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Analysis of Change in Timber Volume on Non-Federal Timberlands in Washington

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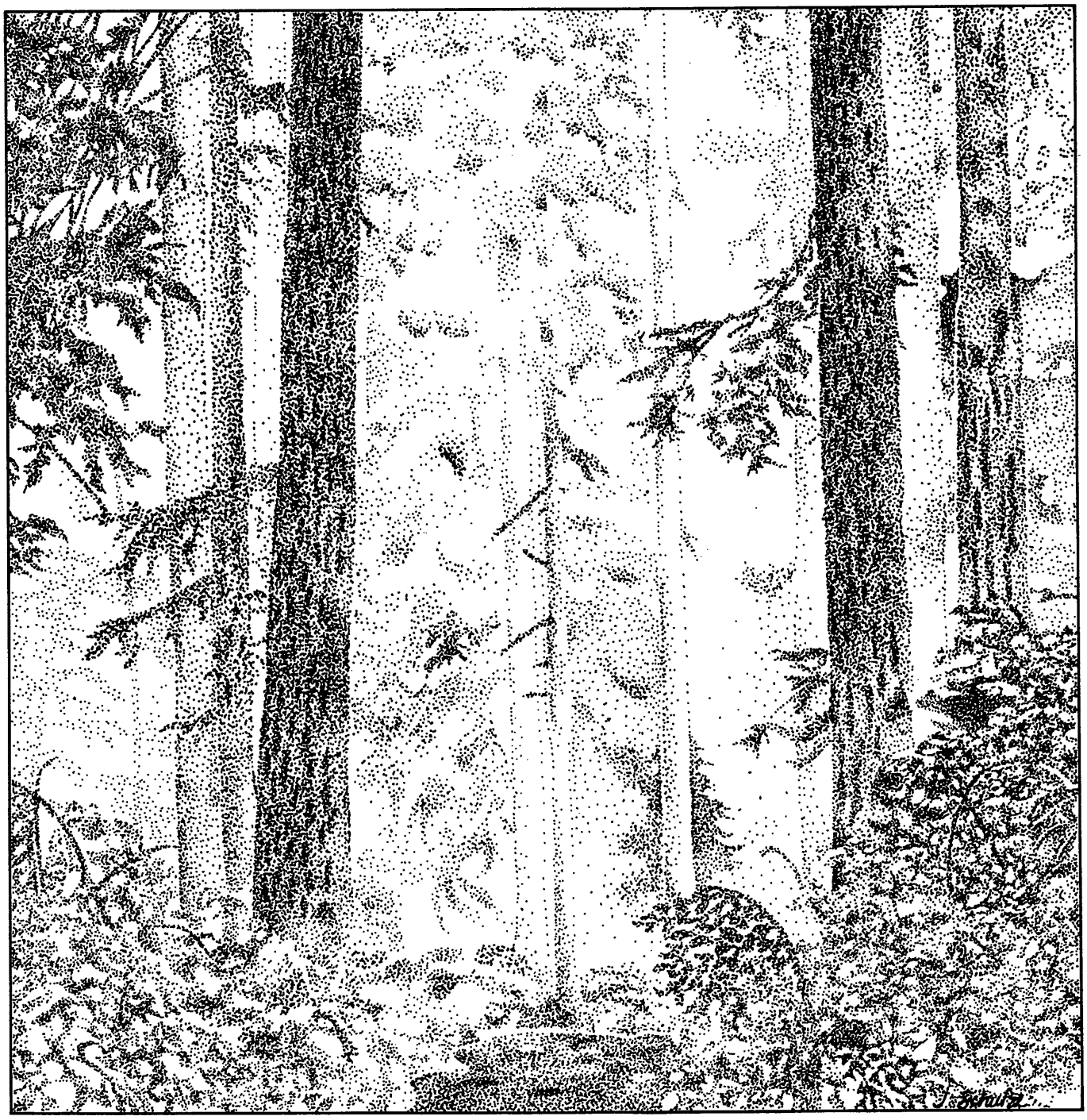

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Abstract

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This report presents the findings of a study conducted to determine change in per acre timber volume on non-Federal timberlands in Washington from the mid-1960's to 1978-80. The basis for the study was the measurement of 1,576 permanent plots at two occasions. The study findings include estimates of change in volume and of the components of change-growth, mortality, and timber cut. Timber volume increased during the period in eastern Washington but was apparently stable in western Washington. The findings differ, however, among owners and geographic areas. Tables of volume change, growth, harvest, and mortality are presented by owner group and geographic area.

Keywords: Timber volume, non-Federal lands, forest surveys, Washington.

Summary

Non-Federal forests in Washington were sampled on two occasions with one set of permanent plots to determine changes in timber volume and elements of those changes. The paired-measurement sampling approach made possible determination of volume change due to growth, harvest, and mortality, thereby eliminating the often confusing influences of changes in land base estimation, ownership shifts, definitions, and design. Results of the volume change analysis indicated significant increases in softwood and hardwood timber volume in eastern Washington; each of the three sampled owner groups had per-acre volume increases of 200 to 300 cubic feet (10 to 22 percent) during the period. In western Washington the change in softwood volume for all non-Federal lands combined proved small and statistically not significant. But there were significant volume changes for some of the sampled owner groups and geographic areas. Per-acre softwood volume decreased over 500 cubic feet (14 percent) on forest industry lands, but increased over 500 cubic feet (26 percent) on nonindustrial private lands. The decrease in softwood volume was concentrated in southwest Washington. There were substantial increases in hardwood volume in all owner groups and all geographic areas in western Washington. The results of this study provide information on the recent dynamics of non-Federal timber stocks in Washington.

Contents

Introduction

Findings are summarized from a study of change in timber volume on non-Federal timberlands in Washington from the 1960's to 1978-80.' The study was undertaken to estimate the magnitude and direction of change in timber volume for important geographic areas and owner groups. An added objective was to determine the contribution of harvest, mortality, and growth to changes in timber volume. The impacts of changes in the timberland area base were not addressed.*

The study was undertaken in response to frequent, often unanswered questions about recent dynamics in the timber resource situation in Washington. Planners and land managers, in both public and private sectors, and formulators of public policy and programs are major users of the results of extensive sample-based timber inventories, which provide information on the current status of timber resources. This same audience needs information on trends—a means of monitoring the effects of past management, use, programs, and policies on timber resources in the State. This study was intended to partially address that need.

Background

Regional timber inventories often have as their primary objective an assessment of the current status of timber resources to answer questions about quantity, quality, location, ownership, and condition. Inventory design, definitions, and standards change in response to changing objectives and information needs. These changes have made the determination of trends in timber resources difficult. As a consequence, the summaries of regional inventories such as those recently published for Washington are often limited to information on the current status of timber resources (Bassett and Oswald 1981a, 1981b, 1982, 1983). The results of those inventories cannot be compared directly to published results of earlier timber inventories to determine changes.

The problems encountered in attempting such comparisons are little understood but are receiving increased recognition (Oswald 1983, Powell and Cost 1983). Changes between inventories in standards, definitions, the estimated area base, and assumptions about utilization result in apparent changes in the inventory volume estimates that are indistinguishable from real changes. Users comparing published results of two inventories done at different times for any of the inventory units in Washington could reach erroneous conclusions regarding the direction or magnitude of change. And the user's ability to identify the magnitude of the causal factors-growth, mortality, and harvest—would be limited.

In Washington, general trends in timber resource use and development were monitored through independent studies designed to determine changes in timber stocks and the causal factors. This report outlines the process used to monitor changes in timber volume and to identify components. Results of the analysis of change are presented for each of the units inventoried and for the half-State areas, eastern and western Washington.

'Timberland is unreserved forest land producing or capable of producing 20 cubic feet of wood per acre per year under natural conditions.

[2]Non-Federal timberland area in Washington decreased an estimated 3 percent from the mid-1960's to the late 1970's. This change in timberland area had relatively little effect on timber volume. Change in timberland area is the subject of another study.

