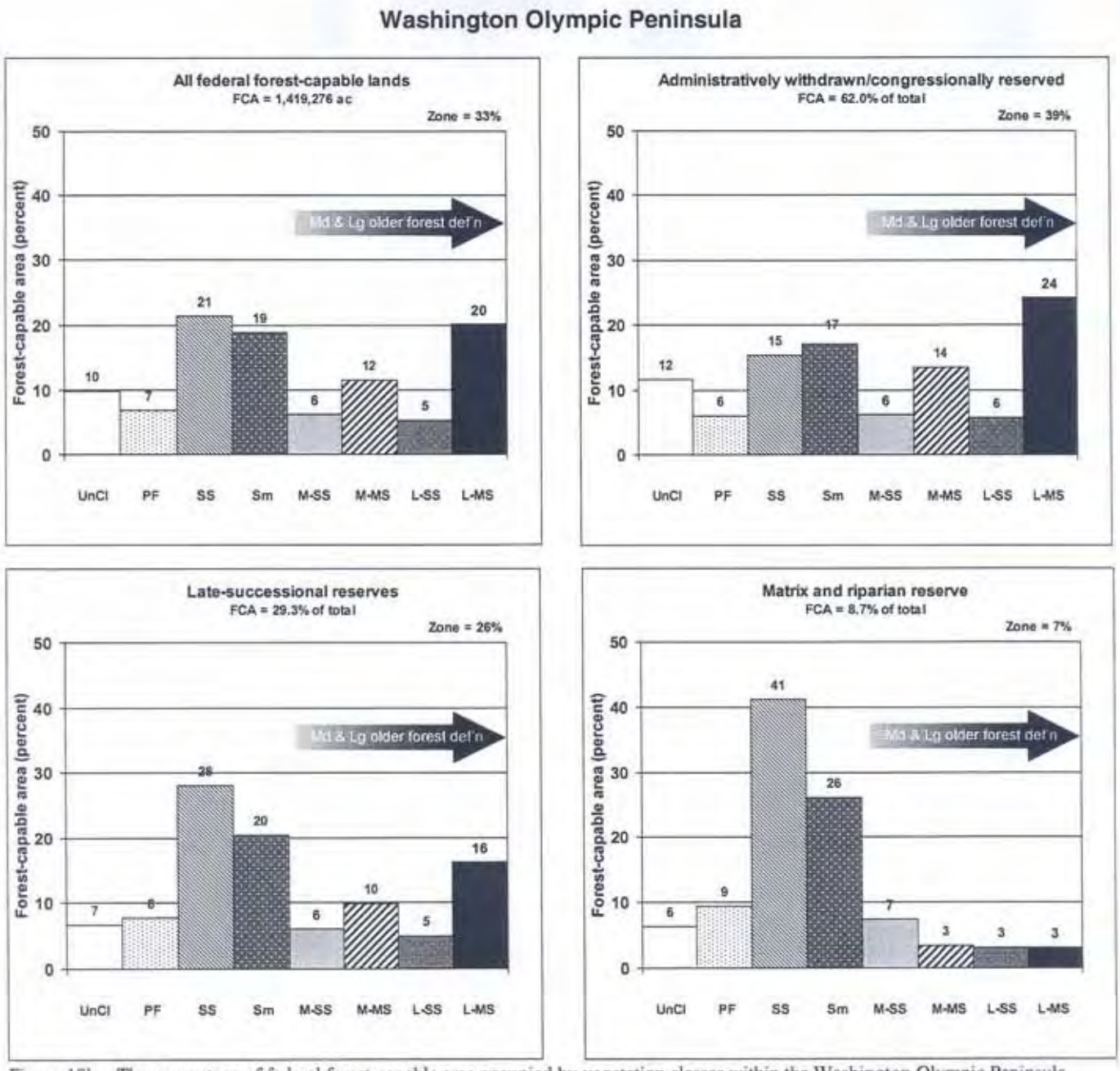


Figure 18k—The percentage of federal forest-capable area occupied by vegetation classes within the Washington Olympic Peninsula physiographic province, by land use allocation group. (See fig. 18a for code definitions).

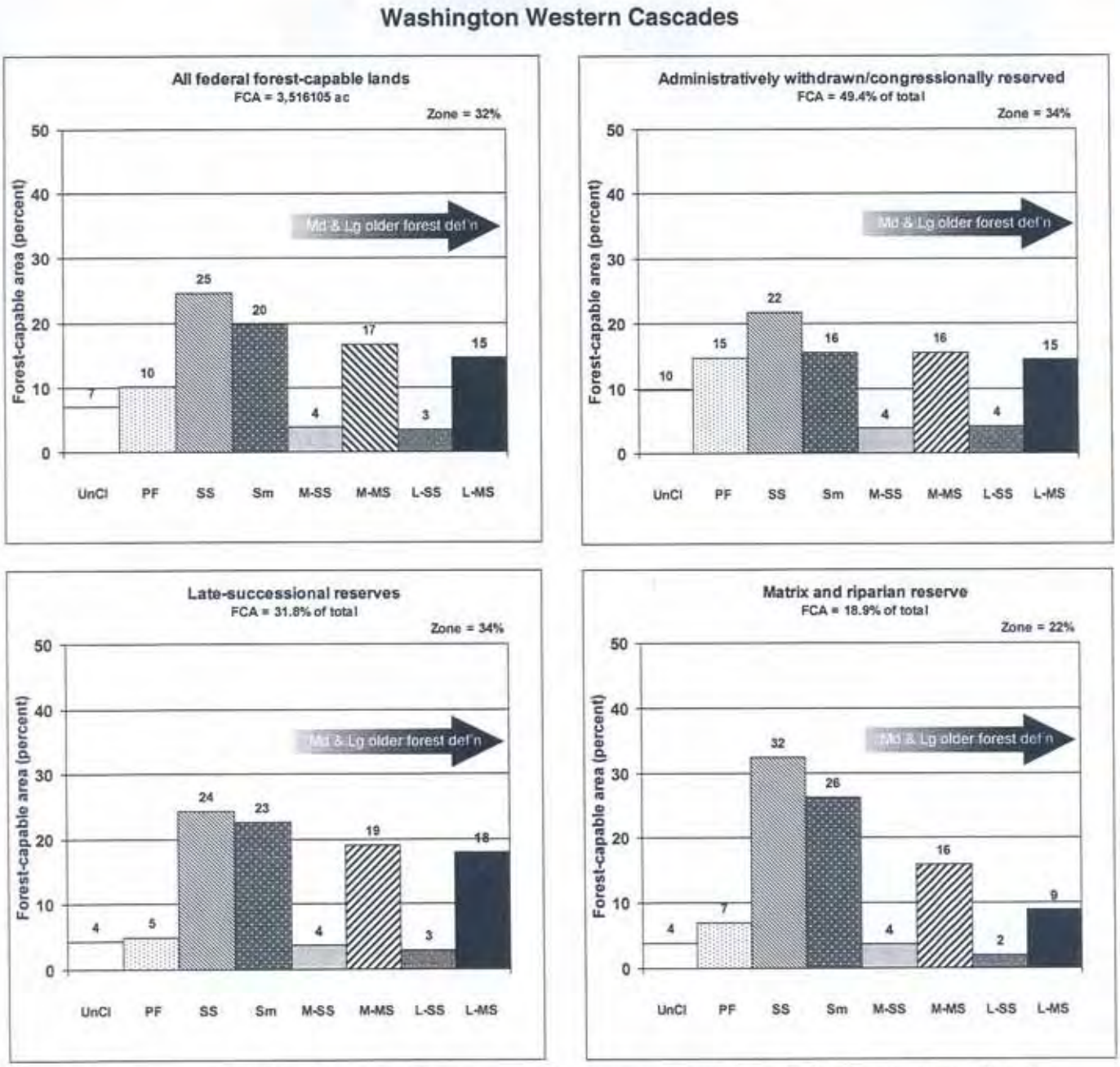


Figure 18l—The percentage of federal forest-capable area occupied by vegetation classes within the Washington Western Cascades physiographic province, by land use allocation group. (See fig. 18a for code definitions).

