# IMPACT OF RECENT TIMBER HARVESTS ON AUTUMN SCENIC BEAUTY OF NEAR-STAND VIEWS

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**Abstract**—This study estimated the impact of 10 recent timber cutting regimes on the autumn scenic beauty of shortleaf pine-hardwood forests in the Ouachita Mountains of Arkansas. Scenes were photographed near forest stand edges—views typically observed by sightseeing visitors—from 36 treated areas cut the previous winter and 3 comparable untreated areas. Cutting regimes varied in hardwood retention, spatial arrangement, and harvest intensity. We averaged scenic beauty ratings from several groups of judges. Results showed that scenic beauty of autumn, near-stand views were significantly ($P<0.05$) lower and in inverse proportion to the amount of wood recently removed. Pine vs. pine-hardwood retention and differences among groups of judges had no significant effect on scenic beauty ratings among various treatments. The treatments—grouped into similar impact categories and in order of increasing negative impact—were: (1) low-impact and pine single-tree selection, (2) pine-hardwood single-tree selection, pine and pine-hardwood group selection, and pine and pine-hardwood shelterwood, (3) pine and pine-hardwood seed tree, and (4) clearcut harvest.

## INTRODUCTION

Public interest in aesthetics for forest management appears in Federal legislation such as the National Environmental Policy Act of 1969, the Forest and Rangeland Renewable Resources Act of 1974, and the National Environmental Policy Act of 1976. The visual impact of cutting activities on forests is well known, but predicting the mitigating effects of different silvicultural treatments is uncertain.

Scenic beauty, as used in this study, is a measure of the aesthetic significance given to a scene by an observer. Scenic beauty is influenced by both the observer's culture and by the properties of the scene being observed (Smardon and others 1986). Reaction of observers to the aesthetics of forest scenery depends partly on the observer's ability—or lack of ability—to perceive and distinguish among different management activities (Magill 1990).

Daniel and Boster (1976) contend that scenic beauty is not totally "in the eye of the beholder," but inferred from the observer's perception of the landscape. The Scenic Beauty Estimation (SBE) method developed by Daniel and Boster (1976) is a procedure for rating the visual quality of scenes. Individuals typically rate representations of these scenes by numerically scoring their preference for the "scenic beauty" depicted in photographic images shown to them.

## OBJECTIVES AND STUDY AREA

The main objectives of the study were to estimate the impact of silvicultural treatments on the scenic beauty of shortleaf pine-hardwood forest stands in the Ouachita and Ozark National Forests and to compare scenic beauty trade-offs when selecting silvicultural treatments (Mersmann and others 1994).

The study locations were part of a 9,600 square mile study area established by the USDA Forest Service on the Ouachita and Ozark National Forest land located in northwest Arkansas and eastern Oklahoma (Baker 1994, Guldin and others 1994). Quadrants of the study area corresponded to regions with similar land surface forms, potential natural vegetation, and geology. These quadrants (and nearby Arkansas cities) were: north (Danville), east (Cedar Creek), south (Mount Ida), and west (Black Fork). The USDA Forest Service randomly assigned silvicultural treatments to one of 13 stands in each quadrant of the study region, with trees mostly cut to promote pine reproduction (Baker 1994). We used the north, east and south quadrants of the region; costs and time constraints excluded consideration of the west quadrant.

Harvesting of treated stands occurred in the winter of 1992 to 1993; reproduction treatments were planned for 1994. The conditions, treatments, and their abbreviation are listed first by increasing intensity of harvesting (untreated, single-tree selection, group selection, shelterwood, seed tree, clearcut), second by an estimate of the square feet of basal area removed, and third by square feet of hardwood basal area removed:

1. CON: untreated stands retained in their natural state, averaging 130 $ft^2$ per ac
2. LIST: low impact single-tree selection: about 70 $ft^2$ per ac retained (about 60 $ft^2$ per ac removed). Retention of 30 to 55 trees per ac shortleaf pines and 10 $ft^2$ per ac hardwoods
3. PSTS: pine single-tree selection: 63 $ft^2$ per ac retained (67 $ft^2$ per ac removed). Retention of 30 to 55 trees per ac shortleaf pines and 0 to 5 $ft^2$ per ac hardwoods
4. PHSTS: pine-hardwood single-tree selection: 60 $ft^2$ per ac retained (70 $ft^2$ per ac removed). Retention of 20 to 45 trees per ac shortleaf pines and 10 $ft^2$ per ac hardwoods. Planned for 1994, vegetative management treatments, e.g., mechanical versus chemical treatment

