AN ANALYSIS OF ENVIRONMENTAL QUALITY RANKING SYSTEMS

by JULIUS GY. FABOS, *Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, Mass.*
This paper was prepared while the author served as National Science Faculty Fellow in the School of Natural Resources, University of Michigan, 1970-71. The author acknowledges the helpful advice and encouragement of Dr. Gunter Schramm.

ABSTRACT. A review and analysis of the quantitative ranking systems that have been developed during the past decade for measuring environmental quality.

DURING THE PAST decade many quantitative ranking systems have been developed for measuring environmental quality. This upsurge of quality quantification has paralleled the renewed interest in environmental quality. Most of the systems were designed to estimate the qualitative values of the natural or cultural landscapes.[1] Others were designed to test cultural preferences of people or their behavior in relation to complexity in the environment. Many disciplines have contributed to the development of the systems, ranging from landscape architects through geographers, psychologists, and economists to engineers. Some systems have been designed by interdisciplinary teams.

In this paper I aim to bring together information about the art of environmental quality-ranking systems; to analyze them against an appropriate set of criteria; and to identify areas where improvement and further research are needed.

Some personal biases and value judgments are inherent in such a study, and a completely objective evaluation would be impossible because the available literature on the systems is incomplete. I will not try to provide a detailed analysis of all systems reviewed, rather to provide only brief abstract interpretations of them.

This study focuses on the analysis of those ranking systems that deal with landscape qualities, but it does not exclude urban scapes such as residential neighborhoods. Analysis of this kind is not available at this time; however, the upsurge of the numerous systems warrants a continuing analysis and evaluation of them. Their values ought to be questioned, and the techniques must be improved, if we aim to estimate landscape qualities and predict changes resulting from the activities of men.

GENERAL BACKGROUND

The norms used in evaluating environmental qualities are believed to be influenced by two sets of factors: The first is cultural and has long historical roots. This can be analyzed with relative certainty. The second is psychological. For instance, human beings react to complex physical environments differently than to simple, monotone surroundings; and often there are large deviations between individuals.[2] Research on these factors is very limited at present.

Historical Factors

The 19th century concern for romantic landscape quality has had a major influence on present landscape values in the United States. Coming mainly from England, the interest in romantic landscape spread rapidly sometime after 1830. Tree-planting societies were beautifying and laying out village commons, cemeteries, and local academies in the picturesque romantic style.[3] Today the fenceless suburbias with winding roads and large setbacks provide the same parklike quality developed during the 19th century romantic-landscape movement.

Thoreau, Olmsted, and their contemporaries have greatly influenced our values towards nature. They preached the need for harmony between man and nature, and they later had great impact on the 19th century movement to protect the "monumental beauty" of the West.[4] Olmsted and others helped to bring about the preservation of some unique landscapes in several parts of the U. S., and their values have influenced the attitudes of the National Park Service.[5]

Charles Eliot articulated well the landscape values at the turn of the century. In his plan for the Boston metropolitan area, he proposed the protection of estuaries, spaces on the ocean front, island and bay areas, and wild forests on the outskirts. He proposed squares, playgrounds, and parks throughout the city.[6] The sum of these amenities meant environmental quality to him.

Conventional Non-quantitative Evaluation of Landscapes

In addition to natural and cultural factors, landscape architects and land planners traditionally have evaluated and mapped the visual qualities of landscapes and urban scapes. Through drawings and writing they have described the attributes of such variables as spatial enclosure, form, edge configurations (shoreline), dominant features, views, vistas, and contrast.

During the past two decades, descriptions of the sequential experiences have intensified.[7] In a recent study, Burton Litton[8] described in detail the visual variables generally accepted as norms by the design profession. According to Litton, the quality of the scenic resource depends on distance of view, the observer's position, form, spatial definition, light, and sequence. The landscape composition is based on the panoramic quality type and quality of features in the landscape, enclosure on the side and or by canopy. In addition, he described the detail and ephemeral components of the landscape.

The variables used in conventional landscape evaluations are the basis for most of the qualitative ranking systems. The major difference between conventional evaluation and ranking systems seems to be that the latter quantify areas with various characteristics and often place number values on the variables.

Recent Factors in the Upsurge of Quantitative Environmental Ranking Systems:

The first factors are the increased wealth and mobility during the post World War II era, which escalated the demand on the natural resources. For instance, Wyckoff[9] compared the urban land demand per person before and after 1950 and found that the 18 percent population growth in the Springfield, Mass., area increased urban land use by 136 percent between 1951 and 1965. The recreation demand escalated similarly, though detailed study is not available on recreation land use increase per person. By the 1960's recreation demand was so significant that it created national attention. The Outdoor Recreation Review Commission[10] was set up to prepare a nationwide study of the recreation demand and problems.

The need for natural stock resources (coal, oil, gas, etc.) escalated in the same manner. The problems of strip-mining have received wide attention, and evaluation of their effect on the landscape has begun.[11] Our society is increasingly aware of environmental concerns and the costs of resource utilization and has recently undertaken surveys of the combined effects of resource uses such as electric power, which is dependent on both stock resources and land for power lines and stations, and flow resources (water for hydroelectric power). Abrahamson[12] estimated a twelvefold increase of electric consumption between 1950 and 2000. The impact of such an increase on the Nation's landscape might be extremely significant.

Another factor for ranking systems design is the increasing role of the U.S. and other industrialized nations in land-use through large-scale planning, management, and policy formulation.[13] These governmental activities are directly responsible for several ranking systems discussed in this study.[14]

A third factor is the availability of sophisticated data-analysis techniques and hardware. For instance Steinitz et. al. developed computer graphic techniques appropriate for regional landscape analysis.[15] The symap version of that technique has been adopted by the State of New York to make an inventory of the natural resources of the entire State. Disciplines interested in the environment are discovering statistical and other mathematical tools essential for quantitative evaluations.[16]

A fourth factor is that the number of disciplines making environmental quality oriented studies and research have skyrocketed during the past decade. The directory of *Behavior & Environmental Design* by the Research & Design Institute lists 34 disciplines and 290 professionals and organizations conducting behavior and environmental research. The directory listing increased by over 70 percent in 4 years.[17] Furthermore, several students of environmental quality concerns are interested in ranking systems that can be used to predict consequences of urbanization of the landscape.[18] Predictive models are widely used by physical and social scientists, who often use normative variables and measures for evaluation, such as the G.N.P., to predict the change of life standards.[19]

The last factor is described by Michael Novak[20] in his recent book *The Experience of Nothingness*. He argues that our cultural norms are such that the demand for "objectivity" and "pragmatism" becomes more and more important and that we ought to have the "hard facts and figures" to influence successfully the decision-making. The planning and design professions, through designing quality ranking systems, are able to provide the facts and figures our culture demands for decision-making.

