# Chapter 3: Blue Ridge Layout and Stand Measurements

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This chapter describes the experimental site, the physical arrangement of treatment units and of measurement plots within units, and the silvicultural operations and vegetation measurements carried out from establishment in 1997-98 through 2002.

## Location

The Blue Ridge installation, the first block in the Capitol Forest study, is located in sections 22 and 23, T. 16 N, R. 2 W. Topography is quite gentle. Elevation is about 1,100 ft. It is within the high-rainfall (60+ in per year) western portion of Capitol Forest. Soils are Olympic silt clay loam (deep and well-drained from weathered basalt) as shown in generalized maps in *Soil Survey of Thurston County*, *Washington* (Pringle 1990).[1]

The dominant plant association in all units is TSHE/POMU-OXOR (western hemlock/swordfern-Oregon oxalis).[2] There are also limited inclusions of several other associations, the most important being an area of TSHE/GASH (western hemlock/salal) in the clearcut treatment, TSHE/GASH-BENE2 (western hemlock/salal/Cascade Oregon grape) in the patch cut, and TSHE/GASH/POMU (western hemlock/salal/swordfern) in the two-age, patch cut, and repeated thinning treatments (Henderson et al. 1989).

A site index determination based on the pretreatment measurements indicates an average site index (King 1966) of about 128, a high site II. An immediately adjacent plantation appears to indicate a somewhat higher site index.

## Initial Stand

The initial stand was of natural origin, with an estimated date of origin of 1929. Average age from seed was 69 years (as estimated from stumps in 1998), although there is considerable variation in individual tree ages. The area was clearcut and burned sometime in the late 1920s. The 1997 stand was predominantly Douglas-fir (*Pseudotsuga menziesii*

[1] A representative Blue Ridge soil profile description by John Shumway is given in appendix 1, soil description at Blue Ridge.

[2] Classification by David Peter, appendix 2, Blue Ridge vegetation assessment.

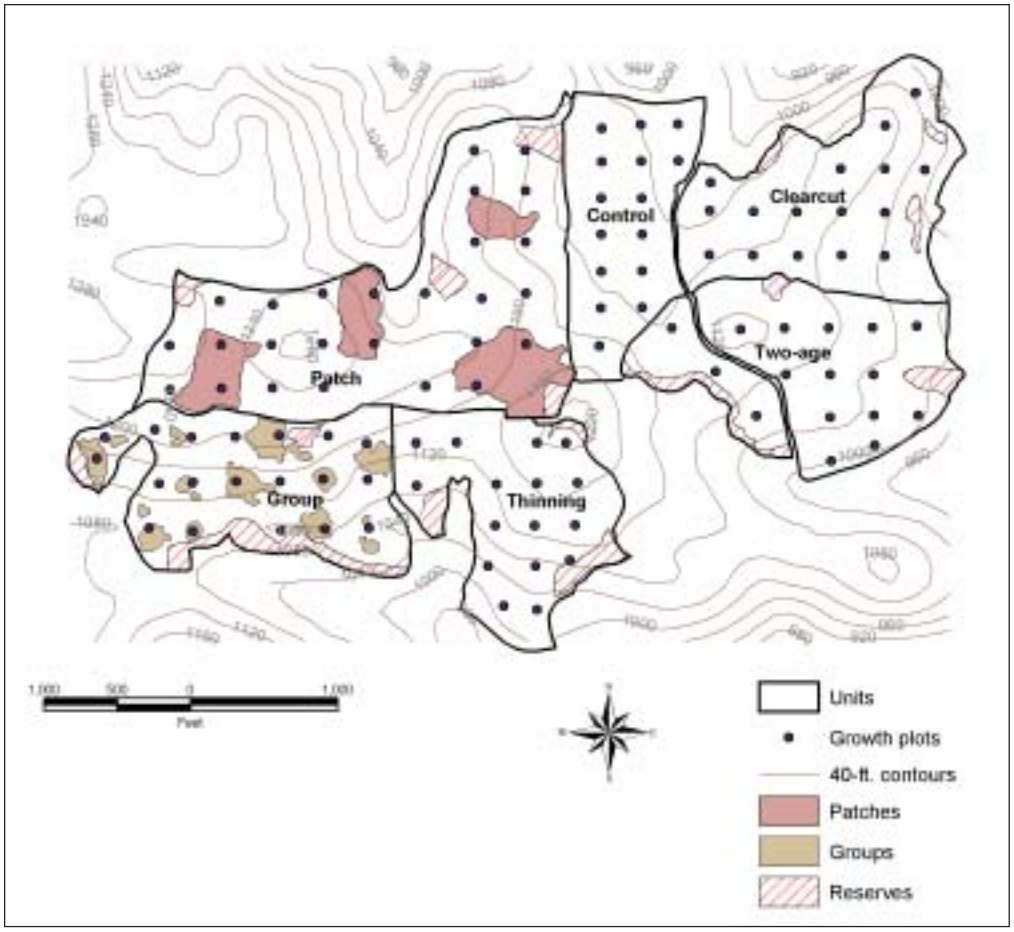


Figure 3-1—Blue ridge installation, plot locations and unit boundaries.

(Mirb.) Franco), with some hemlock (*Tsuga heterophylla* (Raf.) Sarg.), a very small amount of redcedar (*Thuja plicata* Donn ex D. Don), and considerable red alder (*Alnus rubra* Bong.). An ice storm in the winter of 1997 severely damaged the alder but had little effect on the conifers. Most of the area had been thinned in about 1971. Several old portable mill sites date from this thinning and had seeded in to alder.

Terrain is moderate and elevations are about 1,000 to 1,300 ft. Most slopes were in the range of 10 to 30 percent, with occasional slopes to 50 percent. Contours are shown in figure 3-1.

The area is remarkable for a degree of homogeneity in stand conditions unusual in naturally seeded stands without early density control, extending over an area sufficient to accommodate all six regimes. There is little evidence of site differences. This allows contiguous location of regimes and makes this an excellent demonstration area.

## Layout of the Experiment (1996-97)

### Unit Delineation

The boundaries of the suitable area were roughly delineated by using existing maps, air photos, and limited field reconnaissance. Six equally spaced points were superimposed, and the area subdivided into six more or less equal portions, each centered on one point. The six treatments were randomly assigned to these portions. After assignment, boundaries were expanded or contracted as needed to approximate the desired area for each

regime (some, such as the patch cut, require larger areas than others because of the nature of the regime). Unit boundaries drawn on the photos were then flagged on the ground.

### Road Layout and Unit Surveys

The Washington Department of Natural Resources (DNR) established access road locations, marked rights-of-way, and handled road construction. Unit boundaries were surveyed jointly by DNR and Pacific Northwest Research Station (PNW), allowing for leave tree clumps and buffers in streamside zones as required by DNR. Final boundaries (after minor changes, below) are shown in figure 3-1. Areas of the silvicultural units, as determined by a combination of photogrammetric measurements and ground survey with global positioning system (GPS) reference points, are shown in table 3-1.

### Plot Location

Plots were established in a systematic grid within each regime unit, at spacings designed to produce the desired number of plots for the unit. Because expected variability in growth rates was unknown, number of plots for each regime was a judgment call, with more plots taken in the patch cut and group selection cut than in other more uniform regimes. Plot centers were marked with white plastic pipe and were referenced to three witness trees at each location.

After initial plot location, changes in DNR requirements for streamside buffers and for leave tree clumps required shifting location of a number of plots. These changes are expected to have negligible effect on results but did produce a plot distribution that differs somewhat from the original systematic grid and a slight reduction in the number of plots in the group selection unit. Final locations are shown on map (fig. 3-1). The GPS coordinates for these plots have since been determined.

## Pretreatment Plot Measurements (1997)

Pretreatment measurements of all plots were made in late 1996 and early 1997. Tree measurements consisted of species and diameter at breast height (d.b.h., to nearest inch) of all trees on concentric circular plots centered on the plot stake, with a subsample of heights. Trees 1.6 to 5.5 in d.b.h were measured on a central 0.025-acre subplot, trees >5.5 and ≤9.5 in on a concentric 0.10-acre plot, and trees >9.5 in on the full 0.2-acre plot.

Concurrent measurements were made of advance regeneration of tree species on a central 4-milacre plot. Information recorded was (1) height (for trees of height <4.5 ft) or d.b.h (for trees of height >4.5 ft and d.b.h <1.6 in) of the two tallest acceptable seedlings or saplings, and (2) stem count, by species, of trees >1 ft in height and <1.6 in d.b.h.

