Silviculture and Forest Aesthetics Within Stands

by

Robin E. Hoffman and James F. Palmer

Research supported by the USDA Forest Service, Northeast Experiment Station (Burlington, Vermont) Northeast Decision Model Project, and
published by The New York Center for Forestry Research and Development.

INTRODUCTION

One of the original goals of environmental perception research was to allow the prediction of scenic beauty based on landscape attributes, with much of this effort focusing on the forested landscape. For instance, Shafer, Hamilton and Schmidt (1969) sought:

> … to identify what quantitative variables in a natural landscape are significantly related to public preference for that landscape. By knowing what quantitative features in a landscape affect its aesthetic appeal, natural resource planners can make decisions on a factual basis about purchasing, developing, or preserving these features.

With 25 years of empirical research investigating the relationship of landscape attributes to scenic beauty, several have found that managed forests can be more scenic than unmanaged forests in some circumstances (Yarrow 1966, Brush 1979 and 1980, Kelomänki & Savolainen 1984). It now seems appropriate to incorporate the findings into one of the new forest management expert systems.

The goal of this study is to do just that -- review the existing forest aesthetics literature with an eye toward developing a rule base for the aesthetics module of the Northeast Decision Model (NED). The foundation for this literature review rests on two assumptions:

1. Aesthetics focuses on preference for **visible aspects** of forest environments.

2. NED requires preference to be linked to forest **measurements used by silviculturalists**.

These assumptions were used as criteria to cull the several hundred book chapters, articles, and other reports relating to forest landscape perception to those that would be useful for NED's purposes. Of these, just over 100 were empirical research reports -- a surprising number of articles were based on assertions without any reported empirical basis. Of these empirical studies, many also failed to use environmental measurements that could be used in managing a forest. For example some studies only included perceptual measurements, or measurements of photographic composition.

There are 43 reports that were identified as potentially useful for developing an aesthetic rule base for NED. A detailed review of these studies was conducted and a computer data base built to identify the salient attributes and findings of each study. The framework, which is included as appendix A, was developed to assure that the review

systematically checked for potentially useful results. The detailed review narrowed the number meeting the criteria to only 30 reports drawn from 17 independent sets of forest data. Some of these were studies of forests types not found within the northeast. About half of these studies were relatively comprehensive attempts to relate aesthetics to forest measurements, though the results may have been spread over several reports. The rest focused on only one or two specific aspects of the forest--usually the recovery immediately after harvest and the visual effects of residual slash. Table 1 lists the reviewed empirical literature and provides a summary of their forest type, the forest measurements used, and the silvicultural systems considered.

The following sections of this report summarize the findings from the literature as they relate to forest type, forest measurements, and silvicultural systems. The discussion will draw on the insights from all the literature reviewed, however the emphasis is on those reports listed in table 1 which met both the criteria for use in building NED's decision rules.

FOREST TYPES

The Northeast Decision Model supports twelve hard and softwood forest types.[1] There are only a dozen studies of scenic value conducted in the northeast, and these do not give complete coverage of all its forest types. However, these studies can

[1] The supported forest types are: (1)spruce-fir, (2) mixed wood (spruce-fir/northern hardwoods), (3) northern hardwoods (beech-birch-maple), (4) hemlock/hardwoods (hemlock and northern hardwood mix), (5) Allegheny hardwoods (cherry-maple), (6) cove hardwoods (mixture dominated by yellow-popular in the Appalachians), (7) oak-northern hardwoods (beech-birch-maple and oak-hickory mix), (8) oak-hickory, (9) oak-southern pine (oak-hickory and southern pine mix), (10) pine-hardwood (white pine and northern hardwood mix), (11) white pine, and (12) aspen-birch.

Table 1. Empirical literature relating forest types, measurements, and management systems to scenic value.

	Northern hardwoods	Northern conifers	Aspen or birch	Oak-hickery	Southern conifers	Western conifers (dry)	Western conifers (wet)	Species composition	Slash/Down wood	Herbaceous cover	Smaller trees/Understory	Bigger trees	Basal area/Totao density	Crown cover	Time since harvest	Clearcutting	Shelterwood	Patch	Selection
Anderson et al., 1982						•			–						+				•
Arthur, 1977						•			–	+		+	+			•	•		
Benson & Ullrich, 1981 [A]						•			–						+	•	•		
Brown & Daniel, 1984, 1986 [B]						•		+	–	+	–	+	–	?					
Brunson & Shelby, 1991							•									•	•	•	
Brush, 1979, 1980	•	•	•	•							–	+	?	?					
Buhyoff et al., 1986					•			+			∩		?		+				
Hull & Buhyoff, 1986					•				–		–		–		+				
Kellomäki, 1975		•						+			?	+	+			•			
Nyland et al., 1976 [D]	•								–				?			•		•	•
Palmer, 1990; — & Sena, 1993	•								?	?	–	+		?	+				•
Patey & Evans, 1979				•	•					?	–		?						
Ribe, 1990, 1992	•	•	•	•				+	–	+	∩	+	+			•	•		
Rudis et al., 1988					•			?	+		–	+	+						
Savolainen & Kellomäki, 1984 [C]		•	•					+	–		∩	+	?		+	•			
Schroeder et al., 1993		•							–							•			
Vodak et al., 1985				•				?	–		?		+			•			

Table notes: The effect on scenic value of stand attributes marked with a **+** is positive, with a **–** is negative, with an inverted-**U** is curvilinear, and with a **?** either non-significant or ambiguous.

A Same sites used in Schweitzer, et al., 1976.

B Same sites used Brown, 1987; Daniel, et al., 1989; Daniel & Schroeder, 1979; Schroeder & Brown, 1983; and Schroeder & Daniel, 1981.

C Same sites used Savolainen & Kellomäki, 1981.

D Same sites used Echelberger, 1979.

be supplemented somewhat by several studies from outside the region that include forest types found both inside and outside the northeast.

Forest type establishes a basic pattern and structure which establishes the limitations and potentialities for scenic value (USDA Forest Service, 1980). Brush (1979) sees the work of a forest landscape architect concerned with scenic value as similar to other forest managers. The major difference is that the landscape architect describes the forest using terms like visual variety, contrasts, colors, textures, and scale (USDA Forest Service, 1973 & 1980), while silviculturists describe the forest using terms like basal area, percent ground cover, residual volume, percent canopy closure, and number of stems. However, Brush sees both as "sculptors" using plant material as their medium. A forest has a floor, walls and a ceiling which forester or landscape architect can manipulate to create spaces which are visually appealing.

This analogy for describing forest scenes was further extended by Arisó-Campà and Palmer (1989). For the purpose of visual perception analysis, they divided the forest scene into three main components: the ground plane, the trees, and the surrounding matrix. These three components, illustrated in figure 1, can be described in terms of the characteristics of the following units and subunits associated with them. The *ground plane* is characterized by the forest floor's form, extension, cover type, color, and texture. The lower understory or shrub layer's height, density, plant type, color, and texture are also descriptive of the ground plane. The *trees* component is characterized by the size, density, species composition, color, and texture of trunks, and the pattern of branches. Finally, the *surrounding matrix* is composed of foliage (form distinction, density, color, and texture), sky (extension, location, color, and light saturation) and background (silhouette distinction, color, and texture).

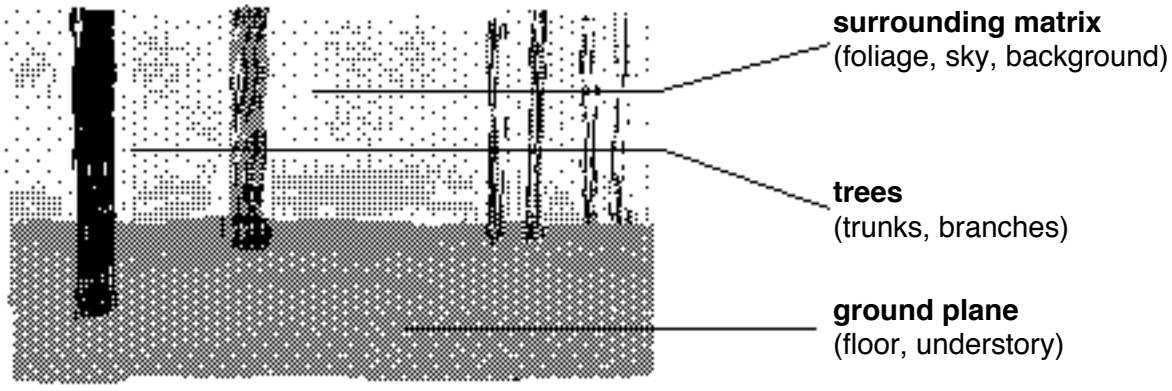

Figure 1. A schematic description of the visual structure in forest stands (Arisó-Campà & Palmer 1989).