ANALYSIS PROCEDURE

The ranking systems analyzed here were grouped into three major categories based on their scale characteristics and overall purpose. Each of the systems within each category is described briefly, and the categories are analyzed against each of the eight criteria.

Major Categories of Environmental Quality-Ranking Systems

I. Quality-ranking systems to evaluate resources for policy planning. These systems are providing gross appreciation of the environmental quality of a large region such as the North Atlantic region of the United States. The category is further subdivided into the following groups:

   A. Systems on professional planning and design norms to evaluate landscape qualities.

   B. Systems to evaluate peoples' preferences towards regional landscape characteristics and complexities.

II. Quality-ranking systems to evaluate resources for the purpose of planning and action on interstate, state, and subregional scale. These systems can be used to influence physical decisions on the land; for instance, the selection and allocation of land for various kinds of recreation and conservation uses of a region. The subcategories are:

   A. Systems evaluating landscape qualities (1) for landscape development and protection type decisions; (2) for highway planning decisions. This subgroup is different, because highway oriented landscapes are mostly viewed in motion.

   B. Systems to evaluate peoples' preferences of landscape characteristics.

III. Quality-ranking systems for the purpose of evaluating the landscape for a single use such as camping or boating. These techniques are used mainly to evaluate sites from among which the more appropriate sites are selected for development.

Format for the Description of the Ranking Systems

Where information is available, the ranking system is abstracted as follows. The agencies and disciplines who conducted the study are identified. The situation that provided the impetus for the study is described. Then the factors and variables used in the study are summarized, and finally the procedure of the study is briefly presented.

Criteria for Analysis

The major categories are analyzed against each of the eight criteria described below. In instances, reference is made to the individual ranking systems to emphasize optimum use or negligence of the criteria under analysis. It is not suggested, however, that each ranking system ought to satisfy each of the criteria developed here.

1. The system is designed to evaluate the entire landscape continuum. – The landscape continuum has three components. First is the unique landscape. It includes those natural or cultural landscapes that have the characteristics of one of a kind within a study area such as a region, or it has some superb quality characteristics of one kind or another. Agreement about what constituted the unique landscape was not too difficult in the past. No one refutes the unique quality of the Grand Canyon, for instance. The evaluation of uniqueness, however, is getting more difficult in places where the unique attribute serves only a special interest group; for example, wilderness areas for wild river canoeing.

The second component of the landscape continuum is the opposite of uniqueness, often referred to as misfit.[21] Misfits are results of human activity, and they can have a significant regional impact. The problem remains, however, how to define "misfit" or "bad quality." For instance, billboards are eyesores to conservationists and beautiful art to the graphic artists.

The third component of the landscape is the largest and the most difficult to deal with. It includes all landscapes that are neither unique nor misfits. Several of the ranking systems reviewed here are developed to evaluate exclusively these in-between landscapes, which have the attributes of what Ervin Zube[22] describes as "ubiquities or regionally pervasive values." He suggests for this type of landscape assessments and measurements to focus on the "critical landscape attributes."

2. The permanent or immutable and the changeable or mutable landscape attributes are evaluated separately.–The permanent landscape attributes are those that cannot be changed easily or significantly by man. They include land form characteristics, major water bodies, and climatic characteristics. The changeable landscape attributes are all those that are influenced or determined by human activity or the lack of it such as farm, urban, or wilderness landscape characteristics.

3. The factors and variables used are appropriate to the scale and purpose of the ranking system. – A ranking system designed to evaluate a large region for the purpose of formulating a land-use policy may necessitate an entirely different set of factors and variables than a system prepared to evaluate a camping site. For instance, the evaluation of the shoreline quality of a small lake within a campsite area is essential for the latter, but would be totally useless for a land-use policy formulation for a state or a large region.

4. The system is designed to be used universally, given that scale and purpose are basically constant.–The design of a system demands skills and time. Once a system is developed, it should be applicable anywhere where similar conditions and needs for evaluation arise. For instance, a shoreline quality for swimming is equally important in Europe and in America.

5. The ranking system can be reproduced by others.–Scientists have accepted this criteria for a long time and for good reasons. People having similar skills or coming from the same discipline as those who developed a system should be able to reproduce and evaluate it. Several of the ranking systems published to date are extremely inadequate when analyzed against this criteria.

6. The system can be used to predict changes of quality as result of human activity.—Two kinds of changes need to be predicted. First is the decreased amount or degree in the environmental quality. Second is the increase of it. In some instances a study might indicate that certain proposed changes would have neutral effects on the existing quality.

7. The quantitative tools and techniques used are appropriate for the ranking system.—Several systems use statistical techniques, computers, and other tools such as a photometer to measure tonal values. There may be instances where the ranking system could be improved by using appropriate tools and techniques. In other cases, tools and techniques are used unnecessarily or the process is poorly documented so that objective evaluation by others is impossible. Mark Twain[23] once commented, "He uses statistics as a drunk uses a lamppost; not for light but for support." Similar problems often occur with the use of the computer.

8. The system has the ability to reduce or eliminate conflicts in the decision-making process.—The most obvious factors that influence environmental quality are political, economic, technical, or technological. Special-interest groups might constitute an added factor in the decision making process. The designers of the systems should be aware of these factors at the outset and should develop the ranking system in such a way that it communicates the measured values effectively, thus reducing the conflicts and boundaries between the influencing factors. For instance, alternative route proposals of electric power lines or highways might have very different effects on a given landscape. A quality ranking system might clarify the degrees of negative changes for each of the possible alternative routes.

DESCRIPTION AND ANALYSIS OF EXISTING OR PROPOSED SYSTEMS

I. For Policy Planning

Nine systems have been classified. Five of them were designed to evaluate national or regional landscape qualities, and four deal with peoples' preferences.