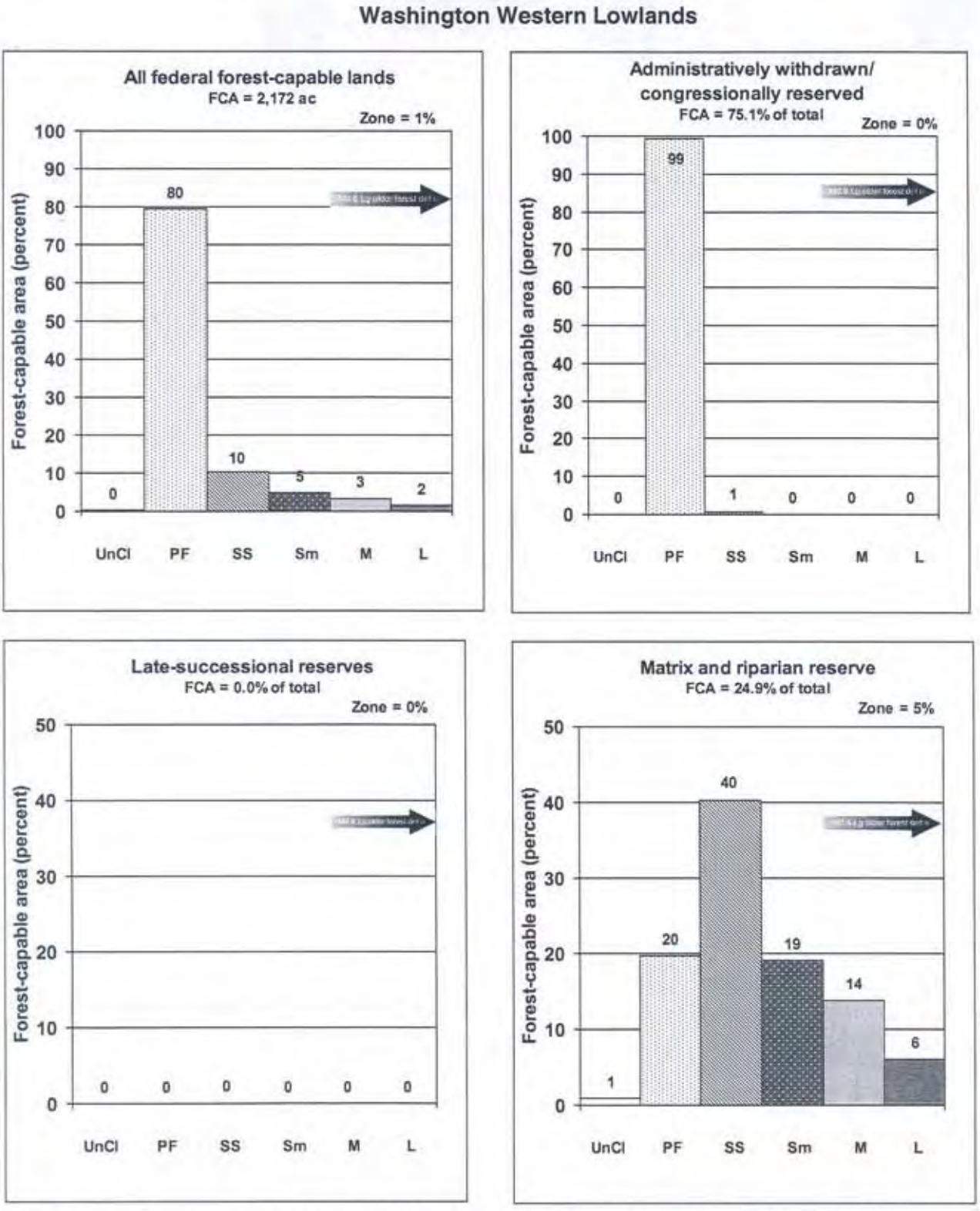


Figure 18m—The percentage of federal forest-capable area occupied by vegetation classes within the Washington Western Lowlands physiographic province, by land use allocation group. (See fig. 18a for code definitions).

zone" is reported in the upper right-hand corner of each chart in figure 18. Note that in each chart, a small proportion of acres are shown as "unclassified." This number represents forest-capable land for which the thematic data required for classification of a map unit was missing, as discussed previously in the section titled, "Classification of Existing Vegetation." For example, there were always a small number of IVMP pixels or CALVEG polygons in which average tree size could not be reliably modeled. As a result, these pixels or polygons could not be assigned to a vegetation size class. The amount ranged from none of the landscape in Oregon Eastern Cascades, to 15 percent of the landscape in Washington Eastern Cascades.

Although generalizing the results across physiographic provinces is somewhat difficult, there are interesting patterns shown in figure 18. For example, multistoried classes (labeled M-MS and L-MS) constituted most of the "medium and large" older forest in most provinces. In the coastal provinces (California Coast Range, Oregon Coast Range, Oregon Klamath, and Washington Olympic Peninsula), the large, multistoried class (L-MS) tended to dominate the older forest classes. With respect to land use allocation groups (see table 5), generally the province charts verified that there was a higher proportion of older forest in reserve group allocations than in nonreserve group allocations in every province. Younger forests (those in seedling/sapling (SS) and small (Sm) classes tended to occupy a larger proportion in the matrix group than in the fragmented administratively withdrawn/congressionally reserved or late-successional reserves groups. Still, "medium and large older forest" occupied nearly one-third of forest-capable area in the matrix group in several provinces. The provinces with the highest proportion of "medium and large older forest" in matrix group lands were Oregon Western Cascades (38 percent), California Klamath (35 percent), Oregon Klamath (33 percent), and Washington Western Cascades (31 percent). California Cascades, California Coast Range, and Oregon Coast Range followed closely, with 29 percent of federal forest-capable area in "medium and large older forest." The eastern Cascades provinces in Washington and Oregon each contained about the same percentage of "medium and large older forest" in the nonreserve allocations as in the reserve allocations. The Olympic province had a much lower percentage of "medium and large older forest" allocated to the nonreserve class (16 percent) than the reserve classes (43 percent).

Table 12 shows the acres of land and percentage of area occupied by "medium and large older forest" on Department of Defense and Fish and Wildlife Service lands within the Plan area. Together, these lands account for less than seven-tenths of a percent of the federal land base, and contain an estimated 30,700 ac of "medium and large older forest." Because these lands are not covered by the Plan, they are not discussed further in this report.

Older Forest Statistical Estimates

Figure 19 displays the acres of older forest estimated from inventory plot data for the three older forest definitions. The values are smaller than the values reported from the map analysis because they reflect only sampled areas on Forest Service-Region 5, Forest Service-Region 6, and Bureau of Land Management-Oregon lands. The estimates do not include older forests on National Park Service or Bureau of Land Management-California lands, because we did not have sample data from these lands.

Relative amounts of older forest estimated from plot data were consistent with relative amounts estimated from the map analyses (compare fig. 20, 'ALL' category, with fig. 13). Differences generally were accounted for by the differences in the populations represented by the two estimates. For example, because Park Service lands (which have a congressionally reserved land use allocation) were not represented in the inventory sample, the plot versus map estimates for the land allocation group labeled, "administratively withdrawn/congressionally reserved," were quite different in provinces with a large proportion of Park Service lands.

For the "medium and large older forest" definition, we compared estimates of older forest amounts made from the plot data versus the map data for the lands represented by

Table 12—Forest-capable area of land managed by Department of Defense and Fish and Wildlife Service and portion that is medium and large older forest

Province	Department of Defense			Fish & Wildlife Service		
	Total	Older forest		Total	Older forest	
	Acres	*Acres*	*Percent*	*Acres*	*Acres*	*Percent*
California Coast Range	22,300	1,800	8.1	100	0	0.0
Oregon Coast Range	700	100	14.3	0	0	0
Oregon Western Cascades	0	0	0	100	0	0.0
Oregon Willamette Valley	0	0	0	19,100	1,000	5.2
Washington Eastern Cascades	0	0	0	6,900	200	2.9
Washington Olympic Peninsula	0	0	0	100	0	0.0
Washington Western Cascades	100	0	0.0	600	100	16.7
Washington Western Lowlands	110,300	27,100	24.6	8,100	200	2.5
Northwest Forest Plan	133,400	29,000	21.7	35,000	1,500	4.3