The literature on forest scenic value is frequently vague about forest type, or uses scenes from several forest types without distinguishing them from each other during analysis. This situation, combined with the relatively small number of studies, led to the use of a simplified list of seven forest types in this review.

Northern hardwoods. This type of mixed hardwoods, includes maples, beach and birch, on the wetter and cooler sites that are found in the northeastern United States. Young stands are lushly vegetated and have a dense surrounding matrix that restricts visual penetration. Mature stands usually have ground cover and understory components. Seasonal changes provide significant scenic variation in form, color and texture. Occasional conifers provide a striking contrast to hardwood trees, particularly after leaves have fallen. The deciduous nature of these stands is highlighted by the winter snow cover.

Northern conifers. This type includes spruce–fir, hemlock and white pine stands. Large areas of relatively pure conifers occur at higher altitudes on cooler, more northern sites. Conifers have a coarser texture and are a darker green than northern hardwoods. It is common for northern conifers to be mixed with northern hardwoods.

Aspen or birch. This type includes stands dominated by either aspen or birch. These are short lived and early successional species. They are frequently found in relatively pure stands or clumps. Their lighter trunks and winnowy leaves provide a lighter more open appearance during the summer than do northern hardwoods.

Oak–hickory. This type includes mixed hardwoods, such as oaks, hickory, cherry, and maple, that occur on dryer and warmer sites. Young stands may have a very dense surrounding matrix, much like northern hardwoods. However, mature stands tend to have less ground plane vegetation and an appearance that is generally less lush.

Southern conifers. This type includes loblolly, slash, shortleaf and other southern pines. They are closely associated with the well drained sandy Coastal Plans found primarily outside the northeastern region. Some dry-site hardwoods, usually oaks, may be found in these stands.

Western conifers (dry). This type includes ponderosa and lodgepole pine. The sites are arid and support little ground vegetation. While young stands may have a very high stem count, the surrounding matrix is usually not lush. Mature stands may be relatively open and have very large trees with little understory or ground vegetation.

Western conifers (wet). This type includes douglas fir and redwood stands. The region's rainfall is plentiful, therefore young stands can have a dense surrounding matrix at eye-level. Mature stands may have very large trees standing in a green carpet of ground cover vegetation.

FOREST MEASUREMENTS

There are eight forest measurements listed in table 1 that can frequently be found in the literature as relating to scenic value: species composition, slash or downed wood, herbaceous cover, smaller trees and understory, bigger trees, basal area or other measures of total tree density, crown closure, and times since harvest. The following review summarizes the findings of these studies and divides them into those from the northeast and those from outside the northeast.

Species Composition

After a careful review, Ribe (1989) concluded that species preference appear to be partly influenced by cultural, regional, contextual, and subjective expectations. A review of those studies examining the role of species composition in scenic beauty evaluations shows that stands composed of a mix of species are preferred, as they provide visual diversity. Future research should look at common species mixes, how species might be distributed throughout a stand, and what concentrations of species are necessary to have a positive impact on scenic beauty.

Forests in the northeast. Ribe (1990) looked at the impact on scenic beauty estimations of what he refers to as contrasting tree types commonly found in northern hardwood forests. These include both birch (Betula alleghaniensis or B. papyifera) and evergreens. When residual scenic beauty estimations (SBE's) were plotted against the square feet of basal area per acre, results indicate that for each increase of 20 square feet of basal area per acre in birch trees scenic beauty estimates increase by about 10 percent of the possible range of positive scenic beauty. The impact of the evergreen component on scenic beauty estimations were not as apparent. Ribe suggests that this may be due in part to the hardwood forests sampled having little or no evergreens, and the samples were taken during the summer when evergreen trees are less noticeable. While Ribe admits that further study would be more conclusive, a least squares analysis does suggest that each increase of 10 square feet of basal area in evergreen trees may contribute to an increase of scenic beauty estimates by about 2 percent of its possible positive range.

Forests outside the northeast. Kellomäki (1975) examined the concept of species composition in three ways -- the scenic beauty of a species in pure stands, the scenic beauty of a species occurring in mixed stands, and the scenic beauty of mixed coniferous or deciduous stands versus pure coniferous or deciduous stands. The three species the study looked at were birch, Scots pine, and Norway spruce. When pure stands were ranked in order of scenic beauty, the results show that birch and Scots pine were favored over Norway spruce. When asked to rank stands composed of Scots pine-Norway spruce, Norway spruce-birch, and Scots pine-birch into order of preferred scenic beauty, the combination of Scots pine-birch was ranked highest, confirming the notion that Scots pine and birch were preferred over Norway spruce. As a third measure of scenic beauty, participants were asked to rank stands composed of one tree species (pure stands), two tree species, and three or more tree species. The results confirmed that there is a positive correlation between a mixture of tree species composing a stand and scenic beauty.

In another study, Savolainen and Kellomäki (1981, 1984) looked at the scenic beauty of individual tree species and the effect of species mix. These results indicated that birch had the highest scenic beauty and the scenic beauty of Norway spruce and Scots pine were almost the same. They also found that a mixed stand structure with a variegated appearance had the greatest effect on variances in scenic beauty evaluations.

Brown and Daniel (1984) evaluated pre- and post-treatment sites of ponderosa pine stands which also included some Gambel oak. For pre-treatment sites basal area averaged 125 and 19 square feet per acre in ponderosa pine and Gambel oak, respectively. They reported that on these sites, increases in scenic beauty were associated with increases in Gambel oak basal area. On the post-treatment sites, Gambel oak basal area was positively associated with scenic beauty. Schroeder and Daniel (1981) reported similar results for the presence of Aspen, Fir, Juniper, and Gambel oak in these ponderosa pine stands.

Buhyoff and his colleagues' (1986) study of southern pine also found that the basal area of the hardwood component contributed positively to scenic beauty. While both Vodak et al.'s (1985) study of oaks and Rudis et al.'s (1988) study of pines gathered separate data on hardwoods and softwoods, they do not attribute any importance to the minor species in their results.

In contrast to the studies reviewed above, Klukas and Duncan (1967) found that among Minnesota residents visiting Itasca Park, mature red pine trees were preferred to white pine trees, both of which were preferred to paper birch trees.

Slash or Downed Wood

Of the eight forest attributes reviewed for their influence on scenic beauty, only slash is consistently associated with negative ratings. The impact of slash varies depending upon its amount, how it is treated, the length of time since treatment occurred, and differences between man-made slash and wood downed by natural causes. Independent of its treatment, slash is least acceptable immediately after logging operations are completed. However, evaluations done on stands two or more years after treatment show that the negative impact of slash was greatly reduced with the passage of time since treatment. This is due primarily to growth of vegetation to hide slash and decomposition of the slash giving it a more natural "downed wood" look.

Forests in the northeast. Nyland et al. (1976) reported on the application of special practices to reduce the impacts of logging operations on residual trees, regeneration, soil, and post-logging appearances. The effects of commercial logging operations in northern hardwood stands at three locations in Central New York were assessed. At each of these locations treatments included individual tree selection, strip clearcutting, and patch clearcutting. In viewers' rating of ten different post-treatment stand attributes, high (>3') and low (<3') slash received strong negative

response in a majority of the stands and among many viewers. Lopping of the slash elicited mixed viewer ratings. However, most viewers seemed willing to spend some money for top lopping to reduce the negative visual impact of slash.

Palmer and Sena (1993) refer to slash as downed wood and only considered downed wood visible above the litter layer, whether it was from natural causes or man-made. Their study focused on forest scenic value as a function of forest structure and seasonal variations. The results for three seasons suggest a negative, though non-significant relationship. However, the winter scenes garnered a significant positive linear relationship, which was unexpected. The authors postulate that this may be because slash produces wonderful sculptural forms and shadows patterns under snow cover.

Ribe (1990) found the negative scenic effect of down wood (from natural or man-made causes) to be the most powerful single predictor of variance in a general regression model of scenic beauty. This study had 139 participants rate 93 slides -- 3 slides from each of 31 predominantly hardwood stands -- for scenic beauty on a scale from -5 to +5. In measuring the negative impact of all down wood in cubic feet per acre greater than 1 inch in diameter, the model suggests that for each increase of 1,000 cubic feet per acre of down wood the perceived scenic beauty is reduced by about 10 percent.