The Inventories

The inventories conducted in the period 4978-80 to determine current status of Washington's forests were organized into four inventory units (fig. 1). In each unit, lands other than National Forest lands were sampled using double sampling for stratification (Cochran 1963). The first phase sample consisted of a large number of photo plots that were classified according to major land class and ownership. The second phase sample consisted of field plots located on a 3.4-mile square grid. **A** total of 1,651 field plots were established on non-Federal timberland.

Although most of the field plot locations were also used for the inventories conducted in the 196O's, the plot sizes and configurations for the new inventories in western Washington were different from those used in the 1960's. But, because the plots from all the earlier inventories were permanent and monumented, they could be located and remeasured at the time the new plots were established. The remeasured plots were the basis for this study of change in timber volume.

Each of the plots established in the 1960's was actually a cluster of 10 variable-radius plots. Each cluster sampled approximately 1 acre of forest land. When the grid locations were visited in 1978-80 to install the new plots, **4** plots (in western Washington) or 5 plots (in eastern Washington) of each original cluster were examined to account for trees that had died or had been harvested and to measure growth of surviving trees. New trees (ingrowth) were also tallied. The tallies and measurements taken on the remeasured plots provided the information needed for a complete accounting of volume change and its components.

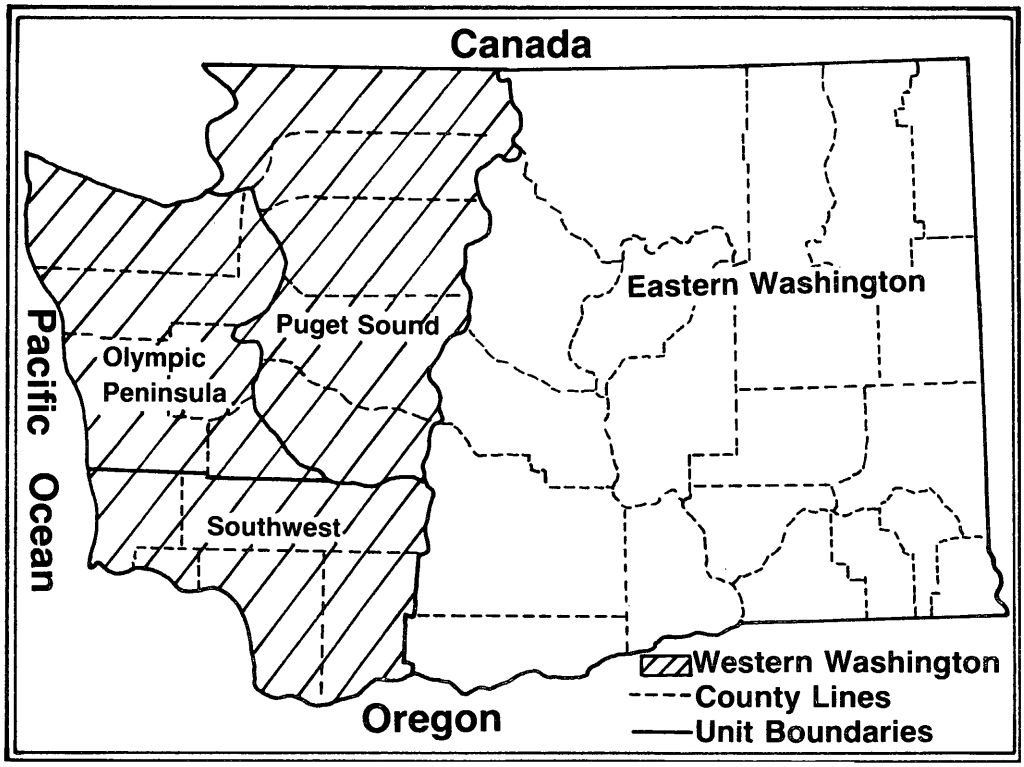

Figure 1.—inventory units, Washington.

The inventories conducted in the mid-1960's excluded some suburban forested areas that were included in the recent inventories. Because of these differences in the area inventoried, remeasurement plots were not available for all of the areas represented in the new inventories. For all of Washington, 1,576 timberland plots were remeasured; these plots represented 95 percent of all timberland area covered by the new inventories. Although this percentage varied by inventory unit and owner group, at least 80 percent of the newly inventoried timberland area was also sampled for volume change in every area-ownership stratum (table 1).

As was mentioned, the recent current status inventories use a design known as double sampling for stratification. In that design, the second-phase samples—the field plots—are given area weights based on the estimated area of the photo strata from which they are drawn. As a consequence, the plot weights vary.

Table I—Summary of remeasured timberland plots and percentage of area sampled, by inventory unit and owner, Washington

Inventory unit and owner	Date of first measurement	Date of remeasurement	Measurement period	Number of remeasured timberland plots	Percent of timberland area 1/ sampled
			Years		Percent
Western Washington:					
Southwest--					
Public	1953	1973	15	54	95
Forest industry	1963	1978	15	210	96
Nonindustrial private	1963	1978	15	74	94
Total or average				338	95
Olympic Peninsula--					
Public	1965	1978-79	13	96	96
Forest industry	1965	1978-79	14	164	99
Nonindustrial private	1965	1978-79	14	66	66
Total or average				326	95
Puget Sound--					
Public	1966-67	1979	13	85	96
Forest industry	1966-67	1979	13	137	99
Nonindustrial private	1966-67	1979	13	101	30
Total or average				323	92
Eastern Washington:					
Public	1367-68	1980	13	273	99
Forest industry	1967-68	1980	13	113	98
Nonindustrial private	1967-68	1980	13	203	98
Total or average				589	98

1/Percentage of timberland area sdrnpled for cnange in timber volunie equals the number of remeasured plots divided by the number of new inventory plots, multiplied by 100.

For this study of change in volume, I have used the fixed grid of remeasurement plots as a simple sample with equal plot weights. This approach fixes the weights for both measurement occasions, thus eliminating area estimation changes as a factor in volume differences. (In the periodic current status inventories, plot weights change at each inventory occasion because of changes in stratum area estimates, which are based on photo samples.)

The Owner Groups

This paper is titled, in part, "... on non-Federal timberlands." The title is slightly misleading. The private land owner categories that were part of the study (forest industry and nonindustrial private) included the full spectrum of private owners. The public lands included in the study, though referred to as non-Federal for convenience, really excluded only National Forest timberlands, which account for 96 percent of all Federal timberlands. The National Forests were not included in the study because of a lack of comparable data based on plot remeasurement. The "non-Federal" public timberland area sampled for this study was 54 percent State-owned, 36 percent Indian lands managed in trust by the Bureau of Indian Affairs, 5 percent county and municipal lands, and 5 percent Federal lands managed by the Bureau of Land Management and the Department of Defense.

Differences Between inventory and Study Results

Although this study of change in timber volume was based on sampling of the same timber resource at the same times as the inventories already reported, it was an independent study focused on estimates of volume change due to harvest, mortality, and growth. It would, as a consequence, provide different estimates of volume than those already published, if compiled as a current status inventory. The published inventory summaries (Bassett and Oswald 1981a, 1981b, 1982, 1983) are the preferred estimates of current status. This report provides the information needed to discuss trends in volume for timber resources in Washington.

Method of Analyzing Change

The objective in remeasurement of the permanent plots was to account for all trees that existed at the first measurement, to record size (diameter and height) for trees that survived the measurement period, and to identify and measure new trees that were not present at the first measurement. The trees of concern in this study were those that contained "growing stock" volume, sound live trees 5.0 inches (12.5 cm) d.b.h. (diameter at breast height) or larger. The change in volume for a plot equals the volume of growing stock at the second occasion of measurement minus the volume of growing stock at the first occasion:

$$AV = V_2 - V_1, \text{ or } G - M - C, \text{ and}$$

$$V_2 = V_1 - C - M + G;$$

where:

AV = change in volume during the measurement period;

V_1 = volume of growing stock trees at the beginning of the growth measurement period;

V_2 = volume of growing stock trees at the end of the growth measurement period;

M = mortality, the volum'e at the beginning of the growth measurement period of trees dying during the measurement period;

C = cut, the volume at the beginning of the growth measurement period of trees cut during the measurement period;

G. = growth, the volume increase on growing stock trees surviving the growth measurement period, and volume of ingrowth trees; and

I = ingrowth, the volume at the end of the growth measurement period of trees reaching the minimum size for volume (5-inch d.b.h.) during the growth measurement period, and surviving to the end of the period.

