

Complexity and Valued Landscapes¹

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Abstract: The variable "complexity," or "diversity," has received a great deal of attention in recent research efforts concerned with visual resource management, including the identification of complexity as one of the primary evaluation measures. This paper describes research efforts that support the hypothesis that the landscapes we value are those with perceived diverse and variable environments.

INTRODUCTION

In the following discussion, the terms "complexity," "diversity" and "variety" are used interchangeably. As defined here, the three words are all related to opportunities available in a given environmental setting. It is hypothesized that:

The most complex or variable environments offer the greatest potential for quality experiences. The landscapes that we value would be those that maintain a variety of recognizable entities (rather than unordered diversity which is simply confusion). Such variety can be either within place (diversity) or from the norm (uniqueness or rarity). To search for valued landscapes is a process of noting variety or complexity.

The following expression would represent linear form of the proposed hypothesis.

$VL = TS, MA, P.$

where

$VL =$ valued landscapes

$TS =$ time and scale

$MA =$ measurable attributes

$P =$ perceptions

The specification of time period (era) and scale (boundary conditions and unit size) allow the other measurable attributes to determine the importance of a cultural or natural resource being examined. Often linear changes in time or scale will introduce non-linear changes in measurable attributes. As a consequence: a) time and scale can alter the manner in which an entity can be measured and b) properties may emerge at one time or scale of consideration but not at another.

This difference in measurable attributes of complexity can be presented by the following descriptors (the initial idea of such an evaluation of measurable attributes was presented by the author in an earlier paper, Zube et al. 1978).

rarity: the state of being permanently infrequent, the only one or one of remaining few.

uniqueness: archetypal, the best of its kind.

Part of a complex; diversity:

- 1) an ensemble of different landscapes;
- 2) a network of varied landscapes.
- 3) a permanent, periodic or seasonal series of natural or cultural processes.

Perceptions constitute the entire range of individual, societal and political concerns that affect the selection and management of natural and cultural resource areas. In a mathematical sense, these concerns are the coefficients or weights that influence the measurable attributes.

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If a relationship could be demonstrated between independent measures of landscape complexity and perceived environmental quality, then a preliminary verification of the above hypotheses could be made. This paper describes research efforts that reinforce those assertions. This study includes:

1. Identification of different study areas representing a variety of ecosystems and levels of complexity.
2. Data collection of information about the areas including remote sensing and in situ techniques.
3. Independent assessment of complexity levels from the collected data.
4. Independent assessment of environmental quality/visual interest of sites within the study areas.
5. Correlation and analysis of relationships.

METHOD

Study Areas

Data for this research were collected from a series of transects throughout southern Arizona. The basin and range landform conditions of this region have resulted in a variety of ecosystems. A number of different classification systems have been proposed as descriptors of these different plant and animal communities (Lowe and Brown 1973, Shreve and Wiggins 1964). The communities in which transects were laid out include: 1. Montane coniferous forest, 2. riparian deciduous woodland, 3. encinal and mexican oak woodland area, 4. plains and desert grasslands. To illustrate the arguments of this paper two specific transects and two study areas within this range of communities were selected:

1. Plains and desert grassland--A grama grass (Bouteloua spp.) dominated community. The specific study transect described throughout the remainder of this paper is located in the San Rafael Valley, Santa Cruz County, Arizona, at a mean elevation of 4900' (1490 m.). The study area is 3.4-miles long and 2.0-miles wide (5.6 x 3.2 km.). Occasional wet areas or "cienagas" throughout the site give rise to some riparian vegetation which are utilized by the rancher-owners of the land to form earthen water "tanks." The primary land ownership is private and the use is essentially ranching/beef production.
2. Riparian woodland - an ecologically diverse community typically restricted to

permanent or periodic water courses along canyon or arroyo sites. Distinctive wildlife and plant communities distinguish these areas from surrounding arid areas. The study transect utilized in this paper is located near the town of Patagonia, in Santa Cruz County, Arizona. At a mean elevation of 4300' (1300 m.) the site is dominated by woody vegetation, predominantly Fremont Cottonwood (Populus fremontii), and Arizona Sycamore (Platanus wrightii). The study area is 3.4-miles long and 2.1-miles wide (5.4 x 3.4 km.). The ownership within the area includes a non-profit conservation organization and individual private holdings. The uses of the area are principally related to nature appreciation.

