



A computerized visual resource analysis system based on landscape view preferences as tool in recreation subdivision planning
by Roger Rae Sandiland

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Agronomy
Montana State University
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Abstract:

In recognizing the need of resource managers and developers for quantitative assessment of the visual resource, a sample population of Bozeman, Montana area residents was surveyed as to view preference using a set of photographs taken from the Story Hills Planned Unit Development. Through statistical analysis the significant differences in the order of preference of landscape scenes based on landscape zones was determined. The most preferred photographs had all three landscape zones. The next preferred photographs had two of the landscape zones present, either immediate and intermediate zones or immediate and distant zones. Least preferred were photographs containing only the immediate zone.

Using this preference ranking, two computer programs were written that produced a printout which was made into an overlay for a map of a portion of the Story Hills Planned Unit Development. The overlay outlines areas that have preferred vistas from them.

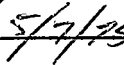
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Date

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A COMPUTERIZED VISUAL RESOURCE ANALYSIS SYSTEM
BASED ON LANDSCAPE VIEW PREFERENCES AS A TOOL
IN RECREATION SUBDIVISION PLANNING

by

ROGER RAE SANDILAND

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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ABSTRACT

In recognizing the need of resource managers and developers for quantitative assessment of the visual resource, a sample population of Bozeman, Montana area residents was surveyed as to view preference using a set of photographs taken from the Story Hills Planned Unit Development. Through statistical analysis the significant differences in the order of preference of landscape scenes based on landscape zones was determined. The most preferred photographs had all three landscape zones. The next preferred photographs had two of the landscape zones present, either immediate and intermediate zones or immediate and distant zones. Least preferred were photographs containing only the immediate zone.

Using this preference ranking, two computer programs were written that produced a printout which was made into an overlay for a map of a portion of the Story Hills Planned Unit Development. The overlay outlines areas that have preferred vistas from them.

INTRODUCTION

Too often in the past the visual resource has been treated in a most superficial manner. Time and time again it is not even mentioned in natural resource inventories or environmental impact statements. A few sentences describing "beautiful" views or the number and distance of the possible views from an area have been considered as a treatment of the visual resource. The other side of the coin, what the public will have to look at after a proposed development or action, has often been inadequately treated. Today with the public's awakened environmental awareness and the fact that environmental degradation is often first mirrored in the visual resource, numerous visual analysis systems are being developed.

This research effort concerned the problem of predicting or modeling preferred landscape vistas. Through a survey, preferences for landscapes based on zones visible and landscape components of the zones were to be established. A computer program to analyze the vistas from a study area in the Story Hills Planned Unit Development northeast of Bozeman, Montana and printout a formula of the visible landscape from the study area was then needed. The formula was to contain the area of the zones visible from the study area and the landscape components of the immediate zone. Using the formula, the computer was then to produce a printout to be made into an overlay of the Story Hills Planned Unit Development. The overlay was to identify the quality of the vistas from potential home sites in the development.

LITERATURE REVIEW

"Eighty-seven percent of man's perception is based on sight".
(U. S. Department of Agriculture, 1973).

Assuming this statement to be true or even a rough estimate, the paucity of research devoted to discovering just what constitutes an aesthetic vista is appalling. The need for research in the visual resource field has been expounded on by persons ranging from philosophers and psychologists to resource managers and landscape architects. (Thayer 1974, Shafer 1969, National Science Foundation 1973, Hamill 1971, Craik 1971, Diffey 1967).

Man's activities, almost without exception, have some effect on the visual resource and as Litton (1972) points out, "Neither extractive industries in particular nor resource management efforts in general have given much recognition to the visual modifications in the landscape that are the outcome of their actions or decisions". Litton goes on to explain the awakened environmental awareness in the general public today and that critic's charges of insensitivity and environmental degradation is most often triggered by effects on the visual resource. "Yet all the while the notion of a landscape as a special kind of visual composition that creates an environment seldom emerges with clarity". (Litton 1972).

The evaluation of non-monetary benefits of man's activities is difficult at best. At the same time economic analysis of man's activities that lend themselves to cost-benefit comparisons are common place. (Leopold 1969). Recently, however, this field of

economic intangibles is being explored. Economic models for the intangible benefits are being developed and used. (Coomber 1973, VanderRyn 1963, Washington Environmental Research Center 1973, National Science Foundation 1973).

Thayer (1974) in his opening remarks at the National Recreation and Parks Association Annual Convention in Denver referred to "years of total neglect by the behavioral sciences" in the study of man in his physical environment. He further states, "In the wide field of planning and design for recreation, the need for predicting human response to the environment is paramount". The rest of Thayer's presentation outlined thirteen major areas of research which make up the field of environmental psychology, one of which is outdoor recreation and response to landscape.

Craik (1971) gives a brief review of five components to be studied in the comprehensive analysis of places (environments). The five components are: 1) physical-spatial properties, 2) organization of entities and components, 3) traits of places, 4) behavioral attributes of places and 5) the institutional attributes of places. Craik also includes an extensive bibliography of researchers in each of these fields.

Craik (1972) in his studies of human response to landscapes distinguishes among three types of reactions: descriptive assessments, evaluative appraisals, and preferential judgements. The rest of this work detailed development of Landscape Rating Scales and Graphic Land-

scape Typology which are examples of descriptive assessments of landscapes but can be related to the two other reactions.

In recognizing the need for quantitative analysis of the landscape various techniques have come about for landscape inventorying and description (Litton 1968). The U. S. Forest Service in trying to manage its vast acreages in the multiple use concept has developed management tools based on analysis of the visual resource (Litton 1973, U. S. Department of Agriculture 1971, 1973, 1974).

Quantitative measurement and assessment of the visual resource is being developed in many diverse fields of study. Physically, pupillary response to forest scenes has been used to measure aesthetic reactions (Wenger 1968). The comparison of different factors among river scenes has been used to quantify the visual resource (Leopold 1969). Leopold considered physical, biological, and human interest and use factors, and then developed uniqueness ratios of these factors to compare river scenes.

Hecock (1970) in his discussions of behavior patterns of beach users at Cape Cod analyzed many different factors: availability, development of nearby beaches, and demographic data of users, along with the physical characteristics of the beaches. Peterson (1960) in analyzing Lake Michigan beaches was specifically interested in the user response to the visual environment and developed methodologies to predict and model this response. Peterson first analyzed photographs of the beaches for gross visual characteristics and used user's free

responses and semantic differentials (the ranking of each photograph from good through bad) in constructing his models.

Shafer (1969) used photographs from around the United States of various natural landscape scenes to construct a mathematical model for predicting human response to the landscape. Photographs were ranked by interviewees and a preference score was computed. Through factor analysis and multiple regression analysis an equation was developed using six measurable components of the photographs that accounted for 66% of the variation among preference scores.

Carls (1974) using Shafer's methodology predicted the effects of man and his activities on preferences for landscape scenes. He concluded that the presence of man or his actions in photographs of outdoor scenes diminishes preference for those scenes.