A. Systems to evaluate landscape qualities.—The first attempt to rank regional landscape resource qualities was made in the 1930's by the staff of the National Park Service.[24] The purpose of the study was to evaluate the Nation's vacation resources. Natural factors provided the dominant determinants for the ranking. The quality of topography, water, climate, (immutable resources) and the plant life (mutable resource) were described. Criteria were developed for summer, winter, and year-round vacation lands. The three types of vacation regions were identified and mapped.

The second national effort to rank recreational resources was made by the Outdoor Recreation Resource Review Commission (ORRRC)[25] as part of their assessment of the Nation's outdoor recreation needs, around 1960. ORRRC proposed a system for classifying recreation resources into six use classes: high-density recreation areas, general outdoor recreation areas, natural environmental areas, outstanding natural areas, primitive areas, and historic and cultural sites.

A set of natural-physical requirements, in combination with proximity to population, determines the use class. Landscape attractiveness is a major factor for determining each class. For instance, natural environment class areas ought to have "varied and interesting land forms, lakes, streams, flora and fauna within attractive natural settings."

The outstanding natural class area includes "individual areas of remarkable natural wonder, high scenic splendor, or features of scenic importance." A ranking system determining what constitutes these qualities was not developed by the Commission.

The ORRRC study could well be developed further and could be applied to the three types of vacation land developed by the National Park Service.

Ian McHarg[26] with his students at the University of Pennsylvania, developed a ranking system, on a river-basin scale. A matrix was developed, in which the full compatibility (as opposed to incompatibility) of a given land use (industrial, forestry) was measured against the natural determinants (climate, slope). The use consequences range from good, fair, and poor to bad. The matrix suggests that those areas where the use consequences are good are the high-quality environments.

The development of two other ranking systems was made possible by the Water Resources Planning Act of 1965. Under the guidelines of the Water Resources Council established by the Act, "framework" type studies have been conducted for each of the nineteen water resource regions of the U.S. One of the four objectives of the Council is to achieve environmental quality. Planners in two of the regional study groups, Upper Mississippi and North Atlantic, found it necessary to design ranking systems for evaluating the existing environmental qualities.

The Upper Mississippi system was developed by Philip H. Lewis, Jr., and Associates, Landscape Architects,[27] to provide an assessment of the aesthetic and cultural values for this region. A system was developed to evaluate 13 natural and cultural factors. Each of the factors was further subdivided into variables. A resource-value point system was assigned intuitively to each of the 120 variables, ranging from 1 to 20. The variables included such items as high points, caves, virgin stands, and old mills. The inventory technique and criteria for the point system were not described. The environmental quality of an area was assumed to be determined by the total number of points it received. Application of this ranking system to the huge Upper Mississippi region is unclear.

The ranking system for the North Atlantic Region was designed by Research Planning & Design Associates, Inc., a consulting firm in Amherst, Mass.,[28] to evaluate the regionally pervasive[29] visual and cultural environment of the 167,000 square miles of the region. The permanent and changeable landscapes were evaluated separately.

The permanent landscape was classified into five landscape series, ranging from mountains to flat lands. Each landscape series was evaluated for the quality of contrast, spatial sequence, and water variables, and was ranked as high, medial, or low quality.

The changeable landscapes were classified into eight units, determined by intensity of use, ranging from center-city unit to forest wildland landscape unit. The landscape units were evaluated on the same three-level ranking of high, medial, and low. The major variables for the unit evaluations were variety and diversity within the use patterns.

Finally a system was devised to combine the permanent and changeable visual landscape values into one existing landscape value, using the same three-level ranking.

B. Systems to evaluate people's preferences towards regional landscape characteristics and complexities.—Three landscape preference systems for evaluation were developed at the Department of Landscape Architecture, University of Massachusetts,[30] to validate the hypothesis of the ranking system for the North Atlantic Region. The studies were initiated and directed by Professor Zube and were prepared by four landscape architect students, Albert, Burns, Rundell, and Halverson.[31]

The hypothesis tested by the students was that the quality of land form, water, and contrast (the variables of the permanent landscape) and variety, diversity (the variables of the changeable landscape) are essential components and determinants of overall landscape quality.

Albert used color slides of New England landscapes and tested and evaluated the responses of university students, using tachistoscopic projection.

Burns and Rundell used a set of 10 photo-montages. The pattern in the middle ground was developed in five combinations of field and forest. The horizon line was either mountains or rolling hills. A random sample test on the adult population of

Amherst was conducted, using the paired comparison format.

The study of Halverson was similar to that of Burns and Rundell, using line drawings in place of photo-montages.

The studies showed that greater variety of pattern and changes in topography were preferred over little variety of pattern and flatter landscapes.

A unique study was made by Joachim Wohlwill[32] on human reaction to complexity in the physical environment. Wohlwill's purpose was to "determine whether relationships between stimulus complexity on the one hand, and interest and preference on the other, as previously determined for artificial stimuli in the laboratory, could be generalized to stimulus domains involving ready made stimuli." He used two classes of stimuli—environmental and artistic—as examples of such domains.

A 7-point scale of complexity was established by obtaining judges' ratings of amount of variation present in environmental and art pictures. The exploratory behavior, (the number of times the subject chose to expose each slide briefly) and the subjects' preference (evaluation ratings on a 7-point scale), was tested and analyzed through regression. The preference for complexity increased from levels 1 to 4; then, as complexity further increased to level 7, the preference decreased. This type of studies could have influence on planning policy formulation.

Analysis of Category I

The ranking systems of this category deal with regionally pervasive landscapes only, and do not rate the unique landscapes nor the misfit landscapes. Zube justifies this exclusion as follows: "The search for uniqueness and to a lesser extent the concern for misfits tends to focus on discrete sites, on specific well defined segments of the landscape."[33]

It is true in most cases, however, that a unique quality might extend far beyond a site. For instance, the wilderness type landscape of northern Maine or the embayed rocky cliffs of the Maine shoreline constitute unique attributes on a subregional scale within the North Atlantic Region. Without much effort, the highest and lowest values could be built into the ranking systems on this scale. Hence the entire landscape continuum could be evaluated.

