11-1-1981

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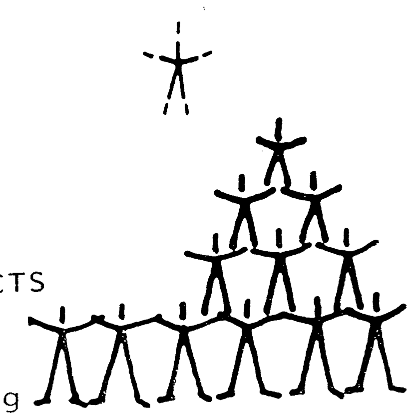
Proceedings of 3 Educational Sessions

1981 ANNUAL MEETING
AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS

Organized by:
ASLA Task Force on Regional Landscape Planning



A COMPUTER-AIDED TECHNIQUE FOR THE ANALYSIS OF VISUAL COMPOSITION

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Abstract

This paper describes a computer-aided technique for analyzing visual composition in the landscape by examining relationships among grid cells. Within a seen area, edge relationships and areal proportions of selected factors are examined for their compositional qualities. This is achieved by computer routines with capabilities for vertical searching, horizontal searching to determine adjacencies of characteristics, and horizontal searching to determine the proportion of a seen area displaying a selected characteristic. An application of the technique to an 86,000 acre study area in the Shawnee National Forest is described.

Introduction

Visual Composition

Computer programs described here allow users of a region-wide grid cell data base to interpret compositional relationships experienced by observers on the ground. Few would disagree that the ideal way to assess the visual quality of a landscape is to look at the landscape. We might not agree about who is to do the looking, or where or when the looking is to be done; but undoubtedly we would find that the best way to assess landscape visual quality is to experience subtleties of composition, form, line, texture, and color on the site. Of these qualities, composition seldom has been addressed in regional visual assessment.

While some of the completeness of on site visual experience must be sacrificed to breadth of coverage in regional work, concepts of visual composition can be retained, in part, in the conduct of such studies. On site the viewer sees the elements of a view in their landscape context. Landscape elements interact to frame, enclose, direct, and attract views. Together the elements make a visual composition.

In this paper, "visual composition" means a collection of landscape elements which seen together make a visual impact different from the sum of their individual visual impacts. For example, a white barn has some visual effect; a wooded hill has some visual effect. A white barn backed by a wooded hill has an effect greater than the combined effects of the parts evaluated separately. The barn and the hill are changed by their composition.

Variety and Unity

Variety and unity are most meaningful when they are considered across a visual composition and in the broadest sense, i.e., to include not only immediate sensual effects but also effects of meaning and function (Aldrich, 1963). Although the variety in line, form, color or texture that occurs within a landscape element is important to visual quality, the variety that results from the juxtaposition of landscape elements within a view defines the broader compositional pattern. Beyond this, the visual composition is more than a simple sensual object. The meaning and function of land use have aesthetic connotations as well (e.g., Palmer, 1977); unity in the meaning of the viewed land uses also increases visual quality.

Considering the wooded hill once again, we see that many different foliage colors on the slope exhibit variety within a landscape element and enhance visual quality. If the wooded hill is adjacent to a flat meadow, we can see that the variety between the landscape elements also increases visual quality Finally, both of the elements have a natural appearance. They exhibit unity in meaning, and further enhance the view.

Variety among landscape elements and unity in the meaning of landscape elements across a visual composition are the concepts addressed by the procedure described here. Variety has been discussed previously as a criterion for evaluating landscape factors, e.g., vegetation, rather than for evaluating visual composition. Following the attribution of variety to individual factors, the variety of whole landscapes has been assumed to be represented by the combined variety of the factors (Forest Service, 1974; Bureau of Land Management, 1980). Variety within a landscape element may be captured by such an approach, but interactions among elements cannot be described in this way. Such an approach leaves the variety that results from the interaction among factors to be examined only implicitly.

Terms closely synonymous with variety and unity, landscape complexity and land use compatibility, have been examined in a more explicit assessment of these intereactions (Fabos and Caswell, 1976). But in application these factors have been described as components of a landscape feature, like a wetland or forested slope (Fabos, Greene, and Joyner, 1978), rather than as parts of a view. The procedure described here allows variety and unity to be examined within a visual composition.