Needed research and developed methodologies in the forementioned categories are outlined and analyzed in Coomber (1973), Washington Environmental Research Center (1973) and National Science Foundation (1973).

Research in measuring the visual resource in the urban environment has been done by VanderRyn (1963). The conclusions reached after this research were: that people do have a consistent value structure when rating views of the urban landscape, and economically "quantitative value differences can be obtained in cases where only one or very few significant changes are made in the visual surroundings".

MaGill (1965) has published a guideline for the photographic

recording of aesthetic and biologic changes. The guideline suggests a method of setting up permanent camera points, recording and analyzing visual conditions over a period of time, and the keeping of photographic records.

Amidon (1968) developed a computer program (VIEWIT) which can quickly and accurately predict the area visible from a given point. Elsner (1971) applied the VIEWIT program to a resource study in the Black Hills National Forest, South Dakota. The program produced overlay maps of visible areas from proposed scenic tramline routes and existing highway scenic vista lookouts.

METHODS AND MATERIALS

The area selected for the study of landscape view preferences was the Story Hills Planned Unit Development. The development is located in Sections 2, 3, 4, and 5 in Township 2S, Range 6E and is situated northeast of Bozeman, Montana (Figure 1). The area has been utilized primarily for livestock grazing with the exception of about 200 acres in the south portion of Section 4 which has been intermittently cropped (Overturf, Strand & Assoc., 1974). The area has also been used by local residents for hiking and horseback riding.

The development provides many diverse landscape types and features ranging from relatively flat native grasslands and sagebrush hills to steep wooded hillsides and coolies with thick pockets of shrubs and deciduous trees. There are also many diverse vistas from the Story Hills.

Familiarization of the area with air photographs and topographic maps, and on site inspection yielded various sites to take photographs. The sites were chosen for landscape variability and high probability of becoming future homesites. The sites were permanently marked with wooden survey stakes and small blue flags, and were recorded on an air photograph. All but four pictures were taken between June 13 and June 18, 1974 and from 8:35 A.M. to 2:30 P.M. Mountain Daylight Time. Photographs facing westerly and northerly were taken in the morning and those facing easterly and southerly were taken in the afternoon. The four other pictures were taken on July 10 and were retakes of evergreen tree close-ups. To keep light intensity a relative constant and to reduce the

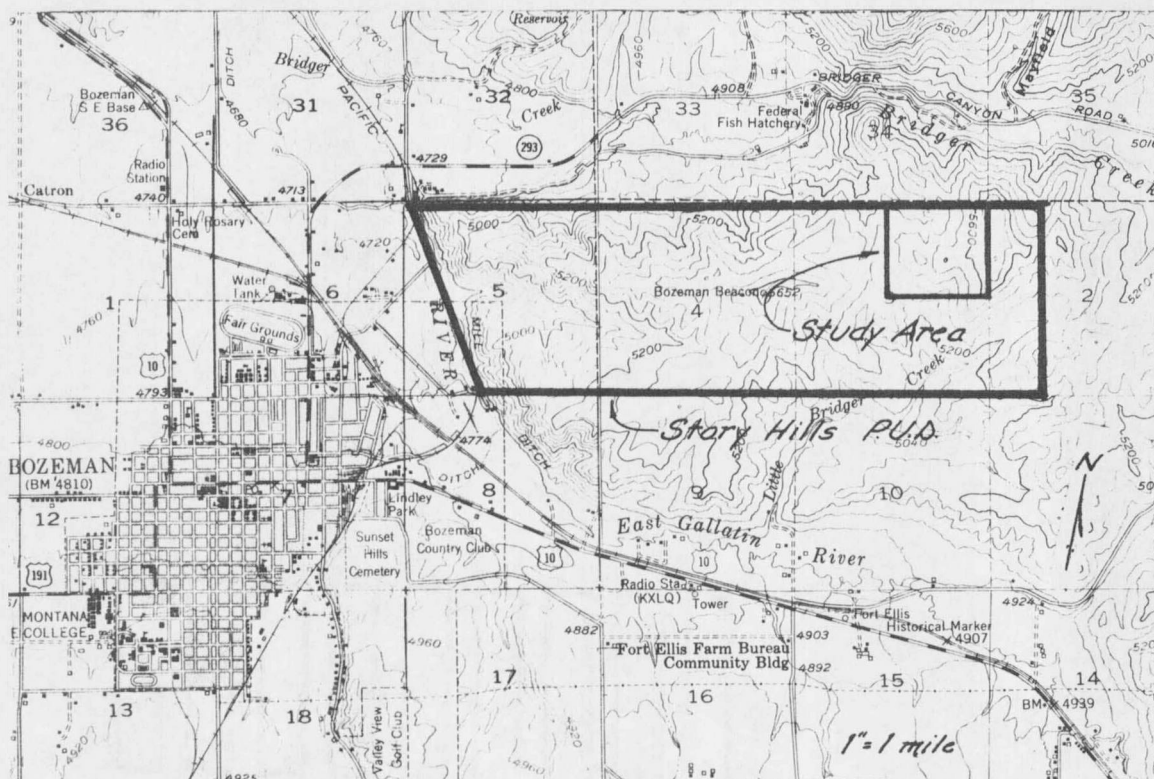


Figure 1. Story Hills Planned Unit Develop (P.U.D.), location of view preference study area northeast of Bozeman, Montana, 1974. (From U.S.G.S. 15 minute series topographic map, Bozeman Quadrangle, Montana - Gallatin County. 1953).

complexity of photographs, no photographs were taken when cloud cover was greater than 10%. The photographs were taken with a Pentax Spotmatic II, 35 mm single lens reflex camera with Pentax lenses, 50 & 28 mm. The camera was mounted on a surveyor's transit and as each photograph was taken the horizontal and vertical angles read from the instrument were recorded. A diary was thus kept for each photograph recording: site number, date, time of day, percent cloud cover, horizontal angle, vertical angle, lens, and camera setting (f-stop and shutter speed). Notes were added recording the landscape zones that were in each photograph. A total of 77 photographs were taken at 19 sites. This number was reduced to 20 photographs during preliminary screening. A set of 10 photographs was finally selected that would be representative of different landscape zones. Photographs 1 and 2 represented only the immediate landscape zone (see Figures 2 and 3); photograph 4 represented the immediate and intermediate landscape zones; photographs 5, 6, and 7 represented the immediate and distant landscape zones (see Figure 4); and photographs 3, 8, 9, and 10 represented all landscape zones (see Figures 5, 6, and 7). The landscape zones were modelled after Shafer's (1969) where in the immediate zone the characteristics of individual leaves, bark, stems, or needles were distinguishable; in the intermediate zone the outlines of individual trees and shrubs are recognizable, and in the distant zone, groves or areas of vegetation cover are discernible but individual plants are not. The ten 35 mm Ektachrome X slides were enlarged to 8" by 10" for the preference survey.



Figure 2. Photograph number 1 containing immediate zone only used in Story Hills View Preference Survey, Bozeman, Montana, 1974.



Figure 3. Photograph number 2 containing immediate zone only used in Story Hills View Preference Survey, Bozeman, Montana, 1974.