For the purposes of this paper it was deemed important to select two rather different study areas to illustrate a partial proof of the advanced hypotheses. It is important to add, however, that in examining other transect areas throughout the southern Arizona region similar results were identified as those presented in this paper.

Data Collection

In addition to extensive in situ investigations and collections of existing data, a great deal of information was collected expressly for this study. In the summer of 1977 through the spring of 1978 a series of aerial photographic missions were conducted over all the communities/study area transects noted previously. On each of these multi-day, multi-seasonal studies a two 35-mm camera bank system was utilized. One camera was loaded with normal color slide film and the other camera with color infrared slide film. The importance of multi-seasonal aerial photography has been noted before (McCarthy 1972). From the information collected from these oblique photographs it was determined to subcontract for a professional aerial photographic mission during March 1978. The resultant stereo 9" x 9" color infrared (02443) film transparencies were at a scale of 1" = 1000' or 1:1200. The rationale for early color infrared aerial photography and the resulting information relative to the emergence characteristics of plants have been documented (McCarthy 1972). Zube (1974) has shown that aerial photographs can be a major data source for regional scenic inventories. The final collection of data consisted of this described color infrared photography and traditional sources (i.e., U.S.G.S. maps, in situ site evaluations, etc.).

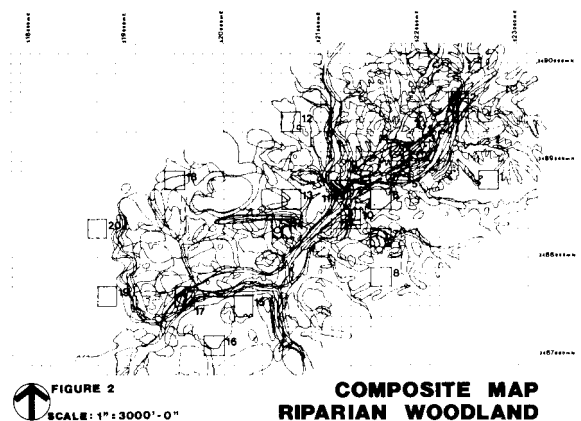
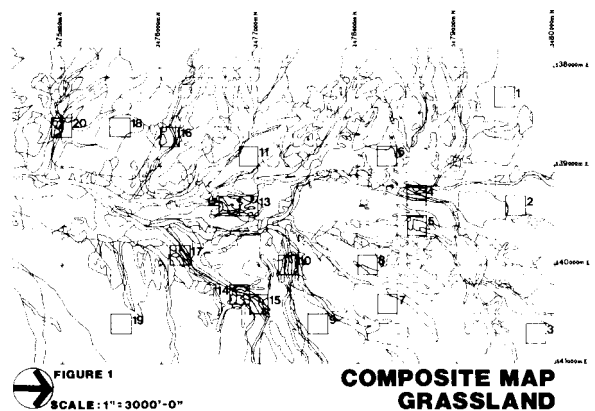
Data Analysis

Procedure

It should be remembered that a goal of this research design was to produce two independent measures of both resource complexity and perceived environmental quality. Therefore, the procedures utilized emphasized separate analysis techniques. In order to assess resource complexity advanced students trained in air photo interpretation and land analysis studies were instructed to create overlay maps of landscape units. This method has recently been expanded by work done by Fuller and Fish (1978) Rodiek (1978) and Frondorf *et al.* (1978). The basic concepts, however, still reflect the ideas of Christian and Steward (1968). In this experiment landscape units were defined by both those traditional measures (i.e., water features, unique attributes, landforms as interpreted by stereo images, etc.) and the color variation noted on the color infrared film as exemplary of vegetational difference. From the combination of these features composite maps of landscape units were delineated.