Assessing the Effects of Visual Composition

Numerous studies have recognized the importance of composition to visual assessment. Litton's classic study (1968) described compositional types, whole landscape views characterized by salient visual properties. However, Litton's purpose was limited to landscape description, and succeeding studies of landscape compositional types have had a similarly limited intent (e.g., Tetlow & Sheppard, 1979). Preference studies have proceeded from the evaluation of whole landscape views (e.g., Zube, Pitt, and Anderson, 1974; Nassauer, 1979). But compositional effects have not been emphasized in the analysis of preference. Even effects that have been described (Kaplan, 1975) or implied (Shafer, Hamilton, and Schmidt, 1969), have not been explicitly treated in regional visual assessment procedures. So, while composition is a familiar idea in descriptive applications, and has been dealt with at least implicitly, in research, the concept has not been applied in visual assessment.

One reason for this absence might be that the extensive ground level reconnaissance and familiarity with place that have been assumed to be necessary for evaluation of composition are not within the practical limits of regional applications. Hopkins (1977) provides an excellent explanation of this and other limitations of what he terms "gestalt analysis", in which "homogeneous regions are determined through field observation, or perhaps aerial photos or topographic maps, without consideration of individual factors such as slope, soils, vegetation and so on." A comprehensive gestalt analysis of visual compositions throughout a region would undoubtedly be time-consuming beyond reason. But a strategy of sampling the region in field reconaissance, judging and describing landscape types in the field, and explicitly describing those types for location within a grid cell data set, greatly reduces the time required. In this way, visual composition can be included in regional visual assessment.

Locating Compositional Types Within a Grid Cell Data Set

Conceptual Issues

Computer mapping procedures can demonstrate compositional effects. Certainly visual composition cannot be detected solely by analysis of computer-coded data. But salient combinations of factors can be evaluated and described in field sampling and some of these, call them compositional types, can be located within a grid cell data base. The first step in the use of the procedures is the identification and evaluation of visual compositions in the field. Next, the factors that consitute the composition, i.e., the compositional type, are described. Finally, this objective description can be used to locate the compositional type in a grid cell data base.

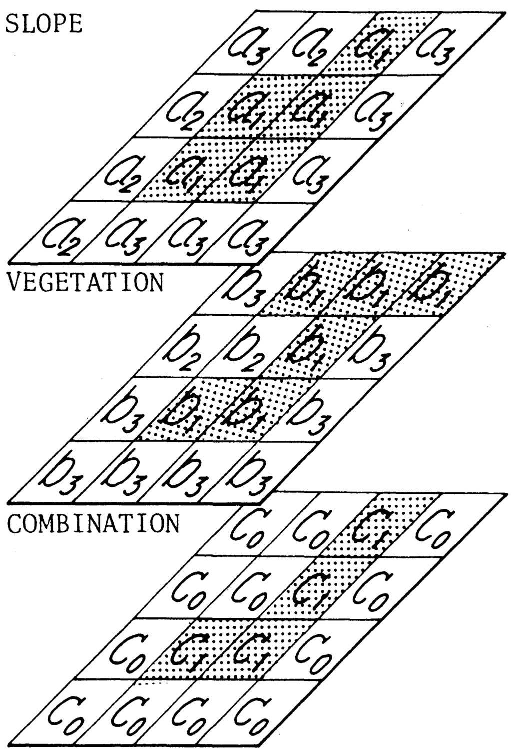
One way of locating compositional types is to combine separate landscape factors by rules rather than by mathematical equations (Nassauer, 1980). Rules do not attribute visual value directly to a single landscape characteristic, say residential land use rated at "5". Only the combination of characteristics, e.g., steep slopes with dense forest and residential land use, is evaluated. In this way, the effect of residential land use on a steep wooded slope may be described as different from the effect of residential land use on a flat open area.

However, in computer applications, the rules of combination technique is limited by the typical format for combining landscape factors: Factors are combined vertically, i.e., across factors but within a single cell as defined by the uniform grid (fig. 1). The grid cell is the only unit of analysis (a_1 or b_1 below), the only piece into which a data factor can be broken; it is also the unit of evaluation, (c_1 below), the largest unit for assessment of the region.