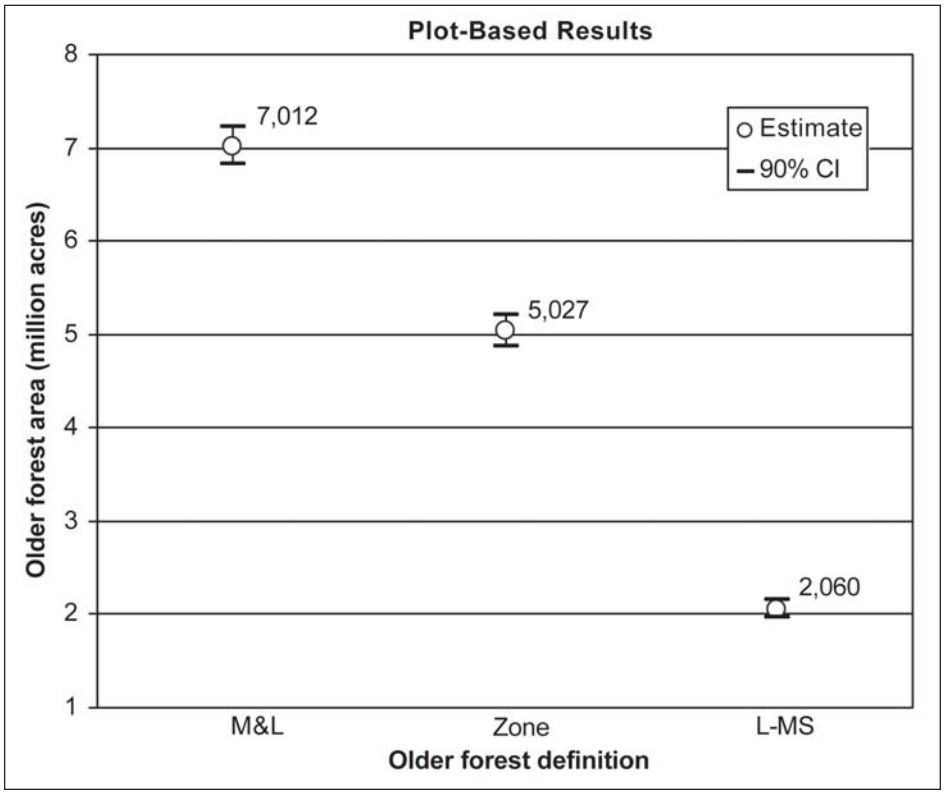


Figure 19—Area of older forest estimated from inventory plot data at the start of the Northwest Forest Plan.The values are smaller than those reported from the map analysis because they reflect only sampled areas of Forest Service-Region 5, Forest Service-Region 6, and Bureau of Land Management-Oregon lands. The estimates do not include National Park Service or Bureau of Land Management-California lands. Bootstrapped confidence intervals were estimated from 40,995 individual sample points. Older forest definitions: M&L = medium and large older forest; Zone = older forest with size indexed to vegetation zone; L-MS = large, multistoried older forest.

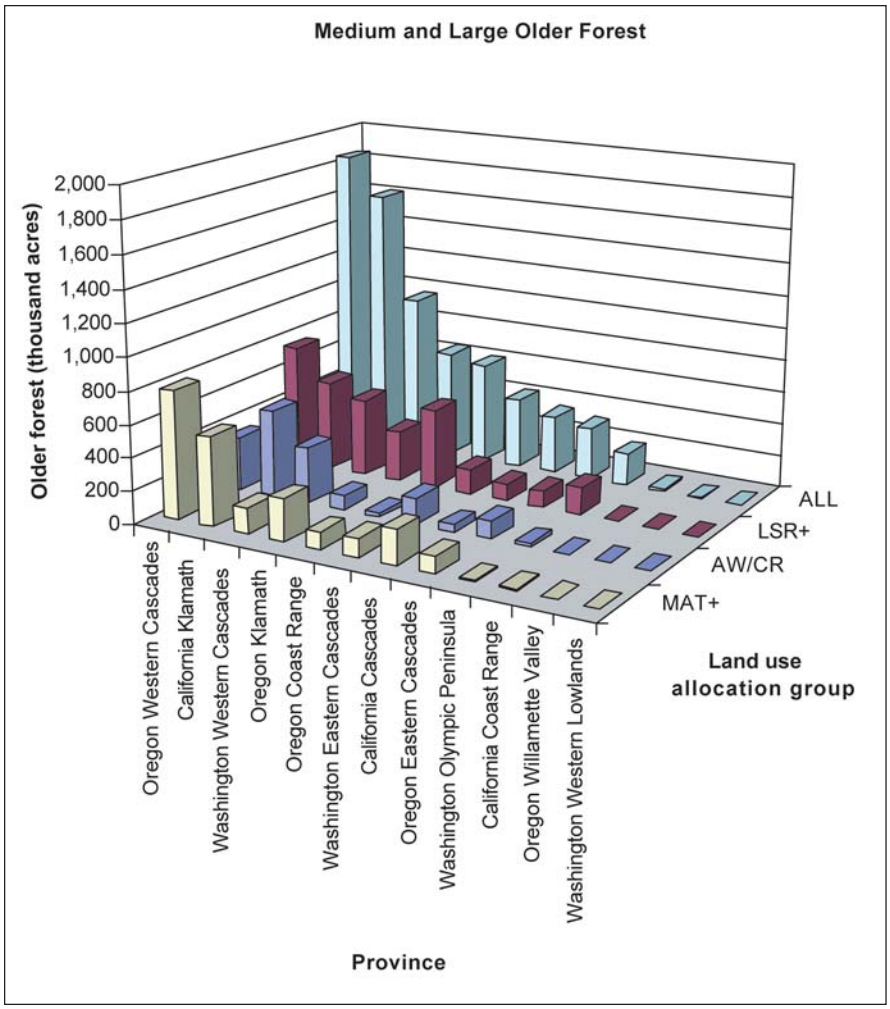


Figure 20a—Area of older forest by province and land allocation group estimated from inventory plot data. Results represent sampled areas only on lands administered by Forest Service-Region 6, Forest Service-Region 5, and Bureau of Land Management-Oregon. LSR+ = late-successional reserve group, AW/CR = administratively withdrawn/congressionally reserved group, MAT+ = matrix group, ALL = all allocations combined. See table 5 for individual land use allocations included in groups.

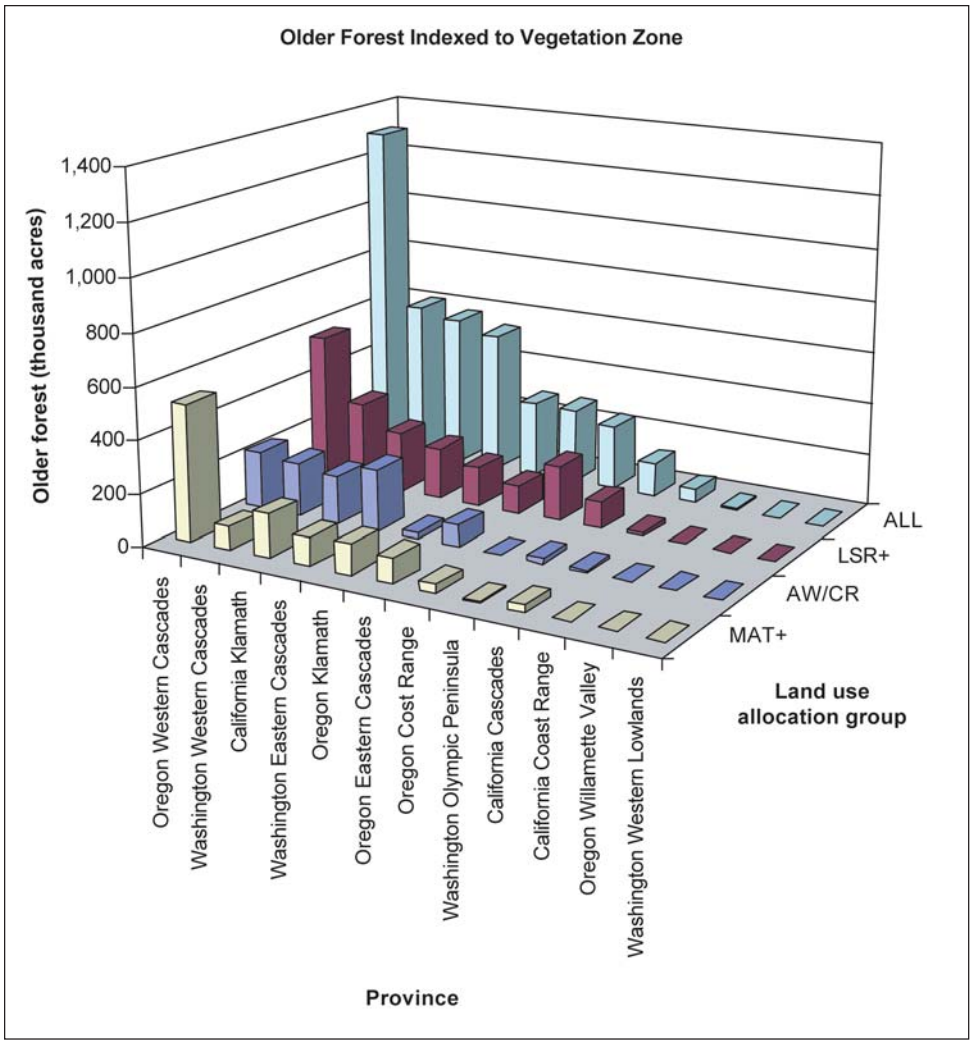


Figure 20b—"Older forest with size indexed to vegetation zone" definition.