Schroeder and his colleague's (1993) study assessed and compared public preferences for human-made forest openings in central Michigan conifer forests that differed with respect to the size of the opening, the presence or absence of slash, and the length of time since treatment. Ten small clearcuts were made in predominantly red pine stands; two cuts were made at each of five sizes: 1, 4, 7, 10 and 15 acres. Slash was completely removed from one clearing of each size; slash was lopped to 12 to 24 inches and left on the ground in each of the remaining openings. Ninety visitors (recreationists) completed scenic beauty estimates for each of the 10 openings. They were instructed that the openings occurred as the result of "timber treatment", however the word "clearcut" did not appear in the instructions. A second set of ratings was completed for the same ten sites two years later. Slash consistently had a negative effect on scenic quality with some variation depending on the size of the plots and the time since treatment. Slash had less effect on the 10 acre plot than on the other plots. This was especially true 2 years after treatment, when the 10 acre plots with and without slash were rated essentially equal. This may be due to vegetation that had grown up over the two years and obscured the view of the slash.

Vodak et al. (1985) studied perceptions of the scenic beauty of hardwood stands on national forest lands in Virginia under varying management regimes. They found that two variables -- dead and down wood between 18 and 36 inches in height and dead and down wood greater than 36 inches in height -- were common to the four predictive models developed. They reported that as might be expected intuitively, both of these variables adversely affected scenic beauty and as the amount of dead and down material 18 inches in height and above increased, scenic preference decreased.

Hamilton et al. (1973) solicited responses from 84 randomly selected suburban forest owners located within Chemung County, New York. In their slide evaluations of aesthetic quality in recently cut hardwood stands, 75 percent of the participants rated slash as being unpleasant, 7 percent rated it as pleasant and, 18 percent recorded a neutral response. Further, unsanitary logging that left trees hanging and excessive slash that had not been neatly piled produced "unpleasant" responses. The orderly piling of cordwood as well as logs and slash gave an impression of neatness and industrious endeavor despite the intensive logging that was being done at the time.

In Langenau et al.'s (1977) study of attitudes toward clearcutting among landowners in Roscommon County in the Northern Lower Peninsula of Michigan, they found mostly negative reactions to logging slash in clearcut stands of white and red pine. Their results came from questionnaires mailed to people living in close proximity to clearcut areas. A total of 352 questionnaires, 66 percent of those delivered, were returned from property owners sampled in 1974. In 1976, property owners returned 378 questionnaires or 64 percent of those delivered. When given the statement, "Slash in these clearings limits recreational use", 45 percent of the respondents from 1974 agreed, while 40 percent agreed in 1976. Other statements included on the questionnaire that approximately 40 percent of the respondents agreed with included: "Slash in these clearings is a fire hazard", "There is no cover for deer in these clearings" and, "Slash in these clearings will take too long to rot".

Rader and Hamilton (n.d.) had forest landowners give their visual impression of photographs depicting eastern hardwood forests to determine both the pleasant and unpleasant features associated with certain kinds of forest practices. Seventy-five percent of the respondents rated slash as unpleasant. However, piled slash was rated as pleasant, and inconspicuous or less prominent slash was given neutral ratings.

Forests outside the northeast. Anderson et al. (1982) conducted a study of the effects on scenic beauty of prescribed burning to remove logging slash. Respondents completed scenic beauty evaluations for two selectively logged Ponderosa pine stands - a control plot which received no treatment of slash after the overstory treatment and a plot where a prescribed burn reduced slash less than 3-inch in diameter by 65%. Evaluations for both plots were done from slides representing the condition of the plots over a five year period. Results from the first year's slides showed that both stands received low scenic evaluations shortly after the treatment, with the burned plot receiving a slightly lower rating than the control plot. Evaluations for the subsequent years indicated that the scenic beauty of the burned plot was higher than the control plot for the second and third years following treatment. However, the evaluations for the last two years showed very small differences between the ratings of the two plots, indicating nearly equal scenic beauty.

Arthur (1977) found slash to be a negative variable in the development of three different scenic beauty estimation models, one each based on physical features, design scales, and timber cruise data. She found that ratings of slash was the first variable to enter all of the equations. These had R-values ranging from -.36 to -.72, indicating that larger piles of slash are associated with lower scenic beauty estimations. In the development of the physical features

regression equation, both the distribution of the slash and the volume of the slash were factors suggesting that piling of slash has negative effects independent of those associated with the amount of slash.

The findings of a study done by Benson and Ullrich (1981) again confirm the negative impact of slash on visual quality. Four methods of treatment to slash are examined to determine what, if any, positive impact they may have on improving visual quality. Their studies used color slides of the study sites over a five-year period and had participants rate the scenes with the Scenic Beauty Estimation method (Daniel and Boster, 1976).

In the first part of the study they report on one Lodgepole pine stand in the Teton National Forest that was clearcut and received four different treatments to slash. These treatments included: near-complete removal of slash, chipping of slash and spreading it back over the site, tractor piling the slash into windrows and burning it, and broadcast burning of the slash. Scenic beauty ratings were completed from slides taken over a five-year period. The results suggested only small differences among treatments, with near-complete removal of slash receiving higher ratings. This suggests that slash is a factor in detracting from a site's visual quality.

In the second part of the study the authors reported similar results in an old growth Douglas-fir forest in Montana where near-complete removal of slash, broadcast burning, and protection of an advanced understory treatments were used on clearcut and shelterwood sites. They found that a mature uncut stand was preferred over the treated sites, particularly in the first years after treatment; removal of the slash, which included removal of the understory, was rated about the same as protected understories (no slash removed); and, ratings increased in the years after treatment for all treatments, although in some cases the year-to-year changes were not significantly different.

Data collected in Hull and Buhyoff's (1986) study of loblolly pine stands suggested a moderate negative relationship between scenic beauty and downed wood. The data also supported the hypothesis that the impact of slash from thinning operations was expected to decrease with time as the downed wood became less visible.

Rudis et al. reported in their study of pine and oak-pine forest types in east Texas that limited amounts of downed wood was positively associated with scenic beauty. Realizing that their findings contrasted other studies they hypothesized two possible reasons for this positive relationship. The different character of the downed wood - most downed wood on the east Texas plots was not "visually predominant" as reported by Vodak et al. (1985); and, lower volume of downed wood - their study plots averaged less than one-tenth of the volume reported by Brown and Daniel (1984).

Savolainen and Kellomäki's (1981, 1984) study of forested areas near Helsinki, Finland found that one of the most important factors influencing scenic beauty was what they referred to as harvesting residues. They reported a linear decrease in scenic value with an increase in the amount of harvesting residues. In an earlier study Kellomäki (9175) found harvesting residues to be negatively correlated with perceived naturalness.

In Brown and Daniel's (1984) study of ponderosa pine in Arizona's Coconino National Forest, several models were developed to predict scenic beauty before and after treatment. For modeling the impacts of downed wood, (this included downed wood on the pre-treatment sites and slash from the recent treatment and downed wood on the post-treatment sites), they had participants rate 130 slides from 23 sites in pre-and post-treatment conditions. Site inventories revealed that the total downed wood for both pre- and post-treatment sites averaged about 1,200 cubic feet per acre. Ratings indicate that downed wood volumes were negatively correlated with scenic beauty for both pre- and post-treatment sites. Percentages of the small downed wood, less than 1/4-inch diameter, was also negatively correlated with scenic beauty, especially for the post-treatment sites. A measure of the distribution of downed wood was not significantly correlated to scenic beauty; but, number of brush piles were clearly negatively correlated with scenic beauty.

Slash was found to have a negative effect on scenic beauty estimates in the development of a model for application to predominantly ponderosa pine forests by Schroeder and Daniel (1981). They found that the character of the downed wood (natural or man-made) entered the model more strongly than the volume of downed wood suggesting that there are negative aesthetic effects of man-caused slash which are relatively independent of the volume of material. Their model, which accounts for 60 percent of the variation in scenic beauty estimates, indicates that the predicted scenic beauty estimates will decrease by 0.768 units with a 10 percent increase in cubic feet per acre of downed wood.

Schweitzer et al. (1976) report results similar to Benson and Ullrich (1981) in examining the impact of various treatments on slash in aesthetic evaluations. A total of 6 stands -- 2 old-growth Lodgepole pine stands and 4 clearcut stands which each had received different treatments to slash were evaluated. Two of the 4 clearcut units had saw logs to a 6 inch top removed; the remaining slash was burned. The other 2 clearcut units had "near-complete" removal of the slash; any remaining slash was yarded and chipped to be spread back over these clearcut units. In their evaluation of a series of slides of the 6 stands, participants most preferred the scenes of the old-growth stands and least preferred scenes of a recent clearcut where logging slash had been piled and burned. This study reports that in the clearcut units where new vegetation had started to mask the burned area (5 years after the clearcutting and burning had been done), or where the slash had been chipped and spread over the clearcut unit, received intermediate aesthetic ratings.

Herbaceous Ground Cover

Forests in the northeast. Hamilton et al. (1973) solicited responses from 84 randomly selected suburban forest owners located within Chemung County, New York. In their slide evaluations of aesthetic quality in recently cut hardwood stands, 70 percent of the participants rated green ground cover as being pleasant, 12 percent rated it as unpleasant and, 18 percent recorded a neutral response.