The components of volume change fall into two categories—those that add volume and those that subtract volume. Those that add volume are often collectively termed "growth." Growth consists of increases in volume on trees present at both measurement occasions (increment) and the volume of trees attaining measurable volume size between the first and second occasions (ingrowth). The negative components are mortality and cut, collectively referred to as "drain." Mortality is volume loss due to death by natural causes of trees that were tallied at the first occasion (measurement). Cut is volume lost due to harvesting plus volume loss from cultural killing (that is, precommercia1 thinning) of trees that were tallied at the first occasion (measurement). In this study, both cut and mortality volume estimates were based on the dimensions of the trees at the first occasion.

Because of the estimation procedures for growth, cut, and mortality, estimated volumes of each of these components of change is biased on the low side. The estimated volumes of mortality and cut trees were understated because the trees were actually cut or died during the interval between measurements; most of them actually increased in size and volume before they were harvested or they died. This ignored growth on trees that died or were cut also represents an unestimated amount of growth.

In practice, estimates of growth on trees that have died or have been cut are commonly disregarded because of a lack of tree measurement at the time of the loss (Davis 1966). The biases have no effect on estimates of change in timber volume because the volume of unestimated growth is equal to the unestimated drain. The net gain or loss attributable to the plus and minus factors combined—hang—is correct and is consistent with the mean volume difference between growing stock volume estimates at the two measurement occasions.

Assumptions about the timberland area base for this study were straightforward. The paired measurement data were for plots that were classed as timberland on both occasions. The study, then, was for that part of the timberland base that had been stable in use and availability for the entire period. Plots on lands that, through exchange, passed to or from National Forest ownership are excluded. Plots on lands that had real or previously perceived limitations on past use for timber production were also excluded.

Another assumption was made about the stability of the timberland area base. The three major owner groups used in the presentation represent the current ownership of the timberland. There have been internal shifts in acreage among these three owner groups during the measurement period. But the complexities of tracking the impacts of owner

shifts on volume change are many. An attempt to incorporate the impacts of owner shifts on volume change in this study would distract from the primary objective of identifying the impacts of natural processes and of management and harvest activities on the timber resource.

Results

The major findings of the study were estimates of mean differences (volume change) for the measurement period. These, and the estimates of components of change (growth, mortality, and cut), are presented on either a per-acre basis or on a percentage -of-change basis for the measurement period. In cases where the inventory units were combined for presentation, no adjustments were made for the differences in length of measurement periods for the inventory units (table 1).

Many of the estimates are presented either graphically or in the form xxx ± xx with associated 95-percent confidence intervals. When data are shown in this form, the first value, (xxx), is the estimated mean, and (±xx) is the 95-percent confidence interval.

For volume change, the estimated difference indicates a significant change in volume if the range of values excludes the zero change volume. But if the range of values **includes** the zero change value, the sample data indicate no significant change in volume.

In this study, the confidence intervals were often very wide because of high variability in the sampled population; in such cases, inclusion of the zero change value in the confidence interval was not conclusive evidence that timber volume remained unchanged during the measurement period. The sample provided insufficient information to determine what has happened in such instances.

Volume Change by Area, Inventory Unit, and Owner Group

In western Washington, softwood volume did not change significantly during the measurement period (-71 ± 286 cubic feevacre); hardwood volume increased (+278 ± 66 cubic feevacre). In eastern Washington, significant volume increases were found for both softwoods (+271 ± 82 cubic feevacre) and hardwoods (+ 10 ± 6 cubic feevacre) (table 2). These aggregates across ownerships and large geographic areas tend to mask some changes that were identified for individual owner groups and the smaller inventory units. The following discussion points out some of the important volume changes that were identified in the study. Table 2 provides detailed findings on volume changes and related confidence intervals. Table 3 provides detailed findings on the components of the volume changes (growth, harvest, and mortality) with related confidence intervals.

Eastern Washington.—The overall increases in timber volume on non-Federal timberlands in eastern Washington during the 1967-68 to 1980 period were indicative of volume changes found in each owner group. Significant increases were found in softwood volume for each owner group, and in hardwood volume for all but forest industry lands (fig. 2). Softwood volume increases averaged 10 percent on public lands, 13 percent on forest industry lands, and 22 percent on nonindustrial lands.

Although softwood growing stock volumes were substantially higher on public and forest industry lands than on nonindustrial lands at both measurement occasions, the nonindustrial timberlands had almost as much cut and growth per acre as did the public and industrial timberlands during the measurement period (fig. 3). In all owner groups, growth exceeded drain during the measurement period.

Table 2—Average volume change by species group, area, inventory unit, and owner group, Washington

Area, inventory unit, and owner group	Volume change and 95-percent confidence interval		
	Softwoods	Hardwoods	All species
	Cubic feet per acre		
Western Washington:			
Southwest--			
Public	+97 ± 1,355	+53 ± 207	+150 ± 1,396
Forest industry	-1,381 ± 820	+196 ± 132	-1,175 ± 845
Nonindustrial private	+543 ± 760	+574 ± 334	+1,123 ± 842
Olympic Peninsula--			
Puolic	-108 ± 1,097	+137 ± 104	+29 ± 1,112
Forest industry	+ 59 ± 764	+328 ± 164	+387 ± 970
Nonindustrial private	+151 ± 834	+398 ± 442	+549 ± 992
Puget Sound--			
Public	+906 ± 655	+284 ± 188	+1,190 ± 713
Forest industry	+34 ± 647	+131 ± 162	+165 ± 691
Nonindustrial private	+820 ± 396	+528 ± 246	+1,348 ± 514
All western Washington units--			
Public	+306 ± 586	+171 ± 91	+477 ± 604
Forest industry	-539 ± 451	+221 ± 87	-318 ± 471
Nonindustrial private	+554 ± 360	+507 ± 186	+1,061 ± 425
Eastern Washington:			
Public	+230 ± 122	+13 ± 13	+243 ± 123
Forest industry	+303 ± 221	-1 ± 7	+302 ± 223
donindustrial private	+310 ± 136	+12 ± 8	+322 ± 138

Table &Average volume at 2 occasions, and components of volume change, by species group, area, inventory unit, and owner group, Washington

Area, inventory unit, and owner group	Average volume and 95-percent confidence interval									
	Volume, occasion one		Components of volume change						Volume, occasion two	
			Mortality		cut		Growth			
	Softwoods	Hardwoods	Softwoods	Hardwoods	Softwoods	Hardwoods	Softwoods	Hardwoods	Softwoods	Hardwoods
	Cubic feet per acre									
Western Washington:										
Southwest--										
Public	3,348 ± 1,620	315 ± 244	19 ± 36	65 ± 64	1,413 ± 1,196	97 ± 165	1,529 ± 606	215 ± 136	3,445 ± 1,506	414 ± 274
Forest industry	4,088 ± 788	369 ± 129	139 ± 74	31 ± 24	2,626 ± 719	85 ± 59	1,385 ± 319	312 ± 120	2,707 ± 604	565 ± 200
Nonindustrial private	1,92d ± 856	538 ± 288	89 ± 88	34 ± 48	684 ± 592	30 ± 46	1,322 ± 498	639 ± 330	2,477 ± 946	**1,082** ± 580
Olympic Peninsula--										
Public	5,709 ± 1,427	157 ± 107	206 ± 115	18 ± 23	1,959 ± 940	4 ± 8	2,058 ± 528	159 ± 107	5,601 ± 1,467	294 ± 184
Forest industry	3,909 ± 827	587 ± 172	105 ± 63	30 ± 21	1,653 ± 633	94 ± 65	1,817 ± 370	452 ± 153	3,968 ± 864	915 ± 286
Nonindustrial private	2,608 ± 952	988 ± 428	50 ± 58	.67 ± 56	1,108 ± 676	229 ± 234	1,309 ± 482	694 ± 380	2,759 ± 1,070	1,386 ± 618
Puget Sound-										
Public	2,989 ± 940	671 ± 294	177 ± 106	22 ± 22	572 ± 440	121 ± 126	1,654 ± 486	327 ± 188	3,895 ± 1,158	955 ± 406
Forest industry	3,266 ± 794	554 ± 192	140 ± 75	61 ± 36	1,130 ± 540	170 ± 101	1,304 ± 315	362 ± 132	3,299 ± 788	685 ± 251
Noninaustrial private	1,928 ± 565	360 ± 283	99 ± 95	30 ± 29	355 ± 176	197 ± 119	1,274 ± 353	755 ± 227	2,748 ± 798	1,488 ± 447
All western Washington units:										
Public	4,183 ± 760	350 ± 125	152 ± 60	30 ± 19	1,332 ± 492	68 ± 59	1,790 ± 308	269 ± 84	4,489 ± 798	561 ± 172
Forest industry	3,810 ± 468	489 ± 92	128 ± 42	38 ± 16	1.912 ± 386	111 ± 41	1,502 ± 196	370 ± 78	3,271 ± 427	710 ± 141
Nonindustrial private	2,114 ± 431	828 ± 186	83 ± 50	41 ± 24	662 ± 265	154 ± 80	1,298 ± 247	703 ± 171	2,668 ± 523	1,335 ± 298
Eastern Washington:										
Public	2,398 ± 316	28 ± 17	153 ± 36	1 ± 1	372 ± 102	2 ± 3	755 ± 91	16 ± 14	2,628 ± 337	42 ± 28
Forest industry	2,338 ± 528	10 ± 8	164 ± 75	3 ± 4	386 ± 177	2 ± 4	852 ± 175	4 ± 5	2,641 ± 587	9 ± 11
Nonindustrial private	1,436 ± 221	42 ± 26	95 ± 41	6 ± 6	342 ± 95	2 ± 3	745 ± 113	20 ± 12	1,746 ± 268	54 ± 32