Permanent and changeable landscape attributes are separated in the Potomac and the North Atlantic Region systems. In the matrix of the Potomac system, the major emphasis is based on the differentiation between natural determinants and compatibility of land uses, while in the North Atlantic Region study between the landscape systems (permanent) and the landscape units (changeable), landscape is emphasized. Both systems evaluate successfully those resources that need protection or preservation and those that are modified constantly by human activity and can be improved at will.

The appropriateness of the factors and variables used in these appears to be optimum for this category, except for the Upper Mississippi system. The evaluation of 13 factors and 120 variables within a region that consists of several hundred square miles seems to present a monumental and unnecessary task. Variables such as an old mill or a small waterfall might have significance for a specific local planning effort, but add little to the environmental quality of a huge region.

Unfortunately, for neither of the three systems—National Park Service, Potomac, and Upper Mississippi—are the analytical and ranking procedures presented in sufficient detail to permit wider adaption or evaluation by others. Furthermore, they could not easily be reproduced by students of quality ranking systems.

An evaluation of the category I ranking systems against criterion six (predictability) leads to the conclusion that no one system in this group was designed for predicting quality changes as a result of human activity. Probably the system designed for the North Atlantic Region could be developed further for such predictive purposes because it evaluates the changeable landscape attributes separately. If the variety and diversity change of the proposed landscape pattern are known, the new combined landscape quality could be estimated because the value of the permanent landscape remains constant.

Quantitative techniques for the purpose of evaluation were used only in the systems that were designed to evaluate people preferences. For each of these systems, simple statistical techniques were used to set up the experiment and to evaluate them. The explanations are simple and adequate, and the test could be made easily to validate them.

The last criterion deals with the ability of the systems to reduce conflicts in the decision-making process. To satisfy this criterion, the systems ought to be presented in such a way that nonprofessionals can understand them. No one of the systems in category I was found to fully satisfy this criterion. The ORRRC and the NAR studies are the most convincing, while the Mississippi system is the most complex. It is presented in a 600-page report, and it communicates poorly even to other professionals.

II. For Physical Planning and Action

The greatest number of ranking systems was found in this category. Seven of the 11 systems were designed to evaluate regional landscape qualities, and the other four dealt with preferences and perceptions of people.

A. Systems to evaluate landscape qualities

1. For landscape development and protection type decisions.—The state-wide recreation study in Wisconsin gave the impetus for the development of an environmental quality ranking system by Philip H. Lewis, Jr.[34] This study was one of the first efforts to rank environmental qualities on a regional scale. The purpose was to evaluate "the state wide pattern of resources values" for recreation. Lewis inventoried and evaluated on the basis of 11 natural and cultural factors, which were further subdivided into 220 resource variables. The concentration of these resources in so-called "environmental corridors" provided the high quality statewide pattern of resource values.

A landscape resource evaluation for Nantucket Island, Massachusetts, was prepared by Ervin Zube and the author in 1966.[35] The landscape evaluation was a portion of a comprehensive natural resources inventory, done in collaboration with the University of Massachusetts Extension Service and the State Department of Natural Resources, who gave the impetus for the study. The team evaluated three resource factors: biophysical resources, natural factors, and landscape types and values. Eight areas were flagged for protection where concentration of high-quality landscape resources occurred. Furthermore, high-quality, fragile, or scarce resources were ranked as unique for preservation. The unique landscapes included the heath, dune, and salt-marsh landscapes, and five areas of high points that provided panoramic views of the island and the ocean. In addition, the land-form attributes were evaluated and ranked into four categories. This ranking system later influenced the system developed for the North Atlantic Region.

A resource evaluation system for the Department of Parks of Staten Island, New York, was designed by Ian McHarg and Juneja, landscape architects.[36] The purpose of the study was to evaluate potential land uses for the island, based on the intrinsic values. They described and interpreted 32 ecological factors (land features, aquifers, etc.). Ranking criteria were developed for each of the ecological factors, ranging from maximum to minimum. A system of "phenomena ranking" placed a value on each resource factor, having highest, medium, low, or lowest value. Based on this evaluation, each resource was assigned for a compatible land use.

An environmental quality-ranking system was recently developed by Handley, Jordan, and Patterson[37] of the Bureau of Outdoor Recreation's Northeast Regional Office. The system was an attempt to quantify levels of environmental quality in a segment of the total possible spectrum. The primary purpose of the system was to provide a basis for environmental quality evaluations of a single area under varying conditions. The intent was to predict consequences by varying the individual environmental factors through different combinations of time, intensity, and input interrelationships.

The portion of the environmental spectrum covered by the system is indicated by the use of eight broad categories: resident population, community resources, water resources, land forms, leisure resources, vegetative resources, wildlife resources, and historical/archaeological concerns. Each of these categories was further broken down into those factors believed to contribute the most to its meaning.[38] Numerical values assigned to each factor produced a positive base value. This base value was subsequently modified by application of weighting factors (multipliers) to reflect incremental value not solely attributable to the degree to which a category's factors are present. Negative factors—air, water, visual, audio, and crowding—were used to reflect the value limitations these sources impose on the derivable benefits of the base values.

The next system described here was developed in England. A landscape evaluation research project for East Sussex County was prepared by K. D. Fines[39] at the East Sussex County Planning Department. The aim of the study was to design a method of landscape and townscape evaluation. At the start, a world wide scale of the natural and cultural values was devised, ranging from unsightly, undistinguished, pleasant, distinguished, and superb, to spectacular. To eliminate personal bias in landscape appreciation, a representative group of 45 persons was selected to rank and evaluate color photographs of landscape and townscape views of the entire landscape continuum. The result of the view evaluations was converted to land-surface values of landscape types, features, and viewpoints. The landscape of East Sussex was evaluated and measured against the landscape value profile of England. Application of the technique was briefly discussed. It was suggested to be used as a guide to the formulation of urban expansion policy and in the section of routes and sites in open country. The report demonstrated the application of the technique to predict the change of landscape values created by a 400 kV supergrid transmission line on alternative routes. The evaluation system would also be used for protecting valuable landscapes against what Fines describes as "the process of landscape erosion."[40]

2. *For highway planning decisions.*—The following two systems of category II (evaluation of landscape qualities) were designed to measure highway-oriented landscapes. Before development of these systems, several planners were interested to describe the components of a quality highway.[41] Others were interested to study the driver's experience in motion and record the visual sequence.[42]

The first quantitative ranking system of highway landscapes that is known to the author was developed by Frederic O. Sargent[43] at the Vermont Resources Research Center. Sargent, a resource economist, evaluated highway scenery by ranking two components—distance and variety—and then adjusting this total rating with reference to depth, breadth, intermittency of the view, and eyesores if any. Distance was rated from 1 to 5; the greater the distance, the higher the rating. Variety was also rated from 1 to 5; the greater the variety, the higher the rating. The distance and variety ratings were added to provide the total rating at one observation point. A series of ratings every ½ mile characterized the scenic quality of a road. The system was designed to (1) facilitate justifying scenic road designations, (2) facilitate location of scenic turnouts on highways, and (3) determine the need for scenic access on a given road.