In Palmer and Sena's (1992) study of forest structure in six northern hardwood sites they found no statistically significant results in the impact of ground cover in predicting scenic beauty. They concluded that ground cover appears to be randomly associated with scenic beauty.

Rader and Hamilton (n.d.) had forest landowners give their visual impression of photographs depicting eastern hardwood forests to determine both the pleasant and unpleasant features associated with certain kinds of forest practices. The term "green ground cover" was used to describe an assortment of relatively low plants on the forest floor including tree seedlings, annual weeds, and other low herbaceous cover. Ground cover received an overall pleasant rating with responses ranging from 61 percent to 74 percent. They concluded that the differences appear to be correlated with density - the more dense, the lower the number of pleasant responses.

Ribe (1990) study of 31 predominantly hardwood stands found that ground cover, measured in percent of cover, had a positive influence on scenic beauty. According to Ribe, this forest attribute was the fifth, out of seven, most important variable in the prediction of scenic beauty.

Forests outside the northeast. In Arthur's (1977) development of three different scenic beauty estimation models for predominantly ponderosa pine stands, one each based on physical features, design scales, and timber cruise data, she found that ground cover only entered the physical feature model. This regression model had ground cover identified as a positive variable suggesting that the presence of ground cover is associated with positive scenic beauty.

In Brown and Daniel's (1984) study of ponderosa pine in Arizona's Coconino National Forest, several models were developed to predict scenic beauty before and after treatment. For modeling the impacts of ground cover, they had participants rate 130 slides from 23 sites in pre-and post-treatment conditions. Site inventories revealed that the average total weight and height of grasses, forbs, and shrubs in the pre-treatment condition was 87 pounds per acre and 10 inches, respectively. In the post-treatment condition herbage quantities averaged slightly higher than on the pre-treatment sites. All measures of grasses, forbs, and shrubs were strongly, positively correlated with scenic beauty for both conditions, with the exception of low positive correlations between scenic beauty and forb weight and height for the post-treatment sites.

Ground covers in the form of grasses and forbs were found to have a positive effect on scenic beauty estimates in the development of models for application to predominantly ponderosa pine forests by Schroeder and Daniel (1981) and Brown (1987).

While Patey and Evans (1979) inventoried and provide data describing herbaceous cover, they failed to report any relationship to scenic value.

Smaller Trees and Understory

The condition of the understory vegetation is also considered a forest attribute which influences scenic beauty evaluations. However there is scant empirical data which describes this attribute. As with big trees, there is little written as to the specifics of understory vegetation -- what distinguishes it from saplings?, what are it's physical dimensions?, how do different densities effect scenic beauty? Finally, a standard measure of understory vegetation must be established.

Forests in the northeast. In looking at forest scenic value as a function of understory vegetation in northern hardwood stands, Palmer and Sena (1992) report that it decreases as the understory becomes established, moderately dense vegetation has a small negative effect, and at higher densities understory vegetation rapidly decreases scenic value. Their measure of understory vegetation is a count of all stems with less than 4 inch dbh and less than 1 meter high; it only extends out 10 meters from the viewpoint.

Brush (1979) found that of the 20 sites rated in a study by Massachusetts landowners three of the four lowest ranked sites were all characterized by close spacing of many small stems, limited visual penetration, and a closed rather than open quality.

Patey and Evans (1979) examined the effect of understory vegetation in both mixed hardwoods and coniferous stands in eastern Tennessee. To determine differences in scenic beauty ratings between stands receiving treatment (understory vegetation manipulation by burning, grazing, and mechanical means) and those that did not receive treatment. In 12 of the 13 pairs of stands (manipulated versus non-manipulated) they found scenic beauty ratings to be higher in the manipulated stands, independent of which treatment the stand had received. They also found that a decrease in the understory vegetation cover in the manipulated stands increased the amount of herbaceous cover. A composite of landscape preference ratings and landscape site data indicated that on the basis of scenic beauty, respondents preferred landscapes with less dense woody shrub cover and a higher percent of herbaceous ground cover.

Ribe (1990) describes understory vegetation density as the number of trees per acre at least 5 feet tall and less than 5 inches dbh. In his study of 31 predominantly hardwood stands, he found that up to 4,000 trees per acre of understory vegetation have a negligible marginal impact upon scenic beauty values. As numbers of trees in the understory increases, their negative impact upon scenic beauty becomes increasingly pronounced.

Forests outside the northeast. In their study of pine and oak-pine forest types in east Texas, Rudis et al. (1988) found that the least preferred scenes were those with a large amount of foliage and trees less than 5 inches dbh. They suggest that this is due to the low levels of visual penetration in these scenes.

In Brown and Daniel's (1984, 1986) studies of the influence of stand variables on scenic beauty in ponderosa pine stands they found that increasing numbers of saplings detract from scenic beauty.

Several studies have found that the relation of the density of saplings has an inverted-U shaped relationship to scenic value. In their study of southern pines, Buyhoff et al. (1986) place the optimal stocking at 1,100 to 1,200 1-5 inch stems per acre. Savolainen and Kellomäki (1984) found this optimal effect to be between 1,000 and 1,500 understory stems per hectare (2,470 to 3,705 stems per acre) in their study of primarily pine and spruce stands. Ribe's (1990, 1992) study of primarily hardwoods placed the asymptote at 4,000 .5 to 5 inch stems per acre.

Buhyoff et al. (1986) developed two models to predict scenic beauty in southern pine stands between 10 and 72 years old located in the Piedmont of North Carolina. These models indicate that the number of stems per acre 1 to 5 inches dbh is related to scenic beauty in a negative quadratic fashion - scenic beauty will increase until the number of stems per acre 1 to 5 inches dbh reaches 1,100 to 1,200. While higher numbers of stems per acre will decrease visual quality, a greater number of 1 to 5 inches dbh stems can be visually absorbed if the average stand age and stand diameter increase. The authors suggest that people may be willing to "visually tolerate" a greater density of small trees in a stand if they are interspersed with larger trees. The same is true if stands include a higher basal area per acre of hardwoods which provide visual variety and contrast.

Hull and Buhyoff's (1986) study of southern pine focused on the temporal distribution of scenic beauty. In general, natural and less productive stands were preferred because they had fewer saplings per acre. While heavy thinning produced slash which significantly reduces scenic value, over time the reduced density leads to higher scenic value than if the stands had been only lightly thinned or not thinned at all.

Bigger Trees

Numerous studies have suggested that big trees have a positive influence on the predicted scenic beauty of forest stands. These studies also agree that a more specific definition is needed for this particular forest attribute. The definition should include measurements of big trees or threshold parameter(s) that make them big. These parameters need to be defined on three different levels: (1) individual tree measurements, most likely expressed in dbh, height, standing volume, age or a combination of all of these; (2) how do these parameters, and their influence on scenic beauty evaluations, vary from species to species; and, (3) the minimum number of big trees per acre necessary to have a cumulative positive effect on scenic ratings. A rule describing the effect of the number of big trees per acre on scenic beauty should parallel Buhyoff et al. (1986) quantification of the negative effect of saplings, 1-5 inches dbh, on scenic beauty ratings as their number increased beyond 1,200 per acre.

Forests in the northeast. As reported by Ribe (1989), the presence or dominance of large trees is positively related to aesthetic preference. The presence of large trees is thought to be even more influential in stands with fewer trees

per acre. Ribe also notes that reported findings on the aesthetic impacts of large trees show that the preference for them may be due in part to other associated forest attributes, such as lower tree densities and understory vegetation. By plotting basal area per acre in trees greater than 15 inches dbh against scenic beauty, Ribe (1990) found that the percent of the total basal area per acre in big trees is more strongly related to forests' scenic beauty than the actual number of big trees per acre. He concluded that with each increase of basal area per acre by 15 square feet in trees exceeding 15 inches dbh, all other factors being equal, there is a significant increase in scenic beauty.

Of the 20 sites rated in a study by Massachusetts forest landowners (Brush, 1979), those stands with large trees tended to be rated as more attractive. Except for a recently harvested shelterwood site, all 5 of the stands with trees 11 inches dbh or greater were ranked among the 10 more attractive sites.

In their analysis of scenic beauty in northern hardwood stands, Palmer and Sena (1992) found no significant relationship between the number of trees 18-24 inches dbh and the predictability of scenic beauty. They state that this may be due to the fact that the trees on the sites evaluated were too small and among too many other small trees to create the necessary scenic effect.

Forests outside the northeast. Brown and Daniel (1984) evaluated pre- and post-treatment sites of ponderosa pine stands which also included some Gambel oak. They found that increased numbers of oak and large pine trees were associated with increased scenic beauty. In a subsequent study, Brown (1987), again found that large, mature ponderosa pine had a positive influence on scenic beauty.

