Appropriate Combinations of Technology for Solving Landscape Management Problems—
Session J: Timber Management

Scenic Beauty Estimation Model: Predicting Perceived Beauty of Forest Landscapes[1]

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Abstract: An important activity in any land-use planning process is prediction of the consequences of alternative management approaches. Alternative plans must be compared in terms of their respective costs (economic and environmental) and benefits (in market and non-market values) if rational choice among them is to be made. The purpose of this paper is to describe a model for quantitatively predicting the effects of alternative vegetation management programs on landscape scenic beauty. Scenic beauty is assessed in terms of quantitative indices based upon public aesthetic judgments. Predictor variables are forest characteristics normally inventoried in the process of land use planning or timber sale administration. The primary goal of the Scenic Beauty Estimation Model is to provide quantitative predictions to facilitate the evaluation of tradeoffs between scenic beauty and other objectives of forest management.

INTRODUCTION

An essential element in any land-use planning process is the simulation (prediction) of the consequences of alternative management approaches. Alternative plans must be compared in terms of their respective costs (economic and environmental) and benefits (in market and non-market values). A rational decision can then be made as to which alternative should be pursued. In this context quantitative simulation models are being developed to improve managers' ability to determine the effects of contemplated actions. For example, the effects of implementing different harvest methods may be simulated to predict subsequent water production and quality, erosion, future tree growth and other factors.

The purpose of this paper is to describe the development and testing of a model for predicting the effects of alternative vegetation management programs on landscape scenic beauty. Scenic beauty is assessed in terms of quantitative indices based upon public aesthetic judgments. Independent (predictor) variables were selected from among a set of forest characteristics that are normally inventoried in the process of developing a land use plan or preparing a timber sale or other management action. These same variables frequently serve as predictor (input) and/or product (output) variables in other simulation models now being used or developed. The primary goal of the Scenic Beauty Estimation Model is to provide valid and useful predictions of the scenic consequences of alternative actions--quantitative predictions that will facilitate the evaluation of tradeoffs between scenic beauty and other objectives of forest management.

SBE METHOD

The prediction model presented in this paper has been developed in the context of a more general landscape assessment methodology. Development of the Scenic Beauty Estimation (SBE) Method has been ongoing since 1972. The SBE Method is a system for quantitatively indexing the aesthetic quality of landscapes.

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Interval scale measures of scenic beauty are derived from the aesthetic perceptions and judgments of selected human observer panels. Panels may represent the "general public," or they may be selected from specific populations such as landscape managers, special interest or user groups, or experts of various kinds. In any event, it is the human observers' perception and judgment of the aesthetic qualities of the landscape (or simulations thereof) that determine the index, the "Scenic Beauty Estimate (SBE)," assigned to that landscape.

Implementing the SBE Method

The most frequent applications of the SBE Method have involved the use of color-slide simulations of forested landscapes. Typically 15 to 30 color-slides are taken within each landscape area that is to be assessed. In order to reduce any bias that the photographer might introduce in the representation of the landscape, photos are taken according to a predetermined stratified random sampling procedure. Slides from a number of different areas are then presented to selected observer panels. Each observer independently judges the scenic beauty of the area represented by each color slide.

Judgments are usually reported (and recorded) in terms of a 10-point rating scale, where a 1 indicates a judgment of "very low scenic beauty" and a 10 "very high scenic beauty." The simple rating responses can be useful indicators of landscape scenic beauty in many situations. Frequently individual ratings (or mean ratings) can be used in statistical analyses (such as correlation/regression or various hypothesis-test statistics) aimed at determining similarities and differences among landscapes and/or observers. Because there is no assurance that different observers will use the rating scale in the same way--that one observer's "6" indicates the same perception of scenic beauty that another observer's "6" does--the ratings should not be treated as a direct or absolute indicator of scenic beauty. Ratings (and mean ratings) are influenced by idiosyncrasies of individual observer's use of the rating scale such as individual standards for assigning high, medium or low ratings. Also, a number of arbitrary procedural features, such as the number of points (categories) in the rating scale and the number and type of landscapes judged in a session, will affect the rating scores obtained for a given landscape and the magnitude of any difference in ratings for different landscapes.