Percentage cover and average height of each shrub species with more than 10 percent cover were ocularly estimated on a central 0.025-acre subplot.

## Marking for Cut (1997)

Based on the initial stand measurements, targets for the residual stand were chosen as follows:

- Clearcut—all trees to be removed except for designated green tree retention groups as required by DNR standards.
- Two-age—15 uniformly distributed trees per acre, except for designated reserve groups.
- Patch cut—20 percent of area to be in cut patches ranging from 1.5 to 5.0 acres. Remainder to be comparable to the repeated thinning treatment.
- Group selection—average residual stocking (basal area) to be roughly comparable to that in the patch unit.

**Table 3-1—Unit (treatment) areas in the Blue Ridge installation**

| Treatment | Excluding new roads and reserves | Reserves | New roads | Total including roads and reserves |
|---|---|---|---|---|
| | | *Acres* | | |
| Clearcut | 40.5 | 1.3 | 0 | 45.5 |
| Two-age | 43.1 (42.9)[a] | 3.9 | 0 | 47 |
| Patch cut | 71.8 | 3.8 | 5.5 | 81.1 |
| Group selection | 37.7 | 5.3 | 1.4 | 44.4 |
| Repeated thinning | 32.9 (32.6) | 3.1 | 1.7 | 37.7 |
| Control | 31.6 | 0 | 0 | 31.6 |

[a] Values in parentheses are areas remaining after new road construction in 2001.

- Repeated thinning—residual stand to be in the range 160 to 180 $ft^2$/acre, except for designated reserve groups. Cutting primarily from below, with removal of some larger trees of poor stem quality, vigor, or spacing.
- Control—no cutting.

The units were marked for cutting in late summer and early fall 1997, by DNR personnel with some assistance from PNW. Leave trees were marked in the two-age treatment. In patch and group selection, the units were first marked for thinning, and cut patches or groups were then superimposed on the prior marking, with all trees to be cut being marked. The DNR designated patch boundaries and skid trail locations. (Some of these had to be modified later to allow for efficient equipment operation.) Sale preparation costs, including marking, are given in chapter 4.

Harvesting operations were carried out during 1998 and are discussed in chapter 5. Locations of patches and groups in the patch cut and group selection regimes are shown in figure 3-2.

## Planting

The cut areas were planted in February 1999, at nominal 10 by 10 ft spacing. Stock was primarily Douglas-fir bareroot 1-1, plus a limited amount of western redcedar plug 1 in root rot areas. Areas planted consisted of (1) clearcut, (2) two-age, (3) cut patches within the patch cut unit, and (4) openings of 0.10 acre and larger in the group selection unit.

These areas were planted by the Cedar Creek Corrections Camp crew. Costs are summarized in table 3-2.

## Posttreatment Plot Measurements (Late 1998 to Early 1999)

### Stand Age

Ring counts were made on the first sound Douglas-fir stump encountered on each plot that was obviously a dominant or strong codominant, proceeding clockwise from north. Mean across all units was 66.25 rings at stump. Mean stump height was 1.3 ft. Assuming 3 years from seed to stump height and 3 years from stump height to breast height, this gives estimates of 69 years total age and 63 years age at breast height in 1998. There was considerable variation in individual tree age counts (standard deviation of 5.8), indicating that the stand seeded in over a period of some years.

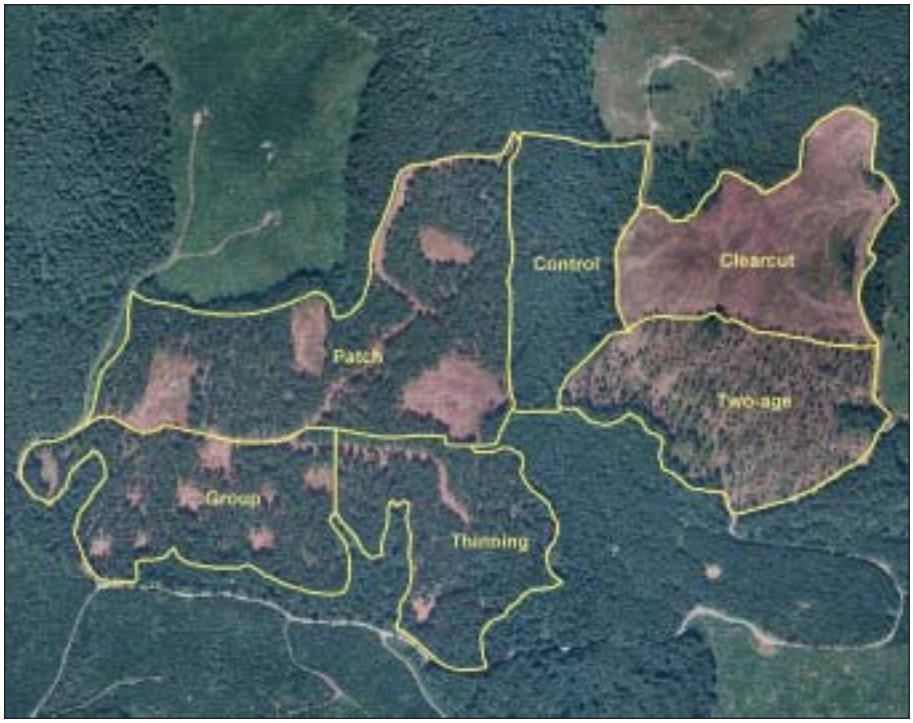


Figure 3-2—Aerial photo after 1998 harvest, showing locations of treatments.

**Table 3-2—Planting costs at the Blue Ridge installation**

| Treatment | Area planted | Labor[a] | Labor[b] | Planting stock | Labor |
|---|---|---|---|---|---|
| | *Acres* | *Dollars* | *Hours* | *Dollars* | *Hours per acre* |
| Clearcut | 40.5 | 1,969 | 446.5 | 5,133 | 11.0 |
| Two-age | 43.1 | 1,876 | 457 | 5,502 | 10.6 |
| Patch cut | 17.0 | 788 | 201.5 | 2,664 | 11.8 |
| Group selection | 7.6[c] | 653 | 144 | 1,993 | 18.9 |

[a] Prison wage rates, unrealistically low.

[b] Includes crew and foreman.

[c] Does not include area in groups less than 0.1 acre.

**Tree measurements—**Posttreatment tree figure measurement procedures were similar to the pretreatment measurements, with the following changes (fig. 3-3):

- Each tree was numbered and tagged, proceeding clockwise from north.
- The plot was divided into quadrants and tree tally subdivided accordingly.
- Diameters were recorded to 0.1 inch.
- In patch cut and group selection units, each plot and each quadrant were classified as in patch, not in patch, or overlap.
- Trees were classified by condition, and damage was recorded.
- Snags were recorded.
- The subsample of heights was increased.

Per acre stand statistics were calculated from these values, including basal area, number of trees, cubic and Scribner volumes, and Douglas-fir H40 (mean height of the largest 40 trees per acre) values. Separate height-diameter equations for each treatment were used for Douglas-fir. Height samples were combined across treatments for each of the other species and height-diameter equations were fit separately for western hemlock, redcedar, and alder.

**Regeneration**

Regeneration measurements were made in spring 1999 and again in spring 2000 by using procedures similar to those in the pretreatment measurements, with the following changes:

- Subsampling was changed to four 4-milacre subplots per main plot, located at the intersections of the plot periphery with east-west and north-south lines through plot center. These were permanently identified with plastic pipe, referenced to the main plot center.
- All planted seedlings on these plots were identified in the record by distance and azimuth from the subplot center.

**Understory Vegetation**

The intent was to make posttreatment measurements as in the pretreatment measurement, except that four 0.025-acre subplots were to be used per main plot, centered on the regeneration subplot stakes. The first posttreatment remeasurement was missed at Blue Ridge, but in the future will be done at the same time as subsequent regeneration plot measurements.

**Stand Characteristics**

The stand had been established by natural seeding after clearcut logging and burning, and there is considerable variation in individual tree ages. In general, the pretreatment stand was vigorous and relatively little affected by damaging agents. As noted earlier, most of the area had been thinned about 1971 and it had not reached excessively high densities by 1998, although another thinning was clearly reasonable. Scattered pockets of root rot were present but did not affect a large proportion of the area. An ice storm in winter 1997-98 caused severe stem breakage in the alder but had relatively little effect on the conifers. There was one area of severe dwarf mistletoe (*Arceuthobium* sp.) damage to hemlock, located in the southeast corner of the patch cut unit; this was removed as one of the patches cut in 1998.