Figure 4. Photograph number 7 containing immediate and distant zones used in Story Hills View Preference Survey, Bozeman, Montana, 1974.



Figure 5. Photograph number 3 containing all three landscape zones used in Story Hills View Preference Survey, Bozeman, Montana, 1974.



Figure 6. Photograph number 8 containing all three landscape zones used in Story Hills View Preference Survey, Bozeman, Montana, 1974.



Figure 7. Photograph number 9 containing all three landscape zones used in Story Hills View Preference Survey, Bozeman, Montana, 1974.

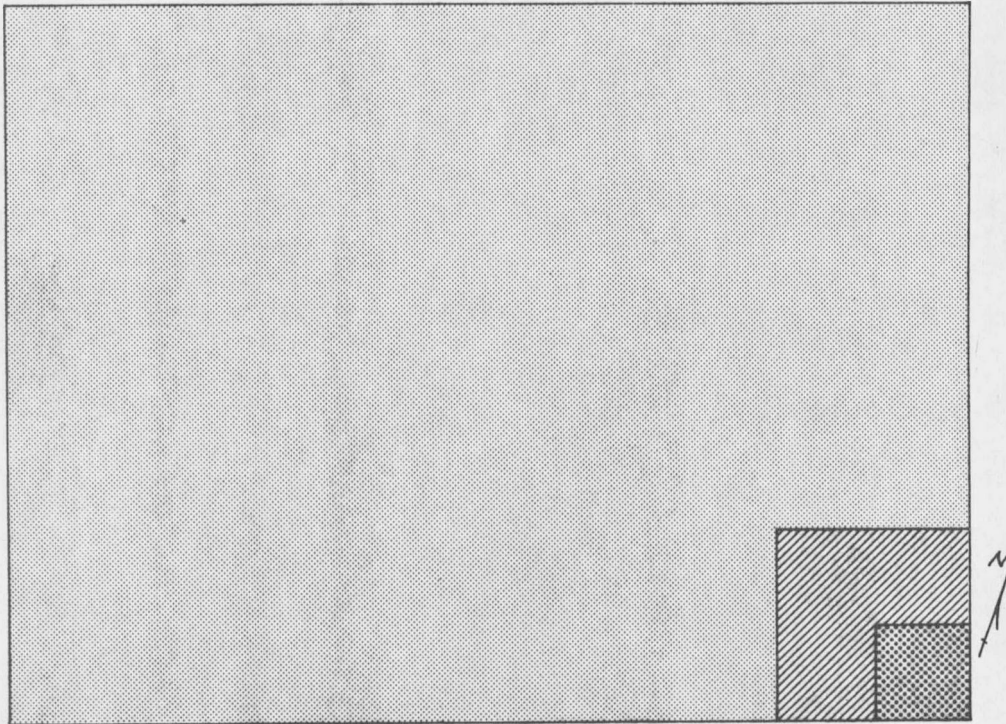
During the survey persons being interviewed were asked to rank the photographs as to preference and fill out a questionnaire (see Appendix 1). Along with demographic data the effects of place of rearing, art training, leisure interests and occupation on landscape preference were thought important. In the interests of time and to survey a cross section of age groups entire families were interviewed. The families were chosen out of the Bozeman, Montana telephone directory by selecting the name that was a set number of inches up or down in a certain column. Initial contact was made over the telephone and the study was explained. A time was then set for the actual survey. A total of 115 homes were called, some of them up to 4 or 5 times. Seventy-three calls were completed which resulted in 82 interviews at 38 homes. Nineteen families refused to be surveyed and the rest of the calls were to disconnected phones or the family had moved. The homes surveyed were plotted on a Bozeman, Montana zoning map and care was taken to survey families from all zoning districts and also include families living out of the city limits. During the actual survey the same format was followed. The study was explained to the assembled family, each member of the family was asked to rank the set of photographs independently and then fill out a questionnaire. The criteria for ranking the photos was that the pictures represented the view out of the picture window of the home. The photos were shuffled between rankings. The survey was conducted from August 3, 1974 through October

15, 1974.

A preference score was calculated for each photograph using the preference ranking of the photographs by the interviewees. For each interviewee the most preferred photograph was given 10 points and so on down until the least preferred photograph was given only one point. The preference score is the mean of all points for each photograph. A planimeter was used to measure landscape zones and areas of vegetation.

Analysis of variance, regression analysis, F-test, T-test, Duncan's Multiple Range Test and Bartlett's test for homogeneity were used in data analysis. Standard deviations (S.D.) were used in assessing the sub-population's agreement on ranking of the photographs.

The computer programs for mapping homesites based on preferred landscape vistas are modifications of Amidon's (1968) program (Appendix II and III). The programs were written by Gail Linnell, a graduate student in the Montana State University Mathematics Department. Different sized cells were used for each landscape zone. The study area (Figure 1), divided into cells 50' x 50', is the NE $\frac{1}{4}$,S3,T2S,R6E. The intermediate zone, divided into cells 330' x 330', is comprised of N $\frac{1}{2}$,S3,T2s,R6E and S $\frac{1}{2}$,S34,T1S,R6E. The distant zone is comprised of the surveyed sections for 30 miles north and 40 miles west of the study area (Figure 8). The elevation above sea level at the middle of each cell was interpolated from topographic maps and entered into the computer. Also for the immediate zone cells the vegetative landscape component; either grass, shrubs, deciduous trees or evergreen trees, derived from air






-  - Story Hills Study Area
Immediate zone - divided into a grid of cells each 50' x 50', covers an area $\frac{1}{2}$ mile x $\frac{1}{2}$ mile.
-  - Intermediate zone - divided into a grid of cells each 330' x 330', covers an area 1 mile x 1 mile.
-  - Distant zone - divided into a grid of cells each 1 mile x 1 mile, covers an area 30 miles x 40 miles.

Figure 8. Representation of grids programmed for computer analysis of views from Story Hills Study Area, Bozeman, Montana, 1974.

photographs superimposed on the topographic maps was entered into the computer. The height of the shrubs and trees was then added to the ground elevation to account for vegetation screening.

The basic process of determining the visible areas from each of the cells in the study area is a trigonometric function of distance between cells and their elevation (Figure 9). The computer was programmed to scan a 90 degree sector NW of the study cell, to scan from 0' to 100' or 2 cells in the immediate zone NW of the study cells, to scan from 100' to 1640' or 8 intermediate cells NW of the study cell and to scan all of the distant cells for each cell in the study area (Figure 10). A printout was generated that yielded the number of cells in the distant zone and in the intermediate zone, and for the immediate zone the number of cells of grass, shrubs, deciduous trees and evergreen trees was printed. A final printout made into an overlay for the study area was produced. The overlay when superimposed over a map of the study area reveals the composition of the view from each study cell.