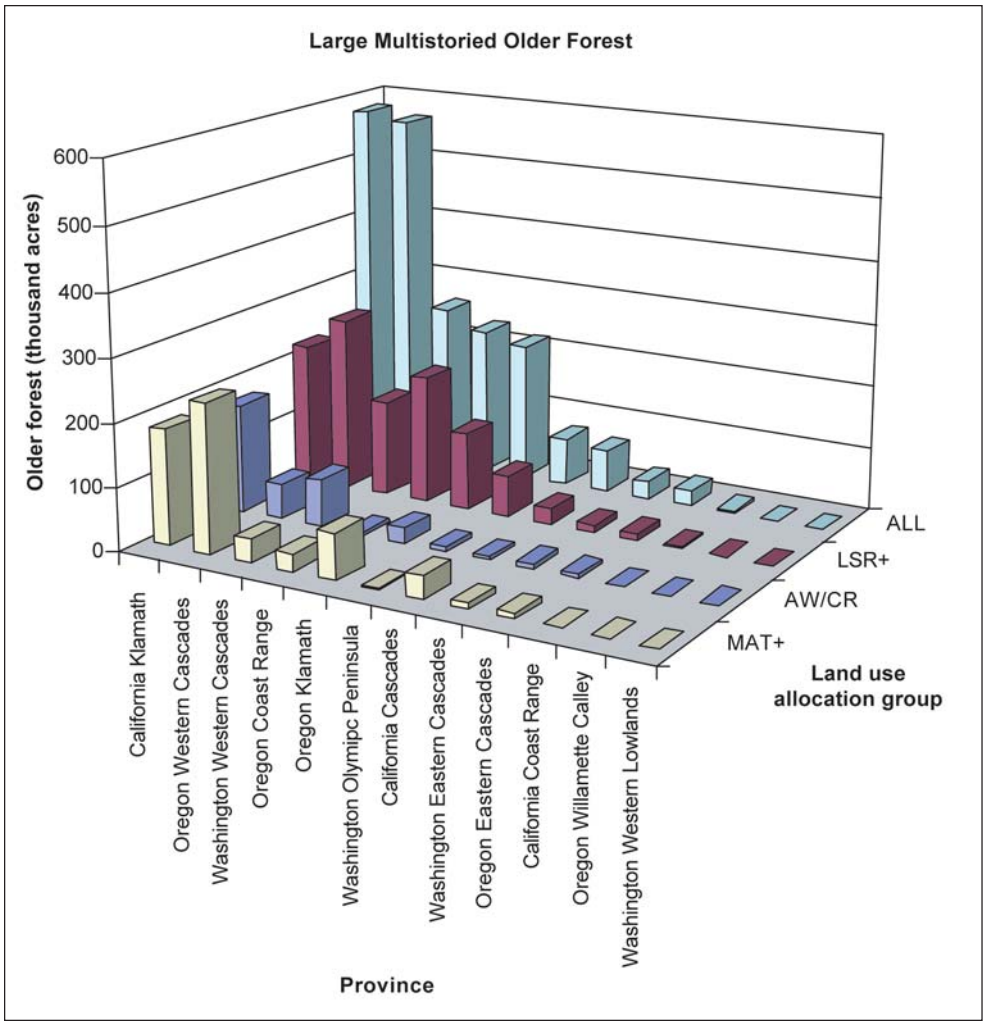


Figure 20c—"Large, multistoried older forest" definition.

inventory plots. Comparison of exact estimates derived from map analysis and plot analysis was a bit of apples and oranges, because the land base in the two estimates was not strictly comparable. The statistical estimates represented an unbiased estimate of acreages for the sampled lands (National Park Service and Bureau of Land Management-California are not included in the statistical estimates). The maps covered all ownerships within the Plan area, but their accuracy was more difficult to quantify. There was good temporal correspondence between the map and plot data. That is, the map was created from satellite imagery collected between 1992 and 1996 (table 10), and the statistical

Large snags and complex canopy layering in an old-growth western hemlock/Douglas-fir forest

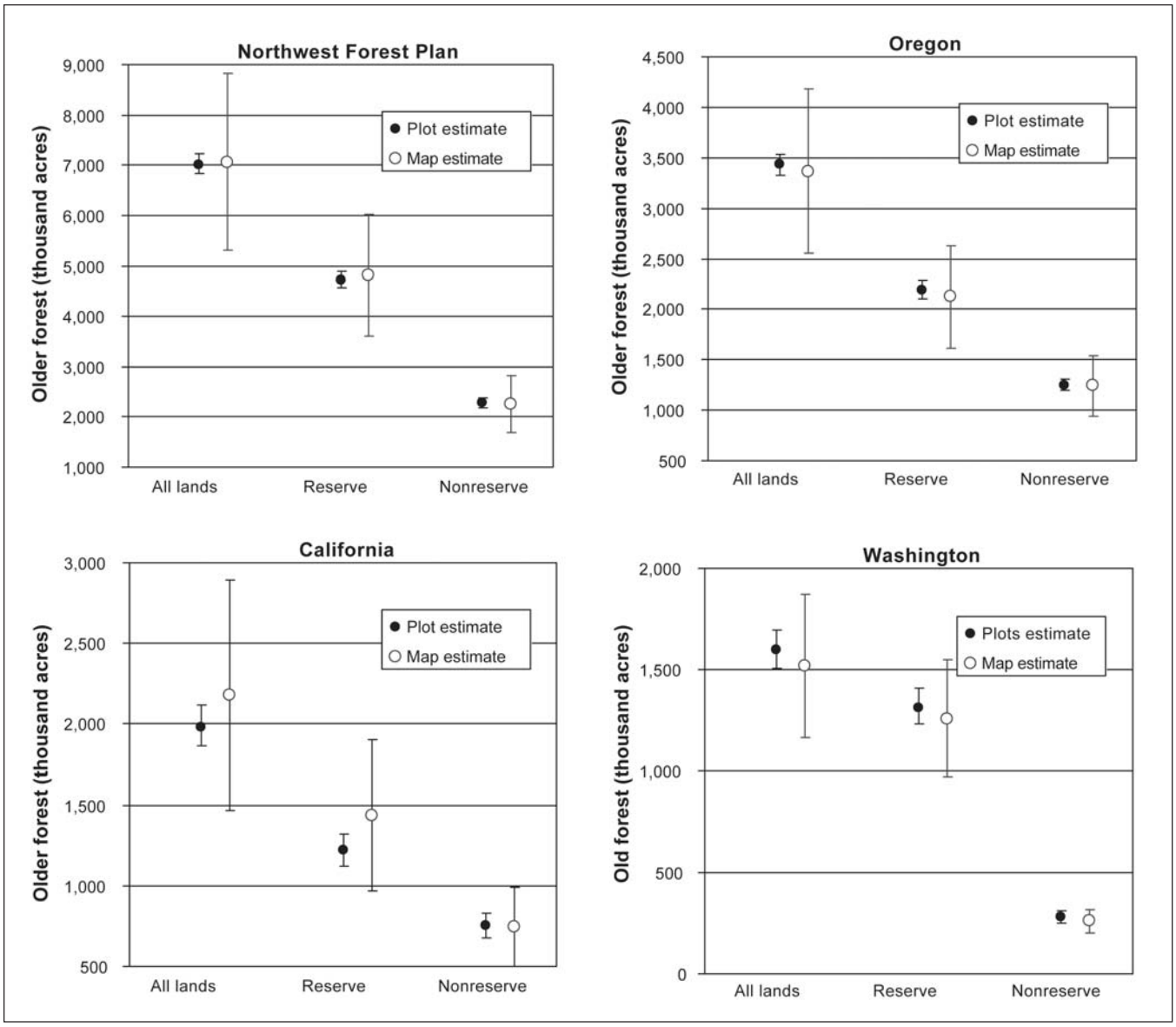


Figure 21a—Comparison of map estimates and statistical estimates from plots for "medium and large older forest" area sampled on lands administered by Forest Service-Region 6, Forest Service-Region 5, and Bureau of Land Management-Oregon. Closed circles = total acres from the plot analysis with 90-percent confidence interval bars computed from a bootstrap variance. Open circles = total acres from the map analysis with map error bars estimated from the map accuracy assessment. See table 5 for individual land use allocations included in reserve and nonreserve categories.

estimate was developed from inventory plots measured between 1993 and 2001 (table 9). Although a formal comparison of the estimates is not statistically valid, a result of consistency between them would lend additional evidence that the older forest maps represent an accurate baseline for the Plan. If the evaluation revealed inconsistencies between the estimates, we would at the least have information about where the maps were weak and be able to assess the effect of the inaccuracies on our interpretations of the results.