In such situations it is common practice in psychological assessment (and other measurement methods) for the "raw responses" to be transformed according to some scaling model. The resulting standardized values (typically adjusted to have a common defined origin or zero point and a standard unit of measure) may be more directly compared across observers, rating scales and other procedural variations. Equally important, the scaling model makes the assumptions that are involved in the interpretation of the resulting indices more explicit.

The scaling model that underlies the SBE Method has been articulated in Daniel and Boster (1976). The model is a Thurstone (1927) type scaling model modified to reflect concepts from the Theory of Signal Detectability (Green and Swetts 1966, Swetts 1973), a more contemporary, but closely related perceptual judgment model. Similar scaling models have been applied in many contexts, ranging from the evaluation of food items and other consumer goods to measuring the quality of television pictures. The application of the SBE model to measure landscape scenic quality is a straightforward extension of well tried psychological assessment concepts. The resulting Scenic Beauty Estimates or "SBE's" are standardized relative indices of perceived scenic beauty that may be directly compared in spite of differences in observers and procedures. The "meaning" of the SBE index is explicitly determined by the features of the scaling model and the associated procedures specified for obtaining the index.

The SBE Method has primarily been developed and tested in the context of forest scenic beauty assessment. Procedures and computation models have primarily been articulated for cases in which independent observers assign ratings to landscapes or landscape simulations. A large number of variations in procedures and some modifications of scaling computations are, however, consistent with the basic model. Certainly many different types of simulation or landscape sampling methods may be (and have been) used, including sketches, photomontages, verbal descriptions and direct on-site observation. Landscape dimensions other than scenic beauty (e.g., recreation value, naturalness, or attractiveness as a summer home site) may be assessed with very minor changes in the method. Changes in the number of categories in the rating scale are readily accommodated. With some changes in the scaling model, forced-choice (e.g., paired-comparison as in Buhyoff et al.) or rank ordering procedures may be substituted for the rating scale. With appropriate models, assessments based on ratings, rankings, or choices may all produce the same scale value or index for a given landscape. The basic SBE procedures have proven very versatile and effective (e.g., Daniel et al. 1977, Schroeder & Daniel in press). Alternative procedures can be adopted, however, depending upon the requirements of particular landscape assessment problems.

Testing the SBE Method

Over the past seven years the SBE Method has been subjected to a number of tests and has undergone several modifications and extensions. Initial efforts were primarily directed at ascertaining the sensitivity and reliability of the method, as these are two properties that are fundamental to any measurement system (Daniel 1976). SBE values do distinguish between different landscapes; sites differing in vegetation and other characteristics consistently yield different SBE's. Further, measures of the same landscape on different occasions (with the same or a comparable panel of observers) will produce equivalent SBE indices (Daniel & Boster 1976). The method has, then, proven sensitive--landscapes differing in (presumably) relevant characteristics yield different SBE's --and reliable--the same landscape yields the same SBE on repeated applications of the measurement system.

Validity is another essential criterion for a measurement system. This property of a measurement method is not, for the most part, subject to direct empirical test. Tests have shown that SBE's based on random color-slide simulations are equivalent to indices obtained when observers' judgments are actually made onsite in the landscapes (Daniel et al. 1973, Daniel & Boster 1976). This confirms the validity of using color slides to represent the landscapes for which assessments were obtained, but it may be that neither slide-based nor onsite judgments reflect the "true" scenic beauty of the landscapes. Several tests have shown close correspondence between SBE's and ranking or paired-comparisons of the same landscapes, and SBE's have been found to correlate strongly with expert judgments of scenic quality (Shoemaker in press). All of these findings are positive indications of the validity of the SBE Method, but none is completely conclusive.

Determining in general whether a method "measures what it is supposed to measure" is largely a theoretical (or even philosophical problem, especially when the property being measured is as poorly understood as "beauty" or "aesthetic quality"). In many respects, the procedures (or operations) employed by a measurement system imply a definition of the property that is being measured.

The SBE Method clearly implies that scenic beauty is fundamentally subjective--beauty is not inherent in a landscape, but depends upon human perceptions and judgments of that landscape. This does not, however, imply that the physical properties of the landscape are unimportant, that beauty is entirely "in the eye of the beholder." Indications are that identifiable properties of the landscape produce consistent perceptions within and between observers and that different observers assign very similar aesthetic judgments based upon these perceptions (Daniel & Boster 1976, Shafer et al. 1969). In the SBE Method it is the perceptual judgments of people that establish the scenic beauty of a landscape. However, people's judgments have been found to be strongly and consistently affected by characteristics of the judged landscape. It is this relationship between perceptual judgments and landscape features that forms the basis of the Scenic Beauty Prediction Model.