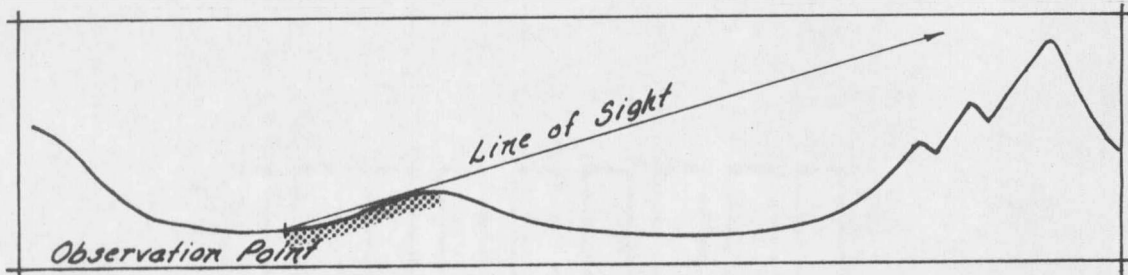


Figure 9A. Only immediate zone visible.

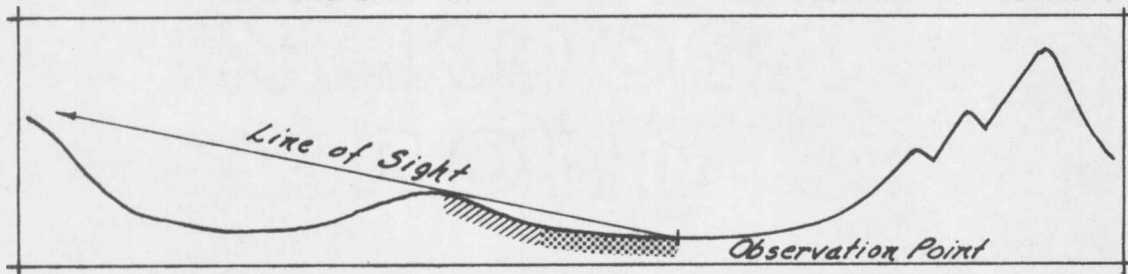


Figure 9B. Immediate and intermediate zones visible.

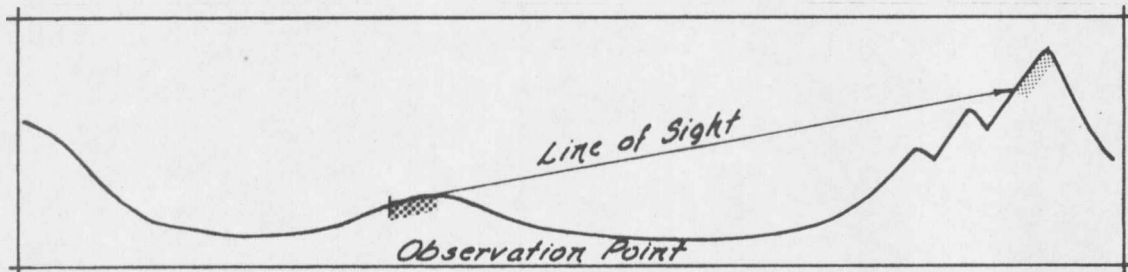


Figure 9C. Immediate and distant zones visible.

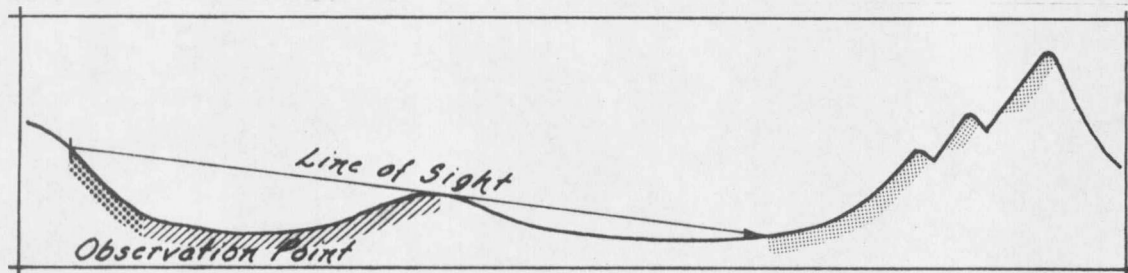


Figure 9D. All zones visible.

Figure 9. Examples of zones visible from different observation points or cells.

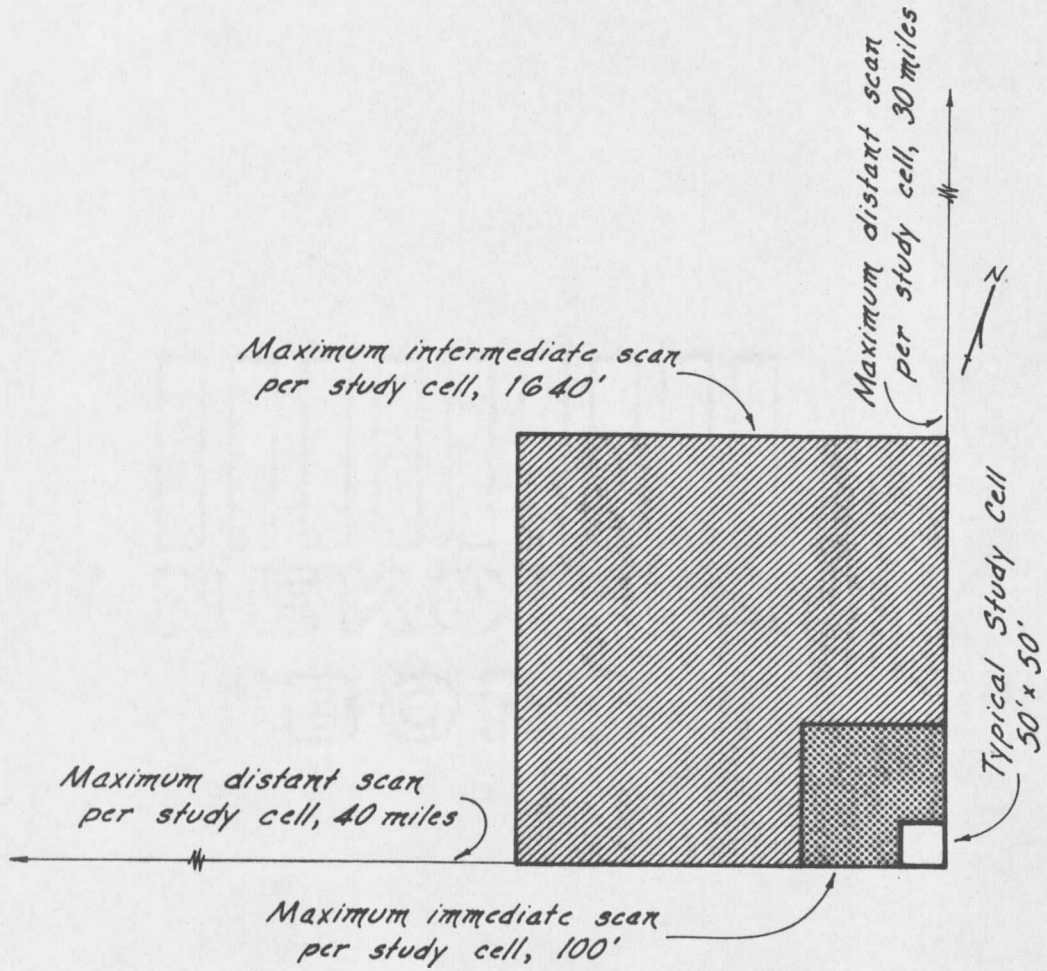


Figure 10. Direction and distance of computer scan to determine visible areas from each study cell in the Story Hills study area, Bozeman, Montana, 1974.