We plotted the population estimates and the 90-percent confidence intervals for the amount of older forest estimated from the plot data in figure 21. We plotted the acreage estimates for the same area derived from the maps (with map

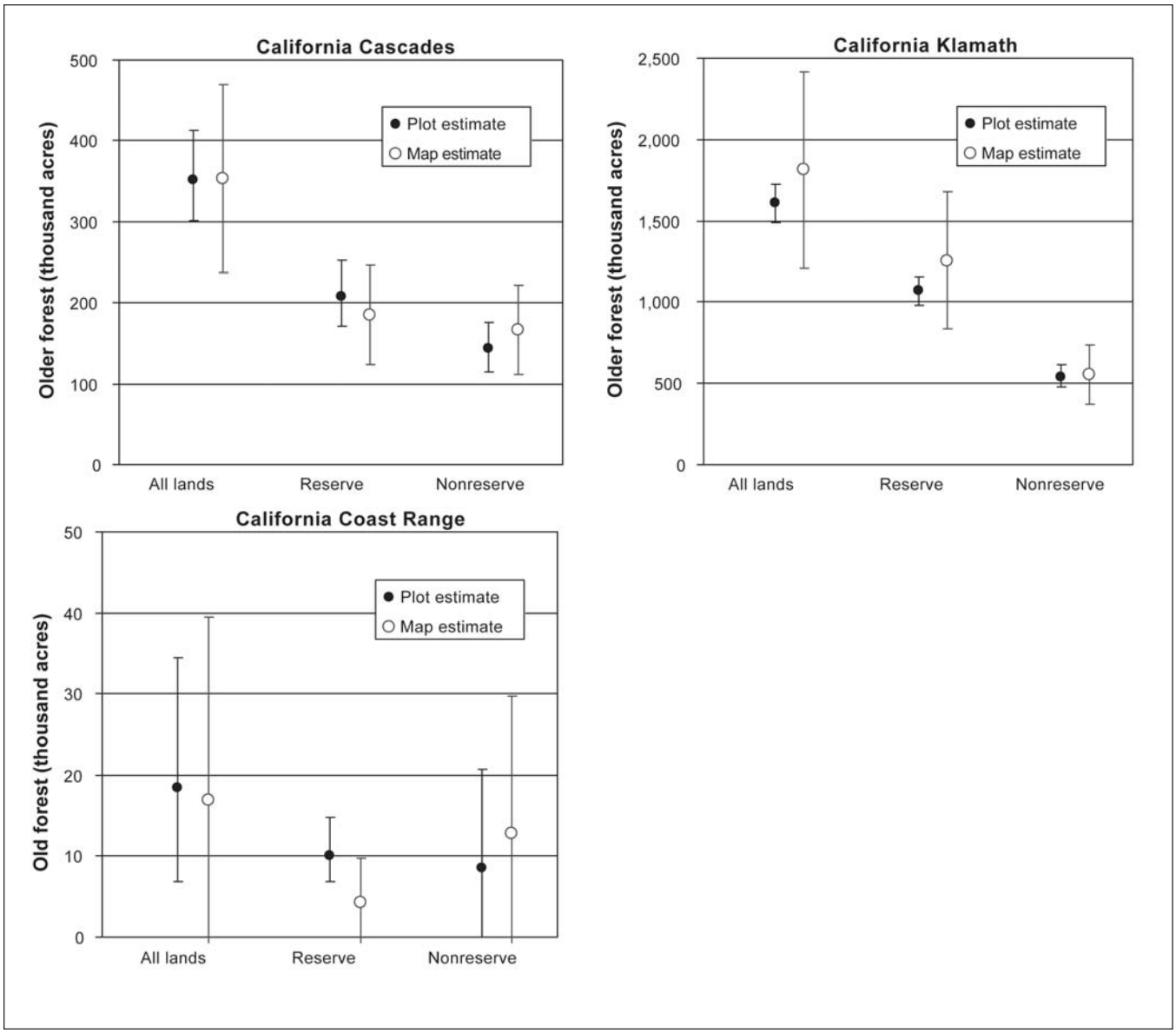
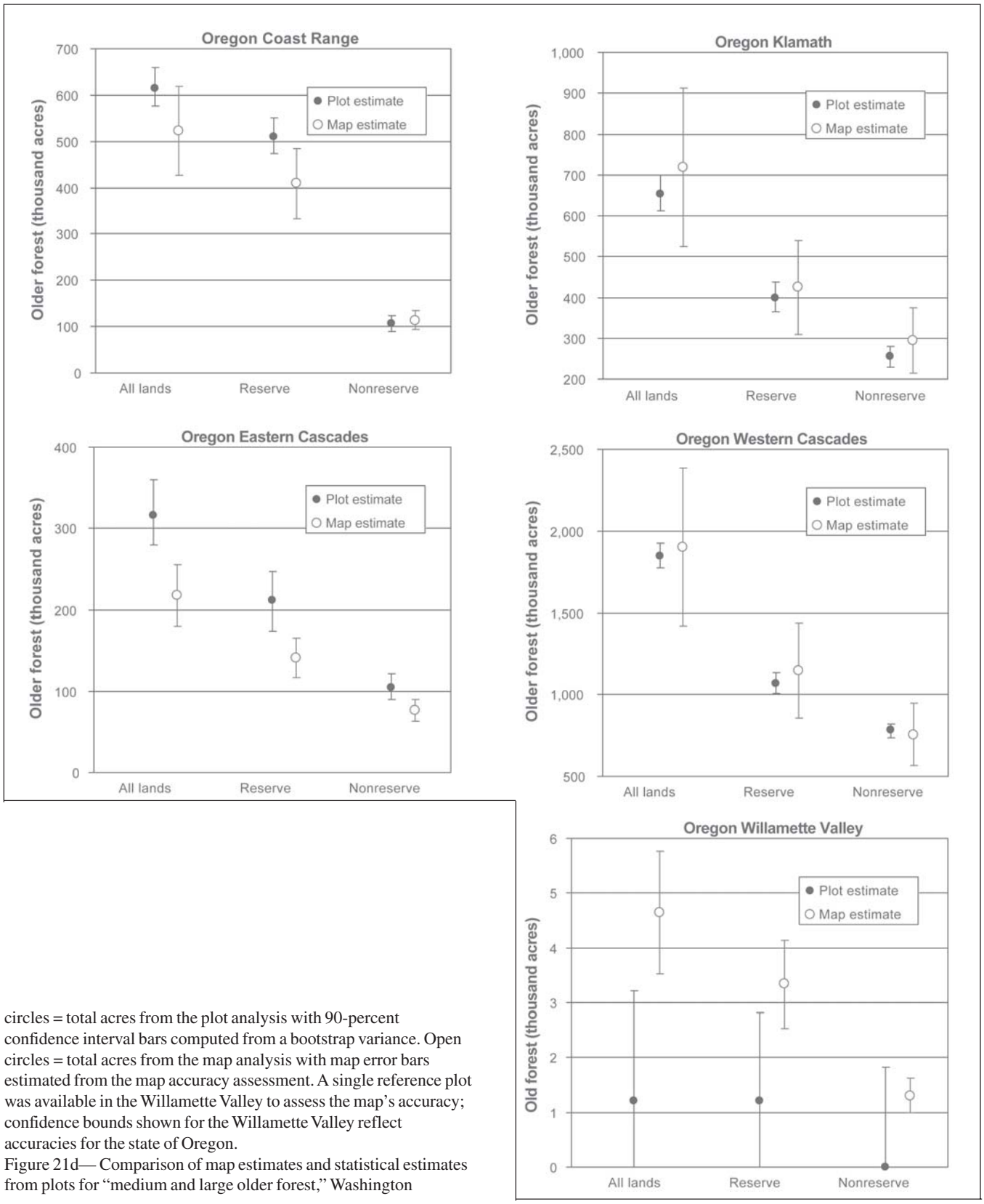
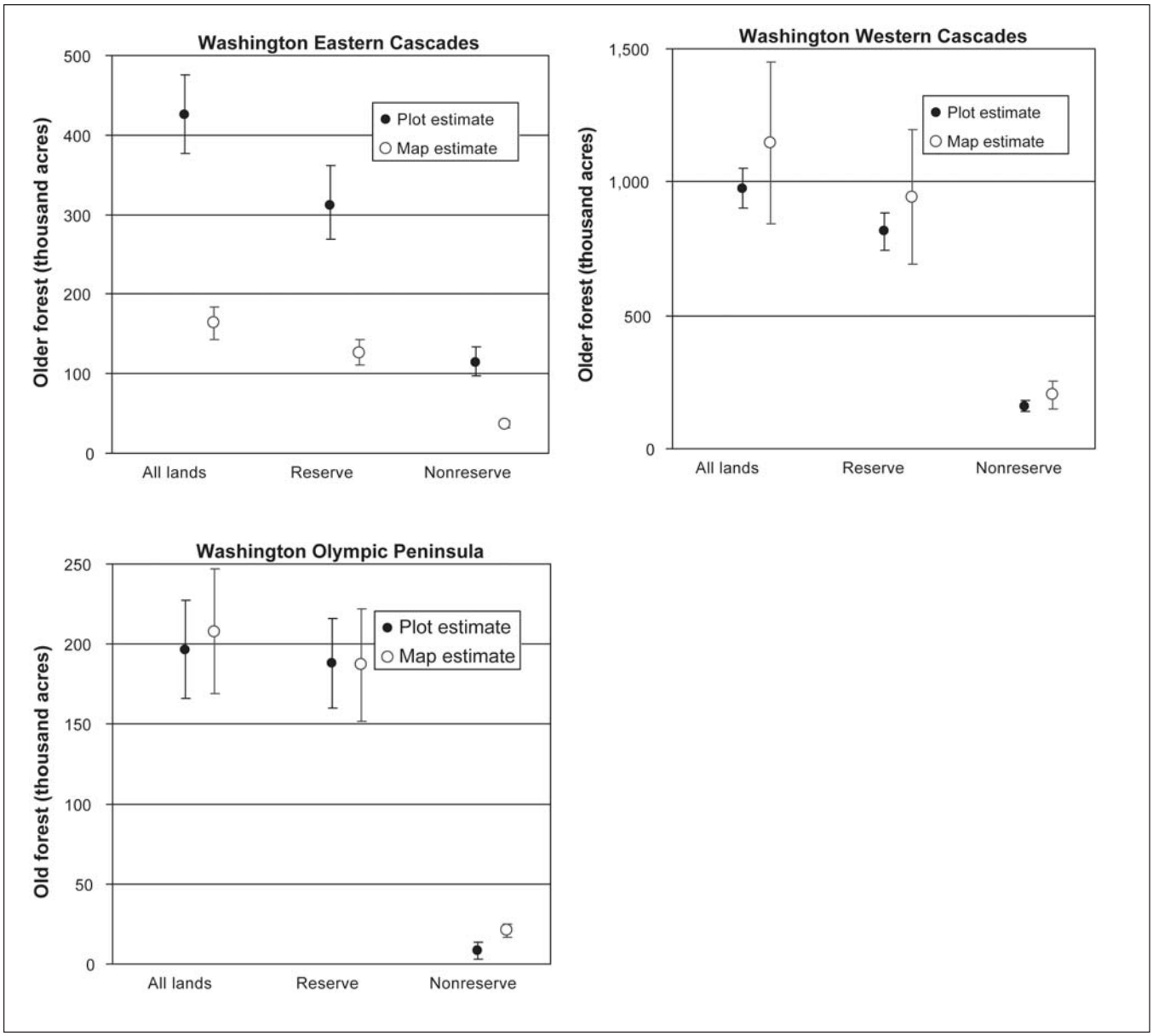