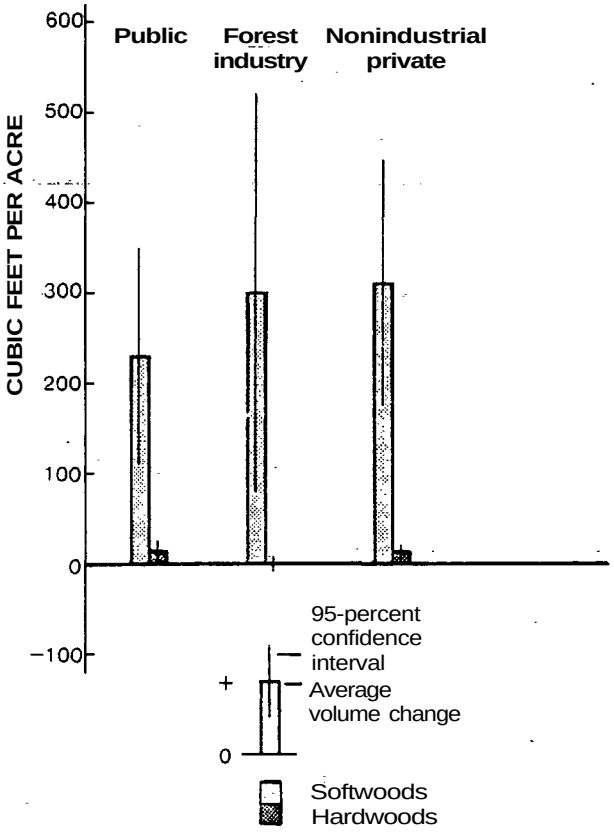

Figure 2.—Average volume change by owner and species group, eastern Washington.

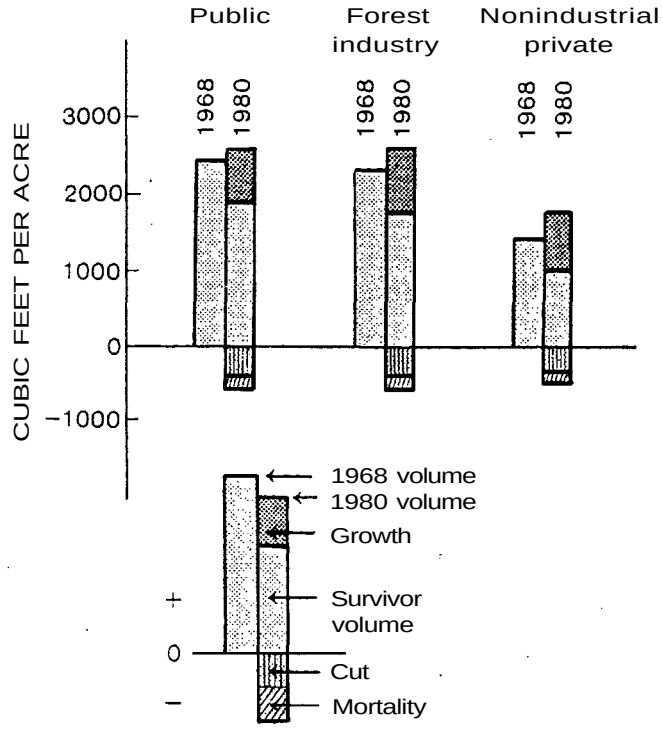

Figure 3.—Components of softwood volume change by owner group, eastern Washington.

Figure 4 expresses volume change by species in eastern Washington as a percentage of growing-stock volume at the beginning of the measurement p e r i ~ d Given a 95-percent confidence interval, the increases in volume in grand fir, lodgepole pine, and Douglas-fir are significant. The increase in ponderosa pine volume and the decrease in western larch volume are not statistically significant. Analysis of species data by owner group indicated significant increases in lodgepole pine volume for all owner groups; Douglas-fir volume increased significantly on public and nonindustrial private lands.

Analysis of change in volume by diameter class in eastern Washington indicated substantial increases in volume in trees up to 20 inches in diameter caused by a positive balance of growth over the combined effects of cut and mortality (fig. 5). The volume in trees 22 to 28 inches in diameter was stable. The decrease in volume in trees 30 inches d.b.h. and larger occurred because of the concentration of cut (21 percent of the total) in this class. The decrease in volume in this largest class was concentrated on public lands where most remaining large timber was and still is concentrated in eastern Washington.

Timber stocks in eastern Washington increased during the measurement period. This trend reflected a positive balance between growth and drain. The general trend was widespread in that it occurred on lands of all owner groups, for most tree species, and for all but the largest sizes of trees.

Western Washington.—Non-Federal ti.mber resources in western Washington differ in many respects from those east of the Cascade Range. The owner composition is different; forest industry is the largest group in terms of area, timber volume, and timber harvest. And the timber resource is different, in terms of major species, productive potential of the timberlands, and rates and patterns of timber utilization.

Although the slight decrease in volume of softwood for all non-Federal owners combined was not significant, two of the three owner groups in western Washington had significant changes in softwood volume during the 1963-66 to 1978-79 measurement period (fig. 6). Forest industry's softwood timber volume decreased 14 percent, a trend that was partially offset by a 26-percent increase in softwood timber volume on nonindustrial private timberlands. The sample indicated an increase in volume on public lands, but the findings were inconclusive.

Forest industry softwood timber stocks declined during the period largely because of an excess of cut over growth of about 400 cubic feet per acre (fig. 7). On nonindustrial private lands growth was almost twice the amount cut, which resulted in substantial volume increases. On public lands, softwood growth slightly exceeded drain during the measurement period.

Mortality was a relatively unimportant component of change in softwood timber volume on all ownerships during the measurement period. Although the period was unewentful in terms of catastrophic mortality losses, it was bracketed by two major natural catastrophies that resulted in huge timber losses before and after the measurement period—the Columbus Day windstorm in October 1962 and the Mount St. Helens eruption in May 1980. Had the measurement period included these events, mortality would have been an important element of volume change in some areas of western Washington.

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[3] **All** species volume change in this report is presented as a percentage of change because per-acre estimates are not meaningful because of the sporadic occurrence of most species.