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of residual trees, were to be split (s) in PHSTSs, but not in nonsplit (ns) PHSTSns stands

5. PHGS: pine-hardwood group selection: 60 $ft^2$ per ac retained (70 $ft^2$ per ac removed); clearcut 0.1 to 2.0 ac. Retention of 20 to 45 trees per ac shortleaf pine and 10 $ft^2$ per ac hardwoods

6. PGS: pine group selection: 60 $ft^2$ per ac retained (70 $ft^2$ per ac removed); clearcut 0.1 to 2.0 ac. Retention of 30 to 55 trees per ac shortleaf pine and 0 to 5 $ft^2$ per ac hardwoods

7. PSW: pine shelterwood: 43 $ft^2$ per ac retained (87 $ft^2$ per ac removed). Retention of 20 to 40 trees per ac shortleaf pines and 0 to 5$ft^2$ per ac hardwoods

8. PHSW: pine-hardwood shelterwood: 40 $ft^2$ per ac retained (90 $ft^2$ per ac removed). Retention of 10 to 30 trees per ac shortleaf pines and 10 $ft^2$ per ac hardwoods. Planned for 1994, vegetative management treatments were to be split (s) in PHSWs, but not in nonsplit (ns) PHSWns stands

9. PST: pine seed tree: 23 $ft^2$ per ac retained (107 $ft^2$ per ac removed). Retention of 15 to 20 trees per ac shortleaf pines and 0 to 5 $ft^2$ per ac hardwoods

10. PHST: pine-hardwood seed tree: 20 $ft^2$ per ac retained (110 $ft^2$ per ac removed). Retention of 5 to 10 trees per ac shortleaf pines and 10 $ft^2$ per ac hardwoods

11. CC: clearcut: 0 to 5 $ft^2$ per ac of trees retained (127 $ft^2$ per ac removed). All trees were removed. Site preparation for planting of genetically improved shortleaf pine was scheduled to begin in 1994.

## METHODS

We examined one untreated stand and stands demonstrating the 10 different timber-harvest regimes listed above. Table 1 lists stand and compartment numbers, and the square feet of basal area retained (and removed) for the 39 stands examined in this study. As outlined elsewhere (Guldin and others 1994), retained basal area estimates were expected values following treatment across the study region. We estimated removed basal area by subtraction from the average basal area prior to harvest treatment (130 $ft^2$ per ac) across the entire study region. Owing to planned 1994 reproduction treatments, PHSTS and PHSW harvest treatments were replicated twice.

The senior author selected three to four representative vantage points per stand from topographic sheets and located them during July 1993 field visits. These points were just outside, or up to 100 feet outside, the stand boundary. Picture taking was conducted from the selected vantage points during three weekends in October 1993. At that time, treated areas were recently disturbed, i.e., stand disturbance had occurred within a year after the cut, but without site preparation.

Stand views were photographed with ASA 100 35 mm transparency film using a single lens reflex camera mounted on a tripod with a 30 to 70 mm zoom lens fixed at 55 mm. To randomize view angles and avoid duplicating scenes, images at each location were taken at three compass directions (azimuths) toward the stand. The initial image was taken in a random azimuth toward the stand. The second and third images were taken 40 degrees to the left and right of the

