Comparing Changes in Scenic Beauty Produced by Green-Tree Retention Harvests, Thinnings and Clearcuts: Evidence From Three Pacific Northwest Experiments

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ABSTRACT

The same in-stand photographs were taken before and after six different green-tree retention harvests, including one in old growth. More such photo replicate pairs were also taken in light and heavy thinnings of young stand and in clearcuts. All the photos were rated for scenic beauty by samples of the public. Short-term changes in scenic beauty attributable to the forest treatments were computed from these ratings. High visual impacts meeting very low scenic integrity standards were observed for clearcuts, 15-percent aggregated-retention harvests of mature forests, and 15-percent mixed-pattern retention harvests of old growth. Moderate impacts meeting low scenic integrity standards were observed in 40-percent aggregated- and 15-percent dispersed-retention harvests of mature forests. Both thinnings produced low impacts meeting moderate scenic integrity standards. Treatments of 40-percent dispersed and 75-percent aggregated retention produced low impacts that can meet high scenic integrity standards. Some green-tree retention harvests have clear value in meeting aesthetic goals in forest management.

KEYWORDS: Scenic beauty, timber harvests, public perceptions, green-tree retention.

INTRODUCTION

Visual aesthetics are often critical factors affecting forest management decisions. Increasing the beauty of managed forests can enhance the social acceptability of forest management (Ribe 2002) and is often required in popular views, recreation areas, frequently seen places, and other areas strongly valued by the public (USDA FS 1995). Forest aesthetic choices often are evaluated through environmental impact statements. Aesthetic impacts must be included in these, and the standard for all assessments is change from baseline environmental conditions (Jain et al. 1993).

Many studies of aesthetic perceptions of forestry have been conducted (Ribe 1989), but few have investigated changes in the same forests or scenes due to forest treatments, as would best inform impact assessments. Instead, studies typically compare different forests and sometimes derive scenic beauty prediction models from which the visual impact of forest changes might be computed or inferred.

The state of the art in scenic impact assessment emphasizes evaluation of scenic change over time against visual standards that describe acceptable amounts of change in different places. The standards used by the USDA Forest Service consist of five “scenic integrity levels” ranging from “very low” to “very high,” with higher levels typically applied to more scenic, seen or valued landscapes (USDA FS 1995). Scientific evidence is needed to inform these assessments.

Study Objectives

This study investigated visual-aesthetic change inside forests as a result of harvests and thinnings in western Oregon and Washington. It investigated the worst-case, short-term impacts of recently conducted harvests. These impacts often need the most attention in improving social

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perceptions of forestry (Sheppard 2001). An investigation of green-tree retention harvests was emphasized because these are gaining attention (Franklin et al. 1997) and need to be compared to more traditional and sometimes aesthetically controversial harvests. Changes in scenic beauty because of clearcuts, thinned forests, and an old-growth harvest were, therefore, compared to green-tree retention harvests.

Numerous photo points were established inside experimental forests throughout western Washington and Oregon. The same scene was photographed from all of these points before and after the various harvests. A sample of these pairs of replicated photos were rated for scenic beauty by public respondents. Estimates of changes in average perceived scenic beauty ratings were found. These were compared to assess which treatments tend to produce which visual impact levels. The same changes in beauty were also compared against acceptable changes indicated by visual integrity standards used by the Forest Service in landscape planning (USDA FS 1995).

Background

Green-tree retention harvests are proposed by "New Forestry" (Franklin 1989) as alternatives to clearcutting. The goals of such alternatives are generally perceived more positively than conventional forestry by placing more emphasis on sustaining ecological health (Ribe and Matteson 2002). When viewed from inside the forest, green-tree retention harvests have aesthetic potential (Brunson and Shelby 1992), but not all aspects of such ecologically-derived harvest prescriptions will be necessarily aesthetically successful (Gobster 1996). Much may depend on how they manifest the "violence" of harvesting (Benson and Ullrich 1981). Scenic impacts, as a result of various forest harvests, should be compared to an old-growth harvest. Harvesting old growth forests is controversial in the Pacific Northwest, in part because of the loss of aesthetic values (Brunson and Shelby 1992).