SCENIC BEAUTY PREDICTION MODEL

Preliminary Efforts

An initial attempt to relate SBE's to the features of the landscape was reported in Daniel and Boster (1976). For this study large numbers of color slides of ponderosa pine forest scenes were inspected in an effort to determine those features that were associated with high or low scenic beauty indices. Intuitively features such as "openness," "visual depth," and "greenness" seemed likely candidates for scenically relevant characteristics. Features such as the size and density of trees, the amount and arrangement (piled or scattered) of downed wood and slash, and the covering (or lack thereof) of the forest floor also appeared to be important. These and a number of other factors such as clouds, stumps, rocks, and slope of the land were included in a systematic study to determine their relationship to scenic beauty judgments.

Measures of the selected landscape features were obtained for 30 scenes by having a panel of five judges rate each scene for each feature. All features were defined as dimensions and judgments for each dimension were recorded in terms of a 6-point scale. For example:

Openness: 1 (very closed in, can't see very far) to
6 (very open, almost unlimited views)

Average tree size: 1 (very small, a few inches in diameter) to
6 (very large, tall, mature trees of large diameter).

Ground cover: 1 (very sparse, mostly bare earth and rocks) to
6 (very lush, thick grass and other plants).

The judges had no formal training in forestry or landscape architecture (in fact the five judges were a psychologist, an economist, and three psychology graduate students). Nonetheless, after some initial practice and discussion, a high degree of consistency was achieved in the forest feature ratings that were assigned (independently) to the slides of forest scenes.

When the ratings for each feature-dimension were correlated with the SBE' for the assessed forest scenes, some very strong relationships were found. The amount of downed-wood, for example, showed a very strong negative association with scenic beauty; the more downed wood, the lower the scenic beauty. Other features, such as openness and tree size had strong positive relationships with perceived scenic beauty. Many interrelationships were observed among the landscape features as well. Scenes with larger trees tended to be more open, for example (Daniel & Boster 1976).

In spite of its many shortcomings, this preliminary study offered substantial encouragement for further efforts to determine the effects of landscape features on perceived scenic beauty. Inspection of the interrelationships among the various features studied suggested that the number of forest characteristics could be reduced with little or no loss in the relationship to the SBE's. Further, it seemed possible to delete many feature-dimensions that had only indirect implications for forest management, such as "openness," in favor of more directly <u>manageable</u> landscape features, such as average tree size. Subsequent work then focused upon determining a predictive relationship between manageable landscape features and public perceptions of scenic beauty.

A Slide-Based Model

A concerted effort to develop a predictive model relating manageable forest features to perceptions of scenic beauty was undertaken by Louise Arthur in her doctoral dissertation. The central aspects of this work were reported in Arthur (1977). As with the preliminary study described above, measures of landscape features (in the principal study) were based on inspection of color-slide representations. In Arthur's study, however, two experienced foresters independently inspected each scene and estimated values for a number of typical forest inventory factors, such as trees per acre in various size classes, volumes of downed wood, and grass and herbage volumes. These and several similar variables were combined into a linear regression equation that successfully predicted (over 80% of variance accounted for) the perceived scenic beauty (SBE's) of the scenes for general public panels.

The model was very effective in predicting the scenic beauty judgments of public observer panels. However, the landscape features were gauged by inspection of photographs, the same photographs that observers judged. Such a procedure is not very representative of how such a model would actually be used to predict the effects of contemplated forest management actions. Landscape characteristics would generally be assessed directly in the field with less than perfect correspondence to scenes that might be observed by visitors. Thus, the next step in the development of a practical scenic beauty prediction model would require that landscape features be assessed by field inventory methods that are in use by forest managers.

Coconino National Forest Model

A recently completed study extended the previous efforts to develop a valid and useful model for predicting perceived scenic beauty of forest landscapes. In this study, forest features were assessed by direct in-the-field inventories of overstory, understory, ground cover and downed wood characteristics of forest sites. Color slides, coordinated with these inventories, were shown to panels of observers to obtain SBE values for each site. The relationship between the physical forest features and the SBE values was then determined and served as the basis for a Scenic Beauty Prediction model.