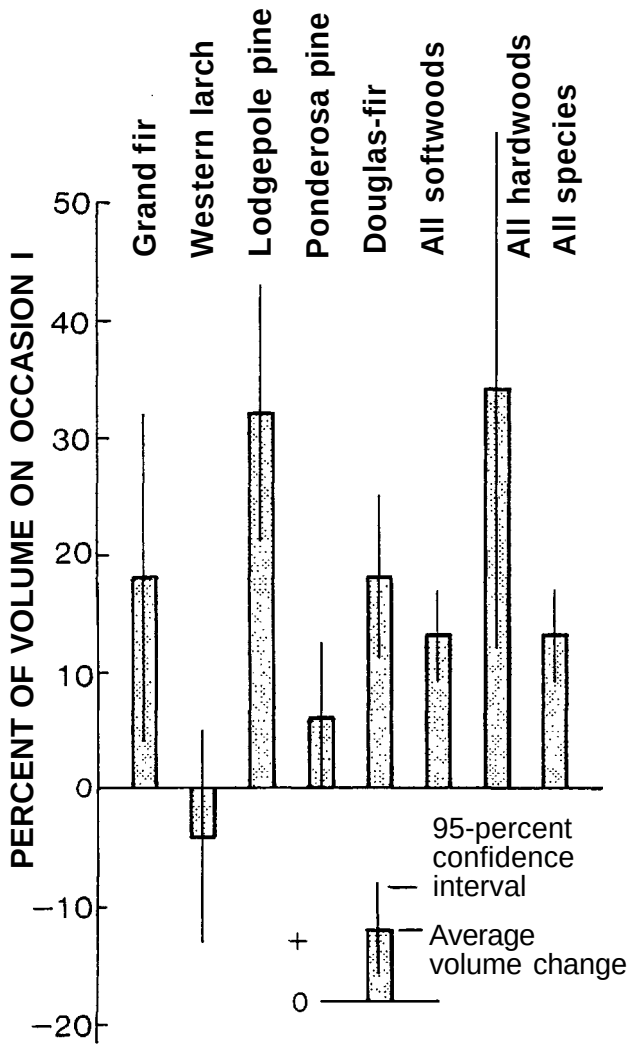

Figure 4.—Average volume change by species, non-Federal owners, eastern Washington.

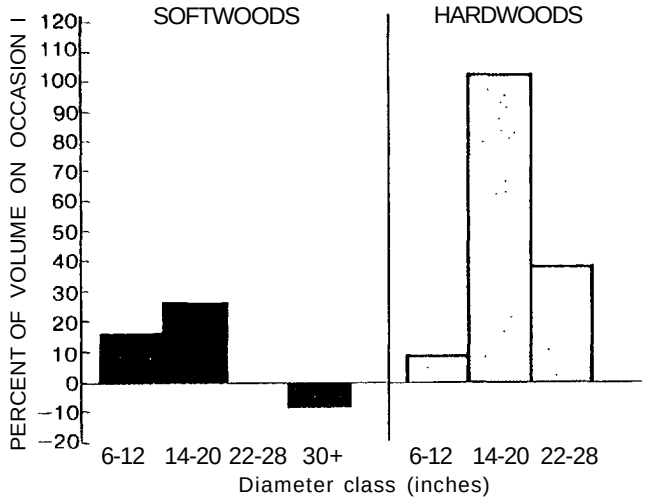

Figure 5.—Average volume change by diameter class and species group, non-Federal owners, eastern Washington.

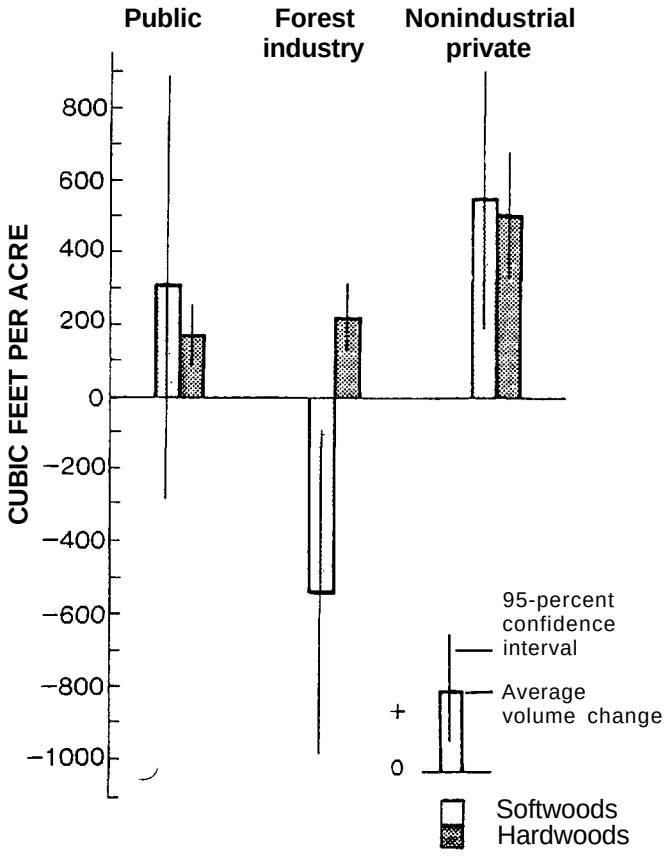

Figure 6.—Average volume change by owner and species group, western Washington, 1965-79.

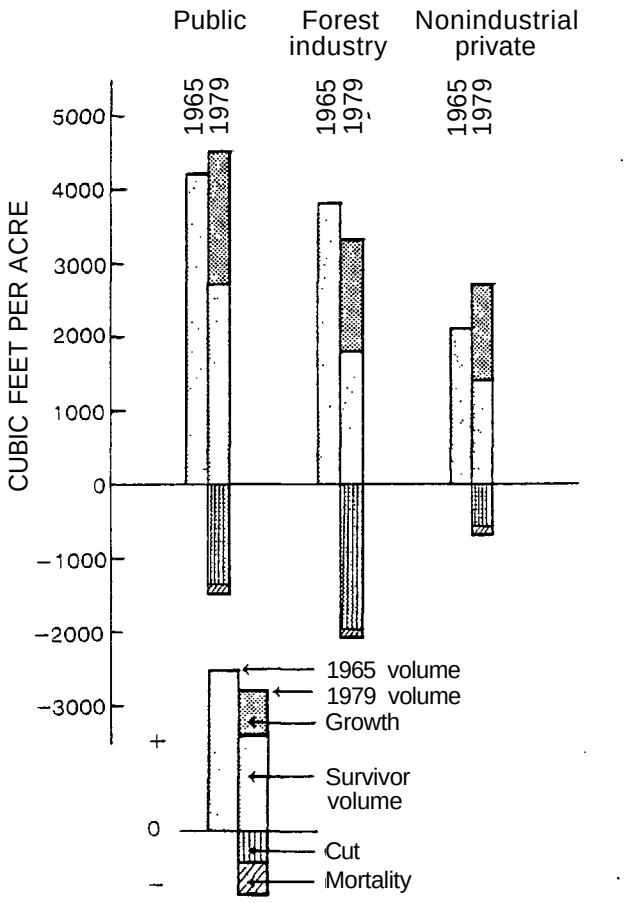

Figure 7.—Components of softwood volume change by owner group, western Washington, 1965-79.

Hardwood volumes increased substantially on the lands of all owner groups in western Washington from 1965 to 1979 (fig. 8). The increases were all statistically significant. The growth component of change was three to four times the cut, which resulted in hardwood volume increases of 44, 45, and 61 percent, respectively, on public, forest industry, and nonindustrial private timberlands.

Most of the important species experienced significant volume changes during the measurement period (fig. 9). Douglas-fir volume increased 15 percent, a trend supported by significant volume increases for this species on both public and nonindustrial private lands. Douglas-fir volume decreased slightly on forest industry lands.

The decrease in Pacific silver fir volume was characterized by decreasing trends in all owner groups, due to ratios of cutting to growth that exceeded 2:1. Most of the volume in this species is in trees 22 inches and larger on public and forest industry timberlands. Volume in these large diameter classes declined 33 percent during the measurement period.