Schroeder and Daniel (1981) found that ponderosa pine trees, greater than 16 inches dbh, accompanied by ground cover (grasses and forbs) have a positive effect on scenic beauty.

Arthur (1977) found that in predominantly ponderosa pine stands, trees greater than 20 inches dbh were associated with high scenic beauty ratings. This finding was further supported by positive correlation's of board feet per acre and large trees with scenic beauty estimation scores.

The results of two studies done in forested areas near Helsinki, Finland --Kellomaki (1975) and Savolainen and Kellomaki (1984) --found that , in general, independent of the main tree species, those stands with relatively large and abundant standing trees had the greatest scenic value. These studies also reported that the scenic value of the tree stands seems to increase further when the succession of the tree stand progresses.

Rudis et al. (1988) reported on their development of models explaining scenic beauty preferences in east Texas pine and oak-pine forest types. They found that scenes with a relatively large number of saw log trees (greater than 21 inches dbh) were most preferred. They suggest that this is strongly related to the high level of visual penetration in these stands.

Basal Area or Total Density

Forests in the northeast. The results of Brush's (1979) study of scenic preferences of Massachusetts forest landowners found no correlation between basal area measurements and scenic beauty ratings. However, of the 20 sites rated those stands characterized by large, enclosed spaces and spaces created by thinning well-stocked stands were more attractive than unbounded openings and dense, overstocked stands.

Vodak et al. (1985) found a significant positive relationship between basal area and scenic value. In verifying the work of Hull and Buhyoff (1986) and Vodak et al. (1985) using his data from Wisconsin, Ribe (1990) also found a positive relationship between basal area and scenic value. However, in developing an optimal model from his data, Ribe (1990 & 1992) represented density with total stems per acre rather than basal area, so the results are more influenced by smaller stems.

Nyland et al. (1976), Kellomäki (1975) and Patey and Evans (1979) all indicated that they measured total basal area, but fail to report any relationship to scenic value.

Forests outside the northeast. Arthur's (1977) found that the variable describing the number of trees per acre only entered the physical feature model in her development of three different models to estimate scenic beauty in predominantly ponderosa pine stands. This variable - density of trees ranging from very sparse to very dense - had a positive value suggesting that higher densities in ponderosa pine stands has a positive influence on scenic beauty.

In Brown (1987) three models were developed to predict scenic beauty in predominantly ponderosa pine stands. Two of the models were for pre-treatment sites; one model was for post-treatment sites. All three models showed a negative correlation between the number of saplings per acre and the amount of ground cover, suggesting that the positive contribution of ground cover to scenic beauty is reduced with an increase in the number of saplings per acre.

Hull and Buhyoff (1986) developed the concept of a scenic beauty temporal distribution (SBTD) using evaluations of existing loblolly pines stands under different thinning regimes. Their results indicated that the heavily thinned stands produced larger SBTD than the lightly thinned stands. They reported that this was expected since the heavier thinnings decreased stand density more than light thinnings, providing the preferred sense of openness. They added that the higher levels of scenic beauty could be expected in the heavily thinned stands once the negative scenic impacts from slash had decreased due to decay.

Rudis et al. (1988) study of pine stands in east Texas reports a positive correlation ($r = .33$) between basal area and scenic value, but fail to include it in any of their regression models.

Crown Closure

Crown closure may be a forest attribute that has little or no significant impact on scenic beauty when isolated from other forest attributes. The percent of closure has a direct influence on other stand attributes that influence scenic beauty such as, understory vegetation, ground cover, survival of shade-intolerant plant species, size and quality of the overstory trees.

Forests in the northeast. Brush's (1979) findings on the scenic preferences of Massachusetts forest landowners, reveals no correlation between percent crown closure and scenic beauty ratings. The authors of this report suggest that this may be due to the fact that respondents evaluated 20 sites with very diverse characteristics. For example, they evaluated an open hayfield, a white pine stand after the first cut of a shelterwood treatment, and an oak stand.

When looking at forest scenic beauty as a function of crown closure over the four seasons, Palmer and Sena (1992) found only the values for the fall were significant. During the fall season, a 10 percent increase in crown closure was associated with a .3 increase in scenic beauty ratings. This accounted for 34 percent of the variation in scenic beauty.

Forests outside the northeast. Crown closure was one of the inventoried variables in Brown and Daniel's (1984) study of Ponderosa pine stands. However, of the seven studies using these data, none repost significant results associated with crown closure (Brown, 1987; Brown & Daniel, 1984 & 1986; Daniel, et al., 1989; Daniel & Schroeder, 1979; Schroeder & Brown, 1983; and Schroeder & Daniel, 1981).

Time Since Harvest

The literature mostly contains reports of the short-term scenic impacts of management activities. However, the forests are constantly growing and changing, so that what appears to be devastation at the time of harvesting, looks simply disturbed a year latter, may become quite acceptable in three years, and over a complete rotation may have a greater net scenic value than if no harvest had occurred.

Forests in the northeast. Rutherford and Shafer (1969) found that stands managed with the selection system were preferred to unmanaged softwood stands, and were judged equally as attractive in hardwood stands. It is important to note that these judgments were made 10 years after the most recent logging activity, which had removed 80 percent of the board feet volume and 35 percent of the basal area. Palmer (1990) found selectively cut northern hardwoods had an initially low scenic value that improved in a year as the ground "greened-up", and then decreased again as saplings obstructed visual penetration, but appeared to completely recover their scenic value after 12 to 15 years.

In their study of loblolly pines Hull and Buhyoff (1986) developed the concept of a scenic beauty temporal distribution (SBTD). They used evaluations of existing stands to create models of SBTD for a variety of situations. They arrived at several useful conclusions: plantations can achieve total scenic values through longer rotations, and the initial negative impacts of heavy thinning due to slash can be offset by later positive effects of lower stand density.

Palmer's (1990) study of northern hardwoods found a distinctive non-linear relationship between time since harvest and scenic value. He found scenic value immediately after treatment to be low, rises as residuals degrade and vegetation develops, then dropping off as regeneration obscures the view. As the stand matures and the visual penetration increases, scenic value also increases.

Forests outside the northeast.

Benson and Ullrich's (1981) studies of Douglas-fir with larch, and Lodgepole pine sites harvested by clearcutting and slash burning identified several stages of recovery with increasing scenic value.

> Both the Douglas-fir and larch (DF/L) and the Lodgepole pine (LPP) harvest areas were rated low initially. About 10 years after harvest the DF/L had reached a point on the 'like' portion of the scale, probably because these stands are on moist sites that "green up" quickly (undergrowth is lush) and trees begin to grow rapidly. LPP took longer to reach this point reflecting the generally sparser vegetation and slower tree growth. When stands had reached heights of about 25 to 75 feet and crowns were green and vigorous, ratings were the highest.
>
> In mature stands aged 150 years or more, ratings were lower. We can speculate that this is due to more dead material and debris, and also that the mature stands with a high dense canopy are darker and more enclosed than in younger stands. (Benson & Ullrich 1981: 10)

In their study of southern pine stands, Buhyoff et al. (1986) model the interaction of stand age and other factors with scenic beauty. Their results indicate a non-linear positive increase in scenic beauty with increasing age. A similar result is graphed by Savolainen and Kellamäki (1984) where spruce stands have a decreasing scenic value until they are about 25 years old, they scenic value begins to rise.

SILVICULTURAL SYSTEMS

The literature relating silvicultural systems to scenic beauty has focused on even-age systems and is strikingly sparse in the area of uneven-aged or non-traditional systems, especially empirical studies. The forest management systems included among the core studies listed in table 1 showed that nine had clearcut sites, and four had sites under the shelterwood system. However, only three studies indicated the inclusion of selection system sites, while only two

indicated sites were under a patch cutting regime. This emphasis on traditional even-aged management systems may become a concern if the ascendancy of "New Forestry" leads to practices and impacts that have not been previously investigated. At this time, we can confidently say that cutting activity evokes emotional responses from the public that is related to scenic as well as other perceived values. The overall conclusion from most of the studies indicates that people prefer the least amount of visible disturbance possible to what they consider a "natural'" forest environment.

One factor that seems consistent throughout the literature is that the background of the viewer seems to effect the way they view timber harvesting. Clearcutting is particularly viewed in a negative light by non-foresters. Willhite and Sise (1974) found that foresters and non-foresters have opposing views on issues associated with harvesting practices. They concluded that non-foresters have an emotional bias when rating the scenic quality of an area which has been harvested. Forester's technical knowledge and professional values tend to influence their evaluations of scenes. Nyland et al. (1976) also found this to be true; group bias and interest strongly influences viewer reactions. There seems to be two general reasons behind this reaction: a negative reaction to what is perceived as "violent" practices that "disturb" the forest, and a general preference for "orderliness" and "neatness" (Benson & Ullrich, 1981; Echelberger, 1979; Langenau, et al., 1977; Nyland et al.; 1976;). Successful new strategies to manage the visual qualities associated with silvicultural practices will seek ways to appear more "gentle" and less "chaotic."