As the smallest unit of analysis, the grid cell suits the task of visual assessment. If the cell size is appropriate, the grid cell may capture areas of homogeneity within a factor; it will accurately describe the small area of the landscape delimited by the cell. But the vertical combination of factors within a single cell does not tell us about the interactions between adjacent landscape elements. In figure 1, we know where we have steep slopes in the same cell as dense forest, but we know nothing about the landscape context of the steep, wooded slopes. Unless we undertake the labor intensive task of coding new data sets describing the adjacencies and proportions that constitute landscape context, vertical combination cannot describe these aspects of composition. A larger unit of analysis is needed.

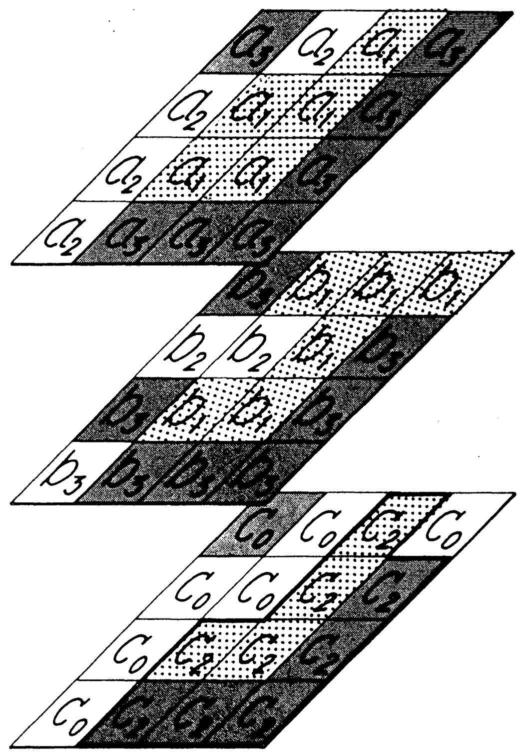
This unit of analysis should include the pattern of elements across the landscape; it should describe compositional effects. To analyze relationships across the landscape, we need a format for combining cells within a landscape factor, horizontal combination (fig. 2). Such a format would allow a unit of analysis to include many cells according to their interaction in a composition, or their compositional type. It would allow variety and unity among adjacent landscape elements to be assessed. In figure 2, we know not only where we have steep slopes and dense forest, (a_1 + b_1) but also where flat areas with row crops, (a_3 + b_3) are adjacent (c_2). We know something about the interaction of landscape elements. We now can search for the existence or number or areal proportion of those interactions within the spatial window defined by a seen area, the ultimate unit of evaluation.

FIGURE 1 - VERTICAL



Steep Slopes (a_1) + Forest (b_1) = (c_1)

FIGURE 2 - VERTICAL & HORIZONTAL



(c_1) adjacent to Flat Lands (a_3) + Row Crops (b_3) = (c_2)

With the computer programs described here, horizontal and vertical combinations are possible. Both individual cells and collections of cells located for their compositional qualities are possible units of analysis. The seen area is the unit of evaluation. Within the seen area window, the data base is searched for compositional types, and the entire seen area is evaluated as a unit for incorporation in a management scheme.

Operational Issues

Interactive computer programs with three basic capabilities were developed for the analysis of a grid cell data base. The programs were written in

FORTRAN 4 EXTENDED and utilize a CDC CYBER 74 mainframe computer. The first capability is vertical searching or sieving between factors. An example of this task would be locating all cells that have a vegetation type 4 (forest) and a slope category 3 (steep). The second basic capability entails horizontal searching which is used to determine adjacencies of characteristics either within one factor or between factors. This is accomplished by performing neighborhood searches for each element in the array. Using a chess analogy, the neighborhood may be defined by the rooks move -- examine cells with common edges, or the queen's move -- edges and vertices are examined. Width of the search radius may be specified. An example of this strategy might be: find those cells with row crops lying within one-quarter mile of forested cells. Mapping options either indicate whether the condition is met or not met, or operate in an accumulative mode, where frequency counts of met conditions are made to yield the strength of the effect surrounding each cell.