Based on the 1997-98 plot measurements, pretreatment basal area distribution (1997) was Douglas-fir 80 percent, western hemlock 15 percent, western redcedar 1 percent, and red alder 4 percent.

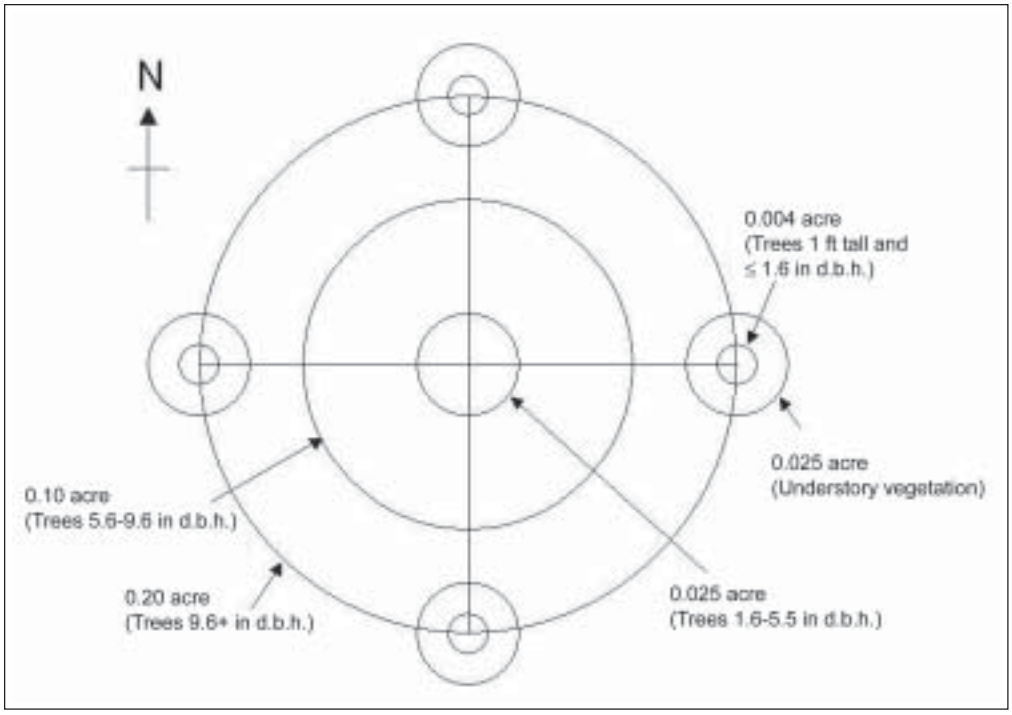


Figure 3-3—Permanent plot design, with associated subplots.

Other pretreatment statistics for area as a whole follow (for trees 5.6 in and larger):

| | |
|---|---|
| Trees per acre | 105.6 |
| Basal area ($ft^2$/acre) | 227.5 |
| QMD (quadratic mean diameter, in) | 19.9 |
| Merchantable $ft^3$/acre (6-in top) | 10,715 |
| Board feet (Scribner 32 ft) per acre | 50,853 |

## Pretreatment and Posttreatment Stand Statistics, by Treatment

Pretreatment and posttreatment stand statistics for all species combined are given in table 3-3, and table C-1 (appendix C). Note that these values are calculated from standing tree measurements on the permanent plots and will not be in complete agreement with values given in chapter 5 that are based on log scale and areas that include road right-of-ways.

Pretreatment and posttreatment diameter distributions are illustrated in figures 3-4 through 3-9. Visual appearance of the various treatments immediately after harvest is illustrated in figures 3-10 through 3-15.

## Pretreatment and Posttreatment Regeneration Statistics, by Treatment

A pretreatment regeneration inventory in late winter 1997 produced the estimates of number of trees given in table 3-4. Values are based on one 4-milacre plot per main plot except in the control, which is based on the four 4-milacre plots per main plot measured in 1999.

*Text continues on page 33*

**Table 3-3—Summaries for pretreatment (winter 1997), posttreatment (fall 1998), and approximate removals of trees 5.6 inches and larger[a]**

| | H40 | Number | Basal area | QMD | CVTS | CV6 | SV632 | RD |
|---|---|---|---|---|---|---|---|---|
| | *Feet* | *Trees per acre* | *Square feet per acre* | *Inches* | *Cubic feet per acre* | | *Board feet per acre* | |
| **Clearcut—16 plots, 40.5 acres** | | | | | | | | |
| Pretreatment | 143.8 | 114.1 | 226.9 | 19.1 | 11,240.6 | 10,808.3 | 52,451.0 | 51.7 |
| Removed | | 114.1 | 226.9 | 19.1 | 11,240.6 | 10,808.3 | 52,451.0 | |
| Posttreatment | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Two-age—16 plots, 43.1 acres** | | | | | | | | |
| Pretreatment | 143.3 | 117.5 | 240.8 | 19.4 | 11,961.4 | 11,528.6 | 55,494.5 | 54.6 |
| Removed | | 101.9 | 194.5 | 18.7 | 9,575.5 | 9,203.3 | 43,932.0 | |
| Posttreatment | 142.7 | 15.6 | 6.3 | 23.3 | 2,385.9 | 2,325.3 | 11,562.5 | 9.5 |
| **Patch cut—26 plots, 71.8 acres** | | | | | | | | |
| Pretreatment (71.8 acres) | 146.2 | 97.9 | 231.0 | 21.4 | 11,578 | 11,191 | 55,384 | 50.4 |
| Removed[b] (71.8 acres) | | 45.4 | 70.9 | 16.9 | 3,560 | 3,392 | 16,245 | |
| Thinned (54.8 acres) | | 29.1 | 21.2 | 11.9 | 1,073 | 973 | 4,103 | |
| (Fraction of total) | | (0.49) | (0.23) | | (0.23) | (0.22) | (0.19) | 17.0 |
| Patches 17.0 acres | | 97.9 | 231.0 | 21.4 | 11,578 | 11,191 | 55,394 | |
| (Fraction of total) | | (0.51) | (0.77) | | (0.77) | (0.78) | (0.81) | |
| Posttreatment (71.8 acres) | 143.2 | 52.5 | 160.1 | 23.6 | 8,017 | 7,799 | 39,139 | 32.9 |
| Thinned (54.8 acres) | | 68.8 | 209.8 | 23.6 | 10,504 | 10,218 | 51,281 | 43.2 |
| **Group selection—19 plots, 37.7 acres** | | | | | | | | |
| Pretreatment (37.7 acres) | 146.3 | 101.6 | 239.0 | 20.8 | 11,919 | 11527 | 57,149 | 51.9 |
| Removed[b] (37.7 acres) | | 59.0 | 104.8 | 18.0 | 5,037 | 4,814 | 23,243 | |
| Thinned (30.1 acres) | | 48.2 | 70.9 | 16.4 | 3,299 | 3,119 | 14,682 | |
| (Fraction of total) | | (0.65) | (0.54) | | (0.52) | (0.52) | (0.50) | |
| Groups (7.6 acres) | | 101.6 | 239.0 | 20.8 | 11,919 | 11,527 | 57,149 | |
| (Fraction of total) | | (0.35) | (0.46) | | (0.48) | (0.48) | (0.50) | |
| Posttreatment (37.7 acres) | 144.2 | 42.6 | 134.2 | 24.0 | 6,882 | 6,713 | 33,906 | 27.4 |
| Thinned (30.1 acres) | | 53.4 | 168.1 | 24.0 | 8,620 | 8,408 | 42,467 | 34.3 |

**Table 3-3—Summaries for pretreatment (winter 1997), posttreatment (fall 1998) and approximate removals of trees 5.6 inches and larger[a] (continued)**

| | H40 | Number | Basal area | QMD | CVTS | CV6 | SV632 | RD |
|---|---|---|---|---|---|---|---|---|
| | *Feet* | *Trees per acre* | *Square feet per acre* | *Inches* | *Cubic feet per acre* | | *Board feet per acre* | |
| | | | | **Thinning—16 plots, 32.9 acres** | | | | |
| Pretreatment | 143.5 | 129.1 | 254.9 | 19.0 | 12,624 | 12,161 | 54,846 | 58.2 |
| Removed | | 57.8 | 62.5 | 14.1 | 2,821 | 2,658 | 7,746 | |
| Posttreatment | 145.7 | 71.3 | 192.4 | 22.3 | 9,803 | 9,536 | 47,100 | 40.7 |
| | | | | **Control—15 plots, 31.6 acres** | | | | |
| Posttreatment | 155.1 | 112.0 | 261.2 | 20.7 | 13,577 | 13,106 | 65,792 | 57.2 |

[a] All values are expressed on a per acre basis, excluding area in roads and reserves. H40 = height of the 40 largest trees per acre, QMD = quadratic mean diameter, CVTS = total stem cubic foot volume, CV6 = merchantable cubic foot volume to a 6-inch top diameter inside bark, SV632 = Scribner board foot volume to a 6-inch top diameter inside bark in 32-foot logs, and RD = relative density (Curtis 1982). For patch and group treatments, only part of the treatment unit was clear felled, and the remainder was thinned.