Western redcedar, a species of regional importance because of the specialty products manufactured from it, decreased over 40 percent in volume on both public and forest industry lands, a trend partially offset by a 25-percent increase in volume on nonindus-

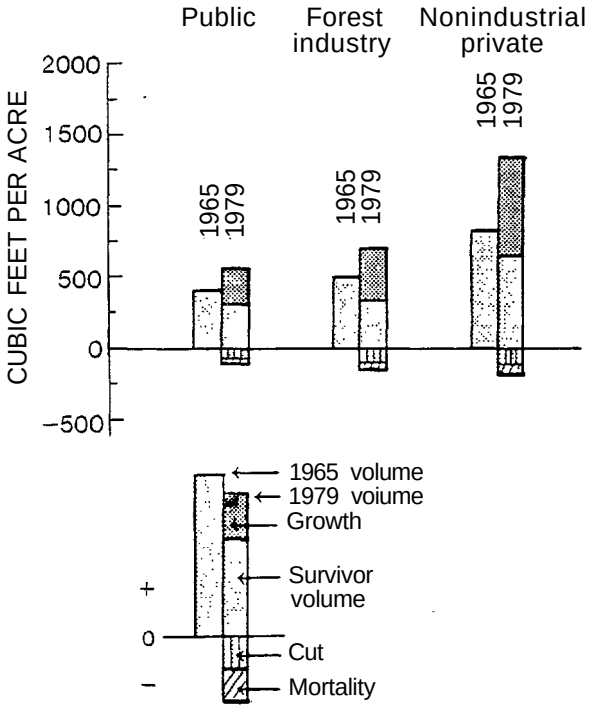

Figure 8.—Components of hardwood volume change by owner group, western Washington, 1965-79.

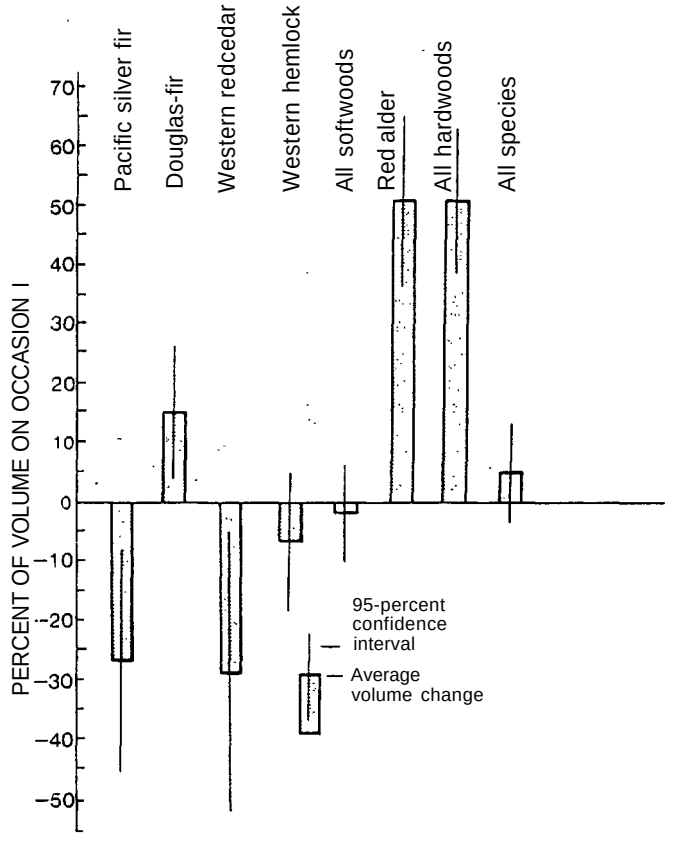

Figure 9.—Average volume change by species, non-Federal owners, western Washington, 1965-79.

trial private land. Although the overall trend in volume in this species was negative, cut was concentrated in large trees. Volume of western redcedar in trees 30 inches d.b.h. and larger decreased 64 percent. Volume in smaller trees increased 16 percent during the measurement period.

Sample results for western hemlock volume on western Washington's non-Federal timberlands indicated a 7-percent decrease in volume. The results, however, are inconclusive owing to sample variability. Declines in hemlock volume were observed in all diameter classes larger than 18 inches; in smaller trees, hemlock volume increased an estimated 30 percent. Forest industry hemlock stocks decreased an estimated 18 percent, a trend partially offset by increases in hemlock stocks on public and nonindustrial lands.

Red alder, which accounts for 75 percent of all hardwood volume in western Washington, increased 51 percent during the measurement period. Alder volume increased 49, 44, and 63 percent, respectively, on public, forest industry, and nonindustrial private timberlands. The increases reflect ratios of growth to cutting of 3:1 to 4:1 for this prolific species during the measurement period.

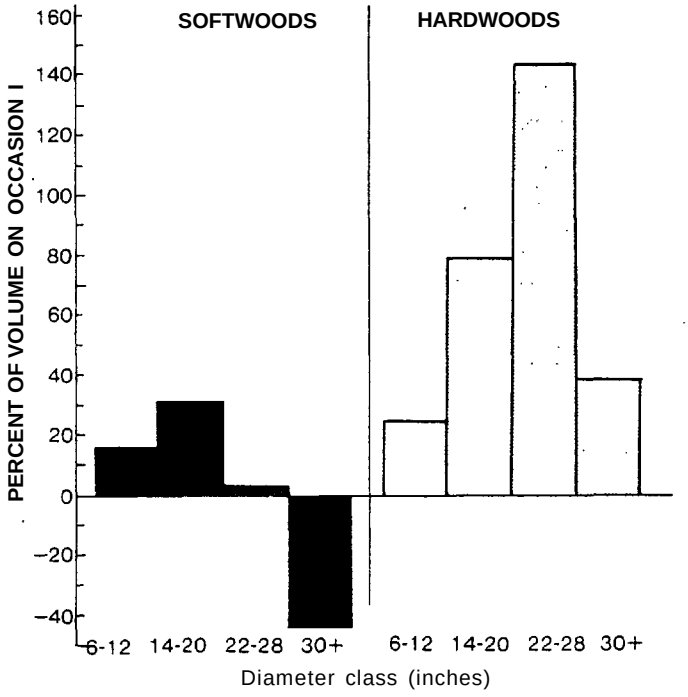

Figure 10.—Average volume change by diameter class and species group, non-Federal owners, western Washington, 1965-79.

The previous discussion mentioned changes in volume by diameter for some softwood species. The combined effect for all species is presented in figure 10. The 44-percent decrease in volume in large softwood trees is due to the concentration of cut (49 percent of total cut) in this diameter group. Volume in softwood trees 22 to 28 inches d.b.h. has remained stable through the measurement period, even though this diameter class provided 22 percent of the cut. The volume increase in smaller diameter classes reflects a positive balance of growth to cutting during the period.

The analysis of volume change by diameter class for all owners combined masks some significant differences in diameter volume changes among owners. The volume change by diameter profile for public owners was similar to the all-owner profile. But on forest industry lands, volume decreases of 22 and 57 percent were observed in the 22- to 28-inch and 30-inch and larger diameter classes. On nonindustrial private timberlands, volume decreased 17 percent in 6- to 12-inch trees; in all other diameter classes, including the largest class, timber volume increased during the measurement period. The decrease in volume in small trees in this owner group is likely due to relatively low cutting rates that, in turn, result in low rates of new stand formation.

In western Washington, the subject of volume change requires discussion of the regional differences among the west-side units. Geography, terrain, species mix, ownership pattern, and other factors have had a tremendous impact on the timing and patterns of timber utilization in western Washington. The centers of harvest and processing have moved in a recognizable pattern (Wall 1972). That movement is reflected in differences in current stocks, harvest levels, and volume change by geographic area.

The trends discussed for western Washington indicate small, statistically insignificant decreases in softwood volume, and significant increases in hardwood volume for all non-Federal lands combined. Although the west-side trend of hardwood volume increases holds up well for each of the inventoried areas, the same cannot be said for softwood volume trends (fig. 11). As this figure illustrates, stable or increasing trends in timber volume were observed for the Olympic Peninsula and Puget Sound units. But in the Southwest Washington unit, cubic volume decreased over 700 cubic feet per acre during the measurement period. This decrease was large enough to reduce the west-side averages to the point that they could easily be misleading as to general trends in timber stocks.