These two capabilities, vertical and horizontal searching, can be combined in a more complex strategy. First, the user performs vertical searches on two sets of multiple factors and forms two composite matrices. Then a horizontal search is initiated on the combined composite elements. An example of this search would be: 1) conduct vertical search A which yields steeply, sloped, forested cells; 2) conduct vertical search B which yields flat, agricultural cells; 3) perform a horizontal search to determine where the steeply sloped, forested cells (composite A) are adjacent to the flat, agricultural cells (composite B).

The third capability, that of determining areal proportions of certain cell types, operates within the seen area window. Using VIEWIT, (Travis, et. al., 1975) to calculate visibility from any point in an elevation matrix, a binary visibility matrix is constructed. Within the resulting window, the proportion of certain cell types within an operationally defined distance zone may be obtained. For instance, the user may determine that steep, wooded slopes cover at least three-quarters of the background of a panoramic view.

The utility of the program for visual assessment is contingent upon a sound set of rules developed from thorough field study, and/or extrapolated from preference research. The following example, in which the program was used to assess the visual quality of an 86,000 acre study area within the Shawnee National Forest of southern Illinois, demonstrates its utility.

Application to the Shawnee National Forest

The Study Area: Variety and Unity

Within the Shawnee study area, the predominant landscape type is the Shawnee Hills, an area of undulating hills and scattered prominent knobs. Stream dissection is pronounced and has resulted in deep valleys with steep side slopes. High relief and strong enclosure characterize this area. In contrast, the study area also contains a broad river valley formerly occupied by the Mississippi River. An essentially flat bottom is bordered by dramatic bluffs and an isolated bluff remnant, giving rise to broad panoramic views from above and well-defined focal views from the bottom.

Across the study area, a highly integrated land use pattern includes forest, agriculture, isolated small commercial uses, and recreation areas. Forest cover is predominantly hardwood with some softwood plantations; the area is not heavily logged. Rowcrops or pasture are typical vegetative cover for agriculture. Recreation areas are scattered throughout the National Forest.

This integrated land use pattern lends broad-scale variety to the Shawnee landscape. Farmland shares extensive sinuous edges with forest. Country churches and wooden barns dot the hills. Generally, landscape elements contribute to a sense of pastoral serenity. Occasional clearctus and powerline alignments visibly disrupt this unity of meaning.

Applied Methodology

These observations follow from analysis of topographic maps, field observations, and slides. USGS 7 1/2 minute quadrangle maps provided an initial overview of broad physiographic areas. These areas along with location of major roads were the basis for a field sampling strategy, and preliminary analysis was verified through on site inspection. Field surveys provided the most important data for evaluation and identification of compositional types. Computer coded data was also checked for accuracy in field excursions. Along with supplementary field surveys, slide analysis was the vehicle for fine-tuning the rules describing compositional types. Rules were defined to exemplify variety among elements and unity of meaning within a visual composition.

Simultaneously, a grid cell data base was developed for the study area. The cell size, or minimum unit of analysis, was 40 acres. The following factors were coded and entered into the data base: 1) vegetation type, 2) slope, 3) structures and linear features, 4) rock outcrops, 5) water features, and 6) elevation.

The vegetation and slope factors were coded on the basis of the predominant attribute of the cell. The structures, outcrops, and water feature factors were coded based on their presence or absence in a cell. The elevation data were obtained from the USGS in computer readable form; each digital elevation matrix tape contains an elevation point every 1/100th inch on a 1:250000 scale topographic map, or every 208.3 feet on the ground. The elevation matrix was sampled from this source and then interpolated to 40 acre cells.

Numerous viewsheds were generated, each representing the area seen from an important existing or planned viewer location, e.g., roads, recreation areas, trails. Each viewshed became the seen area window for a computer-based evaluation of visual composition. Four types of viewsheds were defined borrowing heavily from Litton's descriptions (1968), and rules were developed to resolve the treatment of overlapping viewsheds. For each viewshed type, rules were developed to describe compositional types. Compositional types were selected and described to communicate concomitant assessments of visual quality.