RESULTS AND DISCUSSION

Preference score means and the results of significant difference tests are given in Tables 1 and 2. Duncan's Multiple Range Values show the order of preference according to number of zones visible. Photographs with all three zones visible (Photographs 3,9,10) are most preferred. Photographs with two zones visible, either immediate and intermediate (Photograph 4) or immediate and distant (Photograph 5,6,7) are preferred next. Least preferred were the photographs with the immediate zone only (Photographs 1,2). Duncan's Multiple Range Test did reveal some overlapping of these preference groupings.

Bartlett's test for homogeneity showed that comparatively speaking there was general agreement as to the ranking of the photographs by the total population and within the subpopulations (Tables 1,2). The agreement as to the low ranking of Photograph 2 was comparatively high especially when compared to the low agreement of the ranking of Photograph 8 (see S.D. in Table 1). Photograph 8 had consistently the highest S.D. and according to Bartlett's test fell out of the homogeneous population of S.D. the most times. In other words, there was the least agreement within subpopulations as to the ranking of this photograph. The presence of the city of Bozeman in Photograph 8 seems to have polarized the preference scores. The greatest dichotomy of preferences for Photograph 8 was between the over 54 year old age group and other age groups, and between persons reared in Montana and persons reared outside Montana. Persons over the age of 54 gave Photograph 8 the highest preference score recorded (8.10) and had the most agreement on this ranking (S.D. of 1.45).

Hypothesized reasons for this high ranking are: the nearness of a city to supply services for this subpopulation is preferred, the nearness of other persons represented by the city, and the idea that cities represent progress and success to this subpopulation. The subpopulation of persons reared in Montana ranked Photograph 8 high compared to persons reared out of Montana (Table 1). Persons reared in Montana seems to be less sensitive to development in the vistas they prefer. One could hypothesize that people come to Montana for its non-development and prefer not to see the effects of man's activities in vistas.

The low ranking of Photograph 2 was common to all subpopulations and seems to be due to the screening effect and lack of the interest factor, both of which will be discussed later.

The results of area measurements of zones in the photographs are given in Tables 3, 4, and 5. Each measurement is the mean of three planimeter measurements of the area. Significant correlation coefficients ($p=.05$ with 9 degrees of freedom) for the relationship between preference score and percent of land area in the immediate zone ($r = -0.77$) and percent of land in the distant zone ($r = 0.68$) were obtained. Figure 11 shows the inverse relationship between preference score and percent of photograph occupied by the immediate zone. Photographs 9 and 10 had the highest preference scores in spite of large immediate zone areas as shown in Table 3. The impact of the size of the immediate zone is related to preference score to the extent that it may reduce the size of the other zones by screening them from view. If the

Table 1. Preference score means, standard deviations (S.D.), multiple range values, and Bartlett's test for homogeneity, among sexes, rearing places and degree of art training subpopulations interviewed for Story Hills preference study, Bozeman, Montana, 1974.

Photo no.	Total population(82)		Male(37)		Female(45)		Reared in Mont(50)		Reared outside Mont(32)		No formal art training(56)		Formal art training(16)	
	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.
9	8.07 ^a	2.01	7.70 ^a	2.23	8.36 ^a	1.76	8.08 ^a	1.81	8.03 ^a	2.31	8.02 ^a	1.86	8.19 ^a	2.29
10	7.98 ^a	2.17	7.86 ^a	2.19	8.07 ^a	2.17	8.32 ^a	2.19	7.44 ^{ab}	2.05	8.05 ^a	2.18	8.56 ^a	1.97
3	6.41 ^b	1.98	6.49 ^b	2.04	6.36 ^{bc}	1.96	6.68 ^b	1.96	6.00 ^c	1.97	6.54 ^b	2.03	6.44 ^b	1.79
8	6.39 ^b	2.70 [*]	6.22 ^b	2.60	6.53 ^b	2.80 [*]	6.88 ^b	2.28	5.63 ^c	3.14 [*]	6.67 ^b	2.69 [*]	6.50 ^b	2.80
7	6.10 ^{bc}	2.07	6.05 ^b	2.20	6.13 ^{bcd}	1.98	5.80 ^c	2.03	6.63 ^{bc}	2.06	5.95 ^{bc}	2.07	6.13 ^{bc}	1.78
4	5.46 ^{cd}	2.08	5.30 ^{bc}	2.23	5.56 ^{cde}	1.87	5.48 ^c	2.23	5.38 ^c	1.84	5.60 ^{cd}	2.02	4.56 ^c	1.71
5	5.32 ^d	2.35	5.86 ^{bc}	2.64	4.84 ^e	2.00	5.06 ^{cd}	2.21	5.69 ^c	2.55	5.26 ^{cd}	2.23	5.31 ^{bc}	2.09
6	5.05 ^d	2.31	4.81 ^c	2.25	5.24 ^{de}	2.37	4.56 ^d	2.09	5.81 ^c	2.46	4.88 ^d	2.35	5.13 ^{bc}	2.09
1	2.29 ^e	1.79	2.54 ^d	2.16	2.09 ^f	1.43	2.12 ^e	1.56	2.56 ^d	2.11	2.19 ^e	1.53	2.06 ^d	1.95
2	1.93 ^e	1.53 [*]	2.41 ^d	2.22	1.91 ^f	1.64	2.20 ^e	1.98	1.78 ^d	1.36	1.84 ^e	1.47 [*]	2.54 ^d	2.45

(82) Numbers within parenthesis indicate number of interviewees in subpopulations.

Means followed by a common letter(s) are not different at $p=.05$, according to Duncan's Multiple Range values

* Within subpopulations these S.D. are not in a homogeneous population, according to Bartlett's test.

Table 2. Preference score means, standard deviations (S.D.), multiple range values, and Bartlett's test for homogeneity, among age groups interviewed for Story Hills view preference survey, Bozeman, Montana, 1974.