A highway aesthetics study for the U.S. Department of Transportation was conducted by Professor Hornbeck & Associates,[44] at the Department of Landscape Architecture at Harvard since 1965. The purpose of the study is to develop devices to increase the planning of scenic qualities of highways. The aesthetic factors were identified as visual inputs in the study. They included edge quality, degree and quality of enclosure, object dominance by contrast, size and nearness, the quality of object diversity, and the attributes of the visual alignment. The visual impacts of each input (aesthetic factors) were rated and measured against behavioral outputs (speed control, orientation) of the driver.

B. Systems to evaluate peoples' preferences. —Four studies dealt with peoples' preferences for natural and cultural landscape characteristics. The first of them was done by George Peterson[45] at the Department of Civil Engineering at Northwestern University in 1965. The purpose of the study was to analyze quantitatively the perception of the visual appearance of residential neighborhoods. Nine variables were assumed to contribute to the visual appearance of residential neighborhoods: preference, greenery, open space, age, expensiveness, safety, privacy, beauty, and closeness to nature. A hypothesized model was constructed. Preference to variables was tested and rated on a scale for each variable by projecting 23 slides to 140 individuals. Finally the hypothesis was tested through regression analysis. It was concluded that the most significant dimension for preference of visual appearance "appears to be the general physical quality, which is strongly reflected by the perceived age of the neighborhood."[46]

The next system was an analysis of landscape development by Peter Jacobs and Douglas Way,[47] landscape architects. The purpose of the study was to evaluate the ability of various landscapes to visually absorb land-use activities. The three variables were vegetation density, topographic closure, and visual complexity. A ranking scale was devised, ranging from 0 to 9, "the degree to which undeveloped landscapes differed visually from the identical landscapes with selected activity uses introduced into them."[48] Thirty subjects were tested, using the paired comparison format. The authors concluded that greater vegetation density and topographic closure absorb visual complexity better than little vegetation density and flat topography.

A predictive model for natural landscape preferences was prepared at The Northeastern Forest Experiment Station, USDA Forest Service, by Shafer, Hamilton, and Schmidt,[49] an inter-disciplinary research team at the Station's Syracuse unit. The purpose of the study was "to identify what quantitative variables in photographs of landscapes were significantly related to public preference for those landscapes."[50] Ten variables were identified to describe landscape zones such as, sky zone, vegetation zone, and stream zone in the photographs. Four additional variables identified landscape zone dimensions. They were perimeter, interior, area, and horizontal end squares of various items in the 8 x 10 photographs, overlayed by ¼-inch grid for analysis of pictures. Landscape zone and dimension variables were read into the computer. Tonal variables were determined by the use of photometer and were added. A model was formulated by correlating 46 x 46 total possible variables, and a matrix was computed to describe the landscapes in the photograph.

The next step was the landscape preference test "to see if there was a significant relationship between quantitative items in the photographs of a landscape and the preference score of that landscape."[51] To evaluate preferences, 250 respondents examined 20 packets of 5 photographs each. A landscape preference score from 1 to 5 was obtained from the sample interviews, and a multiple-regression analysis was used to evaluate the dependent variable preference score. The model was quite successful. "In five of the six field tests, the predicted and observed ranks of the landscape pictures showed agreement."[52]

The last study in this category dealt with a system of landscape dimensions developed by K. H. Craik,[53] a psychologist, as a continuation of the forest-landscape description study by Litton.[54] The aim of Craik's study was to improve landscape inventory methods and landscape resource evaluation. First Craik collaborated with Litton in developing a landscape rating scale that contained 10 factors, including observer's position, extent of view, and enclosure; and contained 34 dimensions such as the observer is looking down upon or looking up toward the scene. In addition, he developed a graphic landscape typology, consisting of 10 schematic landscape forms.

A series of test panels, consisting in total of 250 people, were drawn from forestry and conservation students and faculty, landscape architecture students and faculty, U.S. Forest Service personnel, and general university students. To appraise the reliability of the landscape rating scales and graphic landscape typology, the observers judged 50 landscape scenes, rating the scenes on each landscape dimension and assigning each scene to the most appropriate graphic type. The result of the study showed substantial consensus among panels and impressive agreement in the way they employed the landscape rating scales. A detailed explanation of the statistics is included in the report. Preliminary tests of the relationship of the landscape dimensions and types to aesthetic appeal served to illustrate the scientific application of the techniques.

Analysis of Category II

In this category the ranking system by Fines, the study of East Sussex, and in a lesser degree the systems of the Bureau of Outdoor Recreation and the Staten Island Study, evaluated the entire landscape continuum. One aspect of Fines' system is especially remarkable: he appreciated the entire spectrum of the world natural-cultural qualities, ranging from unsightly to spectacular. Then he placed his region into the context of a world-wide scale of values.

The Nantucket study placed great emphasis on unique qualities in addition to pervasive landscape values. Parts of the unique Nantucket landscapes are nationally significant, such as the heath vegetation; others, for example the sand-dune landscapes, have only island-wide significance.

The ranking system should indicate the level of significance of uniqueness. Sargent and especially the BOR systems placed great emphasis on the evaluation of the negative factors or misfits. The BOR listed explicitly the components of negative factors, and the weighting of the values seemed to estimate the environmental problems well.

The second criterion, the separation of permanent and changeable landscapes, was not developed in any of the systems discussed in this category. The systems for Staten Island, Wisconsin, Nantucket, and East Sussex County recognized some of these factors but did not go far enough in separating them.