Viewshed types were distinguished on the basis of size and shape, and classified by visual inspection. Panoramic viewsheds extend at least 3 miles from the viewer and across 120° or more. Focal viewsheds extend at least 2 miles and are limited to a range of less than 60°. Enclosed viewsheds are limited in extent to less than miles 1 mile from the viewer on three sides. Remaining viewsheds are classified as matrix viewsheds, borrowing again from Litton's vocabulary. A set of rules describing compositional types was assigned to each viewshed type.

Examples: Applications of the Program

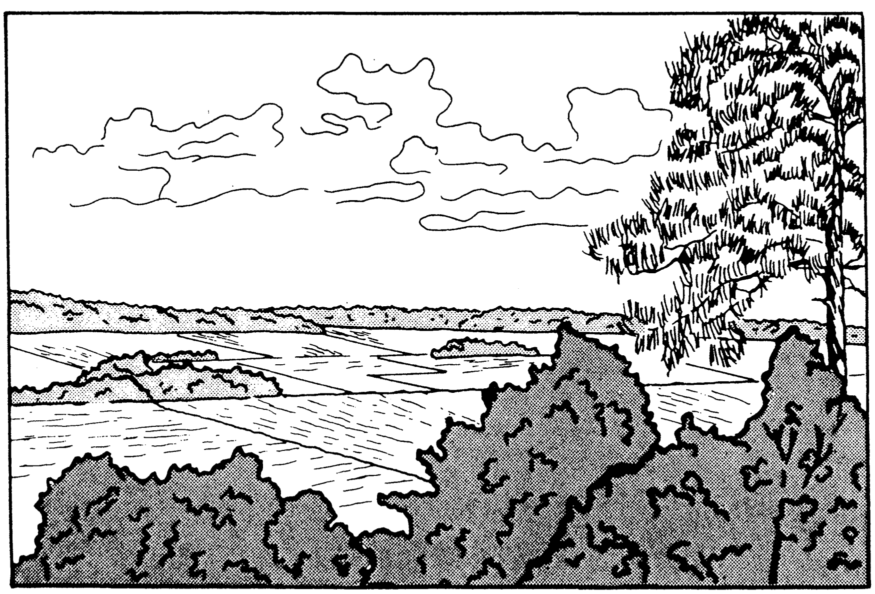
The set of rules for panoramic viewsheds is described below (fig. 3). Capabilities for determining areal proportions within a seen area window and for horizontal searching are used in locating one particular panoramic compositional type. It specifies the visual quality class of views with steep wooded slopes in the background, and a dominant forest-farmland edge with no powerline and no rock or water feature in the foreground/middleground (fig. 4). To locate this compositional type, the program would:

FIGURE 3

FOREGROUND SEARCHES → columns; BACKGROUND SEARCHES → rows

		At least 50% of view with agriculture/forest vegetation pattern				Less than 50% of view with agricultural/forest vegetation pattern			
		Powerline present in less than 10% of view		Powerline present in at least 10% of view		Powerline present in less than 10% of view		Powerline present in at least 10% of view	
		Water/rock feature present	Water/rock feature not present	Water/rock feature present	Water/rock feature not present	Water/rock feature present	Water/rock feature not present	Water/rock feature present	Water/rock feature not present
More than 75% of view with highly sloping landform	More than 75% of view with forest cover	DISTINCT	DISTINCT	COMMON	COMMON	DISTINCT	COMMON	COMMON	MINIMAL
	Less than 75% of view with forest cover	DISTINCT	DISTINCT	COMMON	COMMON	DISTINCT	COMMON	COMMON	MINIMAL
Less than 75% of view with highly sloping landform	More than 75% of view with forest cover	DISTINCT	DISTINCT	COMMON	COMMON	COMMON	COMMON	COMMON	MINIMAL
	Less than 75% of view with forest cover	DISTINCT	COMMON	COMMON	MINIMAL	MINIMAL	MINIMAL	MINIMAL	MINIMAL