**Table 1—National forest stands sampled in October 1993, approximate square feet of basal area per acre retained (removed), treatment, and treatment abbreviation, Ouachita-Ozark National Forests[a]**

| Stands sampled by quadrant and stand—compartment number | | | Retained (removed) | Silvicultural treatment | Treatment abbreviation |
|---|---|---|---|---|---|
| North | East | South | | | |
| | | | *ft²/ac* | | |
| 0284-11 | 0605-05 | 0023-10 | 130 (0) | Untreated (control) | CON |
| 0367-04 | 1077-19 | 0062-08 | 70 (60) | (s) low-impact single-tree selection | LIST |
| 1125-05 | 1044-03 | 1658-16 | 63 (67) | (s) pine single-tree selection | PSTS |
| 0428-02 | 1073-10 | 1654-16 | 60 (70) | (s) pine-hardwood single-tree selection | |
| 0070-10 | 0609-09 | 1649-13 | | (ns) pine-hardwood single-tree selection | PHSTS |
| 0046-18 | 1124-11 | 0035-42 | 60 (70) | (ns) pine-hardwood group selection | PHGS |
| 0014-18 | 1106-09 | 1648-01 | 60 (70) | (ns) pine group selection | PGS |
| 0443-03 | 1097-06 | 0035-41 | 43 (87) | (s) pine shelterwood | PSW |
| 0456-09 | 1094-04 | 1660-06 | 40 (90) | (s) pine-hardwood shelterwood | |
| 0457-12 | 1119-21 | 0027-01 | | (ns) pine-hardwood shelterwood | PHSW |
| 0458-10 | 1084-07 | 1646-08 | 23 (107) | (s) pine seed tree | PST |
| 1036-17 | 1119-5S | 1651-06 | 20 (110) | (s) pine-hardwood seed tree | PHST |
| 0458-16 | 1067-15 | 1658-05 | 3 (127) | (ns) clearcut | CC |

(s) = Split stands; (ns) = nonsplit stands; CON = untreated stands; LIST = low-impact single-tree selection; PSTS = pine single-tree selection; PHSTS = pine-hardwood single-tree selection; PHGS = pine-hardwood group selection; PGS = pine group selection; PSW = pine shelterwood; PHSW = pine-hardwood shelterwood; PST = pine seed tree; PHST = pine-hardwood seed tree; CC = clearcut.

[a] Reproduction treatments, planned for 1994, were to differ for half of the stand area of split (s) stands, but not nonsplit (ns) stands (Baker 1994).

initial azimuth. Acquisition of images incorporated a long depth of view by using an f 22 aperture setting, and bracketed ± 1 f-stop.

After the film was processed, duplicate, over- and under-exposed images were discarded. Only "acceptable" images from which random samples were selected. To simplify analysis for this report, we ignored the initial blocking of the overall study's sample design, i.e., assignment of stands by quadrant. Twelve or more images were chosen to represent each treatment. Random sample selection resulted in one to six images representing a single stand, with most stands represented by three images.

We used groups of students at Mississippi State University to view and rate these images in the spring of 1994. Of the 196 students asked to rate a portion of the images during their class period, 96 percent turned in completed responses. Respondents were predominantly from the southeastern United States, 90 percent were male, with an average age of 21. Previous research has shown that students' visual preferences for natural scenes are representative of the general public (Schroeder and Daniel 1981).

There were three groups of student judges based on attendance in particular classes:

1. informed forestry class: 82 students (78 completed responses) enrolled in an "Introduction to Forest Survey" course. This group received instructions about the different types of harvest practices they were to see
2. senior forestry class: 64 students (63 completed responses) enrolled in a senior-level "Forest Management" course. This group received no message about treatments
3. non-forestry class: 50 students (47 completed responses) enrolled in a "Landscape Architecture Appreciation" course, primarily for non-landscape architecture majors. This group also received no message about treatments. Out of this group, more than 40 percent majored in professional golf management, 22 percent in business, 14 percent in landscape architecture, and the remaining 24 percent in other fields of study.

For the rating sessions, we followed procedures developed by Daniel and Boster (1976) and used RMRATE software (Brown and others 1990). Judges were shown each image for 8 seconds, then asked to rate the image on a scale of 0 to 9, where nine was the highest scenic beauty. In each session, judges viewed 80 different images, 20 of which were "baseline" images shown to every group. These "baselines" were placed in every fourth position of the slide carousel. The score for an image represented the average scenic beauty rating, called SBE, relative to "baseline" images shown to all judges (Brown and Daniel 1990). Subsequent analysis then used ratings only of nonbaseline images.