Photographic and physical data were collected on square plots approximately one acre in area (212 feet on a side). The locations of the plots were selected with the objective of representing a wide range of physical and aesthetic conditions occurring in the ponderosa pine zone of the Coconino National Forest, Arizona. Through discussions with Forest Service personnel familiar with the forest several forest types and geographic regions were delineated. These included some areas bordering on mixed conifer and pinyon-juniper forests, and some areas representing the extremes of aesthetic and physical conditions.

At each sample location, a center point was established and a random compass heading was used to determine the orientation of the diagonals of a square sample plot. Four photographs were taken from the center of the plot, each oriented along one of the plot diagonals. Four additional photographs were taken one from each of the plot corners oriented toward the center point.

After the photographs were taken, timber, downed wood and vegetative ground cover were inventoried at the site, with the assistance of forest technicians. Eight measurements of each physical variable were made on each plot, with each measurement corresponding to one of the eight photographs. The sampling scheme is graphically illustrated in Figure 1.

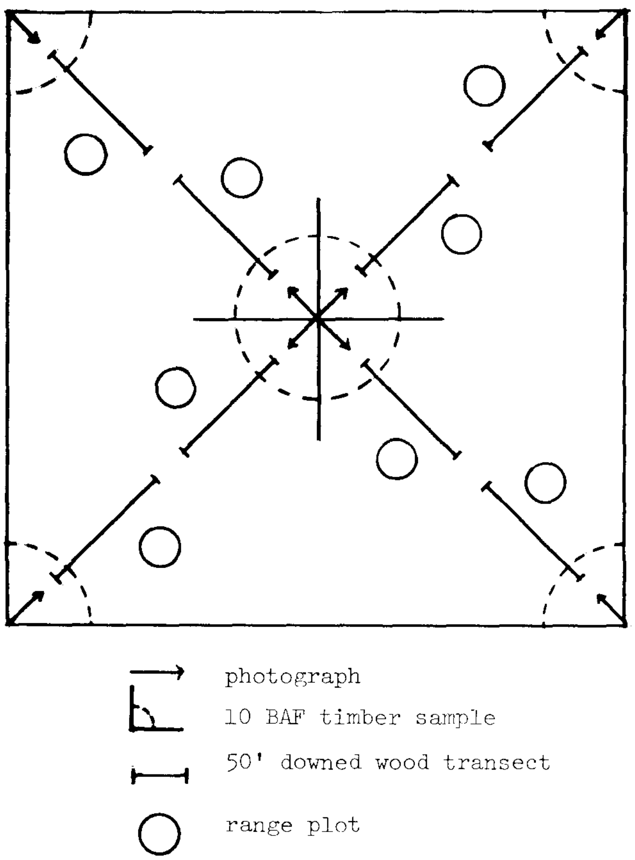

Figure 1 --Schematic of sampling procedure. Each plot was one acre in size, and plot orientation was randomly determined for each plot.

Forest Inventory.--Trees greater than five inches in diameter were inventoried (in 4-inch diameter classes) using a prism with a basal area factor of ten. A complete 360° sample was taken around the center point. This sample was subdivided into four 90° quadrants corresponding to the directions in which the photos were taken. At each corner point another sample was taken covering the 90° quadrant directed toward the interior of the plot. Seedlings and saplings were counted in 150-foot-long strips lying along the diagonals of the plot. The strips were five feet wide for seedlings, and ten feet wide for saplings.

Downed wood was inventoried using the method of Brown (1974). Two fifty-foot sample transects were placed on each line joining the center to a corner of the plot. The numbers of pieces of downed wood intersecting the line were tallied according to size. The species composition of the downed wood and a judgment about whether it was predominately natural or man-caused (slash) were also recorded. Vegetative ground cover was inventoried by placing two small circular plots (9.6 ft^2 area) adjacent to each diagonal of the sample plot. The dry weight in grams of each species occurring within the circular plot was estimated. From the eight ground cover plots one was randomly selected and all of the plants in that plot were clipped. These were later dried and weighed species by species. The actual weight thus obtained was used to correct for any constant bias in the field estimation.