[b] Removals are based on the difference between the pretreatment and posttreatment plot inventories. They included the cut and 1 year of growth. Total removals in the patch and group treatments are divided into removals by patches or groups, and removal as thinnings from the surrounding matrix. There were four patches with a total area of 17.0 acres and ranging from 2.15 to 6.98 acres. There were 16 groups with a total area of 7.6 acres and ranging from 0.05 to 1.32 acres.

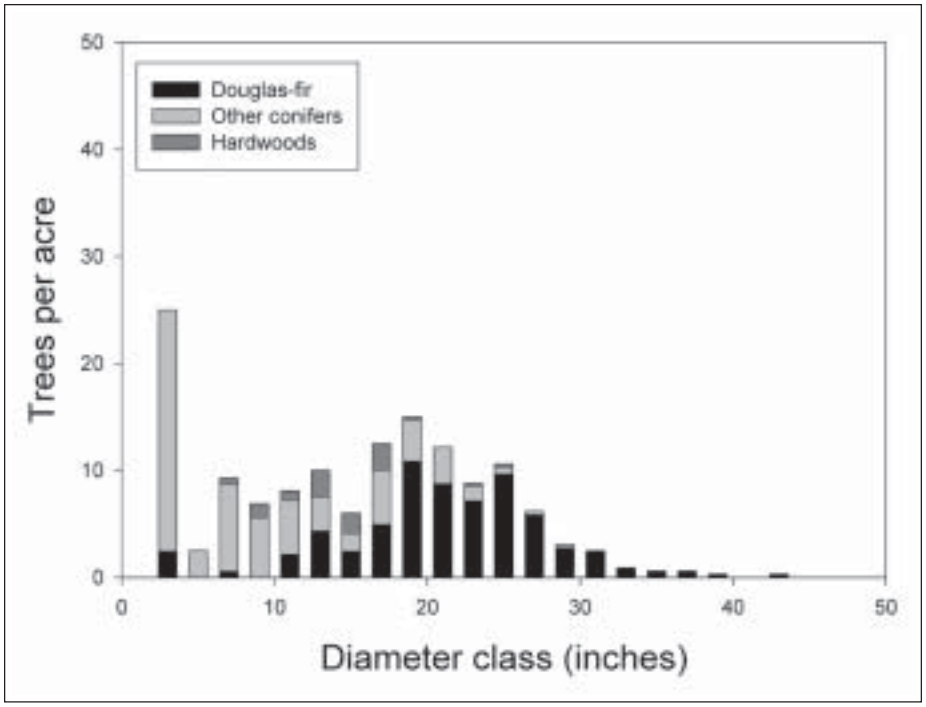


Figure 3-4—Diameter distribution of clearcut stand, pretreatment.

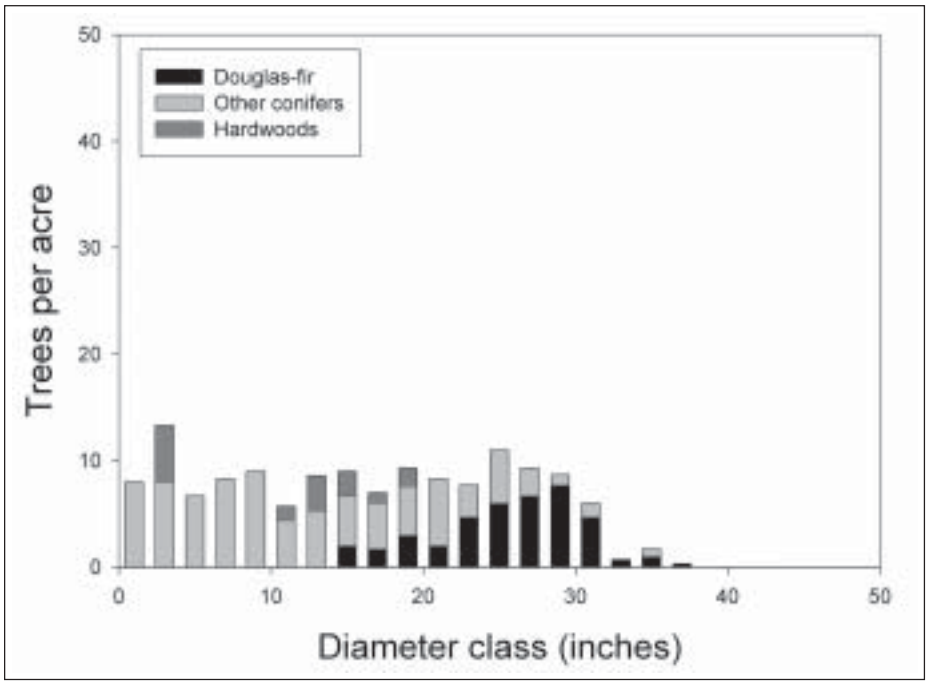


Figure 3-5—Diameter distribution of control (no treatment) stand.

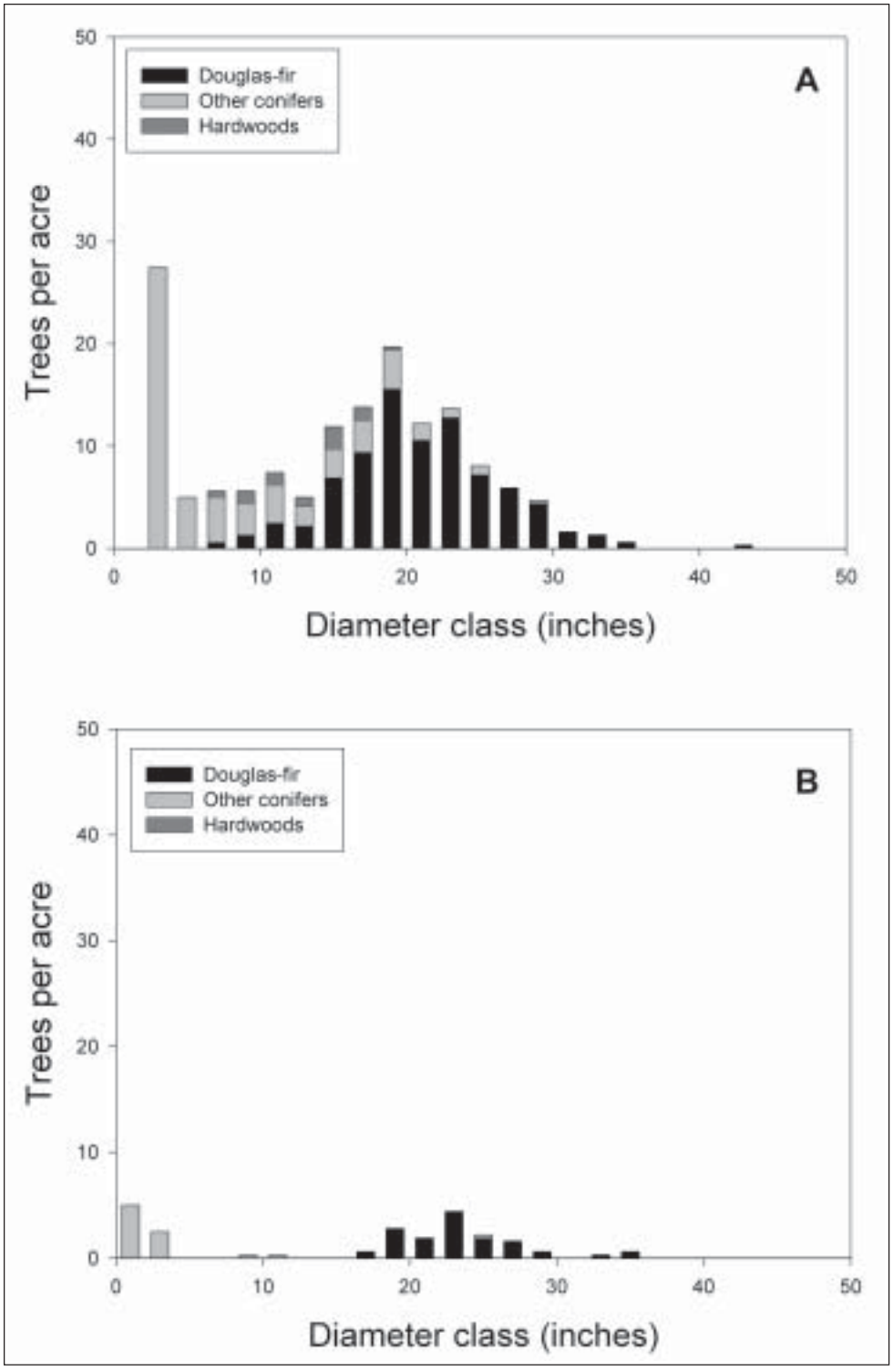


Figure 3-6—Diameter distribution of two-age treatment (a) before cut and (b) after cut.