We used standardized SBE scores, called SBEz, to assure a uniform scale among different groups of judges (Brown and Daniel 1990). A widely accepted and commonly used practice in social science preference studies is to assume resulting ordinal scale preference scores are interval data, with an implied uniform distance between two adjacent scores (Daniel and Vining 1983). Furthermore, ratings with from 20 or more individuals, when normally distributed, have been shown to provide adequate precision and do not seriously violate assumptions of standard statistical tests and procedures (Daniel and Vining 1983). However, one is often cautioned that no true interval exists. That is to say, a difference in rating of 1.0 between 10.0 and 11.0 does not necessarily represent the same difference between 90.0 and 91.0.

Traditional parametric tests—where random samples are taken from one or more populations—assume an underlying normal distribution, but ratings may not follow such a distribution. The distribution of ratings was tested for kurtosis (0=not skewed and normally distributed; plus or minus 1=skewed and not normally distributed) to determine whether the data approximated a normal distribution (SAS Institute Inc. 1990). The kurtosis value of scenic beauty ratings, -0.5, suggested that rating distributions were normally distributed.

Nevertheless, we converted ratings to rankings for ease of interpretation and to minimize our assumptions. Ranked non-baseline image SBEz values served as the basis for conducting an analysis of variance by judge and treatment, calculation of averages, and F- and t-tests of significance at the 0.05 probability level. For brevity, quadrant differences are not included in this report. Statistical software used SAS's General Linear Model procedure (SAS Institute Inc. 1990). Examination of significant differences used the Bonferroni approach to ensure an experimentwise error rate by using t-tests at the 0.05/10=0.005 level (SAS Institute Inc.1990), and the Duncan multiple range (DMR) test (Cochran and Cox 1957) at the P=0.05 level.

## RESULTS AND DISCUSSION

A visual inspection of color images suggested that the amount of sky in the scene and overt evidence of disturbance were negatively associated—and retained vegetation positively associated—with scenic beauty estimates. (A subset of the images with related SBE values is included in the appendix.) Scores ranged from –277.5 to +194.8, with a mean of –48.8 and a median of –58.8. Subsequent analyses used ranked scores ranging from 1 to 179, with a mean of 90.

Though there was considerable variation among the images, the analysis of variance revealed that significant ($P(F)<0.05$) variation in scenic beauty was due to differences among treatments (table 2). Each group of judges considered untreated stands highest and clearcut stands lowest in scenic beauty; other treatments were intermediate between these extremes (fig. 1). Overall average ranking for the informed forestry, senior forestry, and nonforestry classes who rated the images for scenic beauty were 92.0, 93.3, and 84.7, respectively. However, differences were not statistically significant by judge group ($P(F=0.94, df = 2, 166)>0.39$), or the treatment by judge group interaction ($P(F=0.56, df=20, 146)>0.93$).

**Table 2—Analysis of variance of fall scenic beauty rating within a year following treatment, Ouachita-Ozark National Forests**

| Source | Degrees of freedom | Mean square variance | F value | P (larger F) |
|---|---|---|---|---|
| Treatment | 10 | 25,008.51 | 17.45 | < 0.001 |
| Judge group | 2 | 1,275.55 | 0.89 | 0.413 |
| Judge by treatment | 20 | 805.44 | 0.56 | 0.933 |
| Residual | 146 | 1,432.77 | | |