To the extent that green-tree retention harvests leave more standing trees than most traditional harvests, they should be more aesthetically successful (Buhyoff et al. 1986, Schroeder and Daniel 1981, Vodak et al. 1985), although too few trees can be left standing (Daniel and Boster 1976, Schweitzer et al. 1976). Retaining more large green trees should aid aesthetic value (Brown and Daniel 1986, Daniel and Boster 1976, Schroeder and Daniel 1981).

Forest thinnings tend to be aesthetically preferred to other forest harvests, provided that down wood is removed (Kenner and McCool 1985), not too many trees are removed (Vodak et al. 1985), and larger trees are retained (Buhyoff et al. 1986). Thinned forests, after they regain ground vegetation, can be preferred to unmanaged forests of the same age (Bradley et al. 2004, Brush 1979).

METHODS

Study photographs came from the Demonstration of Ecosystem Management Options (DEMO) study (Aubry et al. 1999), the Long-Term Ecosystem Productivity (LTEP) study (Homann et al. 2001), and the Young Stands Study (YSS) (Hunter 2001, Kellog et al. 1998). These studies are all forest harvest experiments conducted in conifer-dominated forests in western Washington and Oregon. All are randomized block designs with harvest treatments replicated at locations exhibiting various altitudes and forest conditions.

The nine forest treatments investigated here were drawn from the three studies listed above. These are listed across the bottom of figure 1 and were implemented in forests outlined below.

The DEMO study provided examples of 15-, 40- and 75-percent retention harvests. The DEMO harvest sites were reasonably representative of mature, coniferous forests on public lands in western Washington and Oregon. The forests at the six DEMO blocks were between 65- and 170-years old and dominated by Douglas-fir (*Pseudotsuga menziessi* (Mirb.) Franco). The DEMO blocks included one on a level site, one on moderate slopes of 9 to 33 degrees, two mostly on moderately steep slopes of 40 to 53 degrees, and two mostly on steep slopes of 50 to 66 degrees. These slopes were relatively even within most of the units at all blocks. Four blocks contained pretreatment stands with densities mainly in the 200 to 500 trees/ha range, and the other two had mainly 700 to 1300 trees/ha. The basal area of the DEMO forests fell mostly in the 40 to 90 m^2/ha range with the mature cohort of trees typically at 38 to 76 cm, 1.37 m above ground (d.b.h.). One block had little ground vegetation and understory with extensive visual penetration. The other five pretreatment forests had ample ground vegetation and were typically heterogeneous enough to include areas of understory and limited visual penetration. (See Aubry et al. (1999) and other articles in this report for greater detail about the DEMO forests.)

The DEMO treatment units were 13 ha and square or slightly rectangular. For the aggregated-retention treatments, the percentage of retention was by area of the unit. For dispersed retention treatments, the percentage of retention was by basal area to match that of the corresponding percentage,