Figure 21b— Comparison of map estimates and statistical estimates from plots for "medium and large older forest," California provinces. Closed circles = total acres from the plot analysis with 90-percent confidence interval bars computed from a bootstrap variance. Open circles = total acres from the map analysis with map error bars estimated from the map accuracy assessment. No reference plots were available in the Coast Range to assess the map's accuracy; confidence bounds shown for the Coast Range reflect accuracies for the state of California.
Figure 21c— Comparison of map estimates and statistical estimates from plots for "medium and large older forest," Oregon provinces. Closed



circles = total acres from the plot analysis with 90-percent confidence interval bars computed from a bootstrap variance. Open circles = total acres from the map analysis with map error bars estimated from the map accuracy assessment. A single reference plot was available in the Willamette Valley to assess the map's accuracy; confidence bounds shown for the Willamette Valley reflect accuracies for the state of Oregon.

Figure 21d— Comparison of map estimates and statistical estimates from plots for "medium and large older forest," Washington



provinces. Closed circles = total acres from the plot analysis with 90-percent confidence interval bars computed from a bootstrap variance. Open circles = total acres from the map analysis with map error bars estimated from the map accuracy assessment. There was less than 100 acres in the Washington Western Lowlands province, so the results are not displayed.

Figure 22a—Distribution of older-forest blocks at the start of the Northwest Forest Plan estimated from the map data. M&L = medium and

errors estimated from the map accuracy assessment) alongside the plot-based estimates. We called the estimates consistent if the map error bars overlapped the confidence interval from the plot-based estimate.

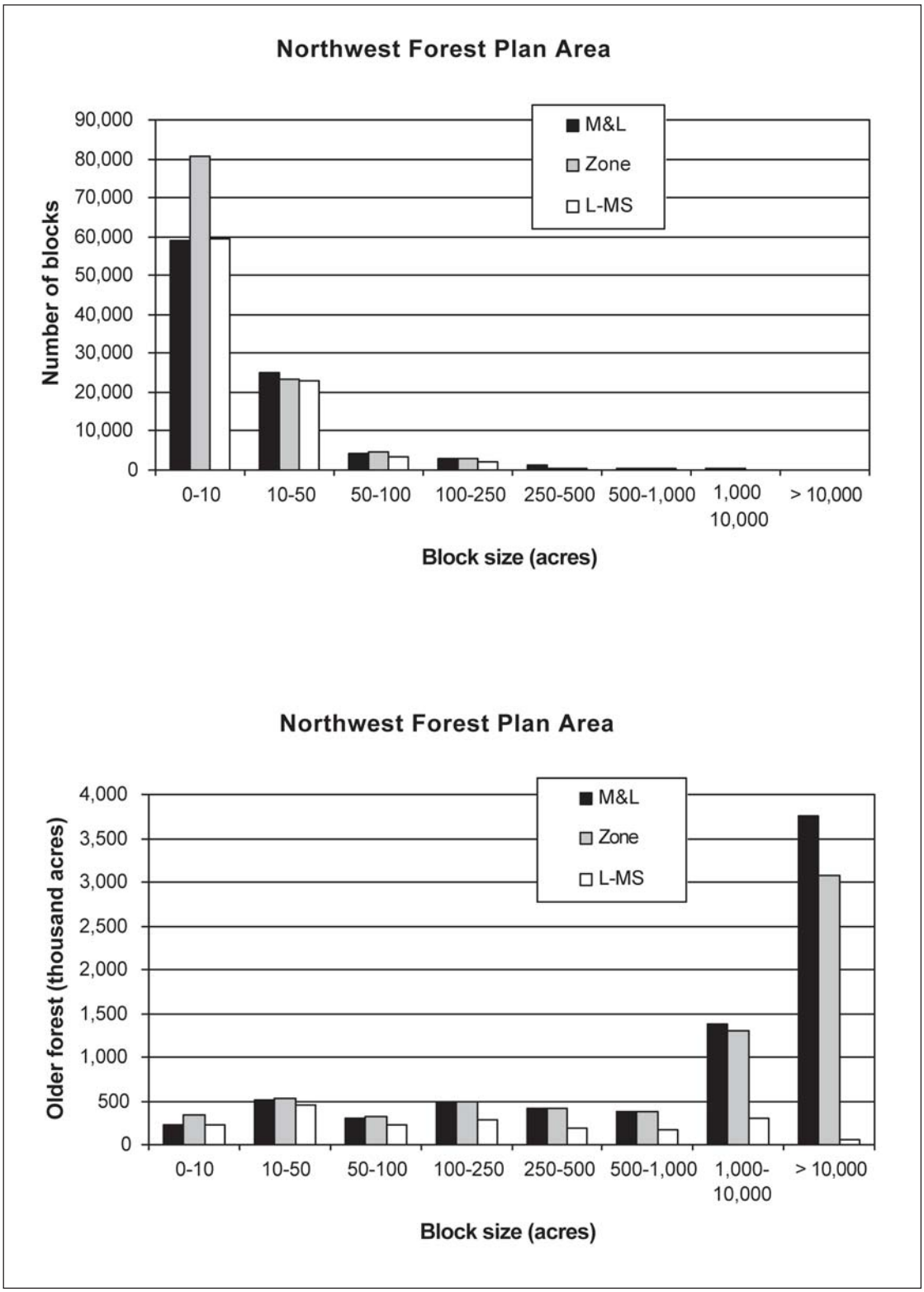
Estimates of "medium and large older forest" acreages developed from statistical analysis of the inventory plot data on Forest Service-Region 5, Forest Service-Region 6, and Bureau of Land Management-Oregon lands were consistent with the amounts estimated by the map analysis at the regional scale, and also at the state level (fig. 21). At the province scale, the map-based and plot-based estimates were consistent, with the following exceptions. Mapped acres derived from the IVMP mapping approach in the eastern Cascades provinces of Oregon and Washington were underestimated compared with plot values (the map error bars were below the 90-percent lower confidence boundary). These two provinces were the map project areas where the relationship between average tree size in the training data, and spectral variables from the satellite data were so weak that the standard modeling protocol was deemed inadequate (see the section on IVMP earlier in this report). Instead of fitting regression models in these provinces, average tree size was mapped by traditional classification methods. Still, there were almost no observations with average size over 20 in on which to base the classification. Thus, the resulting maps predicted very little "medium and large" older forest.