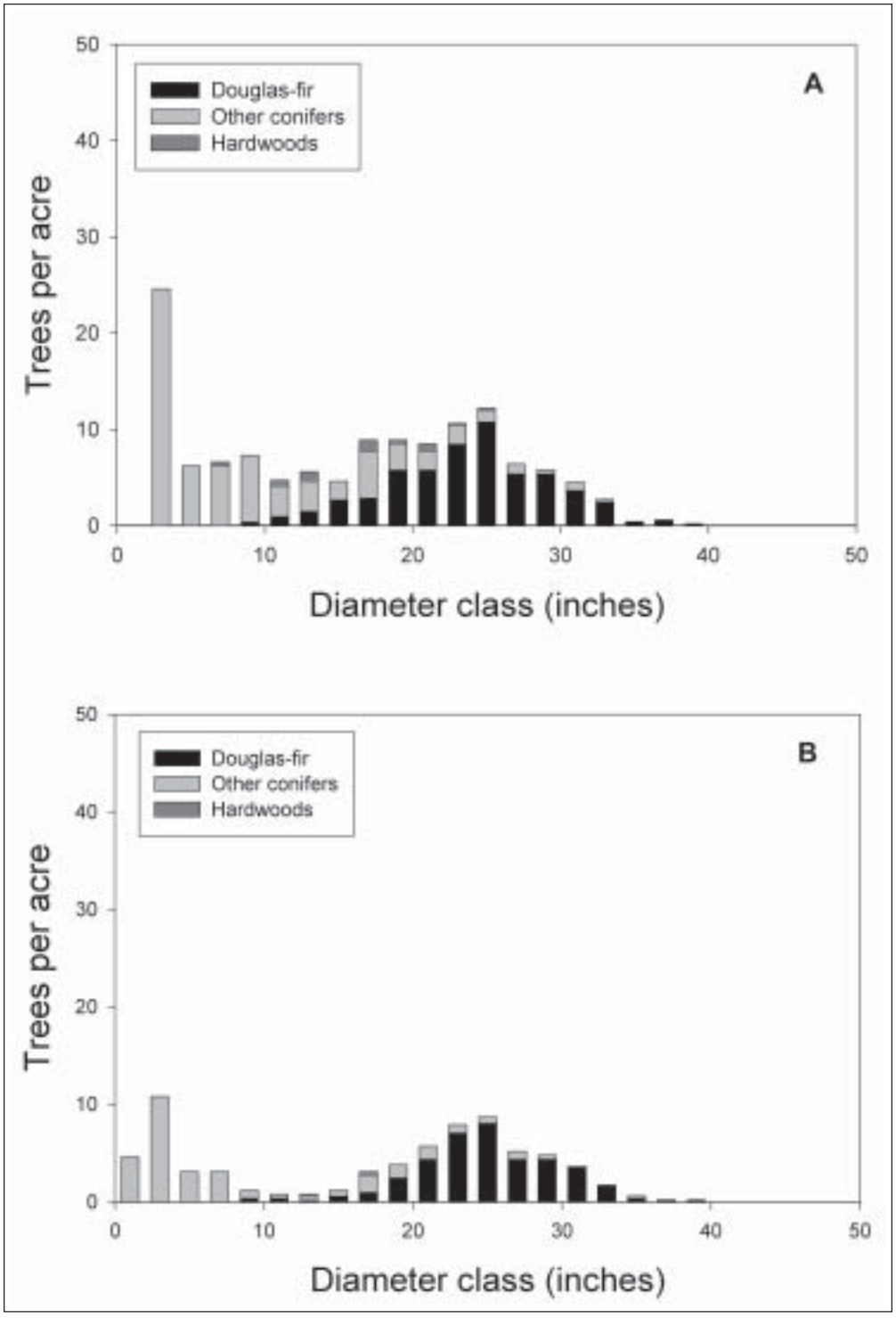


Figure 3-7—Diameter distribution of patch cut treatment (a) before cut and (b) after cut.

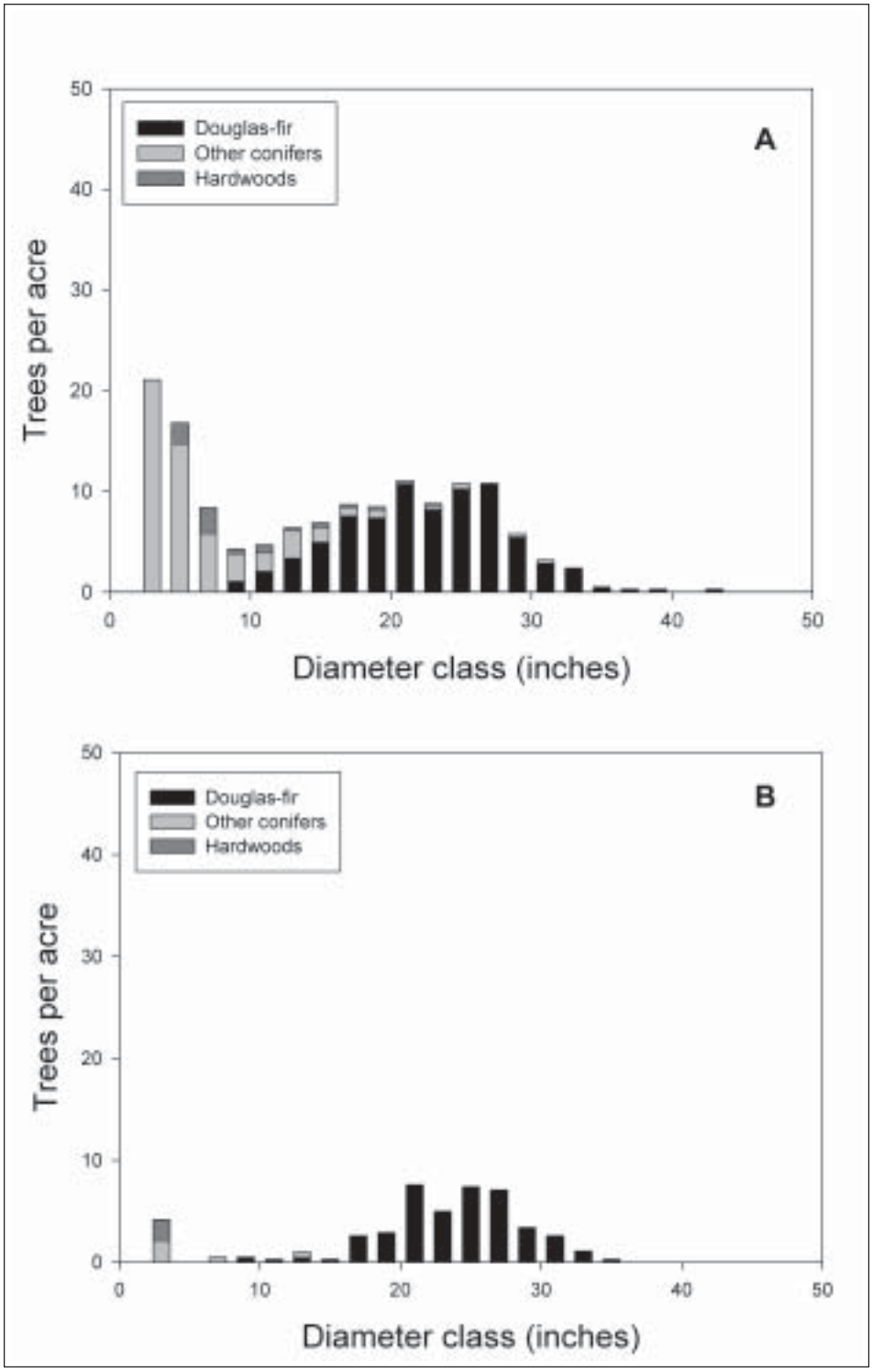


Figure 3-8—Diameter distribution of group selection treatment (a) before cut and (b) after cut.