Comparing managed to unmanaged stands. While people seem to prefer natural to disturbed areas, the question remains whether stands can be managed to appear more scenic--even natural--than unmanaged stands. Rutherford and Shafer (1969) examined preferences for uncut and selection cut hardwood and softwood stands in the Adirondacks. The cut stands were preferred to the uncut in the softwoods, and both were found to be equally attractive in the hardwoods. This lead Rutherford and Shafer to the conclusion to favor selection management over an undisturbed forest policy for enhancing esthetic values in both types of timber. However, it is important to note that cut stands had 10 years to recover from the effects of logging.

Clearcutting. Clearcutting is definitely the most controversial of harvesting systems. It seems to generally evoke a negative emotional response from viewers (Langenau et al., 1977). Vodak et al. (1985) found that both clearcutting and heavily thinned hardwood stands received very low scenic evaluations by landowners compared to lightly thinned or natural stands. Schweitzer et al. (1976) had people rate both near and distant views with visible harvesting. People preferred scenes of unharvested areas and least preferred scenes of recent clearcuts. Frequent reference was made to the piles of residue which may have also been burned.

Schroeder, Gobster & Frid (1993) investigated the visual impacts of clearcuts in predominately red pine stands from 2 to 15 acres in size. All were immediately visible from a road and were evaluated both in the field and using photographs. They found that while the smaller sizes were slightly more preferred, differences in this size range were relatively unimportant compared to the amount and treatment of slash. There is some evidence to suggest that recreationists do not even recognize the small clearcuts commonly used now as 'clearcuts.' For instance, Becker

(1982) interviewed state park visitors who had passed through 4 to 6 acre areas that were four to five years old irregularly shaped clearcuts in Maryland's central broadleaf forest. Den trees had been left at the time of harvest, and slash was somewhat broken down. Just under half of the visitors recognized the areas as clearcuts.

Various strategies and approaches have been proposed to mitigate the unsightly aspect of large clearcut areas. Boster and Daniel (1972) found that both clearcut and heavy thinning (i.e. 75 percent) were negatively perceived, and that the results from strip cutting or conventional logging that retained a healthy understory resulted in visually more attractive sites. Benson and Ullrich (1981) found that retaining the understory had as positive a visual effect as removing all slash residues. Both of these studies are in western forests where trees 10 and 12 inches dbh could be left in the understory. Nyland et al. (1976) evaluated whether top-lopping improved scenic value, and found it to be relatively expensive for its limited positive effect.

Comparing clearcutting and shelterwood. Ribe (1992) compared recent shelterwood cuts to recent clearcuts. Both receive negative ratio-SBE ratings, where a value of zero is scenically neutral. While a recent shelterwood cut in a maple/oak forest type received a score of -72 which is an indicator of ugliness, a recent clearcut received a score of -112. A study that looked at different residue treatments on Douglas-fir with larch, and Lodgepole pine sites harvested using clearcut, shelterwood, and selection systems (Benson and Ullrich ,1981; Schweitzer et al., 1976). Shelterwood cuts were usually preferred over the other two systems, regardless of residue treatment. The ratings increase in the years after harvest, as the trees mature, especially in shelterwood areas where the residue had been removed. They concluded that people like natural versus disturbed areas. Arthur (1977) also found that shelterwood regeneration which converts to an even-age stand which favors healthy trees is highly rated.

Comparing even-aged to uneven-aged systems. Echelburger (1979) found that viewers preferred selection cutting to clearcutting, and patch cutting to strip clearcutting in the Adirondacks. The only other comparison of the visual effects of even-aged to uneven-aged management is by Brunson and Shelby's (1991) who were looking at Douglas-fir stands. They found that year old half-acre patch cuts removing one-third of a stand's volume were judged significantly more scenic than a two year old 45-acre clear cut, or a year old "two-story stand" that left 8 to 10 trees per acre. It seems to be generally expected by policy makers and the public that uneven-aged systems will provide a more scenic alternative to even-aged management. This judgment seems to be based on the general finding that the less cutting activity the higher the scenic value. However, a comprehensive evaluation has yet to be done and must consider the flow of scenic value over time, not just the impacts at the time of harvesting.

BIBLIOGRAPHY

Anderson, L. M. 1981. Land use designations affect perception of scenic beauty in forest landscapes. **Forest Science**, 27(2): 392-400.

Anderson, L. M., D. J. Levi, T. C. Daniel, and J. H. Dietrich. 1982. **The esthetic effects of prescribed burning : A case study.** Research Note RM-413. Fort Collins, CO: U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experiment Station.

Arisó-Campà, A. and J. F. Palmer. 1989. Perceptual description of forest scenes. Syracuse, NY: SUNY College of Environmental Science and forestry. 6 p.

Arthur, L. M. 1977. Predicting scenic beauty of forest environments: Some empirical tests. **Forest Science**, 23(2): 151-159.

Arthur, L. M., and R. S. Boster. 1976. **Measuring scenic beauty: A selected annotated bibliography.** General Technical Report RM-26. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experiment Station.

Arthur, L. M., T. C. Daniel, and R. S. Boster. 1977. Scenic assessment: An overview. **Landscape Planning**, 4(2): 109-129.

Ashcroft, B. C. 1982. **Public attitudes to the exotic pine reforestation program in south east Queensland.** Tech. Paper. Queensland Department of Forestry.

Axelsson-Lindgren, C., and G. Sorte. 1987. Public response to differences between visually distinguishable forest stands in a recreation area. **Landscape and Urban Planning**, 14: 211-217.

Becker, R. H. 1983. Opinions about clear-cutting and recognition of clear-cuts by recreation visitors. **Journal of Environmental Management**, 17: 171-177.

Benson, R. E. 1974. **Lodgepole pine logging residues: Management alternatives.** Research Paper INT-160. Ogden, UT: U.S.D.A Forest Service, Intermountain Forest and Range Experiment Station.

Benson, R. E., S. F. McCool, and J. A. Schlieter. 1985. **Attaining visual quality objectives in timber harvest areas - Landscape Architects' evaluation.** Research Paper INT-348. Ogden, UT: U.S.D.A Forest Service, Intermountain Forest and Range Experiment Station. 7 p.

Benson, R. E., and J. R. Ullrich. 1981. **Visual impacts of forest management activities: Findings on public preferences.** Research Paper INT-262. Ogden, UT: U.S.D.A Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

Boster, R. S., and T. C. Daniel. 1972. Measuring public responses to vegetation management. *In* **16th Annual Arizona Watershed Symposium Proceedings**, [September 20, 1972, Phoenix, AZ] Report Number 2. Phoenix, Arizona: Arizona Water Commission. pp. 38-43.

Brown, T. C. 1987. Production and cost of scenic beauty: Examples for a ponderosa pine forest. **Forest Science**, 33(2): 394-410.

Brown, T. C., and T. C. Daniel 1984. **Modeling forest scenic beauty: Concepts and application to ponderosa pine.** Research Paper RM-256. Fort Collins, CO: U.S.D.A Forest Service, Rocky Mountain Forest and Range Experiment Station. 35 p.

Brown, T. C., and T. C. Daniel. 1986. Predicting scenic beauty of timber stands. **Forest Science**, 32(2): 471-487.

Brunson, M., and B. Shelby 1991. Effects of alternative silvicultural methods on scenic and recreational quality. *In* G. A. Vander Stoep (Ed.), **Proceedings of the 1991 Northeastern Recreation Research Symposium**, [April 7-9, 1991, Saratoga Springs, NY] General Technical Report NE-160. Radnor, PA: U.S.D.A Forest Service, Northeastern Forest Experimental Station. pp. 169-172.

Brush, R. O. 1979. The attractiveness of woodlands: Perceptions of forest landowners in Massachusetts. **Forest Science**, 25(3): 495-506.

Brush, R. O. 1980. Forests can be managed for esthetics: A study of forest-land owners in Massachusetts. *In* G. Hopkins (Ed.), **Proceedings of the National Urban Forestry Conference**, [November 13-16, 1978, Washington, DC]. Syracuse, NY: SUNY College of Environmental Science and Forestry. pp. 349-360.

Buhyoff, G. J., L. K. Arndt, and D. B. Propst. 1981. Interval scaling of landscape preference by direct and indirect-measurement methods. **Landscape Planning**, 8: 257-267.

Buhyoff, G. J., R. B. Hull IV, J. N. Lien, and H. K. Cordell. 1986. Prediction of scenic quality for southern pine stands. **Forest Science**, 32(3): 769-778.