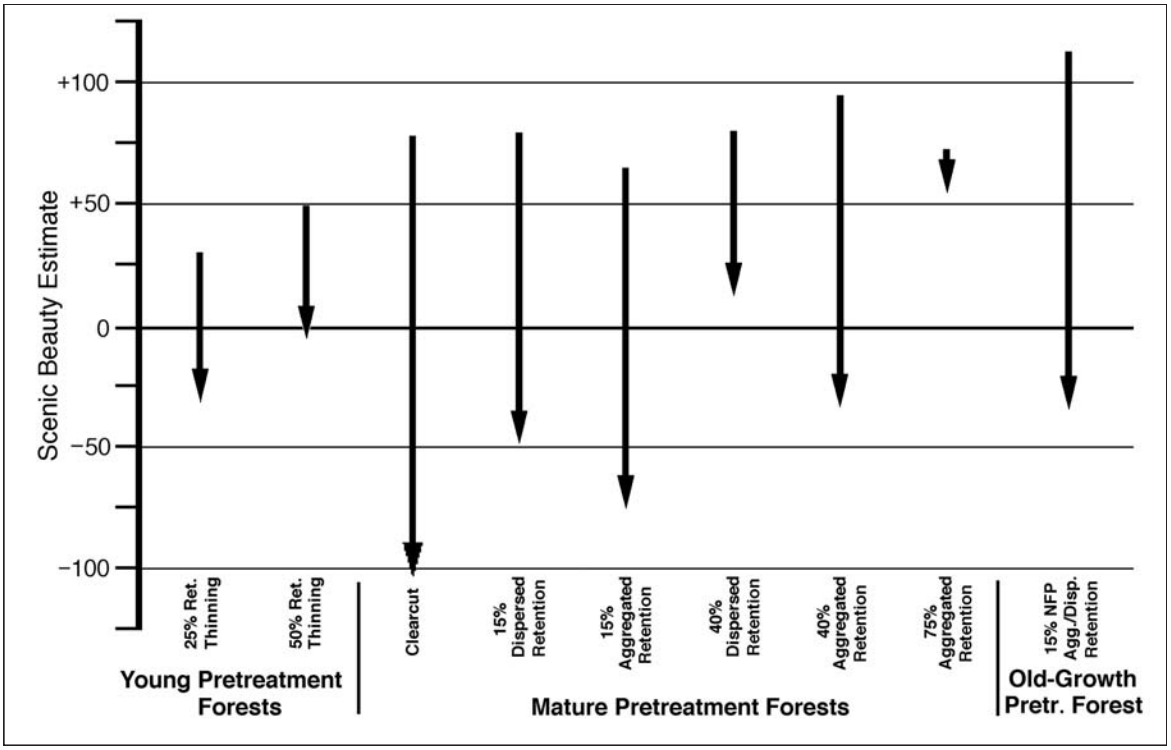

Figure 1—Observed changes in scenic beauty due to forest treatments.

aggregated-retention treatment within the corresponding block. The 15-percent aggregated-retention treatments contained two 1-ha, 56-m diameter, circular aggregates of uncut forest near opposite corners of the unit. The 40-percent aggregated-retention treatments contained five aggregates of the same size and shape, arranged in a dice-shaped pattern (illustrated in other articles in this report). This unnatural geometry of the retention aggregates was for scientific purposes related to other studies. It was not obvious when seen from inside the units and even less detectable in the photographs used for this study.

One LTEP block of four replicates (near Sappho, Washington) provided example clearcuts for comparison to the DEMO and YSS retention harvests. The LTEP block also provided an example of a 40-percent dispersed-retention harvest, by basal area (50 percent by tree density) that was employed in this study. Prior to harvesting, this block contained a 70-year-old, second-growth forest dominated by Douglas-fir on level ground. This block contained pretreatment stands with densities in the 700 to 800 trees/ha range. The basal area of these forests fell mostly in the 55 to 70 m^2/ha range, with the mature cohort of trees typically at 38 to 51 cm d.b.h. The clearcuts units in the LTEP study were 6 ha and square or slightly rectangular.

Four YSS blocks in the Willamette National Forest of Oregon provided examples of thinned young forests. Each of these included a light thin retaining a dispersed pattern of 50 percent stems, and a heavy thin retaining 25 percent dispersed stems. Hardwoods were retained as much as possible. Prior to thinning, these blocks contained 30- to 50-year-old, even-aged forests dominated by Douglas-fir. The YSS blocks included one on a level site and three on moderate slopes of 9 to 24 degrees. These YSS blocks contained pretreatment stands with densities in the 500 to 800 trees/ha range. The basal area of these pretreatment forests fell mostly in the 20 to 25 m^2/ha range, with the trees typically at 25 to 31 cm d.b.h. The YSS thinning units varied from 14 to 53 ha and occurred at altitudes from 134 to 276 m.

An old-growth harvest was included in the study for comparison. This entailed photo sampling from two different sites. Pretreatment photographs (n=48) came from old-growth forests on the Umpqua National Forest of Oregon that were sampled for the DEMO study but not harvested. Corresponding post-treatment photographs came from a recent old-growth harvest in the same national forest, as described later. This old-growth harvest followed Northwest Forest Plan standards (USDA and USDI 1994). It contained 15-percent density retention roughly split between aggregates and dispersed trees elsewhere in the unit. Down wood was mostly removed except for scattered, large logs.

Field Photography

Permanent monuments were driven into the ground within every treatment unit in all three studies. These were laid out in grids in the DEMO and LTEP units, and along transects in the YSS units. In all cases, the array of monuments was small and roughly centered within each unit so that photographs from monuments mainly captured the corresponding treatments. Predetermined subsets of monuments served as photographic sampling points, with care taken to ensure unbiased representation of the scenery. These points were located by protocols determined prior to field inspection of the forests or knowledge of how the monuments would fall within the forest structure and terrain. All photographs were replicated, once before treatment and once within 3 months after treatment.