Photo number	Ages 10-19 yr (12)		Ages 20-34 yr (35)		Ages 35-54 yr (25)		Ages over 54 yr (10)	
	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.
9	8.08 ^a	2.35	7.91 ^a	2.08	8.04 ^a	2.07	8.60 ^a	1.07
10	7.00 ^{ab}	1.95	8.00 ^a	2.45	8.20 ^a	1.89	8.50 ^a	1.90
3	7.75 ^b	2.22	6.49 ^b	1.99	7.16 ^a	1.34	5.10 ^{bc}	2.23
8	5.17 ^{bc}	2.21	5.86 ^{bc}	2.89	7.00 ^a	2.61	8.10 ^a	1.45
7	6.93 ^{ab}	2.44	6.23 ^b	1.94	5.56 ^b	2.12	6.10 ^b	1.85
4	5.58 ^b	2.68	5.60 ^{bc}	2.02	5.48 ^b	1.96	4.60 ^c	1.90
5	5.75 ^b	3.22	5.54 ^{bc}	2.32	4.96 ^b	2.03	4.60 ^c	2.22
6	5.42 ^b	2.64	5.06 ^c	2.35	4.88 ^b	2.19	5.00 ^{bc}	2.36
1	3.25 ^{cd}	2.42	2.54	1.87	1.80 ^c	1.38	1.50 ^d	0.85
2	2.00 ^d	1.86	1.40	0.81 [*]	2.28 ^c	2.23	2.70 ^d	1.49

(12) Numbers within parenthesis indicate number of interviewees in subpopulations.

Means followed by a common letter(s) are not different at $p=.05$, according to Duncan's Multiple Range Values.

* Within subpopulations these S.D. are not in a homogeneous populations, according to Bartlett's test.

Table 3. Immediate zone planimeter measurements; total area of zone, percent of photographs of the zone, and percent of the zone occupied by the landscape components; grass, shrubs, sagebrush, and evergreen trees, of photographs used in Story Hills view preference survey, Bozeman, Montana, 1974.

<u>Photo number</u>	<u>Total area of zone (sq in)</u>	<u>% of photo in zone</u>	<u>% of grass in zone</u>	<u>% of shrub in zone</u>	<u>% of sagebrush in zone</u>	<u>% of evergreen trees in zone</u>
9	24.51	33	100			
10	19.65	27	19	80		
3	8.69	12	100			
8	15.85	21	50		50	
7	14.60	19	100			
4	28.49	39	100			
5	55.82	76	29	5		65
6	35.06	48	100			
1	71.46	97	8			91
2	51.57	71	100			

Table 4. Intermediate zone area measurements; total area of zone, percent of photograph occupied by the zone and percent of the zone occupied by the landscape components; grass, shrubs, evergreen trees and deciduous trees, of photographs used in Story Hills view preference survey, Bozeman, Montana, 1974.

<u>Photo. number</u>	<u>Total area of zone(sq in)</u>	<u>% of photo in zone</u>	<u>% of grass in zone</u>	<u>% of shrubs</u>	<u>% of evergreen trees</u>	<u>% of deciduous trees</u>
9	16.81	22	52	44	2	
10	9.09	12	41	12	45	
3	36.31	50	17	15	58	9
8	17.67	24	28	18	53	
7	28.33	38	24		75	
4	23.40	32	12	31	58	
5	0	0				
6	0	0				
1	0	0				
2	0	0				

Table 5. Distant zone and sky area measurements of photographs used in Story Hills view preference survey, Bozeman, Montana, 1974, including total area measurements and percent of the photograph occupied by that area.

Photo number	Total area of distant zone (sq. in.)	% of photo	Total sky area	% of photo
9	6.47	8	25.58	34
10	19.08	26	23.81	33
3	3.05	4	23.74	33
8	10.99	15	27.58	38
7	11.78	16	18.62	25
4	0	0	20.08	27
5	5.68	7	11.46	15
6	5.61	7	31.95	43
1	0	0	1.93	2
2	0	0	21.04	28

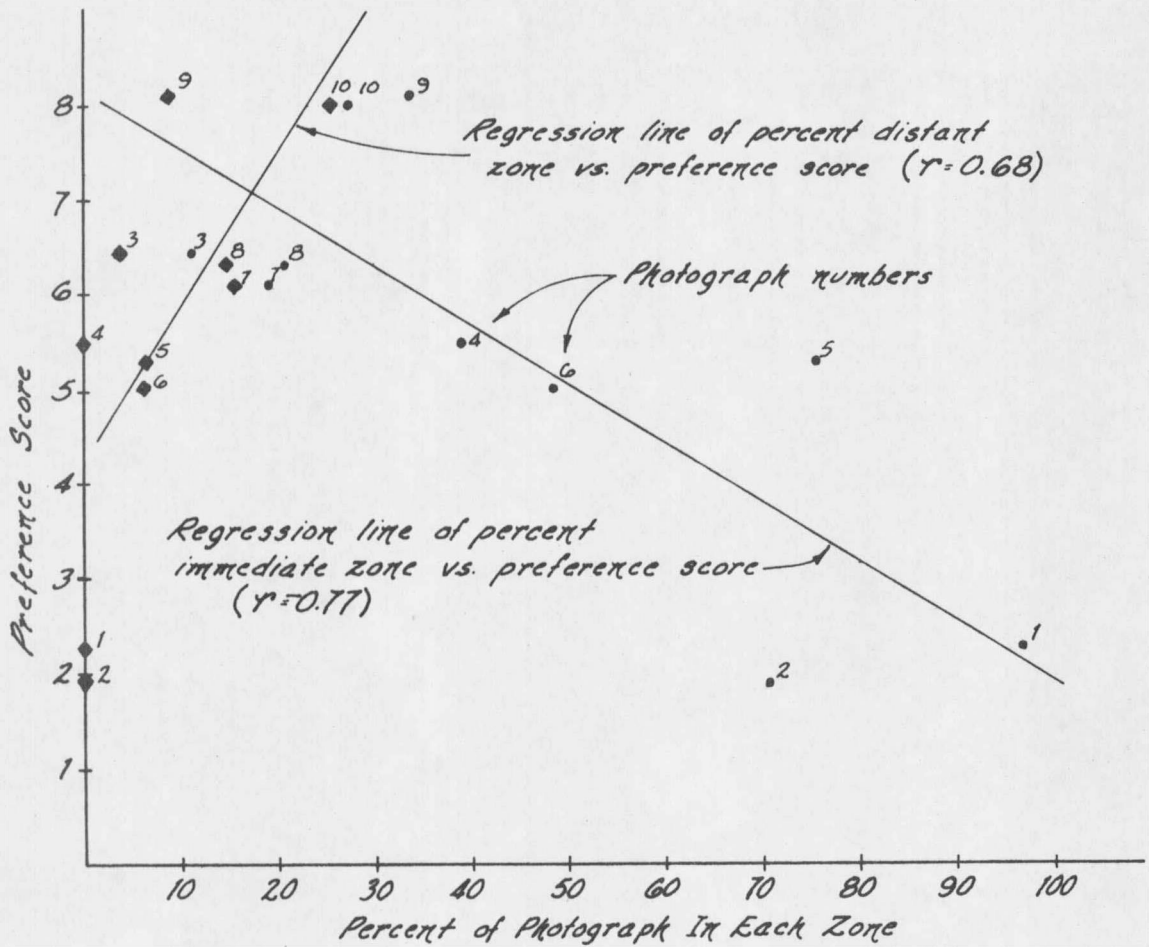


Figure 11. Regression lines showing relationship of immediate zone area vs preference score and distance zone area vs. preference score in photographs used in Story Hills view preference survey, Bozeman, Montana, 1974.

immediate zone screens the other zones as demonstrated in photographs 1 and 2 (Figures 2 and 3) it is not preferred compared to other possible characters of the zone. The interest factor, or as reviewed by Craik (1971), Wohull's complexity factor seems to have an effect on the preference ranking in the immediate zone. Components of the interest factor include: number of different vegetation species, communities or blocks of vegetation, color, shape of dividing line between zones, contrasts within the zone and between zones, and position of observer in relation to zone.