Might the same masking of local trends be true for the individual owner groups? On non-Federal public lands, there was little apparent change in softwood volume in the Olympic Peninsula and Southwest Washington units although sample results were inconclusive. Growth and cut were in apparent balance during the measurement period (fig. 12). For the Puget Sound unit, however, public timber stocks increased 30 percent, not because of unusually high growth, but because per-acre harvests were low during the measurement period. The trend of increasing hardwood volume in this owner group was found in all geographic units.

Softwood timber volume on forest industry lands in the Olympic Peninsula and Puget Sound units was apparently stable during the measurement period, although the results in both cases were inconclusive because of sampling variation (fig. 13). But in the Southwest Washington unit, per-acre softwood volume dropped 34 percent (1,381 cubic feet per acre) during the period; the ratio of cutting to growth approached 2:1. Although the results of the analysis were inconclusive for two of the areas, the difference among trends in the units was consistent with the differences in stages of harvesting history between the units. During the measurement period, much of the industry land in the Southwest Washington unit was undergoing harvest of old-growth timber, a stage during which harvest levels usually exceed current growth by a substantial margin. Most of the timberlands in the Puget Sound and Olympic Peninsula units passed through this first stage of timber utilization long ago and appear to have entered a more stable period of approximate balance in harvest and growth.

On nonindustrial lands, timber volume apparently increased in^all the geographic units (fig. 14). The observed increases in softwood volume in the Southwest and Olympic units were statistically inconclusive but were consistent with relatively low harvest levels in recent years on nonindustrial timberlands. The 820-cubic-foot-per-acre volume increase in the Puget Sound unit was significant, however, and reflected per-acre growth comparable to growth in the other units but much lower levels of cut. The softwood timber resources on nonindustrial lands in the Puget Sound unit displayed the lowest softwood harvest level (355 cubic feet per acre) of all of the owner-acre combinations studied in western Washington.

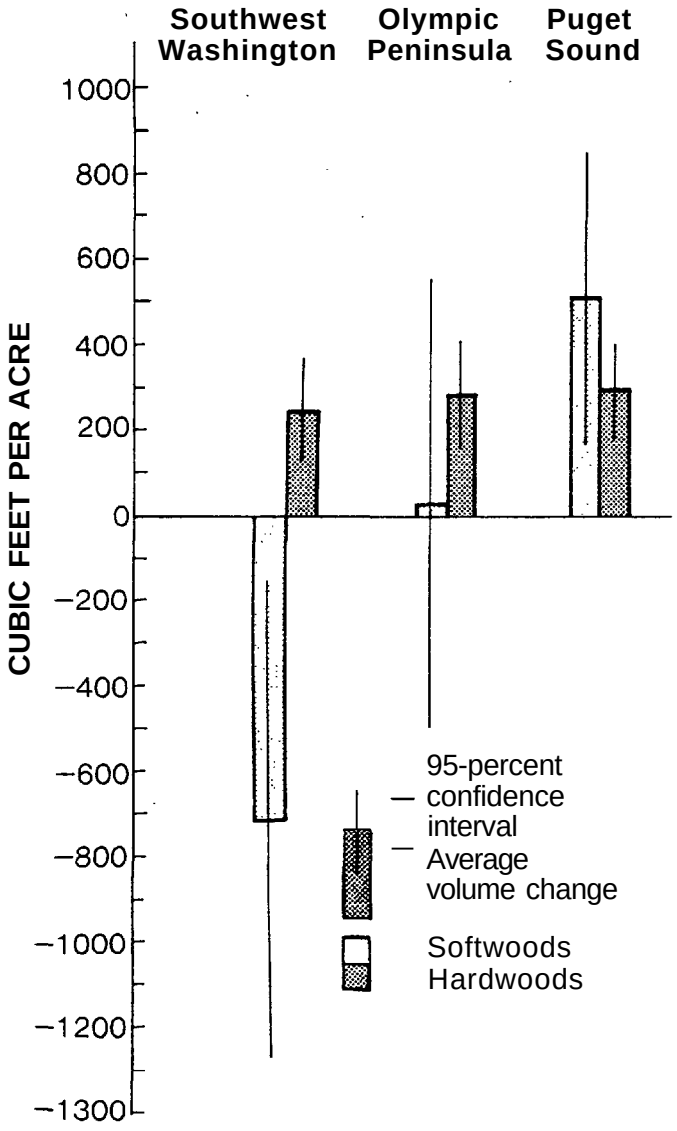

Figure 11.—Average volume change by inventory unit and species group, non-Federal owners, western Washington, 1965-79.

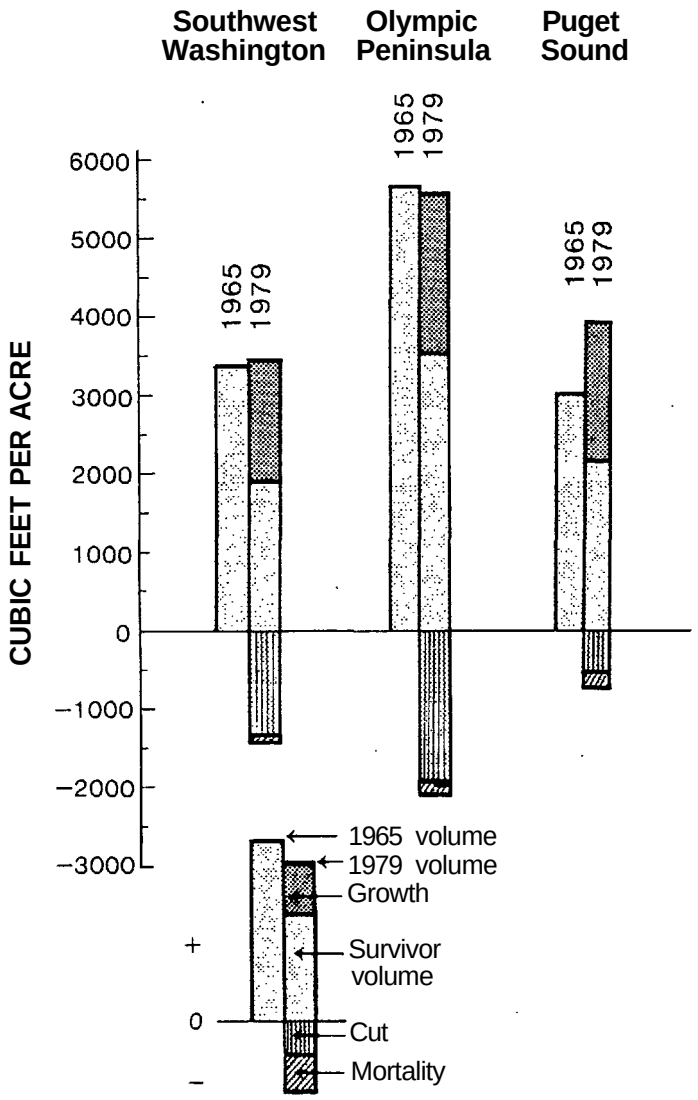

Figure 12.—Components of softwood volume change on non-Federal public lands, by inventory unit, western Washington, 1965-79.