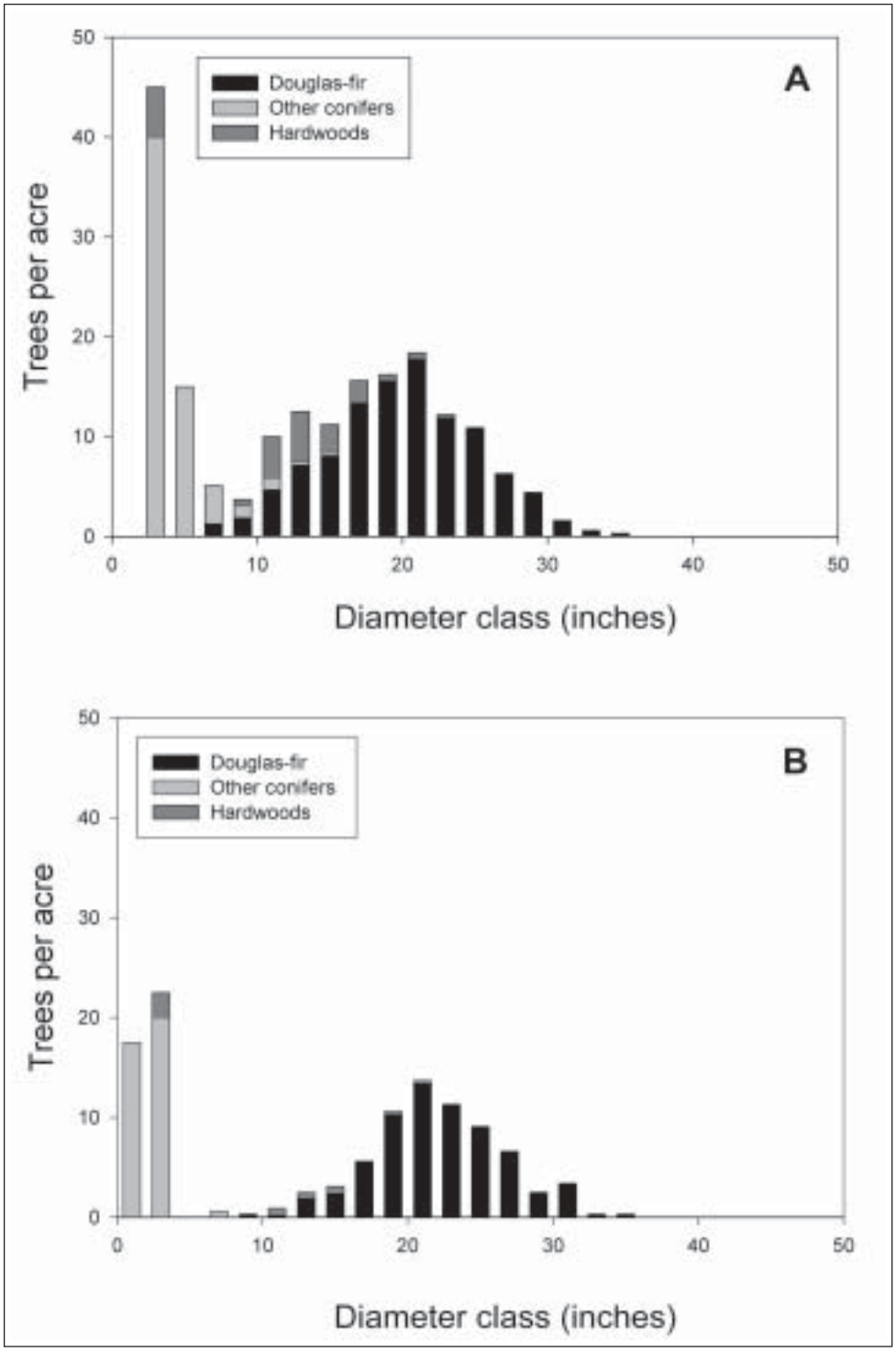


Figure 3-9—Diameter distribution of thinning treatment (a) before cut and (b) after cut.

A

Photo by Gordon Bradley

B

Photo by J. Alan Wagar

Figure 3-10—Clearcut unit immediately after harvest: (a) horizontal view and (b) aerial oblique.

A

Photo by Gordon Bradley

B

Photo by J. Alan Wagar

Figure 3-11—Two-age unit immediately after harvest: (a) within-stand view and (b) aerial oblique.

A

Photo by Gordon Bradley

B

Photo by J. Alan Wagar

Figure 3-12—Patch cut unit immediately after harvest: (a) within-stand view and (b) aerial oblique.

A

Photo by Gordon Bradley

B

Photo by J. Alan Wagar

Figure 3-13—Group selection unit immediately after harvest: (a) within-stand view and (b) aerial oblique.

Photo by David Marshall

Figure 3-14—Continued thinning unit immediately after harvest.

Photo by Gordon Bradley

Figure 3-15—Control (untreated) unit.

**Table 3-4—Pretreatment trees >1.0 foot tall and <1.6 inches diameter at breast height**

| Treatment | Number of 4-milacre subplots | Mean number of trees per subplot | Standard deviation of subplot values | Mean number of trees per acre[a] |
|---|---|---|---|---|
| Clearcut | 16 | 8.19 | 14.2 | 2,047 |
| Two-age | 16 | 3.63 | 5.2 | 906 |
| Patch cut | 26 | 14.58 | 16.0 | 3,995 |
| Group selection | 19 | 2.26 | 5.1 | 566 |
| Repeated thinning | 16 | 2.53 | 2.9 | 656 |
| Control | 60 | 15.39 | 17.3 | 3,848 |
| Overall mean | | | | 2,003 |

[a] Nearly all western hemlock.

Virtually all advance regeneration was western hemlock. Given the small samples and high variability, there is little evidence of real differences among treatment units; any differences were slight and of no importance from the standpoint of the experiment.

Posttreatment measurements made in March and April 1999 of four 4-milacre subplots per main plot in all treatments (fig. 3-3) provided the estimates of natural regeneration in table 3-5. (Values for planted trees are omitted because these, nominally 400 per acre, were known to number about the same across all planted areas). Again, virtually all natural regeneration was western hemlock. Values for the patch cut unit have been further subdivided between matrix and patches. A similar subdivision is not feasible for group selection because of the small size of groups.

Although the above values are not directly comparable to the pretreatment values because of differences in sample size and arrangement, it is obvious that harvesting caused a substantial reduction in number of advance regeneration trees.

In the March 1999 inventory, all planted seedlings were identified by distance and direction from the subplot center stake, so that development of individual seedlings can be followed over time.

A second similar measurement made in spring 2000 (after the 1999 growing season) provided estimates of first-year mortality and growth of planted seedlings (tables 3-6 through 3-8) and extent of browsing damage. The overall mean was 29 percent of planted seedlings with recorded browsing damage. However, the small sample for the patch cut and group selection and some apparent inconsistencies in field procedure (inadequately specified criteria) preclude meaningful comparisons among harvest treatments.

## Harvesting Damage to Residual Trees

In late 1998 and early 1999, each tree on the permanent plots was assessed for defect and damage. Codes included defects, such as forks, crooks, and dead tops, not related to harvesting operations. Damage caused by logging activities was also recorded, including live-branch breakage, root damage (usually caused by skidding), basal bark removal, and upper bole damage. A corresponding severity code also was recorded.

Stem defect occurrence was similar in all regimes where residual trees remained; all regimes had defects on fewer than 15 percent of the trees sampled (fig. 3-16). Frequency of damage from logging activities, however, was much higher in the two-age regime, being 68 percent of trees examined compared to 17 to 23 percent in the other treated stands.

In figure 3-17, logging damage is separated into four categories and corresponding severity levels, although the lowest severity level in each case is probably of slight practical importance for future development of the stands. Number of trees sampled in each treatment is indicated in the figure. Differences in frequency of damage were not great among treatments and damage was not severe, except in the case of the two-age stand.