Figure 11 shows the direct relationship between percent of photograph occupied by the distant zone and preference score. People prefer to see extensive areas in the distant zone. This fact alone does not guarantee a photograph a high preference score as illustrated by photograph 3 (Figure 5) and photograph 9 (Figure 7). The distant zone occupies only 4% and 8%, respectively, of the areas of these photographs. In the case of photograph 3 the interest factor of the intermediate zone seems to outweigh both the small distant visible zone and screening effect of the intermediate zone.

Correlation coefficients between preference score and percent of land in the intermediate zone ($r = 0.51$) and area of sky ($r = 0.50$) were not significant at the $p = .05$ level. The interest factor appears to be the dominant element in the influence of the intermediate zone on photograph preference. The immediate zone by its very nature cannot occupy as much area as can the other zones. At the same time the immediate zone should not screen the other zones and hence, should be limited to

landscape components that are low growing or non-screening in character. This is one reason to allow set-backs or a buffer zone between residences and groves of vegetation such as are encountered in the Story Hills P.U.D. The buffer zone idea is further reinforced ecologically as the buffer zone may allow these micro-environments to retain some of their identity. It has been shown that a vista, only 8% of which is distant zone, is the most preferred. This 8% when compared to the distant zones in photograph 8 and even photograph 3 is rather plain and ordinary. The intermediate zone occupies that part of the landscape where detail is observable and at the same time the observer is far enough away that the character of the zone - flat, rolling hills, wooded, shrub covered, dry - can be identified and appreciated.

Because of the strong influence of the intermediate zone on preference score, development in the intermediate zone is most likely to have the greatest adverse impact on preference scores. These findings lend support to the argument for cluster housing and condominium development in rural settings.

Comparison of preference scores of the paired subpopulations; sex, rearing place, and degree of art training, using the T-test is summarized in Table 6. A person's sex or degree of art training has little effect on view preference scores, there is almost complete agreement on the ranking of the photographs by these subpopulations. Place of rearing, however, seems to greatly effect preference scores. There is agreement in only six of the ten cases as to photograph ranking.

Table 6. Comparison of preference scores by the T-test of paired sub-populations (sexes, rearing place and degree of formal art training) interviewed for Story Hills preference survey, Bozeman, Montana, 1974.

Photo	Male	Female	Reared in Montana	Reared outside Montana	With art training	Without art training
1	2.54 ^a	2.09 ^a	2.12 ^a	2.56 ^a	2.06 ^a	2.19 ^a
2	2.41 ^b	1.91 ^b	2.20 ^b	1.78 ^b	2.56 ^b	1.84 ^b
3	6.49 ^c	6.36 ^c	6.68 ^c	6.00 ^c	6.44 ^c	6.54 ^c
4	5.30 ^d	5.56 ^d	5.48 ^d	5.38 ^d	4.56	5.60
5	5.86	4.84	5.06 ^e	5.69 ^e	5.31 ^d	5.26 ^d
6	4.81 ^e	5.24 ^e	4.56	5.81	5.13 ^e	4.88 ^e
7	6.05 ^f	6.13 ^f	5.80	6.63	6.13 ^f	5.95 ^f
8	6.22 ^g	6.53 ^g	6.88	5.63	6.50 ^g	6.67 ^g
9	7.70 ^h	8.36 ^h	8.08 ^f	8.03 ^f	8.19 ^h	8.02 ^h
10	7.86 ^j	8.07 ^j	8.32	7.44	8.56 ^j	8.05 ^j

a/ within subpopulations preference scores followed by a common letter are not different at $p = .05$.

According to S.D. in Table 2, females, persons over the age of 54, and persons with some formal art training agree more often on the ranking of the photographs when compared to their counterparts. Not much confidence is placed in the ages 10-19 subpopulation data as four families accounted for 10 members of this subpopulation.

Two printouts were generated from the computer programs. Examples of cell formula printouts are given in Table 7.

Table 7. Examples of computer printout of study area cell formulas containing: location, numbers of distant and intermediate visible cells, number and landscape component of visible immediate cells.

<u>Location of cells in study area</u>		<u>Number of cells visible</u>		<u>Number and landscape component of visible immediate zone cells</u>			
<u>Row</u>	<u>Column</u>	<u>Distant zone</u>	<u>Intermediate zone</u>	<u>Ever-green trees</u>	<u>Deci- duous trees</u>	<u>Shrubs</u>	<u>Grass</u>
1	1	32	01	1	0	0	6
12	27	20	01	2	0	3	3
13	30	20	00	1	0	0	6
31	10	4	05			4	0
40	20	13	02	3	0	2	0

Using the cell formulas the computer went on to produce a printout made into an overlay of numbers for the study area cells (Figure 12). Cells 1-1 and 12-27 (Table 1) have 4's printed in them on the overlay map meaning all zones are visible from these cells. The distant zone is considered visible if more than five cells in the zone are visible

from the study cell. There is a three printed in cell 13-30 which means that the distant and immediate zones are visible. A two is printed in cell 31-10 meaning immediate and intermediate zones are visible. The numbers on the overlay correspond to the preference survey results, hence the higher numbers on the overlay define areas that have more preferred vistas. The use of the formula printouts in conjunction with the overlay map would reveal the details of the vista from each cell.

It is apparent from the overlay that there are no ones printed. A one in a cell would signify that only cells in the immediate zone are visible. A modification of the formula in the overlay program would rectify this problem. The overlay program can be modified so that the overlay is generated from any formula (which is merely the number of cells visible in each zone) that is wanted by an interested party. Another reason for the absence of ones on the overlay is the wide field of scan by the computer. For each cell the computer scans a 90° sweep north and west of that cell. A narrower sweep of visible areas from each cell would result in a number of ones on the overlay.

The view from the center of one of the groves of trees would be highly limited and it could be expected that ones would be printed for these areas also. The problem arises because the computer scans from the center of each cell, hence, the closest trees for screening are fifty feet away. The computer can then "see" over the obstructing trees and the visible area is much greater than reality. A modifi-

cation of the program should be able to rectify this problem.

CONCLUSIONS

The results of a view preference survey using sample landscape photographs from the Story Hills Planned Unit Development, and the results of statistical analysis of zones in these photographs and preference scores for the photographs, led to the following conclusions:

- 1) Preference for landscape photographs is related directly to number of landscape zones in the photograph.
- 2) Preference for landscape photographs is related directly to percent of distant zone in the photographs and indirectly to percent of immediate zone in the photograph.
- 3) Preference for landscape photographs is strongly influenced by the intermediate zone and especially by the interest factor of this zone.
- 4) Computer analysis and formula printouts of the vista from a study area offer resource managers and developers a quantitative measurement of the visual resource.
- 5) Refinement of the two computer programs promises accurate and quick analysis of the visual resource.