There are different ways of quantifying the magnitude of the underestimate. One is to compute the relative differences between the population estimates. For example, the underestimate appears to be about one-third of the total in the Oregon Eastern Cascades province (that is, the map estimated 217,800 ac, versus the plot estimate of 316,200 ac), or about 98,000 ac total (28,000 ac on nonreserve lands and 70,000 ac on reserve lands). In the Washington Eastern Cascades province, this method leads to an underestimate of about two-thirds (163,500 map-based ac versus 425,300 plot-based ac), for 262,000 ac total (77,000 ac on nonreserve lands and 185,000 ac on reserve lands). An equally valid alternative is to look at the difference between the lower plot confidence limit and the upper map error bar. By this method, the underestimate for the Oregon Eastern Cascades province is about 24,000 ac total, and for the Washington Eastern Cascades, about 193,000 ac total. It is clear that there is a large underestimate of older forest acres in the eastern Cascades provinces (via the mapping method), but the precise value of the underestimate is unknown from our current data—it is likely to be in the 200,000- to 300,000-ac range. However, the implication is clear that relying strictly on the map estimates will probably lead to misinterpretations of amounts and patterns of older forests predicted in the eastern Cascades provinces. In the results that follow, we will continue to provide reminders that the estimates are low in these provinces.

Older Forest Landscape Patterns

The frequency distribution of older-forest block sizes was reverse J-shaped (fig. 22). That is, the vast majority of contiguous older forest patches were in blocks smaller than 1,000 ac, by any of the definitions. However, large blocks (1,000 ac and larger) accounted for the majority of older forest area according to the "medium and large older forest" definition (65 percent of "medium and large" older forest was in blocks >1,000 ac [table 11]) or "older forest with size indexed to potential natural vegetation zone" definition (62 percent). However, blocks >1,000 ac accounted for only 13 percent covered by "large, multistoried" older forest.

Of "medium and large older forest," very large (at least 10,000 ac) and large (at least 1,000 ac) contiguous older forest blocks were concentrated in the Western Cascades, Klamath, California Cascades, and Olympic Provinces (fig. 22, fig. 23a). Not surprisingly, these provinces had the greatest proportion of land in contiguous federal land ownership. Large blocks were relatively scarce in the Eastern Cascades of Washington and Oregon even though the proportion of federal land was high there. The frequency and acreage of large blocks of older forests in the eastern Cascades provinces is likely higher than shown, because of the underestimate in the map results. In the remaining provinces (Oregon Coast, California Coast), large blocks were scattered, primarily because in those provinces contiguous blocks of federal land are separated by large distances. The relative importance of large older-forest blocks increased in the Eastern Cascades with use of the



large older forest; Zone = older forest with size indexed to vegetation zone; L-MS = large, multistoried older forest.
Figure 22b—Older forest blocks, California provinces.
Figure 22c—Older forest blocks, Oregon provinces.