Superimposed on these final landscape unit composite maps for both the grassland site and the riparian woodland study area was a network grid of the cells that were aligned with the Universal Transverse Mercator System (UTM). Knowing that, at a later time, "on the ground" photos would be taken, a sample cell size of 2 hectares on a side was chosen. The overlay of the UTM system enabled analysis of those grid cells which revealed the most resource complexity as defined by the composite landscape units. From this analysis the 10 most complex cellular units and the 10 least complex units were identified. A total of 20 cells were thus identified for the grassland area and 20 cells for the riparian woodland study area. Figures 1 and 2 illustrate the grid cell overlay superimposed over the composite landscape unit map, with the 20 identified cells shown for each study area.

Maps of the twenty identified cells were given to different students for the purpose of taking photographs "on the ground" to represent the identified cells. Photographs have been shown in other work to be representative of actual site conditions (Daniel and Boster 1976). The students were instructed to identify the center of each cellular unit on the ground using the air photos as an assistance. At each center they were to take a representative photographic print in the same direction so that backgrounds would be similar. All on the ground photographs were taken in March of 1979 to correspond with the color infrared aerial photo-



graphic transparencies taken in March of 1978. The resulting slides and photographs would be used for later perception analysis. That analysis and mode of presentation are described in the following sections. The entire procedure can be represented by figures 1 through 6. Figures 1 and 2 are the composite landscape unit maps for both of the study areas. Figures 3* and 4* are taken from the color-infrared transparencies that were used as a basic data source for the study. In both figures 3* and 4*, specific cellular units are identified that can be examined relative to the earlier composite maps. Figures 5* and 6* illustrate cellular units as illustrated in both the composite maps and the color-infrared photography (i.e., cellular unit #5 grassland, #11 riparian woodland).

Subjects

The subjects used to view the "on the ground photographs" were varied in their background. They (N-60) were drawn from graduate students in resource studies-related disciplines at the University of Arizona and from citizen participants within the Tucson, Arizona, community.

*See color illustration on page 389.

Mode of Presentation and Analysis Technique

The experiments were carried out in small classrooms and home settings. For each area the respondents were asked to rank order a series of 13 photographic prints. The number 13 was arbitrarily selected by the author as a reasonable number to ask respondents to rank order. A random selection of cells was selected from the possible twenty cells to represent the thirteen utilized photographs. The respondents were not informed of any of the previous work relative to complexity that had been undertaken. In each test and subsequent iteration respondents were asked to rank order the photographs (from best to worst) on the basis of perceived environmental quality and visual interest.

Consensus on the rank order of each image relative to its respective study area was determined through a delphi process. Delphi analysis elicits and refines opinion through iterative analysis (Helmer and Rescher 1959, and Dalkey *et al.* 1972). In none of the experiments was it necessary to go beyond two iterations of testing before the author was satisfied with the expressed convergence. Measures of central tendency (the median) and dispersion (upper and lower quartiles) were produced with this technique as a result of all the respondents inputs.

RESULTS AND DISCUSSION

As a concept, the notions of complexity, diversity and variety have received considerable support as a measure of environmental quality and a means of designing and planning. Greenbie (1976) has recently advanced a planning approach based on an ethological recognition of diversity. In a similar manner a number of ecologists beginning with Margalef (1963) have long supported a "diversity - stability" argument relative to a perceived "good" for various ecosystems. Two of the more recent reviews of the ecological diversity concept are those advanced by Goodman (1975) and Ehrenfeld (1978). In addition to the theoretical arguments made; a number of measures of diversity exists in the ecological literature. Most such measures are based on information theory such as the work by MacArthur and Wilson (1967). Other techniques have been based on probability (e.g., Hurlbert 1971) or dimensional or distance measures (McIntosh 1976). As described in this paper however, complexity is a term defined as the number of opportunities present. This concept is more in alignment with the argument made by Cherem (1973) on "change dimensions."