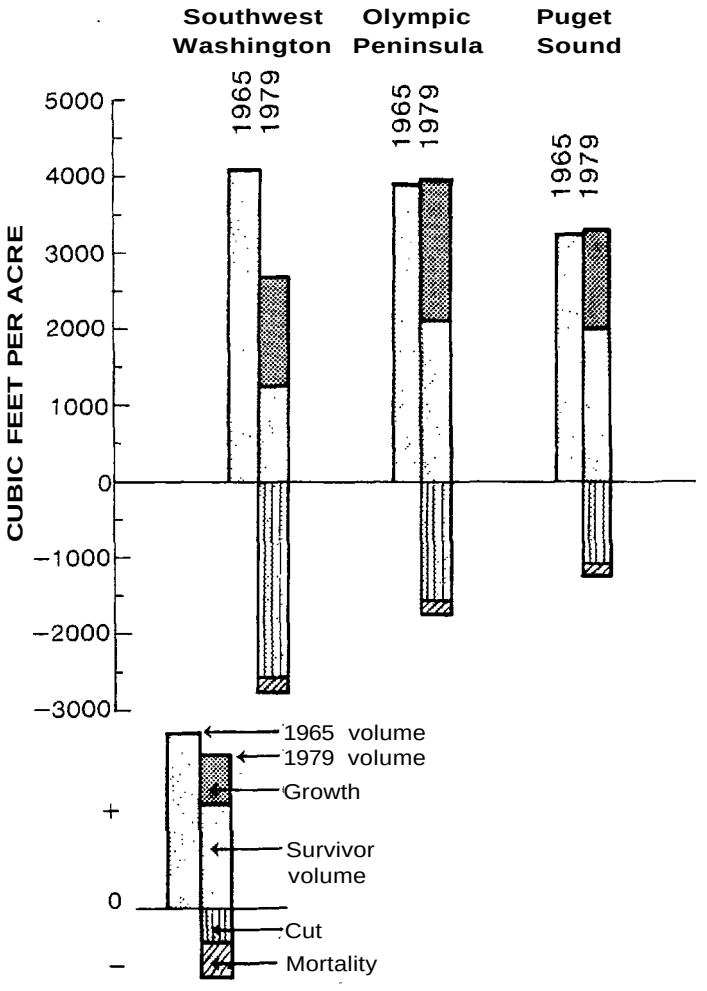

Figure 13.—Components of softwood volume change on forest industry land, by inventory unit, western Washington, 1965-79.

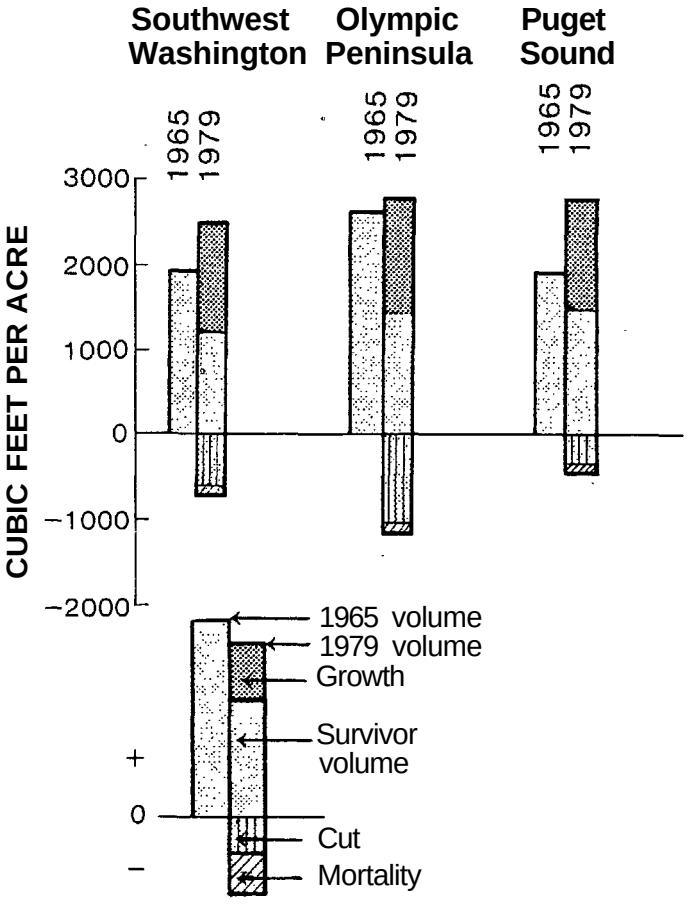

Figure 14.—Components of softwood volume change on nonindustrial private land, by inventory unit, western Washington, 1965-79.

One reason for these low harvest levels might be the location of the timberlands in relation to nonforest development, such as housing. A study of the location of nonindustrial forests in relation to nonforest development was recently completed (Oswald 1984). For that study, the timber resources on non-Federal lands in western Washington were identified by three zones, each characterized by proximity to nonforest development. The zone stratification was designed to test the hypothesis that the nature and utilization of the timber resources varied by location. Most nonindustrial private timberland in urban and suburban/farm zones was in the Puget Sound unit. In that unit, timberland in the urban and suburban/farm zones accounted for 55 percent of all nonindustrial private timberland. As illustrated in figure 15, the softwood timber in those two zones experienced low cutting levels during the measurement period, a significant factor in the low overall cutting level for nonindustrial timberlands.

Although timber stocks on non-Federal timberland in all of western Washington might appear stable, more detailed examination by owner and inventory unit indicates considerable change in timber volume for some owner-area combinations. The decrease in volume of softwood on industry lands in southwest Washington was a very significant trend. That trend has likely continued since the measurement period because of the timber loss and accelerated harvest of damaged timber associated with the Mount St. Helens eruption of May 1980. The stability or increase in softwood timber volumes throughout much of the west side, and the substantial increases in hardwood volumes, are also important trends.

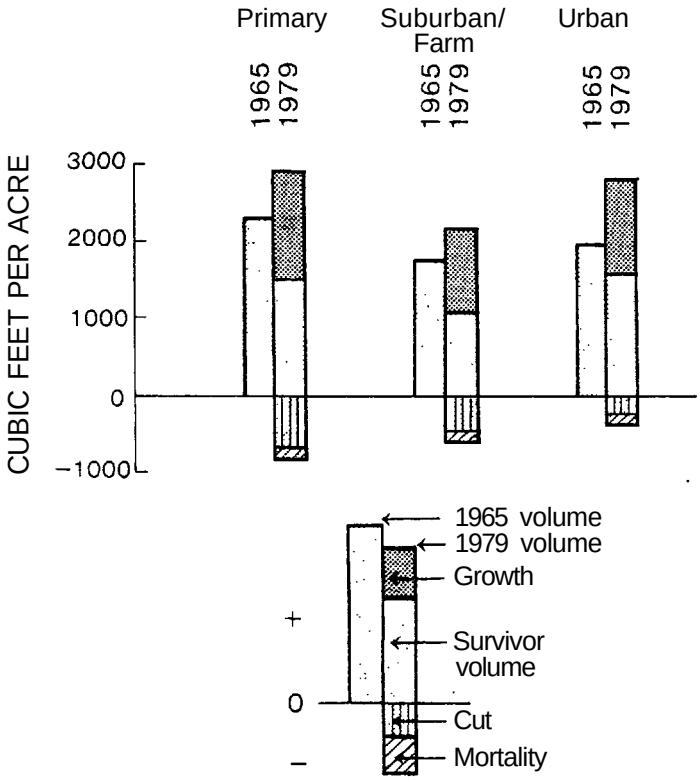

Figure 15.—Components of softwood volume change on nonindustrial private land, by forest zone, western Washington, 1965-79.

Application

This study was undertaken to determine the magnitude and direction of change in timber volume, and the components of change, for timber on non-Federal timberlands in Washington. The study results should have use for those who, having looked at the published reports of current inventory status in Washington (Bassett and Oswald 1981a, 1981b, 1982, 1983), wonder whether timber stocks are increasing or decreasing, and for what reasons. Although this study is independent of the recent inventories, it was designed to adequately sample the same forest population. The findings herein regarding direction and magnitudes of change therefore can be used to draw inferences about recent trends in timber stocks in Washington as reported in the inventory status reports.

Refer to tables 2 and 3 for detailed information on the magnitude of standard errors associated with the mean differences in volume found for the measurement period.

Metric Equivalents

1,000 acres = 404.7 hectares

1,000 cubic feet = 28.3 cubic meters

1 cubic footlacre = 0.07 cubic meter per hectare

1 inch = 2.54 centimeters

1 mile = 1.609 kilometers

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Oswald, Daniel D. Analysis of change in timber volume on non-Federal timberlands in Washington. Resour. Bull. PNW-128. Portland, **OR:** U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; 1986. 22 p.

This report presents the findings of a study conducted to determine change in per acre timber volume on nowfederal timberlands in Washington from the mid-1960's to 1978-80. The basis for the study was the measurement of 1,576 permanent plots at two occasions. The study findings include estimates of change in volume and of the components of change-growth, mortality, and timber cut. Timber volume increased during the period in eastern Washington but was apparently stable in western Washington. The findings differ, however, among owners and geographic areas. Tables of volume change, growth, harvest, and mortality are presented by owner group and geographic area.

Keywords: Timber volume, non-Federal lands, forest surveys, Washington.

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