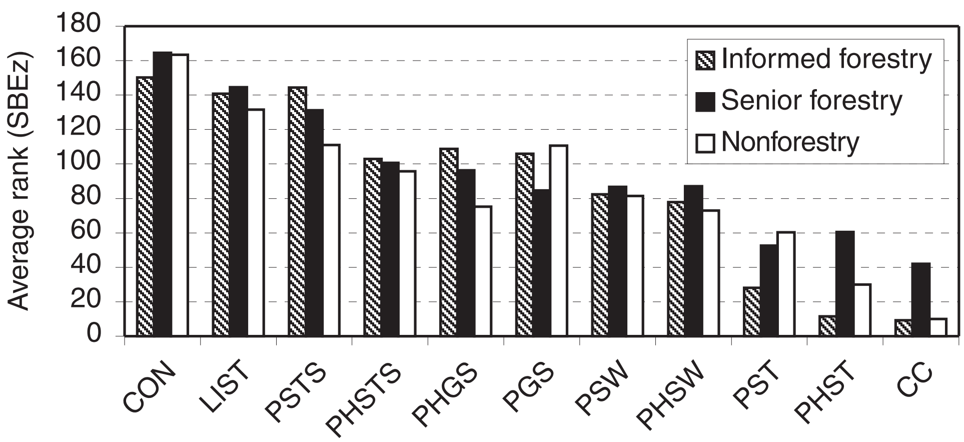


Figure 1—Average rank (standardized scenic beauty values) by judge group and year-earlier treatment for October 1993 shortleaf-hardwood near-stand views, Ouachita-Ozark National Forests. Treatments are listed in declining scenic beauty estimate rank order; CON = untreated stands; LIST = low-impact single-tree selection; PSTS = pine single-tree selection; PHSTS = pine-hardwood single-tree selection; PHGS = pine-hardwood group selection; PGS = pine group selection; PSW = pine shelterwood; PHSW = pine-hardwood shelterwood; PST = pine seed tree; PHST = pine-hardwood seed tree; CC = clearcut.

Treatments were the chief source of variation, with the pooled variance yielding P(F=18.4, df=10, 168)<0.001. Averages showed that untreated stands were rated and ranked highest, clearcut stands lowest, and less extensively cut stands intermediate between these two extremes (table 3). Treatments, grouped into similar impact categories and ordered by ascending negative impact, were: (1) low-impact and pine single-tree selection, (2) pine-hardwood single-tree selection, pine and pine-hardwood group selection, and pine and pine-hardwood shelterwood, (3) pine and pine-hardwood seed tree, and (4) clearcut harvest. Plotting the average ranking by the approximate square feet of basal area removed illustrates an inverse association (fig. 2).

Multiple comparison tests using the Bonferroni approach yielded the most conservative differences, as experiment-wise error rate for t-tests was set to P=0.005. With these test statistics, scenic beauty rankings of (1) untreated stands were indistinguishable from low-impact and pine single-tree selection; (2) group selection and shelterwood treatments were indistinguishable from each other; (3) pine and pine-hardwood treatments for a given cutting intensity were not significant; (4) seed tree cuts ranked lower than pine and low-impact single-tree selection and pine group selection; pine-hardwood seed tree cuts ranked still lower than pine group selection and pine-hardwood single-tree selection; and (5) pine and pine-hardwood seed tree cuts were indistinguishable from clearcuts. With Duncan's multiple range test, at P=0.05, smaller differences among closely ranked treatments were significant, but overall results remained the same.

## CONCLUSIONS

Study results showed that timber cutting in the previous year negatively affected the scenic beauty of near-stand views in autumn. Differences among judge groups used for this study were not significant. We concluded that the use of different judge groups (from informed and uninformed forestry classes and a nonforestry class) had no significant influence on our findings. Our results corroborate Benson and Ullrich's (1981) suggestion that judge group differences (college students, public school teachers, and Forest Service researchers) had little effect on ratings of an array of treatments in Montana and Wyoming.

Scenic beauty of autumn, near-stand views were significantly lower and in inverse proportion to the amount of wood recently removed. Harvest intensity (approximated by square feet of basal area removed), was inversely associated with scenic beauty. Pine vs. pine-hardwood retention had no significant effect on scenic beauty for intensively cut stands. Overt signs of cutting dominated many of the scenes depicted