The markedly greater frequency and severity of damage in the two-age regime reflects in part the much higher volume removed, compared to other partial cutting regimes. Also, the sample was much smaller on this regime than on the others (fig. 3-16). Frequency and severity of damage were also associated with season of harvest. The original plan was to begin harvesting in spring 1998 on the clearcut unit, and to do others subsequently. But a delay in road construction made it necessary to harvest the two-age unit first, in spring when the bark was slipping. This undoubtedly made the damage considerably more severe than would otherwise have been the case and is consistent with the high frequency of basal bark removal and upper bole damage.

**Table 3-5—Natural regeneration immediately after treatment; number of trees >1.0 foot tall and <1.6 inches diameter at breast height, planted trees excluded**

| Treatment | No. of subplots | Mean number per subplot | Number per acre[a] |
|---|---|---|---|
| Clearcut | 64 | 0.42 | 105 |
| Two-age | 64 | .86 | 215 |
| Patch, entire unit | 104 | 3.88 | 970 |
| In patches only | 23[b] | 1.47 | 368 |
| Between patches | 78[b] | 4.67 | 1,168 |
| Group selection | 76 | 2.05 | 513 |
| Repeated thinning | 64 | 1.02 | 255 |
| Control | 60 | 15.39 | 3,848 |

[a] Nearly all western hemlock.

[b] Three subplots omitted because of overlap.

**Table 3-6—Mean diameter growth at 6-inch height of measured planted Douglas-fir trees after one growing season**

| Treatment | Mean growth | Number of trees |
|---|---|---|
| | *Inches* | |
| Clearcut | 0.18 | 100 |
| Two-age | .16 | 81 |
| Patch cut | .19 | 18 |
| Group selection | .14 | 26 |

**Table 3-7—Mean height growth of unbrowsed planted Douglas-fir trees, first growing season**

| Treatment | Mean height growth | Number of trees measured |
|---|---|---|
| | *Feet* | |
| Clearcut | 0.26 | 34 |
| Two-age | .35 | 56 |
| Patch cut | .43 | 12 |
| Group selection | .30 | 17 |

**Table 3-8—Mortality of planted Douglas-fir trees, first growing season**

| Treatment | Number of trees on subplots | One-year mortality |
|---|---|---|
| | | *Percent* |
| Clearcut | 105 | 5 |
| Two-age | 93 | 9 |
| Patch cut | 21 | 14 |
| Group selection | 35 | 17 |
| Weighted mean | — | 9 |

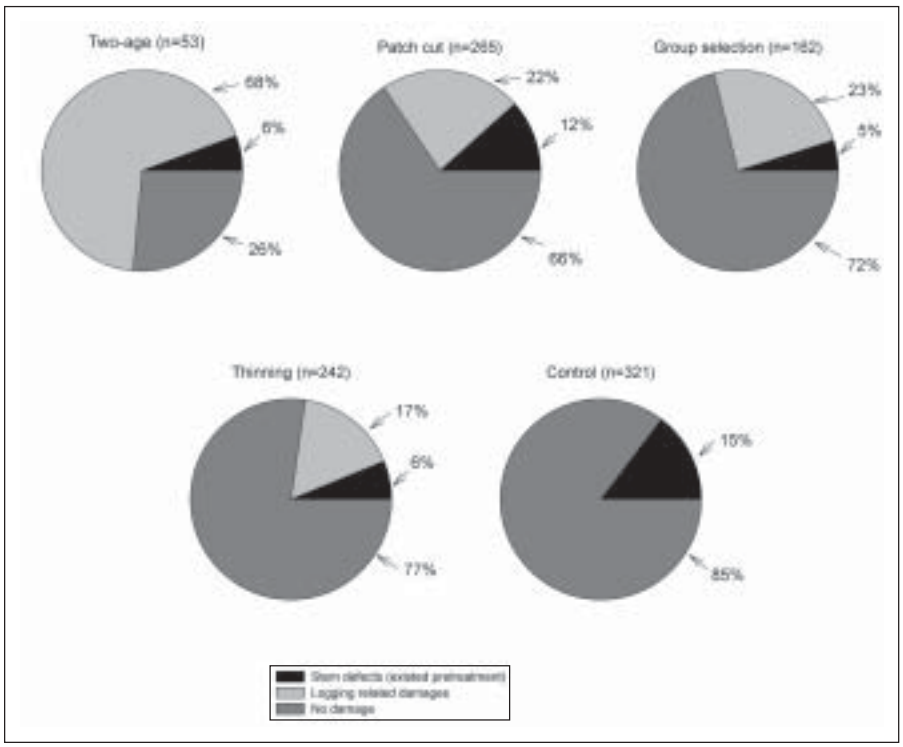


Figure 3-16—Frequencies of stem defects and logging-related damage, by treatment.

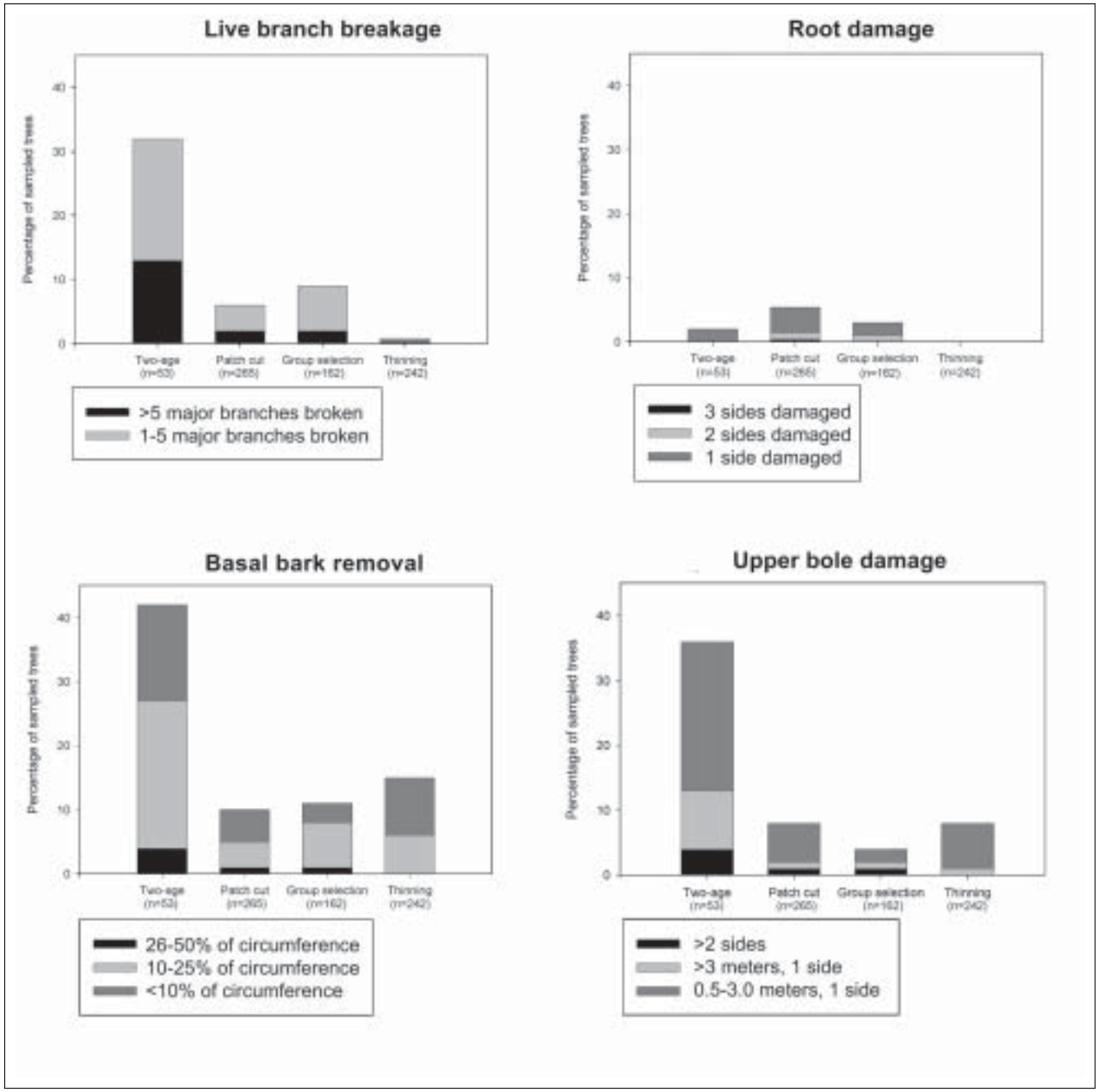


Figure 3-17—Damage to residual trees caused by logging activities, by category and severity. (Damage codes and severity ratings not recorded at significant levels were omitted.)