Scenic Beauty Judgments.--Ninety plots were inventoried between June 7 and July 15, 1977. The eight color slides from each plot were shown to groups of observers, who rated scenic beauty on a 10-point scale. The ratings were analyzed to derive independent SBE`s for each scene.

Regression Models.--Two estimates of the physical and aesthetic characteristics of each of the 90 plots were made, one by averaging the four observations obtained at the center of the plot, and the other by averaging the observations obtained at the corners. Thus 180 cases were available for regression analysis. The 180 cases were classified according to the estimated percent of the trees on the plot which were ponderosa pine. Models were then developed for different types of forests, ranging from predominately ponderosa pine to more diverse mixtures of species.

Stepwise linear regression analyses were performed separately on cases with 90% or more ponderosa pine (64 cases), 50% of more ponderosa pine (87 cases), 30% or more ponderosa pine (113 cases), and finally on all 180 cases regardless of species composition. Scenic beauty was the dependent variable in all analyses. The multiple R's were all reasonably high accounting for from 65% to 73% of the variance in SBE's.

The best predictions resulted when the model was restricted to plots with 90% or more ponderosa pine. Overall, the best predictors seemed to be those relating to vegetative ground cover (grass and forbs) and the character of downed wood (natural or slash). The actual volume of downed wood appeared not to be a very powerful predictor, but in fact, areas in which slash predominated over natural downed wood also tended to have large total volumes of downed wood. The fact that the character of the downed wood entered the equation before the downed wood volume variables may indicate that there are negative aesthetic effects of man-caused slash which are relatively independent of the volume of material (for example piles or windrows, stumps and other visible evidence of cutting).

The initial models are very successful from a statistical point of view, but they present several problems for actual application. The large number of different predictors used, each requiring rather detailed data results in a complex and somewhat unwieldy model. Also, the individual predictors are correlated among themselves, which makes interpretation difficult. A predictor may appear to have a small effect on predicted SBE's either because it is unrelated to scenic beauty, or because it is highly correlated with another variable which is a good predictor (as with downed wood volume and the slash variable). In the latter case, although the variable makes a statistically nonsignificant contribution to the prediction equation, in reality it may be an important factor affecting scenic values.

To obtain models more suited for practical applications, two steps were taken. First, variables which did not appear to contribute to the prediction of scenic beauty, or which would not commonly be available in forest planning applications, were deleted from the model. Second, some of the variables were combined to form a less detailed but more concise set of predictors. For example, the number of seedlings per acre (trees less than 4.5 feet high) and the number of saplings per acre (trees taller than 4.5 feet and less than 5 inches in diameter) were combined to form a single variable (PP/acre < 5" DBE). In this way a more manageable model can be derived, and the complex pattern of intercorrelations can be simplified.

A model for application to predominately ponderosa pine forests was developed using stepwise regression with the predictors shown in Table 1.

Table 1: Limited SEE Model: More than 90% Ponderosa Pine

Variable*	Mean	S.D.	B	Beta	R	Sensitivity
lbs/acre Forbs	36.48	63.93	.2016	.4268	.542	.736
PP/acre, > 16" DBH	14.63	13.62	.6006	.2708	.622	.876
cu. ft./acre Slash	547.24	594.65	-.0141	-.2774	.675	-.774
lbs/acre Shrubs	4.77	21.13	.2620	.1833	.696	.125
lbs/acre Grass	80.06	155.55	.0359	.1849	.709	.288
PP/acre, < 5" DBH	1724.77	2074.30	-.0012	-.0800	.714	-.201
PP/acre, 5-16" DBH	103.01	137.89	-.0196	-.0895	.718	-.202
Constant			-3.871			
Scenic Beauty	4.66	30.20				

N = 64, $F(7, 56) = 8.49$, $p < .001$, $R = .718$, $S_e = 22.31$

* Variables are listed in the order in which they entered the regression equation.

The coefficients of the regression equation (B's) depend on the units of measurement of the predictors and therefore do not directly reflect the importance of individual predictors in the equation. The Beta coefficients (standardized regression coefficients, β) are based upon the standard deviation of the predictors' distributions, and therefore are a better measure of the importance of each variable for predicting scenic beauty. A high beta for a variable indicates that the prediction equation is relatively sensitive to changes in that variable. The table also presents an alternative measure of the sensitivity of the equation to changes in the predictors. The numbers in the column labeled "sensitivity" tell how much the predicted SBE will change as a result of a 10% increase in the predictor, evaluated at the mean value of the predictor.