Buhyoff, G. J., and W. A. Leuschner. 1978. Estimating psychological disutility from damaged forest stands. **Forest Science**, 24(3): 424-432.

Buhyoff, G. J., and M. F. Reisenman. 1979. Experimental manipulation of dimensionality in landscape preference judgments: A quantitative validation. **Leisure Sciences**, 2(3/4): 221-238.

Buhyoff, G. J., and J. D. Wellman. 1980. The specification of a non-linear psychophysical function for visual landscape dimensions. **Journal of Leisure Research**, 12(3): 257-272.

Cats-Baril, W. L., and L. Gibson. 1986. Evaluating aesthetics: The major issues and a bibliography. **Landscape Journal**, 5(2).

Cook, W. L., Jr. 1972. An evaluation of the aesthetic quality of forest trees. **Journal of Leisure Research**, 4(4): 293-302.

Daniel, T. C., L. M. Anderson, H. W. Schroeder, and L. Wheeler III. 1977. Mapping the scenic beauty of forest landscapes. **Leisure Sciences**, 1(1): 35-52.

Daniel, T. C., and R. S. Boster. 1976. **Measuring landscape aesthetics: The Scenic Beauty Estimation Method.** Research Paper RM-167. Fort Collins, CO: U.S.D.A Forest Service, Rocky Mountain Forest and Range Experiment Station.

Daniel, T. C., T. C. Brown, D. A. King, M. T. Richards, and W. P. Stewart. 1989. Perceived scenic beauty and contingent valuation of forest campgrounds. **Forest Science**, 35(1): 76-90.

Daniel, T. C., and H. W. Schroeder. 1979. Scenic beauty estimation model: Predicting perceived beauty of forest landscapes. *In* G. H. Elsner and R. C. Smardon (Ed.), **Proceedings of Our National Landscape**, [April 23-25, 1979, Incline Village, NV] General Technical Report PSW-35. Berkeley, CA: U.S.D.A Forest Service, Pacific Southwest Forest and Range Experiment Station. pp. 514-523.

Duffield, J. W. 1970. Silviculture need not be ugly. **Journal of Forestry**, 68: 464-467.

Echelberger, H. E. 1976. **The visual impact of timber harvests on forest aesthetics**. (Doctoral dissertation) Syracuse, NY: SUNY College of Environmental Science and Forestry.

Echelberger, H. E. 1979. The semantic differential in landscape research. *In* G. H. Elsner and R. C. Smardon (Ed.), **Proceedings of Our National Landscape**, [April 23-25, 1979, Incline Village, NV] General Technical Report PSW-35. Berkeley, CA: U.S.D.A Forest Service, Pacific Southwest Forest and Range Experiment Station. pp. 524-531.

Gobster, P. 1990. **Landscape perception and preference research: A resource guide for the management of forest aesthetics.** Unpublished working paper. Chicago IL: U.S.D.A Forest Service, North Central Forest Experiment Station.

Hamilton, J. W., G. J. Buhyoff, and J. D. Wellman. 1979. The derivation of scenic utility functions and surfaces and their role in landscape management. *In* G. H. Elsner and R. C. Smardon (Ed.), **Proceedings of Our National Landscape**, [April 23-25, 1979, Incline Village, Nevada] General Technical Report PSW-35. Berkeley, CA: U.S.D.A Forest Service, Pacific Southwest Forest and Range Experiment Station. pp. 271-278.

Hamilton, L., T. Rader, and D. Smith. 1973. Aesthetics and owner attitudes toward suburban forest practices. **The Northern Logger and Timber Processor**, 22(3): 18-39.

Hodgson, R. W., and R. L. Thayer Jr. 1980. Implied human influence reduces landscape beauty. **Landscape Planning**, 7: 171-179.

Hull, R. B., IV. 1986. Sensitivity of scenic beauty assessments. **Landscape and Urban Planning**, 13: 319-321.

Hull, R. B., IV 1989. Forest visual quality management and research. *In* A. E. Watson (Ed.), **Outdoor recreation benchmark 1988: Proceedings of the national outdoor recreation forum**, [Tampa, FL] General Technical Report SE-52. Asheville, NC: U.S.D.A Forest Service, Southeastern Forest Experiment Station. pp. 498.

Hull, R. B., IV, and G. J. Buhyoff. 1986. The scenic beauty temporal distribution method: An attempt to make scenic beauty assessments compatible with forest planning efforts. **Forest Science**, 32(2): 271-286.

Hull, R. B., IV, G. J. Buhyoff, and T. C. Daniel. 1984. Measurement of scenic beauty temporal distribution method: The law of comparative judgment and scenic beauty estimation procedures. **Forest Science**, 30(4): 1084-1096.

Jacob, H. 1973. The emotional recreation potential of different forest types. **Natur und Landschaft**, 47: 161-163.

Karhu, I., and S. Kellomäki. 1980. Effects of silvicultural practices on amenity of the forest landscape: A study on attitudes among inhabitants of Puolanka, NE Finland. **Silva Fennica**, 14(4): 409-428.

Kellomäki, S. 1975. Forest stand preferences of recreationists. **Acta Forestalia Fennica**, 146: 1-36.

Kellomäki, S., and T. Pukkala. 1989. Forest landscape: A method of amenity evaluation based on computer simulation. **Landscape and Urban Planning**, 18: 117-125.

Kenner, B., and S. F. McCool. 1985. **Thinning and scenic attractiveness in second growth forests: A preliminary assessment.** Research Note 22. Missoula MT: Montana Forest and Conservation Experiment Station, University of Montana.

Klukas, R. W., and D. P. Duncan. 1967. Vegetation preferences among Itasca Park visitors. **Journal of Forestry**, 65(1): 18-24.

Langenau, E. E., Jr., G. C. Jamsen, and R. L. Levine. 1977. The stability of attitudes toward clearcutting among landowners in Roscommon County, Michigan. **Forest Science**, 23(4): 437-444.

Langenau, E. E., Jr., K. O'Quin, and J. P. Duvendeck. 1980. The response of forest recreationists to clearcutting in northern lower Michigan: A preliminary report. **Forest Science**, 26(1): 81-91.

Levine, R. L., and E. E. Langenau Jr. 1979. Attitudes towards clearcutting and their relationships to the patterning and diversity of forest recreation activities. **Forest Science**, 25(2): 317-327.

Madill, R. J. 1973. **The impact of clearcutting on the perception of forest aesthetics**. (Master's thesis) Toronto, Ontario: University of Toronto.

McCool, S. F., R. E. Benson, and J. L. Ashor. 1986. How the public perceives the visual effects of timber harvesting: An evaluation of interest group preferences. **Environmental Management**, 10(3): 385-391.

Methven, I. R. 1974. **Development of a numerical index to quantify the aesthetic impact of forest management practices.** Information Report PS-X-51. Chalk River, Ontario: Petwawa Forest Experiment Station.

Nyland, R. D., P. J. Craul, D. F. Behrend, H. E. Echelberger, W. J. Gabriel, R. L. Nissen Jr., R. Uebler, and J. Zaenetske. 1976. **Logging and its effects in the northern hardwoods.** Applied Forestry Research Institute Research Report 31. Syracuse, NY: SUNY College of Environmental Science and Forestry. 134 p.

Oka, K., and Y. Ueno. 1982. Landscape management and selective cutting system in the Imasu District, Japan. **Forest Recreation Research**, 6: 1-14.

Palmer, J. F. 1990. Aesthetics of the northeastern forest: The influence of season and time since harvest. *In* T. A. More, M. P. Donnelly, A. R. Graefe, and J. J. Vaske (Ed.), **Proceedings of the 1990 Northeastern Recreation Research Symposium**, [February 25-27, 1990, Saratoga Springs, NY] General Technical Report NE-145. Radnor, PA: U.S.D.A Forest Service, Northeastern Forest Experiment Station. pp. 185-190.

Palmer, J. F., and K. D. Sena. 1993. Seasonal scenic value and forest structure in Northeastern hardwood stands. *In* G. A. Vander Stoep (Ed.), **Proceedings of the 1992 Northeastern Recreation Research Symposium**, [April 5-7,1992, Saratoga Springs, NY] Gen. Tech. Rep. NE-176. Radnor, PA: U.S.D.A Forest Service, Northeastern Forest Experiment Station. pp. 115-121.

Patey, R. C., and R. M. Evans. 1979. Identification of scenically preferred forest landscapes. *In* G. H. Elsner and R. C. Smardon (Ed.), **Proceedings of Our National Landscape**, [April 23-25, 1979, Incline Village, NV] General Technical Report PSW-35. Berkeley, CA: U.S.D.A Forest Service, Pacific Southwest Forest and Range Experiment Station. pp. 532-538.

Rader, T. D., and L. S. Hamilton. n.d. **Aesthetics Related to Selected Forest Practices.** Special Circular 183. University Park, PA: The Pennsylvania State University.