**Table 3—Average scenic beauty estimate and average rank by year-earlier treatment, shortleaf-hardwood near-stand views, Ouachita-Ozark National Forests, October 1993**

| Treatment number and code | Rated images | Average SBEz | Average rank | DMR[b] | T-test results, P(\|t\|<0.005)[a] Treatment number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *no.* | | | | | | | | | | | | | | |
| 1. CON | 14 | 91.1 | 159.9 | A | + | \| | \| | * | * | * | * | * | * | * | * |
| 2. LIST | 13 | 44.4 | 139.1 | AB | \| | + | \| | \| | \| | \| | \| | * | * | * | * |
| 3. PSTS | 13 | 20.1 | 126.5 | BC | \| | \| | + | \| | \| | \| | \| | \| | * | * | * |
| 4. PHSTS | 26 | - 34.0 | 99.4 | CD | * | \| | \| | + | \| | \| | \| | \| | \| | * | * |
| 5. PHGS | 18 | - 43.1 | 92.2 | D | * | \| | \| | \| | + | \| | \| | \| | \| | \| | * |
| 6. PGS | 13 | - 29.6 | 102.1 | CD | * | \| | \| | \| | \| | + | \| | \| | \| | * | * |
| 7. PSW | 15 | - 61.1 | 83.3 | D | * | \| | \| | \| | \| | \| | + | \| | \| | \| | * |
| 8. PHSW | 28 | - 65.7 | 79.9 | D | * | * | \| | \| | \| | \| | \| | + | \| | \| | * |
| 9. PST | 12 | - 118.1 | 48.4 | E | * | * | * | \| | \| | \| | \| | \| | + | \| | \| |
| 10. PHST | 12 | - 133.9 | 42.2 | EF | * | * | * | * | * | \| | \| | \| | \| | + | \| |
| 11. CC | 15 | - 202.0 | 18.3 | F | * | * | * | * | * | * | * | * | \| | \| | + |
| Overall | 179 | - 48.8 | 90.0 | | | | | | | | | | | | |

SBEz = Scenic beauty estimate; CON = untreated stands; LIST = low-impact single-tree selection; PSTS = pine single-tree selection; PHSTS = pine-hardwood single-tree selection; PHGS = pine-hardwood group selection; PGS = pine group selection; PSW = pine shelterwood; PHSW = pine-hardwood shelterwood; PST = pine seed tree; PHST = pine-hardwood seed tree; CC = clearcut.

[a] T-tests (Bonferroni approach): compared with treatment (+) averages, other averages were significantly (*) different at alpha = 0.005, (|) otherwise.

[b] Duncan's Multiple Range test: averages with the same letter are not significantly different, (P < 0.05).