All photographs were taken from sampling monuments in specified directions using a 35mm SLR conventional camera with a 35mm lens. The horizon, or estimated horizon if invisible, was placed one third of the way up each image, even when photographs were taken up or down slopes. For side slopes, the horizon point at the center of the image followed this rule. If a tree, shrub or rock obstructed a prescribed photo, the photographer moved up to 1 m in the shortest possible direction to minimize the obstruction in the photo. Photos were taken within 3 hours of noon, standard time.

A standard pattern of eight photos was taken in each DEMO unit from monuments along the edges and at the corners of the grid, all aimed at the center of the grid. This yielded 48 photo replicate pairs for each DEMO treatment across the six blocks. This pattern of photos was designed for representative post-treatment sampling of the most scenically-complex, 40-percent aggregated-retention treatment. The pattern of photos was designed by reference to the pattern of future felling for that treatment that was fixed in advance in relation to the grid of monuments. The resulting set of post-treatment scenes captured a variety of views, i.e., views inside uncut aggregates, across larger areas of harvested matrix, looking at unharvested matrix between uncut aggregates, and views of nearby aggregates with harvested matrix in the foreground. This mix of sample photos sought to capture views similar to those encountered on a random hike through this treatment. The other DEMO treatments were homogeneous enough for the same photo pattern to representatively sample scenery there as well.

A standard set of five points within the LTEP units were sampled. Photos were taken from each of these in the four cardinal compass directions. This yielded 20 photos per treatment unit. There were 16 clearcuts in the Sappho LTEP block employed in this study. This yielded 320 photos for clearcuts. There was also one dispersed retention harvest unit in the same block that met the same 40-percent, dispersed-retention basal area as one of the DEMO treatments being studied, yielding 20 more sample photos of that treatment.

Photographs were taken within each YSS unit from four randomly selected monuments. Photos were taken at each in the four cardinal compass directions. This yielded 16 photos per unit, or 64 photos per treatment across the four YSS blocks.

Twelve photographs inside old-growth forests were randomly selected. Copies of these were taken into the Umpqua National Forest old-growth harvest described above. Photos of this old-growth harvest were found and taken to match the untreated old-growth photos as closely as possible with respect to slopes and the position of stumps and standing trees within the photo frames. This method served to produce photos that were plausible as "post-treatment replicates" of the pretreatment old-growth photos. This yielded 12 pairs of replicated photos for this constructed example of an old-growth harvest.

Controlling for Down Wood in Photos

Because down wood left after harvest adversely affects scenic beauty perceptions (Brown and Daniel 1986, Daniel and Boster 1976, Schroeder and Daniel 1981, Schweitzer et al. 1976, Vodak et al. 1985), it needed to be controlled for in photos used in public surveys. To represent down wood similarly within all treatments' photo samples, half of each treatment's post-treatment photos were sampled to exhibit a high level of down wood. The pairs of replicated photos that included high post-treatment down wood needed to be separated out prior to final sampling for public surveys. This was done according to different rules depending on the study from which the photos came.

High down wood LTEP and YSS post-treatment photos were those taken of units where most harvest residue, including tops, limbs, and many logs remained on site. This was a prescribed, permanent condition in half the LTEP clearcut units photographed (n=160 photos) and the one 40-percent dispersed retention LTEP unit (n=20). In one of the YSS blocks, high down wood photos were taken before harvest residue were cleaned up (n=16 photos in each of the two treatments). In the other three YSS blocks (n=48 photos per treatment), low down wood photos were taken after harvest residue was removed.

High down wood post-treatment photos from the DEMO treatments were identified according to field measurements of the area depicted within the photos. Threshold values of total down wood per hectare were used. These were derived from sample-based estimates of the volume per hectare of course wood, course litter, and snags leaning more than 15º. The course wood (>10 cm diameter) estimates came from the 6-m transect shown in the photo and closest to the photo point. The course litter (5-10 cm diameter) estimates came from six 0.2-ha x 0.5 m microplots along the same transect. The leaning snags estimate came from the 0.08-ha circular plot shown in the photo and closest to the photo point. Leaning, dead trees, not rooted vertical ones, are more likely to adversely affect beauty perceptions (Brunson and Shelby 1992, Brush 1979).