Ribe, R. G. 1989. The aesthetics of forestry: What has empirical preference research taught us? **Environmental Management**, 13(1): 55-74.

Ribe, R. G. 1990. A general model for understanding the perception of scenic beauty in northern hardwood forests. **Landscape Journal**, 9(2): 86-101.

Ribe, R. G. 1992. The scenic impact of key forest attributes and long-term management alternatives for hardwood forests. *In* L. H. McCormick and K. W. Gottsschalk (Ed.), **8th Central Hardwood Forest Conference**, [The Pennsylvania State University, University Park, PA] General Technical Report NE-148. Radnor PA: U.S.D.A Forest Service, Northeastern Forest Experiment Station. pp. 34-54.

Rozsnyay, Z. 1979. Thoughts on forest beautification and forest aesthetics. **Forstarchiv**, 50(4): 72-74.

Ruddell, E. J., J. H. Gramann, V. A. Rudis, and J. M. Westphal. 1989. The psychological utility of visual penetration in near-view forest scenic beauty models. **Environment and Behavior**, 21(4): 393-412.

Rudis, V. A. 1985. Screenometer: A device for sampling vegetative screening in forested areas. **Canadian Journal of Forest Research**, 15: 996-999.

Rudis, V. A., J. H. Gramnn, E. J. Ruddell, and J. M. Westphal. 1988. Forest inventory and management-based visual preference models of southern pine stands. **Forest Science**, 34(4): 846-863.

Rutherford, W., Jr., and E. L. Shafer Jr. 1969. Selection cuts increased natural beauty in two Adirondack forest stands. **Journal of Forestry**, 67(6): 415-419.

Savolainen, R., and S. Kellomäki. 1981. Scenic value of forest landscape. **Acta Forestalia Fennica**, 170: 1-80.

Savolainen, R., and S. Kellomäki. 1984. The scenic value of the forest landscape as assessed in the field and the laboratory. **Landscape Planning**, 11: 97-107.

Schroeder, H. W. 1982. Managing the aesthetics of outdoor recreation sites: Some analogies with problems in retailing. **Journal of Retailing**, 58(1): 22-33.

Schroeder, H. W., and T. C. Brown. 1983. Alternative functional forms for an inventory based landscape perception model. **Journal of Leisure Research**, 15(2): 156-163.

Schroeder, H. W., and T. C. Daniel. 1981. Progress in predicting the perceived scenic beauty of forest landscapes. **Forest Science**, 27(1): 71-80.

Schroeder, H. W., P. H. Gobster, and R. Frid. 1993. **Visual quality of human-made clearings in central Michigan conifers.** Research Paper NC-313. St. Paul, MN: U.S.D.A Forest Service, North Central Forest Experiment Station. 9 p.

Schweitzer, D. L., J. R. Ullrich, and R. E. Benson. 1976. **Aesthetic evaluation of timber harvesting in the northern Rockies: A progress report.** Research Note INT-203. Ogden, UT: U.S.D.A Forest Service, Intermountain Forest and Range Experiment Station.

Shafer, E. L., Jr., J. F. Hamilton, and E. A. Schmidt. 1969. Natural landscape preferences: A predictive model. **Journal of Leisure Research**, 1(1): 1-19.

Sorg, C. F., and J. B. Loomis. 1984. **Empirical estimates of amenity forest values: A comparative review.** General Technical Report RM-107. Fort Collins, CO: U.S.D.A Forest Service, Rocky Mountain Forest and Range Experiment Station.

Staffelbach, E. 1984. A new foundation for forest aesthetics. **Allgemeine Forstzeitschrift**, 39: 1179-1181.

United States Department of Agriculture, Forest Service. 1973. National Forest Landscape Management. Volume 1. U.S. Department of Agriculture Handbook 434. Washington, DC: U.S. Government Printing Office. 77 p.

United States Department of Agriculture, Forest Service. 1980. National Forest Landscape Management. Volume 2, Chapter 5 (Timber). U.S. Department of Agriculture Handbook 559. Washington, DC: U.S. Government Printing Office. 223 p.

Vodak, M. C., P. L. Roberts, J. D. Wellman, and G. J. Buhyoff. 1985. Scenic impacts of eastern hardwood management. **Forest Science**, 31(2): 289-301.

Wagar, J. A. 1974. Recreational and esthetic considerations. *In* O. P. Cramer (Ed.), **Environmental Effects of Forest Residues Management in the Pacific Northwest: A State-of-Knowledge Compendium**, General Technical Report PNW-24. Portland, OR: U.S.D.A Forest Service, Pacific Northwest Forest and Range Experiment Station. pp. H1-H15.

Willhite, R. G., and W. R. Sise. 1974. Measurement of reaction to forest practices. **Journal of Forestry**, 72(9): 567-571.

Williamson, D. N. 1977. **The Visual Screening Effects of Forest Vegetation: A Pilot Study for the Development of a Visual Absorption Capability Assessment Procedure for Massachusetts**. (Master thesis) University of Massachusetts.

Williamson, D. N., and J. A. Chalmers. 1982. **Perceptions of forest scenic quality in northeast Victoria: A technical report of research.** Melbourne, Australia: Forests Commission Victoria.

Yarrow, C. 1966. A preliminary survey of the public's concepts of amenity in British Forestry. **Forestry**, 39: 59-67.

Yeiser, J. L., and C. L. Shilling. 1978. Student responses to selected terms and scenes in natural resource management. **Journal of Forestry**, 76(8): 497-498.

Zube, E. H., J. L. Sell, and J. G. Taylor. 1982. Landscape perception: Research, application and theory. **Landscape Planning**, 9(1): 1-33.

APPENDIX A

Review Format

A. Citation
[Authors. date. title. city: publisher.]

B. Hypotheses / Purpose

C. Forest type / Location
1. spruce-fir
2. mixed wood (spruce-fir/northern hardwoods)
3. northern hardwoods (beech-birch-maple)
4. hemlock/hardwoods (hemlock and northern hardwood mix)
5. Allegheny hardwoods (cherry-maple)
6. cove hardwoods (mixture dominated by yellow-popular in the Appalachians)
7. oak-northern hardwoods (beech-birch-maple and oak-hickory mix)
8. oak-hickory
9. oak-southern pine (oak-hickory and southern pine mix)
10. pine-hardwood (white pine and northern hardwood mix)
11. white pine
12. aspen-birch

D. Media [describe sample, # of sites, #/site, total #]
1. on-site visit [where: over look, bus on road, in stand?[
2. color or black-and-white
3. slides
4. photographs [size: 5"x7", and mounting: boards, book[
5. video

E. Observers [group and # in group, total #, averaged together?]

F. Dependent variable(s):

G. Independent variables
1. Stand inventory
   a. **Species Composition:** (1) % conifer, (2) % or presence of specific species (e.g. paper and yellow birch, beach, flowering understory plants -- laurel, dogwood), (3) Fall color index -- to be developed.

b. **Downed Wood:** (1) height: breaks at 18", 3' and 5 or 6' seemed suitable, (2) Volume or % coverage in a 6' circular plot, (3) presence of dead logs on the ground. Possibly noting solid vs. rotting, or new vs. old logs.

c. **Understory:** (1) need to develop a visual penetration index that is a function of the # of stems in height classes, (2) visually most sensitive range is 3' to 6'.

d. **Ground Cover:** (1) % cover by green ground cover of a 6' plot, in 10% or 25% increments, (2) separation of ground cover less than 1' high and between 1' and 3' high, (3) consider species flowering time and relate to potential periods of recreation use.

e. **Big Tree Look:** (1) maximum dbh, (2) # of stems in a class, (3) mean dbh for stems over a certain size, (4) species may be important

f. **Crown Closure:** (1) there is a break between open and closed at 50% canopy closure. [There was a discussion of the effectiveness of deferred cuts and 2-aged systems to maintain canopy closure. They may work for distant views outside the stand but not for views within the stand.]

g. **Distinct Features:** (1) note presence and consider protecting: rock outcrops, cultural artifacts/ruins, special species, wetlands, creeks, open water, ledges, cliffs, etc.

h. **Discordant Features:** (1) note presence and consider screening: active roads, harvest activity or yarding areas, 'dumps,' etc.

i. **Topography/Slope:** [It was not clear how topography and slope would affect aesthetic quality, but it was expected that it would be important.]

2. Photo measurement
3. Rater judgments
4. Forest treatment / harvest method
   a. no cutting
   b. single tree selection
   c. group and single tree selection
   d. patch cutting
   e. two-age management
   f. crop tree management
   g. even age; no clearcuts
   h. even age management

I. Abstract of findings / results

J. Models [specific equations / graphs] : These materials may need to be in a clip file rather than the bibliography.