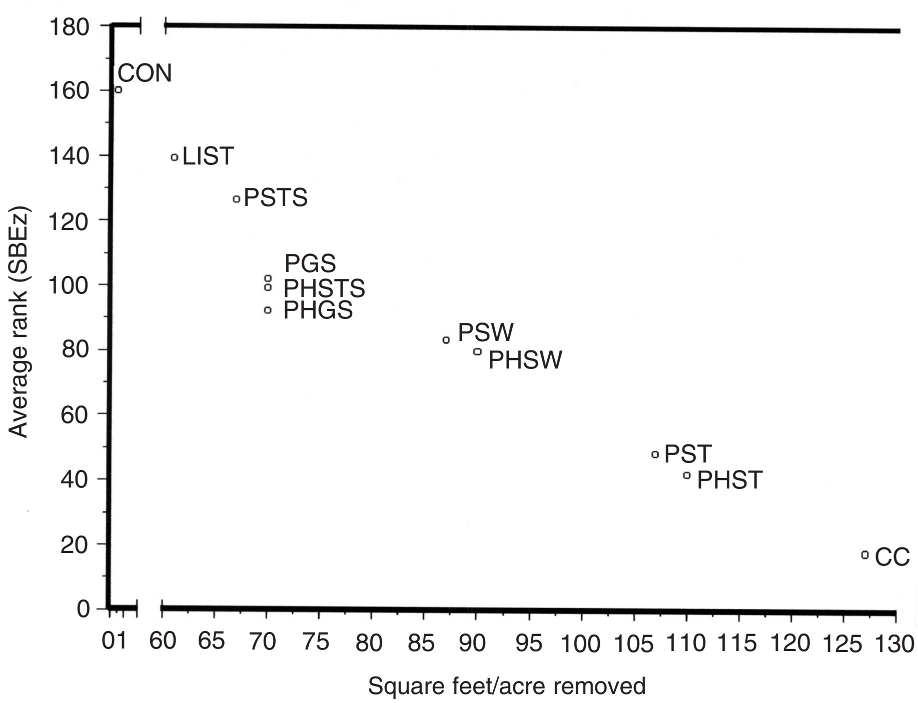


Figure 2—Average scenic beauty rank by approximate square feet of basal area removed in year-earlier treatments for October 1993 shortleaf-hardwood near-stand views, Ouachita-Ozark National Forests; CON = untreated stands; LIST = low-impact single-tree selection; PSTS = pine single-tree selection; PHSTS = pine-hardwood single-tree selection; PHGS = pine-hardwood group selection; PGS = pine group selection; PSW = pine shelterwood; PHSW = pine-hardwood shelterwood; PST = pine seed tree; PHST = pine-hardwood seed tree; CC = clearcut.

in near-stand images of treated stands and may have overwhelmed the finer-scaled differences in pine vs. pine-hardwood retention, and within-stand grouped vs. single-tree cutting arrangements. We further concluded that cutting alternatives fell into four groups according to impact. These were, in order of increasing impact on scenic beauty: (1) low-impact and pine single-tree selection, (2) pine-hardwood single-tree selection, group selection, and shelterwood, (3) seed tree, and (4) clearcut treatments.

Whether the relationships among treatments suggested by our results remain the same for other stand types, within-stand views, or different seasons is uncertain. With foreground views of Montana Douglas fir stands, studies by Benson and Ullrich (1981) yielded scenic beauty ratings for shelterwood significantly greater than clearcut stands. Further refinement could include forecasting the decline in near-stand scenic beauty of shortleaf-hardwood stands as a function of the actual amount of wood removed, rather than the approximate values provided in this report. With the existing images, future image analysis might reveal color (evergreen pine vs. hardwood) differences between pine and pine-hardwood-single-tree retention, and discrimination of image attributes among the four groups of treatment impacts noted above.

Forest managers concerned with public perception of harvests need to consider near-stand scenic beauty impacts when choosing harvest regimes, particularly along roadside views and in public forests. Our study suggests that—within a year of treatment—single-tree selective cutting has the least impact, followed by shelterwood, seed tree, and clearcut treatments. Pine single-tree selective cutting has less of an impact than pine-hardwood group selection and shelterwood cutting. Shelterwood stands have greater scenic beauty than seed tree and clearcut stands; pine seed tree stands have greater scenic beauty than clearcut stands. Our study suggests that the spatial arrangement or proportion of hardwood retained may not influence scenic beauty of near-stand views as much as the basal area of trees removed.

Nevertheless, vegetation structure recovers from harvests, trees regenerate, and scenic beauty improves in the years following treatment, as shown for within-stand views of uneven-aged (Gritter 1997, Rudis and others 1999) and even-aged treatments (Rudis and others, in press) and foreground views of a variety of treatments (Benson and Ullrich 1981). For near-stand views, we suspect that harvest disturbance impacts become less obvious and scenic beauty improves with the passage of time.

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## APPENDIX

The following 12 photographs (six untreated and six clearcut) is a subset of the study's digitally archived images with identifying codes by treatment and stand. Examples are ordered by type of treatment and scenic beauty scores within each treatment. References under each image are the 6-digit stand and compartment code, the 7-digit original compact disk and image code, and the standardized scenic beauty estimate (SBEz).

Untreated

Stand 0284-11 CD 0677-066
SBEz 194.80

Stand 0023-10 CD 0329-017
SBEz 155.45

Stand 0023-10 CD 0329-015
SBEz 134.01

Stand 0284-11 CD 0677-060
SBEz 99.35

Stand 0605-05 CD 0677-018
SBEz 62.40

Stand 0605-05 CD 0677-020
SBEz 19.91

Clearcut

Stand 1067-15 CD 0677-084
SBEz -92.56

Stand 1685-05 CD 0329-061
SBEz -159.75

Stand 1658-05 CD 0329-060
SBEz -212.12

Stand 1067-15 CD 0677-083
SBEz -237.76

Stand 0458-16 CD 0677-028
SBEz -260.24

Stand 0458-16 CD 0677-029
SBEz -277.51