FIGURE 4



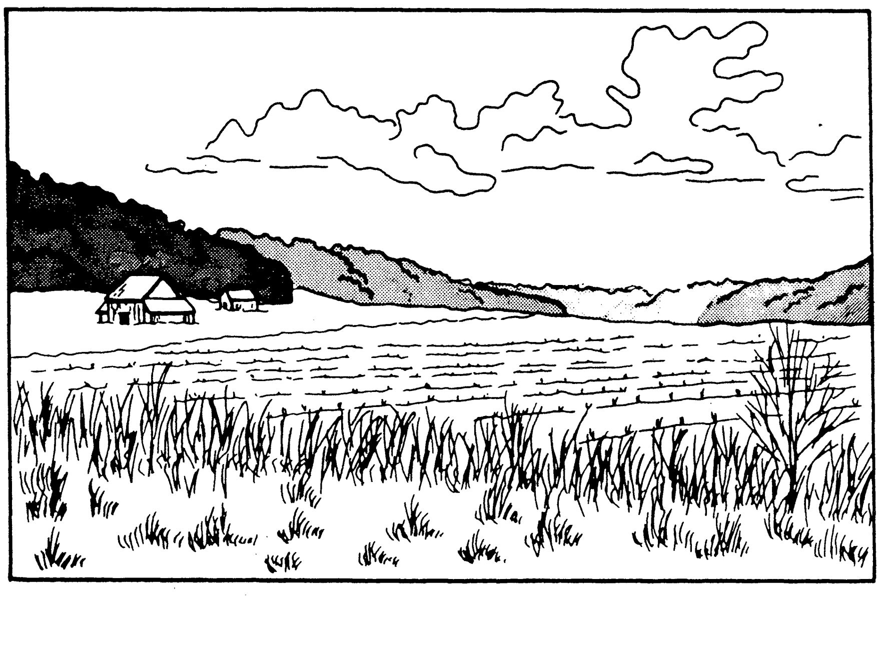
1) In the background, search the seen area window beyond 2 miles from the viewer for steep, wooded slopes. Determine the proportion of cells within the window that meet this condition. Determine whether the existing proportion meets the proportion specified in the rule. 2) In the foreground, confining the search to the seen area window within 2 miles of the viewer, do a horizontal search within the vegetation factor for forest adjacent to farmland. Adjacency is defined in this case by the queen's move within a quarter mile. Next the program would determine whether the proportion of cells meeting the adjacency condition meets the proportion specified by the rule. 3) In the foreground, identify powerlines, and determine whether the proportion of powerline cells in the foreground is less than 10%. 4) Determine whether rock or water features exist in the foreground. 5) Determine whether both distance zones meet the conditions specified by the rule.

A rule for focal viewsheds illustrates the capability for following two vertical searches with a horizontal search (fig. 5). Views with farmsteads on flat agricultural land adjacent to forested slopes without powerlines comprise this compositional type (fig. 6). To locate it, the program would: 1) Do a vertical search of the window for farmsteads on flat agricultural land, and retain the resulting composite matrix. 2) Do a vertical search of the window for forest on steep slopes, and retain the resulting composite matrix. 3) Do a horizontal search of the combined composites for farmsteads on flat land adjacent to forested, steep slopes. 4) Identify powerlines, and determine whether the proportion of powerline cells is less than 10%.

FIGURE 5

	At least 50% of view with flat farmland adjacent to forested slopes		Less than 50% of view with flat farmland adjacent to forested slopes	
	Presence of 1 or more farmsteads by forested slopes	Farmsteads by forested slopes not present	Presence of 1 or more farmsteads by forested slopes	Farmsteads by forested slopes not present
Powerline present in less than 10% of view	[illegible]	COMMON	COMMON	MINIMAL
Powerline present in at least 10% of view	COMMON	MINIMAL	MINIMAL	MINIMAL

FIGURE 6



Summary

The program described here allows visual composition to be assessed on a regional scale. As is true in any computer-based landscape evaluation, the validity of the program's output is dependent upon the soundness of the user's judgments. In this case, familiarity with field conditions is a necessity. Compositional types evaluated and observed in the field, can then be described by rules for location over a region. The program searches a grid-cell data base for adjacency and areal proportion characteristics in locating compositional types. No additional coding of these characteristics is necessary. The characteristics are identified within a seen area window, consistent with their co-occurrence in a single visual composition. Many of the conditions salient to visual experience on the ground can be identified by the program. Users are provided with an efficient means of including visual composition in regional visual assessment.

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