When applied to plots with at least 90% ponderosa pine, the model shown accounted for more than 50% of the variance in SBEs. The coefficients of all predictors are in accord with reasonable intuitive expectations of the aesthetic effects of these variables and are consistent with previous studies (Arthur 1977, Daniel & Boster 1976). Ground cover and large trees are attractive,1slash has a powerful negative influence, and smaller trees appear to have a mild negative effect on scenic beauty. Although this model is statistically less powerful than the more complex models, it appears to be a more accurate representation of the causal factors underlying scenic judgments. It is certainly an easier model to apply to actual scenic beauty predictions.

When the same set of predictors which was used for the ponderosa pine model is applied to plots on which substantial numbers of other tree species occur, the predictive power of the resulting equation is considerably reduced. This is not at all surprising because the ponderosa pine model includes no variables to indicate the presence (or numbers) of other species of trees. The performance of the model on plots with a mixture of species can be improved by including variables to represent the different tree species. When the total numbers of trees other than ponderosa pine, classified by species, are entered into the regression analysis, the model once again accounts for more than 50% of the variance in SBE's. This "mixed species" model is presented in Table 2.

Table 2. Limited Mixed Species Model: All Cases

Variable	Mean	S.D.	B	Beta	R	Sensitivity
lbs/acre Forbs	91.78	164.15	.0671	.3043	.511	.616
other species/acre, < 5" DBH	1754.73	2229.19	.0054	.3295	.600	.939
PP/acre, > 16" DBH	13.01	14.62	.5696	.2301	.635	.741
other species/acre, > 16" DBH	3.14	7.07	1.1745	.2293	.674	.369
lbs/acre Grass	70.17	110.51	.0717	.2189	.706	.503
cu. ft./acre Slash	513.03	711.77	-.0102	-.2010	.732	-.525
PP/acre, 5-16" DBH	103.10	128.40	-.0341	-.1210	.741	-.352
lbs/acre Shrubs	38.31	117.65	-.0213	-.0691	.744	-.087
other species/acre, 5-16" DBH	22.36	46.02	-.0311	-.0395	.745	-.069
Scenic Beauty	22.04	36.20	Constant = .6264			

N = 180, $F(9, 1970) = 23.53$, <.001, $R = .745$, $S_e = 24.79$

In general, tree species other than ponderosa pine seem to make positive contributions to scenic beauty. When other kinds of trees occur along with ponderosa pine, predictions can be improved by including even limited information about the other species. A model designed specifically for forest types other than ponderosa pine (such as mixed conifer or pinyon-juniper) would include even more detailed information and would undoubtedly produce even better results than the simple mixed species model presented here.

Model Tests.--The predictive validity of the ponderosa pine and the mixed species models was tested by withholding a random selection of cases from the data set and deriving models from the remaining cases. These models were then used to predict scenic beauty values for the withheld cases. The correlation between predicted and actual SBEs is an index of the ability of the regression equation to predict scenic beauty. For the ponderosa pine model, 15 of the 64 cases with 90% or more ponderosa pine were withheld. The correlation between actual SBE's of these 15 cases and the SBEs predicted for them by the equation derived from the remaining cases was .71. The same procedure was followed for the mixed species model. A sample of 39 cases was withheld and an equation based on the remaining 141 cases was used to predict SBEs for those cases. The correlation of predicted to actual SBEs was .55. Both models therefore have the ability to predict the scenic beauty of the withheld cases, but the predictions are much better when the analysis is restricted to plots having 90% or more ponderosa pine.

Conclusions.--Application of the models presented in this report requires that some qualifications be met. First, the range of physical conditions within which valid predictions can be made is restricted. If a linear prediction equation, such as the ones described here, is applied to areas which are very different from the ones used to develop the model, inaccurate predictions may result. It should also be realized that the predictions arising from these equations are statistical estimates, and that deviations from predicted values are to be expected. A scenic beauty prediction should be interpreted as representing a range of likely outcomes, rather than as a single, precise prediction. The amount of uncertainty in scenic beauty predictions is indicated by the standard error of estimate (Se), presented in the tables with each model. The higher this standard error, the greater the degree of uncertainly in SBE’s predicted by the model.