## Windfall Losses

In September 2002, four winters after harvest, all trees that had blown down since harvest were located on unit maps, identified by species and direction of fall, and measured for diameter. If the tree was a Douglas-fir, it was examined for indications of root rot. These trees were nearly all uprooted rather than broken. Data were plotted on a map of the experimental area, and each wind-thrown tree was shown in relation to the regimes and patches and gaps that were created (fig. 3-18).

A total of 374 trees blew over during the period from logging in summer of 1998 until the September 2002 inventory (table 3-9). Windthrow was present in all units. About 90 percent of the windfall trees were in the patch cut, clearcut, and two-age units. Of this 90 percent, 44 percent were in the patch cut, 22 percent in the clearcut, and 34 percent in the two-age units. The other units accounted for about 10 percent of the windthrow. The trees that are listed for the clearcut were in the adjacent stand along the northern and eastern border of the unit and in the small reserve patches that were left on the unit. Windfalls in the patch cut and group selection units were mostly associated with the edge of a patch or group. The group selection unit was in a somewhat more topographically sheltered area than the patch cut. Most of the windthrow was western hemlock (72 percent). Douglas-fir was 25 percent, with the remainder being a few western redcedar and red alder. The large proportion of windfall in western hemlock is further emphasized by the fact that the posttreatment stands were (by number of trees) primarily Douglas-fir (75 to 98 percent) with the exception of the control, which was only 36 percent Douglas-fir. The western hemlock blown down in the two-age treatment came mostly from the reserve areas within the unit, as only a small proportion of western hemlock (3.8 percent of the trees) was left in the residual stand.

Quadratic mean diameters (QMDs) of the Douglas-fir and western hemlock (table 3-9) wind-thrown trees were similar to the pretreatment stand QMDs (app. table C-1), but tended to be smaller than the posttreatment QMDs, which were somewhat increased by the harvest of smaller trees. The QMDs of the other species (western redcedar and red alder) were smaller than that of Douglas-fir and western hemlock. Western hemlock has a shallower rooting system than Douglas-fir and would be expected to be less stable. In all treatments except the repeated thinning unit, over 60 percent of the Douglas-fir wind-thrown trees had indications of root rot. All Douglas-fir that blew over in the control had root rot present.

The closest weather station with records for this period is in Olympia, Washington, approximately 14 miles northeast of the study site and 1,000 feet lower in elevation. During the period October 1998 through September 2002, there were 170 occurrences of peak winds of 28 knots (32 mi/hr) or greater. These averaged 30.5 knots (35.1 mi/hr) and generally came from the south (average azimuth of 176 degrees), although they ranged from 150 to 260 degrees. The larger peak winds tended to come from the south to southeast. The greatest peak windspeed recorded was 42 knots (48 mi/hr) on January 29, 1999, and was from the south (table 3-10). The six greatest gusts were 38 knots (44 mi/hr) or greater, and all occurred from late November 1998 to early March 1999. This matches the observation that most of the windfall appears to have occurred within the first 2 years after the treatments were applied.

The direction of fall of wind-thrown trees was quite variable (fig. 3-18, table 3-11), and apparently was much influenced by local topography, cutting pattern, opening configuration, and presence of root rot, in addition to the overall direction of the highest speed winds.

Figure 3-18—Location and direction of fall of trees wind thrown between October 1998 and September 2002. Shaded areas indicate the reserves.

**Table 3-9—Wind-thrown trees at the Blue Ridge installation by treatment unit and species**

| Treatment | Total trees (trees per acre[a]) | Species | Proportion of all windfalls by species | Proportion of Douglas-fir windfalls with root rot | Average (range) diameter at breast height |
|---|---|---|---|---|---|
| | | | | | *Inches* |
| Clearcut[b] | 114 | Douglas-fir | 0.21 | 0.67 | 20.1 (6.1-33.6) |
| | | Western hemlock | .74 | | 12.7 (3.6-27.6) |
| | | Other | .05 | | 13.3 (10.0-16.6) |
| Two-age | 75 | Douglas-fir | .32 | .63 | 19.5 (8.6-26.9) |
| | (1.60) | Western hemlock | .68 | | 15.7 (5.4-27.0) |
| Patch | 148 | Douglas-fir | .17 | .73 | 20.2 (4.3-31.9) |
| | (1.96) | Western hemlock | .82 | | 15.9 (3.6-31.4) |
| | | Other | .01 | | 7.6 |
| Group | 20 | Douglas-fir | .55 | .73 | 19.2 (6.2-29.4) |
| | (0.46) | Western hemlock | .35 | | 12.0 (5.6-22.3) |
| | | Other | .00 | | 7.8 (6.3-9.2) |
| Thin | 9 | Douglas-fir | .55 | .20 | 19.2 (6.2-29.4) |
| | (0.25) | Western hemlock | .23 | | 12.0 (5.6-9.2) |
| | | Other | .22 | | 7.8 (6.3-9.2) |
| Control | 8 | Douglas-fir | .63 | 1.00 | 19.4 (16.5-21.0) |
| | (0.25) | Western hemlock | .37 | | 11.5 (6.8-18.0) |

[a] Area including the reserve areas but not roads.

[b] Trees listed were in margin of adjacent stand or small reserved patches.

**Table 3-10—Extreme windspeeds 1998-2002 as recorded at Olympia, Washington**

| Windspeed | Characteristics of the Beaufort wind scale | Number of records | Average direction (range) |
|---|---|---|---|
| *Knots*[a] | | | *Degrees* |
| 28-33 | Whole tree in motion and difficult to walk | 149 | 177 (150-260) |
| 34-40 | Breaks twigs off trees and impedes progress | 20 | 169 (150-200) |
| 41-47 | Slight structural damage occurs | 1 | 180 |

[a] Knots x 1.1508 = miles per hour, knots x 1.852 = kilometers per hour.

**Table 3-11—Wind-thrown trees, by treatment unit and direction of fall**

| Direction of fall | Clearcut | Two-age | Patch | Group | Thin | Control |
|---|---|---|---|---|---|---|
| | | | *Number of trees* | | | |
| N | 38 | 18 | 28 | 4 | 1 | 1 |
| NE | 21 | 14 | 30 | 1 | 1 | 1 |
| E | 11 | 17 | 44 | 5 | 1 | 0 |
| SE | 16 | 12 | 24 | 3 | 2 | 1 |
| S | 1 | 0 | 7 | 3 | 3 | 1 |
| SW | 2 | 3 | 4 | 2 | 0 | 1 |
| W | 4 | 0 | 4 | 1 | 0 | 0 |
| NW | 21 | 11 | 7 | 1 | 1 | 3 |
| Total | 114 | 75 | 148 | 20 | 9 | 8 |

## Brush Control

As of the end of 2002, the only vegetation control done was a small amount of spraying in September 2002 for brush control in that part of the two-age unit southwest of the road leading to the clearcut unit, two patches in the patch cut unit (one in the southeast corner, the other in the north central portion), and one small area at the old mill site in the western end of the group selection unit. Areas and costs as provided by DNR are summarized below. Agent and dosage used was 37 oz Accord + 15 oz Entry II in 10 gal water per acre.[3]

| Unit | Area treated | Cost per acre | Total cost |
|---|---|---|---|
| | *Acres* | *– – – Dollars – – –* | |
| Two-age | 12 | 85 | 1020 |
| Patch cut | 7 | 138 | 966 |
| Group selection | 1 | 95 | 95 |

## Future Operations at Blue Ridge

Present planning assumes a 15-year entry cycle for harvest cuts and commercial thinning. Minor changes will remain possible until the time of the second entry. This does not imply that all areas will be thinned 15 years hence. Only that they will be inspected and thinning will be done on any portions of the area that are found to be in suitable condition at that time.

Timing and extent of any future precommercial thinning and brush control will be determined according to need.

Stand measurements and measurements of regeneration development and understory will be repeated at 5-year intervals, corresponding to one-third of the entry cycle.

The grid of permanent 1/5-acre plots may not provide an adequate basis for evaluating development of regeneration in the small openings and patches of the patch cut and group selection treatments. Therefore, consideration should be given at the 5-year remeasurement to establishing some transects within these that would allow a better evaluation of effects of competition from the residual stand.

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[3] The use of trade or firm names is for the convenience of the reader and does not imply endorsement by the USDA Forest Service of any product or service.