The factors and variables used in this category are appropriate for the scale and purpose of the systems. However, in some cases the number of variables selected are either too few or too many.

The two extreme cases were the Wisconsin study, which dealt with 220 variables, which seems to be unmanageable and suggests too great an expenditure for inventory. On the other hand, Sargent's classification system, using only a few variables, suggests an oversimplified ranking system.

The more significant problem is that the majority of the variables used were selected intuitively, so that their scoring values were arbitrary. This analysis suggests two important actions to improve the state of the art of the ranking systems: first, the systems should include primarily those variables that are already substantiated by the eight preference studies discussed; second, the designers of preference studies should review the factors and variables used in the ranking systems discussed and should evaluate peoples' preferences to those landscape characteristics.

The universality and the reproducibility of the ranking systems developed by the BOR, Shafer et. al., and Craik are well explained and well described. The three studies that do not fully satisfy the above criteria are: First, the Staten Island system, which describes the phenomena ranking through qualitative terms and also through names of location such as the phenomena rank for the water features and scenic values "the Narrows, Kill Van Kull, and Arthur Kill." The later ranking is meaningful only for those who conducted the study or know the island. Second, the study "highway esthetics." The 1968 report reviewed is extremely complex and difficult to understand. Third, the study "visual analysis of landscape development," because it does not explain adequately the testing method; hence it would be hard to reproduce.

The criterion that the ranking system should be useful for predicting changes was included at the outset in 3 of the 11 systems. They were the ranking systems for East Sussex, BOR, and Shafer's predictive model for natural landscape preferences. These attempts are very encouraging. It is hoped that they will set the example for future ranking systems.

Computer and statistical tests were used primarily in the systems for preference tests. These tests undoubtedly demand statistical techniques. Among the nonpreference systems only the East Sussex study used statistics. Shafer used a photometer to measure tonal values in photographs. Tools of this kind certainly have great potential, but the analysis of their value is difficult, because the testing of the technique is limited at this time.

The last criterion deals with the systems' ability to reduce conflict in the decision-making process. It was suggested earlier that complex studies and professional jargons limit communication. One case study in this category, the Nantucket study, has proved to be successful in communicating the landscape values to the decision-makers. As a result of that study, over 25 percent of the Island's land has been permanently protected, where the majority of the protected areas consist of fragile landscapes.

III. For A Single Use

Four studies are grouped in this category, each based on professional planning and design norms to evaluate qualities. Not one of these systems was designed to evaluate the preferences of people.

A quality ranking system was adopted by Chubb[55] at the Michigan Recreation Resource Planning Division, from a PhD dissertation by Carlton Van Doren[56] at Michigan State University. The purpose of the system was to develop attraction and capacity indices for boating and for other recreational uses. A case study for boating attraction was developed. Twelve variables were identified, among them size, access, fishing, and scenic qualities. A scoring schedule with maximum score was established for each variable. The recreational quality of the attributes of each variable (e.g. size of lake: small 0, medium 10, large 20 points) determined the number of points it received. The score numbers of the variables were totaled to provide the attraction index for the boating site.

An evaluation of forest campground sites was done by Allison and Leighton,[57] foresters at the University of New Hampshire. The purpose of the study was to develop a numerical rating system for campground site selection. Eight physical factors were evaluated: water, topography, potable water, vegetation, natural attractions, vista, forest pests, wildlife, and climate. These factors were further subdivided into 22 variables. (e.g. size and quality of water) Three socio-economic factors – the location, economic-business management, and proposed campground facilities – were expressed by 20 variables (e.g., access to major highway). The condition of variables was ranked from excellent to good, fair, and poor. A point value was assigned to each condition within each of the 42 variables. The point score of the physical factors and socio-economic factors were totaled separately for rating the campground sites as excellent, good, fair, or poor.

An appraisal system for recreation potentials was developed by the USDA Soil Conservation Service (SCS).[58] The purpose of the study was to develop a systematic approach to evaluate the natural resources of the area for potential future outdoor recreation developments by SCS and county recreation planners. Ten key elements were used in evaluating recreational potential for each of 12 standard kinds of outdoor recreation areas (e.g., camping grounds, fishing waters, golf courses). The key elements were climate, scenery, natural areas, historic areas, soils, water, wildlife, size and distribution of population, proximity and access ownership, and land-use pattern. A rating system was devised; and a number from 0 to 10 was assigned to each key element to indicate the degree of excellence represented by the key element for a particular kind of recreation development.[59] A multiplier was assigned for each element within each kind of recreation development to represent the weighted importance of a particular key element. Then a score number was obtained as the result of multiplying the rating number of a particular element with the weighted multiplier. Finally the sum of the scores of all the key elements gave the numerical score for a kind of recreational development.

A method for quantitative comparison of some aesthetic factors among rivers was developed by Luna Leopold.[60] The purpose of his study was to quantify the non-monetary values of various potential hydropower dam sites in river valleys. Leopold described 3 sets of factors; 14 physical factors such as river width, depth, basin area, deposition, and erosion; 14 biologic and water-quality factors, among them water color, amount and type of algae, river fauna, and land flora; and finally 18 human use and interest factors, for instance trash, accessibility, vistas, land use, and misfits. An evaluation number from 1 to 5 was assigned to each of the 42 factors. Then a uniqueness ratio was calculated, which is the number of sites being evaluated divided by a given number for a given factor. For example "if a site factor is one among twelve of the same category, the site shares this characteristic with eleven others. It is unique in the ratio 1 to 12 or its uniqueness ratio is 1 : 12 (.08). If no other site shares the same category position, then the site has a uniqueness ratio of 1 : 1 (1.0). The uniqueness is thus defined on a scale of 0 to 1.0."[61] Finally the *total* uniqueness ratio for a site was determined by adding the ratios of all 46 factors. Leopold applied this quantitative quality evaluation on 12 sites in Idaho. Hells Canyon of the Snake River was shown to be unique and comparable only to Grand Canyon of the Colorado River.

Analysis of Category III

The landscape continuum, as defined in this study, was recognized within this category only by Leopold. He developed the most sophisticated method to evaluate the uniqueness quality and the negative components in the landscape. The Michigan system for boating attraction by Chubb dealt with one aspect of negative factors by deducting points for water pollution.