The threshold values were as follows: among photos that depicted a foreground of 15-percent dispersed retention, or of harvested matrix within any aggregated retention treatment, those with more than 300 m^3/ha of down wood were classified as high down wood. For photos that depicted 40-percent dispersed retention harvests, the threshold was 200 m^3/ha. If a photo depicted unharvested aggregate in the foreground, the threshold value was 100 m^3/ha.

Sampling of Photos for Public Surveys

A subsample of the pairs of replicated photos (the same scene taken before and after forest treatments) was selected to represent each such treatment in public surveys. The number of photos sampled needed to reliably represent the scenic variability encountered within forests produced by any one treatment (Palmer and Hoffman 2001). To identify this sample size, public surveys were conducted in stages, each adding more photos until a reliable sample size was found. The first stage included eight pairs of replicated photos from each treatment. Additional stages added four more of these photo pairs from each treatment. The reliability test after each survey stage was the standard error of the mean perceived scenic beauty value (described later) among the post-treatment scenes for every treatment. Only the samples of the post-treatment scene were tested because they had more variability in scenic beauty ratings. These test values estimated the variability expected in mean scenic beauty found among other samples of the same number of scenes that might be sampled for each treatment. Once the test values for all treatments fell below 10 percent of the full range of perceived scenic beauty observed in the study, the photo sample size was deemed reliable. This occurred after two survey stages, at a final sample size of 12 pairs of replicated photos per treatment.

Some photo replicate pairs were eliminated before final subsampling for the public surveys. These were instances where one or both of the photos in each pair had one of four problems: (1) very poor photographic quality; (2) too much plastic flagging in the immediate foreground (placed by field researchers); (3) a close-up obstruction filling more than 25 percent of the photo; or (4) taken close to and toward the edge of a treatment unit, so that the wrong surrounding forest or neighboring treatment was depicted. This screening eliminated 9 percent of DEMO, 16 percent of LTEP, and 11 percent of YSS photo pairs.

For the first stage of public surveying, four pairs of replicated photos showing higher amounts of down wood, and four other photo pairs showing lower amounts of down wood were randomly selected for each treatment, yielding eight total photo pairs per treatment. The same procedure was used for the second stage, except two pairs per down wood level per treatment were selected. This yielded a total final sample of 12 (8+4) photo pairs per treatment.

Public Perception Surveys

All photo replicate pairs for all treatments were placed into a mail or live-group survey instrument. (Two survey protocols were employed due to funding limitations and the need to keep surveys short enough to elicit high response rates.) For the first stage survey, two randomly selected post-treatment photos of each treatment were allocated to the mail survey. This mail survey also included single, randomly-selected, pretreatment photos of a young forest, a mature forest, and an old-growth forest, as well as forestry attitude questions. All remaining first-stage photos were allocated to a survey of live groups described below. Care was taken to insure the comparability of the survey samples, as described later.

The mail survey photographs were printed in color, in random order, eight to a page, in an 28 x 43 cm (11 x 17 in) fan-fold survey. A random sample of 1,669 residents of western Washington and Oregon received letters requesting participation. Of these, 698 volunteered by returning postcards affirmatively as the compliant sample to whom the survey was sent. Two prompting letters were sent at successive twelve day intervals. In all, 647 returned the survey for a 93-percent response rate within the compliant sample, or 39 percent of the original sample.

Respondents were instructed that the photos included examples of forests with and without various timber harvests. They were instructed to rate the scenes for scenic beauty on a numeric scale from -5 to +5, ranging from "very ugly" (-5) to "very beautiful" (+5), with zero value ratings assigned to photos they found neither beautiful nor ugly or were undecided about.

The photos not allocated to the mail survey were projected as slides for rating by groups as an activity during their regular meetings. The groups included service clubs, higher education classes, outdoor interest groups, and business clubs representing economies significantly dependent on timber harvesting. These respondents were given the same instructions, and used the same rating scale. Each respondent rated the slides privately on their own survey. The photos were projected in random orders, and each slide was shown once for 7 seconds.