Another limitation of the Coconino model, of course, is that it may not apply to forest areas having substantially different features. The areas sampled for the model's development were generally rather gentle in slope and topography, and had few prominent land features. In particular, no significant water features were present in any of the sample plots. Also, human artifacts, such as roads, fences, or cabins, were purposely excluded. Future efforts will be directed at testing the range of forest conditions to which the model may be applied, and at increasing the accuracy and robustness of the model.

Many tests and refinements will be necessary before the Coconino model can be extended into a reliable, valid and useful model for predicting mixed conifer forests. Some such efforts are described in the next section of this paper. In the meantime, the model is being used on an experimental basis in the Coconino National Forest. Predictions: have been made of post-treatment scenic beauty for a number of timber stands that will be subjected to harvest this summer and fall. Unfortunately, such a test of the predictive validity of the model in an operational setting requires considerable time. It will be a couple of years before the results of that test are available. Those tests which have been made do indicate (statistically) that the model can perform well in predicting scenic beauty values for landscapes similar to those used in the model's development.

FUTURE MODEL DEVELOPMENT

A study is in progress that will give some indication of the generality of the current version of the Scenic Beauty Prediction Model. About 40 sample sites in the Arapahoe/ Roosevelt National Forest, Colorado, have been selected, inventoried, and photographed using procedures similar to those used on the Coconino. SBE values have been obtained for these Front Range ponderosa pine sites.

Preliminary indications from the Colorado study have been very encouraging. When the Coconino model is applied without modification to predict the scenic beauty of the Colorado sites, only mediocre results are obtained. However, if the model is calibrated by simply adjusting the coefficients (weights) for the variables in the Coconino model, good results are obtained--over 50% of the variance in scenic beauty values can be accounted for. These results are rather impressive given that the Colorado sites were much steeper in topography and were quite different in timber and vegetation characteristics.

Predictions for the Colorado Front Range sites were improved even more when additional variables were added to the predictive model. All of these sites were in an area that has been greatly affected by an infestation of mountain pine beetle. In some stands sampled, all ponderosa pine trees over a few inches in diameter were dead. When the numbers of small, medium and large categories of dead ponderosa pine trees and the number of lodgepole pines (not found in the Arizona samples) were added to the Coconino model, over 65% of the variance in SBE was explained. The addition of these variables did affect the coefficients for the variables used in the original model, but the original variables still had essentially the same effect on scenic beauty. Large (live) ponderosa pines and lush ground covers produced positive effects on SBEs, and smaller (live) trees and larger volumes of slash produced negative effects on SBEs. Dead trees had negative effects on perceived scenic beauty.

Other studies are in progress that will help to determine the range of applicability of the Scenic Beauty Prediction Model. Additional sites in Arizona and Colorado have been, or soon will be sampled. In each case, a complete "multi-resource" physical inventory will be taken in conjunction with color-slides.

In addition to the tests of the predictive capabilities of the scenic beauty model, several studies of variations in inventory techniques will be undertaken. Downed wood and slash inventory procedures especially have been found to be time consuming and of relatively low reliability. Alternative procedures are being devised and will be tested. Good measures of downed wood and slash are important to the Scenic Beauty Prediction Model, so it is essential that reliable and efficient procedures be developed for obtaining information about this forest feature. Similar problems have been encountered with measures of vegetative ground cover, and alternative inventory methods are being explored with the assistance of forest scientists.

The model has (to date) been developed on the basis of rather intensive inventories and photo samples of small forest areas (approximately one acre). For practical applications, however, larger units and data based on less intensive samples will be typical. Therefore, efforts are being made to apply the model to operational scale areas (timber stands ranging from 10 to 150 acres) that are inventoried less intensively.

Efforts to develop further, refine, and test the Scenic Beauty Prediction Model will continue. The ultimate goal of this effort is to produce a useful tool for quantitatively predicting the perceived scenic consequences of alternative forest management actions. The focus of the model building effort, therefore, is upon manageable forest characteristics, especially vegetation characteristics that are typically considered and manipulated by forest managers. Whether this effort will finally succeed in producing a general prediction model (or family of models) that can accurately predict public perceptions of scenic beauty in many forest settings remains to be seen. Results from recent and ongoing research indicate substantial promise for the approach.

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