The separation of permanent and changeable landscape attributes was also well done by Leopold. One set of factors he developed, the physical factors, represent clearly the permanent attributes. The system for evaluating forest campgrounds by Allison and Leighton lists the biological factors under the physical factors, which could be easily separated; then the system would satisfy this criterion.

The analysis of the appropriateness of factors and variables used suggests that some factors listed for the forest campground—for instance, distance from urban population and climatic factors—should be considered at a higher level, such as in the systems discussed in category II. The number and the kind of variables evaluated in the SCS study (10) and in the Michigan boating attraction system (12) seem to be limited to describing and evaluating the quality of a site. The variables used by Leopold seem better for site level evaluation.

Each of the four systems in this category could be applied universally and reproduced easily. They all are well written and explained. The Leopold system would create some difficulty to reproduce because it is somewhat complex.

Only Leopold's system could be used to predict outcome of changes, though it was designed to measure the relative values of sites as they exist today.

These systems of category III did not demand any sophisticated tools or techniques. Those that were used seem to be appropriate for these systems.

The last criterion deals with the analysis of the system's ability to reduce or eliminate conflicts in the decision-making process. The purpose of the Leopold study was exactly to deal with this problem—to quantify the non-monetary values, which might have great and long-range social values, (the environmental quality uniqueness of Hells Canyon) not yet recognized to the same degree by contemporary economic evaluation techniques.

DISCUSSION

During the 1960's an impressive number of environmental quality-ranking systems have been designed. The ranking systems appear to have several values for estimating environmental qualities on various levels, ranging from site level to regional and national scale. Some aspects of the quality variables have been substantiated by preference studies, and psychological studies have been used to explore the relationship between environmental complexity and stimuli. Several of the systems have attempted to predict outcome of proposed actions.

The ability to predict has become extremely important because the environmental uncertainties are rapidly being increased by our technological actions. Some of the systems have been useful for limiting the conflicts in our complex public decision-making process. The greatest potential value of the ranking systems, however, is that they may be used to create new social norms for greater appreciation of environmental qualities. The systems can be used to create a needed and useful myth that emphasizes quality rather than quantity.

This analysis also suggests several problems and needs for making the existing ranking systems more valuable. One of the most significant problems is that the majority of the systems do not deal with the entire landscape continuum from the large to the small and from the unsightly to the spectacular. The majority of the systems are designed with single purpose to evaluate a limited area, and they are not placed into the context of the scale of landscape and its values.

A system such as Fines' should be expanded, substantiated, and adopted internationally as a frame for all value systems. The designers of quality-ranking systems should evaluate those developed for the sciences. For instance the classification system of the plant kingdom is remarkable as it proceeds with order, class downward, providing more and more information and detail down to plant species and varieties. Fines' and the NAR[62] systems have some attributes that could serve as framework for a similar system for landscape classification and evaluation.

Another general problem with the present system is that the majority of the values placed on environmental factors and variables are intuitive. Many more preference studies are needed to provide a base for a set of normative values to be used in the ranking systems in place of intuitive values. In addition, the increase of preference studies would give impetus to scientists to conduct additional studies on environmental complexity problems, and to develop social indicators.

Furthermore, the separation of mutable and immutable values is absolutely essential in each ranking system. Evaluation of changes or prediction as result of changes by human activity is not possible until the permanent and changeable attributes and their values are separately recognized.

The selection of the proper number and appropriate type of variables for qualitative evaluations has been less than optimum in several of the systems analyzed. One of the reasons for this problem seems to be that the designers of the systems do not alter the variables while developing a ranking system for a larger region.

These problems suggest at least two alternative solutions: people who are designing quantitative ranking systems without sufficient training should collaborate with people who already have the needed tools, or should obtain the necessary tools. It is also suspected that some quantitatively trained people developing quality-ranking systems are lacking the visual awareness of designers such as those who are trained in landscape architecture.

Reference Notes

1. The term "cultural landscape" is used here to describe any or all physical influences of man upon the land resulting from his construction of buildings or from continuous use of land as in farming.

2. Wohlwill, Joachim F. AMOUNT OF STIMULUS EXPLORATION AND PREFERENCE AS DIFFERENTIAL FUNCTIONS OF STIMULUS COMPLEXITY. Perception & Psychophysics 4(5):307-312. 1968.

3. Zube, Ervin. LANDSCAPES: SELECTED WRITINGS OF J. B. JACKSON. Univ. Mass. Press, 1970, pp. 43-54.

4. Fabos, Milde, Weinmayer. F. L. OLMSTEAD SR. FOUNDER OF LANDSCAPE ARCHITECTURE IN AMERICA. Univ. Mass. Press, 1968, pp. 42-47.

5. National Park Service. ADMINISTRATIVE POLICIES: FOR NATURAL AREAS OF THE NATIONAL PARK SERVICE. U.S. Government Printing Office, Washington, D. C., 1968, pp. 10-15.

6. Eliot, Charles. Landscape Architect, pp. 380-384.

7. The best known notation systems for describing sequential experiences are: Thiel, Philip: ENVIRONMENTAL DESIGN ON THE BASIS OF SEQUENTIAL EXPERIENCE, Kenchiku Bunku 18 206:145-149; 1963. Halprin, Lawrence and Associates: A REPORT ON FREEWAY DESIGN IN THE URBAN SETTING, Calif. Div. Highways and Fed. Bur. Public Roads, May 1963; Appleyard, Lynch & Myer, VIEW FROM THE ROAD, MIT Press, Cambridge, Mass., 1966. Each of these descriptions uses abstract symbols to denote the variables perceived visually.

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9. Wyckoff, J. B. RURAL TO URBAN LAND CONVERSION & ENVIRONMENTAL QUALITY, Mass. Heritage 7(4):1-3. 1969.

10. Outdoor Recreation Resources Review Commission: OUTDOOR RECREATION FOR AMERICA: A REPORT TO THE PRESIDENT AND TO THE CONGRESS BY THE ORRRC. U.S. Government Printing Office, Washington, D. C. 1962.

11. Zube, Ervin H. TACONITE AND THE LANDSCAPE. Wis. Dep. Resource Develop., 1963. This study analyzes the attributes of open-pit iron ore mines and proposes a development program to decrease the visual effect of mining on the landscape.