Six of the photo replicate pairs from each treatment, plus the pretreatment photos not included in the mail survey, were allocated to the first-stage, live-groups survey. Fifteen groups participated in this first stage, providing 271 respondents. Four additional photo replicate pairs from every forest treatment were in the second-stage, live-groups survey. Ten groups participated in this stage, providing 210 respondents. A few of the meeting attendees elected not to participate, and were not tracked, so a response rate can not be reported.

The live group slide rating surveys constituted a less random sample of the public than the mail survey. The most likely difference in rating bias between these two samples came from a significant difference in their representation of forest protection versus forest production attitudes. The ratings of these two categories of respondents was strongly correlated but with significantly different average values due to different aesthetic standards (Ribe 2002).

Accordingly, various live groups were recruited seeking a respondent sample with overall attitudes toward timber harvesting like that from the mail survey. The mail survey was completed first, yielding its distribution of attitude questionnaire responses. Live groups of respondents were recruited to roughly duplicate this distribution of environmental biases, as suggested by their defining mission or common interest. Groups' expected attitudes toward timber harvesting were also anticipated according to their urban versus rural location (Hansis 1995, Tremblay and Dunlap 1978), their members' typical length of residence in the region (Xu and Bengston 1997), and gender balance (Hansis 1995, Levine and Langenau 1979).

Measuring Perceptions

A scenic beauty estimate (SBE) was computed for each scene from all its ratings (Daniel and Boster 1976). This method of averaging ratings removes differences in how respondents distribute their ratings along the scale, and thereby standardizes just their perceptions of relative beauty. In this study, the respondents used a bipolar rating scale, producing SBE values that took on both positive and negative values, scaled to a zero point where the average respondent changed from negative (ugly) to positive (beautiful) ratings (Ribe 1988).

RESULTS

The changes in average SBE values across the photos representing each treatment are graphed in figure 1. All treatments produced reductions in scenic beauty. Consequently, the top of each arrow in figure 1 indicates the average SBE of the pretreatment photos, and the bottom indicates the average of the post-treatment photos. Inspection of the top of the arrows suggests an increasing trend in pretreatment scenic beauty from young to mature to old-growth forests. Within that pattern there was some chance variability in the level of SBEs observed in the pretreatment forests assigned to different treatments.

Inspection of figure 1 indicates several results regarding the position of different treatments' scenic beauty changes within the range of observed SBE levels. The two levels of thinning both produced similar reductions in SBEs such that the difference in their post-treatment SBEs may be accounted for by the chance difference in their pretreatment SBEs. Treatments of mature forests exhibited an increasing trend of post-treatment SBEs with increasing levels of green-tree retention. Within single retention levels (15 or 40 percent), dispersed retention produced higher post-treatment SBEs than aggregated retention. The dispersed 40-percent and aggregated 75-percent retention treatments produced positive post-treatment SBEs, while all the other mature forest treatments produced negative post-treatment SBEs. The 15-percent retention treatment of old-growth produced a change from the highest observed pretreatment SBE to a moderately negative post-treatment SBE.

Inspection of figure 2 indicates results about the comparative magnitude of scenic beauty changes due to the treatments. Figure 2 shows differences in scenic impact ordered by absolute change in average SBEs. All pairs of these SBE changes were tested for statistically significant differences using *t* tests, at $p = 0.05$. The sets of scenic impacts that are not statistically different are indicated by the bars across the top of figure 2. Note that the magnitude