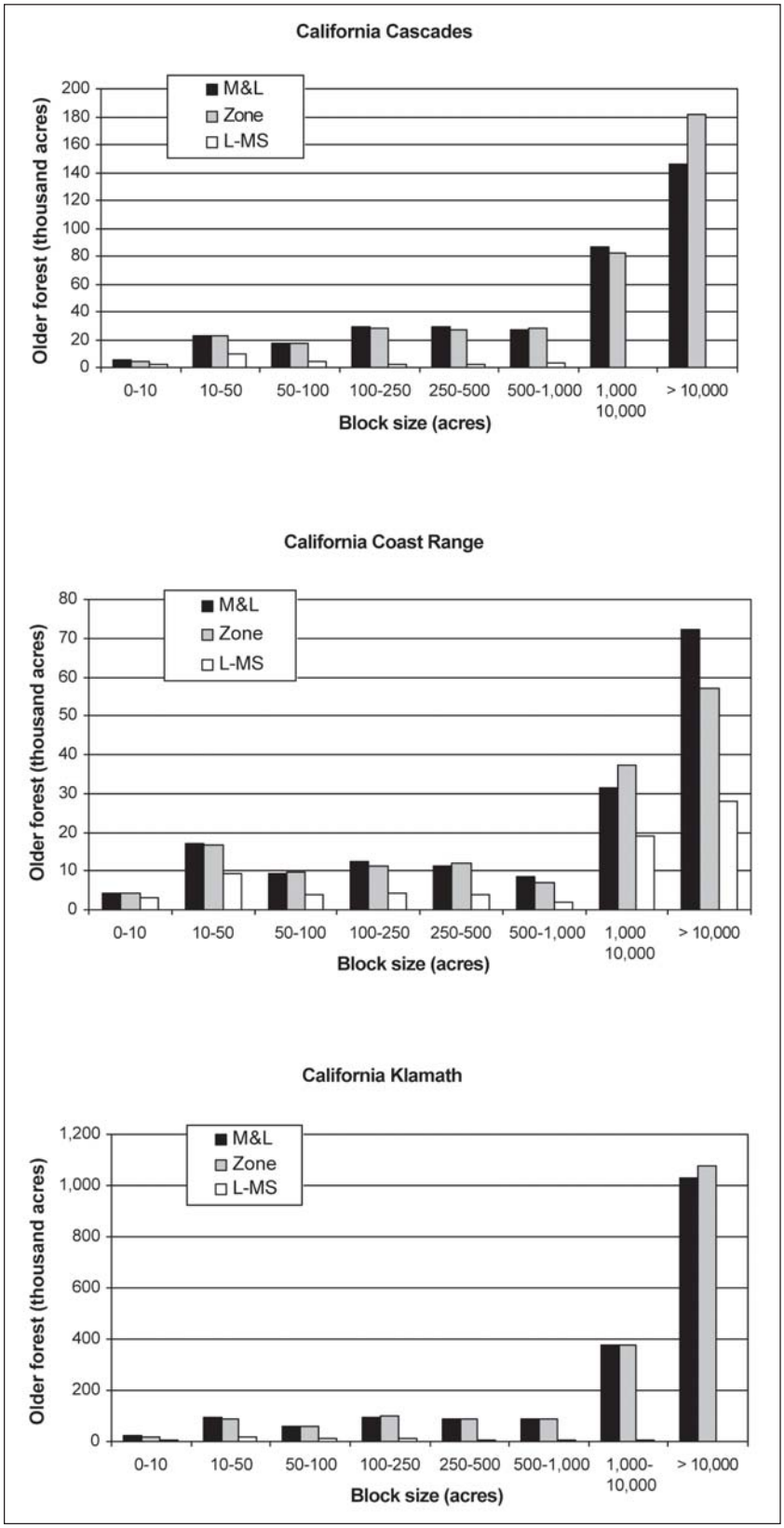
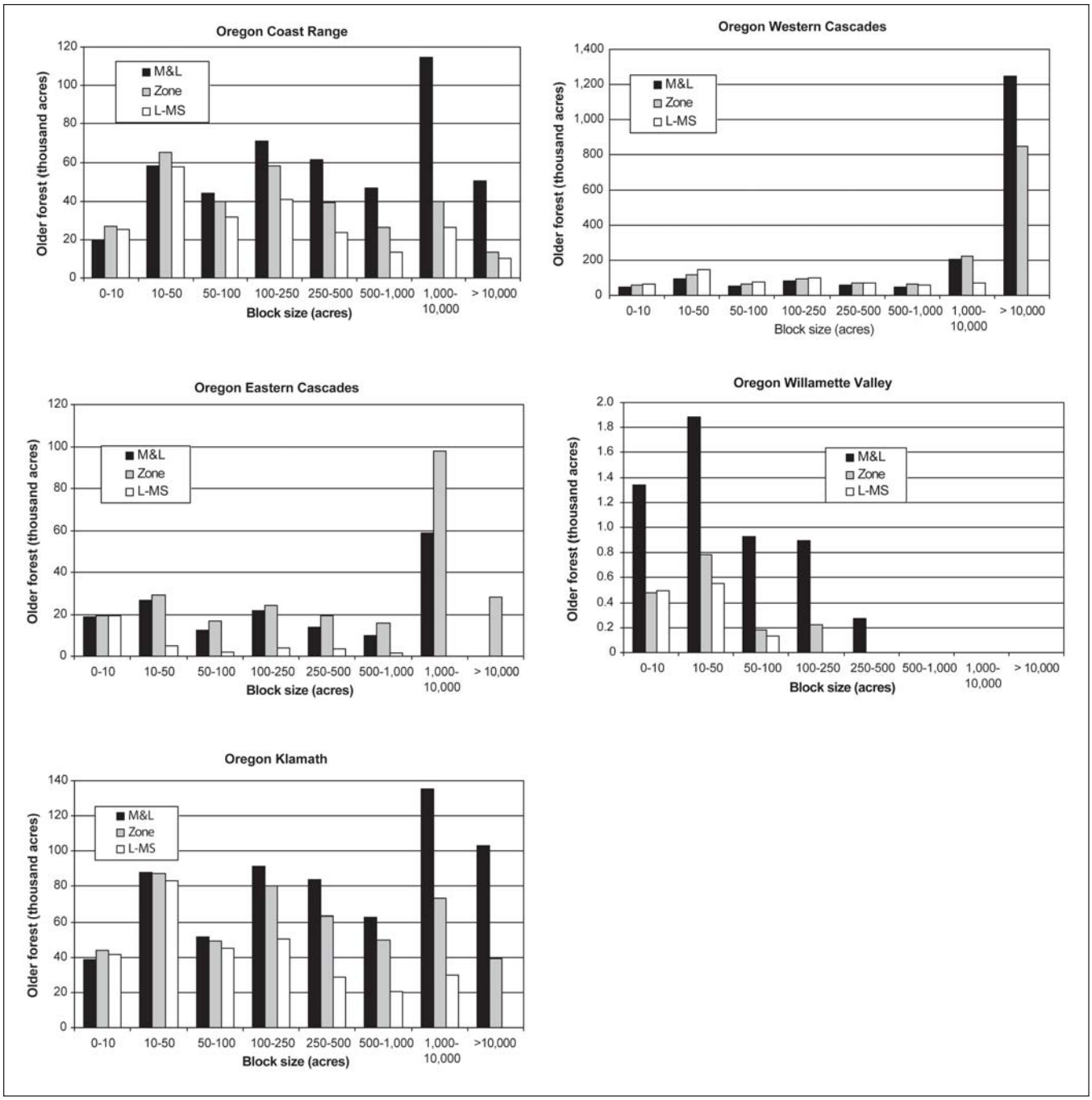
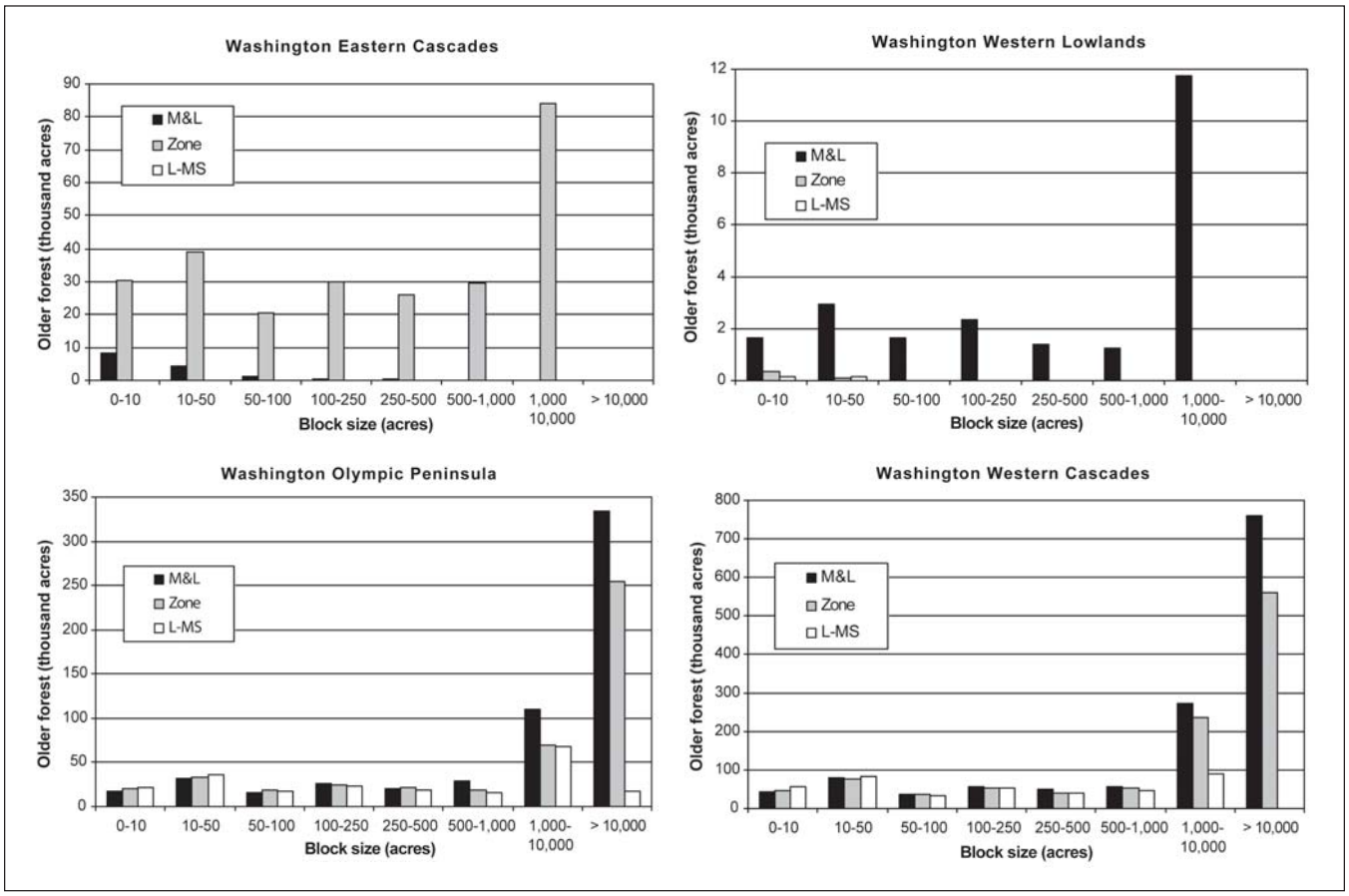


Figure 22d—Older forest blocks, Washington provinces.


Oregon Coast Range
Oregon Western Cascades
Oregon Eastern Cascades
Oregon Willamette Valley
Oregon Klamath
M&L
Zone
L-MS
Older forest (thousand acres)
Block size (acres)
0-10
10-50
50-100
100-250
250-500
500-1,000
1,000-10,000
> 10,000



Continue to Part C

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