In contrast to the positive studies noted

above a number of other research efforts have challenged the concept of complexity by alluding to an optimum level of stimulation along a continuum of complexity. (Wohlwill 1968). In particular Wohlwill (1968) suggests that functions of visual exploration follow an inverted "U"-shaped trend illustrating a decline after complexity reached a certain point. The results of the research reported in this paper do not support this contention or the conclusion that increased complexity and increased preference are directly related along a linear ascending continuum. Although Wohlwill's research included both "nonsense symbols" and slides of cultural and natural environments, it is doubtful if a natural environment can become too complex so as to exclude preference. Such disagreement indicates the need for continued research into the concept of complexity and preference for valued landscapes.

The results of the research described here reveal a direct relation between perceived environmental quality and independent measures of resource complexity. The following tabulation for the two study areas illustrates the 1) cell number, 2) final median rank, 3) final lower quartile rank and 4) final upper quartile rank: (all rankings are expressed as 1=best to n = worst).

Grassland study area:

Cell Number	Median Rank	Lower quartile Rank	Upper quartile Rank
1	11	12	10
2	11	11	10
4	1	2	1
5	4	4	2
6	11	12	8
8	7	8	6
9	7	7	5
11	7	8	6
13	6	8	5
14	3	4	2
15	3	3	2
18	9	9	7
20	4	4	3

Riparian Woodland study area:

Cell Number	Median Rank	Lower quartile Rank	Upper quartile Rank
2	2	2	2
3	6	8	6
4	8	9	8
5	4	5	3
6	8	12	7
9	6	8	6
11	2	2	1
12	12	13	9
13	12	13	12

Cell Number	Median Rank	Lower quartile Rank	Upper quartile Rank
14	2	3	2
15	9	10	6
16	12	13	10
19	9	9	7

The figures 1 and 2 should be examined in relation to the above tabulation for ease of understanding. The importance of the statistical construct provided by the delphi analysis is that the researcher sees not only the upper and lower ranking but also both the relative dispersion.

It is tempting to try to relate total number of lines per cellular unit as shown on figures 1 and 2 to a direct one to one ordinal ranking based on environmental quality and visual interest. (i.e., that the single cell exhibiting the most complexity would also be the specific site that is judged by the respondents as having the most environmental quality and visual interest.) The results do not reveal this to be true. However, it can be asserted from the experiments described here (and other on-going research) that all the cells/specific sites with a large amount of resource complexity were also all the areas perceived as having the highest quality.

SUMMARY

This discussion has attempted to begin to validate the hypothesis that variable environments; landscapes exhibiting multiple opportunities, offer the greatest potential for quality experiences. Although the work reported here is preliminary and still ongoing the tentative results suggest that independent measures of resource complexity are positively related to scenes perceived by groups of respondents as possessing a high degree of environmental quality. Although this is not a direct one to one relationship, there is enough consensus that one can assert that areas of high complexity will also be perceived as valued landscapes.

NOTES

3. The research described in this paper was partially supported by a grant entitled "Identifying, Designating and Managing Arizona's Critical and Prime Environments" from the U.S. Department of Agriculture, under the Hatch Act.
4. Certain of the ideas presented here were first presented by the author to the Scenic Resource Task Force of the Heritage Conservation and Recreation Service. Those

concepts were later included in the evaluation section of the Task Force report Zube *et al.* (1978) and later summarized by Pitt (1978). In addition the comments and ideas of graduate students in a class taught by the author for the past three years "Critical/Significant Environments" are interlaced throughout this paper.

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