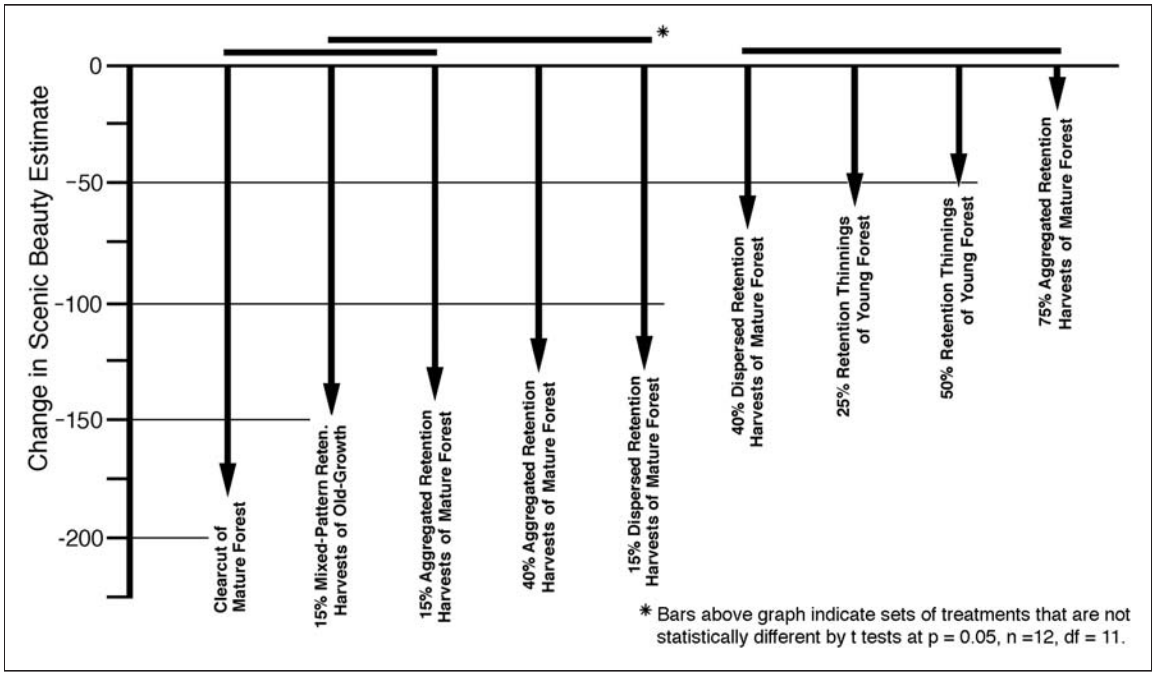

Figure 2—Comparing magnitudes of changes in scenic beauty due to forest treatments.

of average SBE change for the 75-percent aggregated-retention harvest was much smaller than all the other treatments (fig. 2). However, this obscures variation in SBE changes encountered within its various pairs of replicated photos between patches of harvested matrix versus unharvested aggregates. This variation produced a large enough standard deviation in SBE change values to cause it to be statistically the same as the other three treatments at the right of figure 2.

FINDINGS

The three sets of statistically-the-same absolute changes in scenic beauty in figure 2 indicate three short-term, in-stand scenic impact levels. These are generic, evidence-based levels useful for assessing impacts widely, as in forest plans and watershed analyses. At the level of a single harvest, landscape architects may marginally modify these impacts based on the design of each project:

- High impacts = clearcuts.
- High to moderate impacts = old-growth harvests executed under guidelines from the Northwest Forest Plans and 15-percent aggregated-retention harvests in mature forests.
- Moderate impacts = harvests of mature forests that employ 15-percent dispersed retention or 40-percent aggregated retention.
- Low impacts = thinnings and mature-forest harvests employing 40-percent dispersed or 75-percent aggregated retention. The latter can produce very low impacts if the harvested patches are placed out of view.

A comparison of the magnitude and position of scenic changes in figure 1 allows generic comparison to what would be acceptable, low impacts at various visual integrity levels:

- Clearcuts and 15-percent aggregated retention harvests produce very large changes from strongly beautiful to strongly ugly, consistent with low scenic impacts only against the "very low" scenic integrity standard.
- Old-growth harvests executed under the guidelines of the Northwest Forest Plan also fall into this “very low” scenic integrity standard. They produce changes from strongly very beautiful to moderately ugly, a more than moderate change incompatible with preharvest natural landscapes.
- 15-percent dispersed and 40-percent aggregated-retention harvests produce large changes from strongly beautiful to moderately ugly, consistent with low scenic impacts only against the “low” scenic integrity standard.
- Thinned young forests, whether heavy or light, produce short-term changes from moderately beautiful to moderately ugly, consistent with low scenic impacts against

the “moderate” scenic integrity standard. These are slight scenic changes that tend to be visually subordinate to continued, intact forest scenery.

- 40-percent dispersed and 75-percent aggregated-retention harvests produce changes from strongly beautiful to moderately beautiful forest, consistent with low visual impacts against the “high” scenic integrity standard. They maintain the positively beautiful forest landscape.

Further research is needed regarding longer term scenic impacts of these and other alternative timber harvests (Shelby et al. 2003), and how perception of such harvests differs among people with different knowledge of the values and risks each entails (Bradley et al. 2004).

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