12. Abrahamson, Dean E. ENVIRONMENTAL COST OF ELECTRIC POWER. Sci. Insti. Public Inform., 30 East 68th Street, New York, N. Y. 1970.

13. Eckbo, Dean, Austin & Williams. STATE OF HAWAII LAND USE DISTRICTS AND REGULATION REVIEW. Hawaii Land Use Comn. Dep. Planning and Econ. Develop., Honolulu, 1970. Hawaii is the first State in the U.S. that has explicit land-use zoning for the entire State.

U.S. Water Resources Council. NATIONAL WATER RESOURCES. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 1968. The council's recommendation to plan for environmental quality gave the impetus for the development of quality-ranking systems for the North Atlantic Region and the Upper Mississippi River Basin.

14. Additional ranking systems stimulated by governmental activities are: ORRRC study, Potomac River Basin's ranking by McHarg, environmental corridor study for Wisconsin by Lewis, Nantucket study by Zube & Fabos, SCS staff study The Guide to Making Appraisal, and Chubb's system analysis approach in Michigan.

15. Steinits & Rogers Associates, Cambridge, Mass., and Enviromedia, Inc., Minneapolis, Minn. NATURAL RESOURCE PROTECTION STUDY. 1970. Ranks input of resource data and produces composite computer maps with tones.

16. Almost half of the ranking systems reviewed in this study applied statistics or used computer for evaluation.

17. Research and Design Institute, 1969 Directory. BEHAVIOR AND ENVIRONMENTAL DESIGN. Res. & Design Inst., REDE, Providence, R. I., 1969.

18. Among the studies reviewed here, the systems of the Bureau of Outdoor Recreation, Shafer's and Fein's were designed at the outset to predict quality changes in the landscape.

19. It is believed by this author that the economists were successful in creating a myth using the G.N.P. to evaluate life standards and that G.N.P. is not an accurate measure for the quality of life —yet it indicates it. Contemporary planning and design norms for quality evaluation are just as valid as or better than the norms of the economists.

20. Novak, Michael. THE EXPERIENCE OF NOTHINGNESS. Harper & Row, 1970, p. 35.

21. Kates, Robert. THE PURSUIT OF BEAUTY IN THE ENVIRONMENT. Landscape 16(2):21-24. 1966-67.

22. Zube, Ervin. THE VISUAL LANDSCAPE: POLICIES, PROBLEMS AND PRACTICES. Univ. Mass. Dep. Landscape Architect., 28 pp., 1971.

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24. National Park Service. A STUDY OF THE PARK & RECREATION PROBLEM OF THE U.S. 1941. pp. 36-38.

25. Outdoor Recreation Resource Review Commission, *op.cit.*, Chapter 6.

26. McHarg, Ian L. DESIGN WITH NATURE. Amer. Museum Nat. History Press, Garden City, N. Y., 1969, pp. 127-151.

27. Lewis, Philip H. Jr., & Associates. UPPER MISSISSIPPI RIVER COMPREHENSIVE BASIN STUDY, APPENDIX B, AESTHETIC & CULTURAL VALUES. Upper Mississippi River Basin Coordinating Committee, 1969.

28. Research Planning & Design Associates, Inc. NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY, APPENDIX N: VISUAL & CULTURAL ENVIRONMENT. Nov. 1970, pp. 16-24. Three principals of the firm, Ervin Zube, Paul Procopio, and the author of this paper, assisted by Robert Brush, landscape architects, were developing this system in 1967. The ranking system is now being further developed for the State of Vermont by Terrence Boyle, principal, and Peter Olin, assistant of Research Planning & Design Associates, Inc.

29. Zube, Ervin H., op. cit., THE VISUAL LANDSCAPE, p. 17.

30. Ibid, pp. 24-26.

31. Albert, John. A STUDY OF VISUAL RECREATION IN THE NEW ENGLAND LANDSCAPE, 1969.

Burns & Rundell. A TEST OF VISUAL PREFERENCES IN A RURAL NEW ENGLAND LANDSCAPE, 1969.

Halverson, Craig. SCENIC QUALITY IN THE LANDSCAPE: A TESTING FORMAT OF HUMAN PERCEPTUAL VALUES, 1970. This study was also designed to provide supporting data for environmental mapping method developed by Frithgof M. Lunde of Warner, Burns, Toan, and Lunde, architects, of New York.

Master of landscape architecture thesis or terminal project works, University of Massachusetts, Amherst.

32. Wohlwill, Joachim F. AMOUNT OF STIMULUS EXPLORATION AND PREFERENCE AS DIFFERENTIAL FUNCTIONS OF STIMULUS COMPLEXITY. Perception & Psychophysics 4(5):307-312. 1968.

33. Zube, Ervin H., *op. cit.* p. 17.

34. Lewis, Philip H., Jr., QUALITY CORRIDORS IN WISCONSIN. Landscape Architect. 54(2):100-107. 1964.

35. Zube, Ervin, and Carlozzi, Carl, editors. AN INVENTORY AND INTERPRETATION: SELECTED RESOURCES OF THE ISLAND OF NANTUCKET. Univ. Mass. Coop. Ext. Serv. Pub. 4, pp. 62-72 and 112-128. 1967. Mr. Zube and the author developed the quality evaluation system presented in the report.

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58. Soil conservation Service Staff. GUIDE TO MAKING APPRAISALS OF POTENTIALS FOR OUTDOOR RECREATION DEVELOPMENTS. USDA SCS, 1966.

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60. Leopold, Luna B. LANDSCAPE AESTHETICS. Nat. History, Oct. 1969, pp. 37-44; and QUANTITATIVE COMPARISON OF SOME AESTHETIC FACTORS AMONG RIVERS, U.S. Geol. Survey Circ. 620, 1968, pp. 1-16, Washington, D. C.

61. Ibid., p. 5.

62. In 1967, during the development of the ranking system for the North Atlantic Region, the team at R.P.D. was very much aware of a need to design a classification system which begins with the landscape and ends up with the varieties of site level landscapes. The landscape series, system, and unit classification developed for the N.A.R. resembles the classification of the plant kingdom. This similarity was recognized first by Carl Carlozzi, a principal of Research Planning and Design Associates, Inc. Dr. Carlozzi prepared the section on ecological considerations for the N.A.R. study.

63. Alinsky, *op. cit.*