TOPICS FOR FURTHER RESEARCH

In recognizing the fact that any research turns up more questions than it answers the author would like to point out some topics he thought would be interesting to research and needed in the field of landscape view preference.

Zone Analysis - analysis of each zone in terms of area and components for preferences.

- development of a new system of zones
- further analysis of the "interest factor" in the different zones
- "screen" effect of one zone on another zone is almost untouched
- analysis of man's impact (roads, transmission lines, buildings, etc.) in different zones on preference

Seasonal Effects on the landscape of preference score.

Observer Position - whether people prefer to look down and out across vistas or across and up at vistas or prefer a more neutral viewing position.

Surveys - a different system of assigning points in preference scoring would allow more techniques of data analysis to be applied. A system of ranking and assigning points according to this ranking eliminates steps in factor analysis and other statistical analysis techniques.

Computer Program - the use of landscape components in all zones

- refinement of formulas from which overlay maps are produced
- the use of the computer in scanning from narrow angles to 360° scans
- refinement of the program to show the screening effects of vegetation

Appendix I

Sample, View Preference Questionnaire

Picture Window View Preference

QUESTIONNAIRE

What are your major leisure time activities: (Please list both indoor and outdoor activities.)

How long have you lived continuously in the Bozeman area: _____ years.

Would you consider living in an area such as the Story Hills?

_____ Yes _____ No

Why or why not?

Sex: _____ Male _____ Female

Age: 10-14 _____	35-39 _____	60-64 _____	over 85 _____
15-19 _____	40-44 _____	65-69 _____	
20-24 _____	45-49 _____	70-74 _____	
25-29 _____	50-54 _____	75-79 _____	
30-34 _____	55-59 _____	80-84 _____	

Occupation: _____

Where were you raised: _____ State

_____ Farm or ranch

_____ Town less than 2500 _____ City of 50,000-100,000

_____ City of 2500-10,000 _____ City over 100,000

_____ City of 10,000-50,000

Level of Education:

Some grade school _____

Some College _____

Completed grade school _____

Completed College _____

Some high school _____

Post graduate work _____

Completed high school _____

How many years of formal art training have you had since high school?

(i.e. painting, drawing, ceramics, photography, jewelry, etc.)

_____ years.

APPENDIX II
SCAN PROGRAM

```
C THIS PROGRAM IS DESIGNED TO READ IN ALTITUDES FOR THREE
C GRIDS-IMMEDIATE, INTERMEDIATE, AND DISTANT. THE IMMEDIATE
C GRID IS 52 X 52 AND IN THIS GRID A VEGETATION COMPONENT
C IS ALSO READ-EVERGREEN, ASPEN, SHRUB, OR GRASS. THE EVERGREENS
C ARE ASSUMED TO ADD 35 FT. TO THE ALTITUDE IF TRYING
C TO LOOK OVER THE POSITION AND NONE IF LOOKING FROM THE
C POSITION. THE ASPENS ADD 26 FT., THE SHRUBS 15 FT. AND
C THE GRASS NONE.
C THE SEARCH FOR WHAT CELLS CAN BE SEEN FROM A CERTAIN
C POSITION LOOKS OUT 2 CELLS IN THE IMMEDIATE GRID,
C 8 CELLS IN THE INTERMEDIATE GRID, AND OVER THE COMPLETE
C DISTANT GRID. THE INTERMEDIATE GRID IS 16 X 16.
C THE DISTANT GRID IS 30 X 40.
C A 50 X 50 SET OF CELLS ARE CHECKED TO FIND WHAT CAN
C BE SEEN FROM THEM. THE INFORMATION FROM THE IMMEDIATE
C GRID IS USED IN SEARCHING THE INTERMEDIATE GRID AND THAT
C INFORMATION IN TURN IS USED ON THE DISTANT GRID.
C     DIMENSION LEVEL (52,52), LEVEL2 (16,16), LEVEL3 (30,40)
C     &, LEV (4), LC D (4), IVIS (52,52), INVIS (16,16), IDISVIS (30,40)
C     DIMENSION LEV12 (52,52), II (8), JJ (8), LEV13 (52,52)
C     COMMON JLEG, ILEG
C     INTEGER TEMP1 (8), TEMP2 (8)
C INITIALIZE MATRICES TO ZERO IN WHICH CODE WILL BE
C STORED ON CELLS VISIBILITY FROM LOCATION I0BS, JOBS
C THERE IS ONE MATRIX FOR EACH OF THE THREE GRIDS
C     DO 11 I=1,52
C     DO 11 J=1,52
11     IVIS (I,J)=0
C     DO 12 I=1,16
C     DO 12 J=1,16
12     INVIS (I,J)=0
C     DO 13 I=1,30
C     DO 13 J=1,40
13     IDISVIS (I,J)=0
C     SIZE1=104; SIZE2=16; SIZE3=1
C LEV CONTAINS # 8F FEET TO BE ADDED TO ALTITUDE
C FOR VARIOUS TYPES OF VEGETATION.
C 1=GRASS (0 FT.)
C 2=SHRUBS (15 FT.)
C 3=ASPENS (25 FT.)
C 4=EVERGREEN (35 FT.)
C     LEV (1)=0; LEV (2)=15; LEV (4)=35
C LCOD CONTAINS THE CODES THAT WILL BE PRINTED OUT FOR
```

```
C FINAL RESULTS ON VISIBILITY OF DIFFERENT TYPES OF
C VEGETATION IN THE IMMEDIATE GRID.
C THE UNITS DIGIT WILL CONTAIN # OF GRASS SITES VISIBLE
C THE TENS DIGIT WILL CONTAIN # OF SHRUB SITES VISIBLE
C THE HUNDREDS DIGIT WILL CONTAIN # OF ASPEN SITES VISIBLE
C THE THOUSANDS DIGIT WILL CONTAIN # OF EVERGREEN SITES VISIBLE
  LCOD(1)=1;LCOD(2)=10;LCOD(3)=1000;LCOD(4)=1000
C READ IN ALTITUDES, IN ORDER OF GRIDS, IMMEDIATE FIRST,
C INTERMEDIATE SECOND, AND DISTANT LAST.
C IN THE IMMEDIATE, A VEGETATION TYPE IF READ IN AS WELL AS
C THE COORDINATES AND THE ALTITUDE. THE COORDINATES ARE
C READ AS AN X COMPONENT AND A Y COMPONENT BEING INTEGERS
C FROM 1 TO 50
C THE INTERMEDIATE AND DISTANT GRIDS DO NOT HAVE THE VEGETATION
C COMPONENT READ.
C IN ALL THREE GRIDS THERE ARE EIGHT OBSERVATIONS ON EACH CARD
C AND ALL OBSERVATIONS IN A ROW ARE ON A SERIES OF CARDS
C IN IMMEDIATE GRID THIS MEANS 7 CARDS PER ROW
C IN INTERMEDIATE GRID - 2 CARDS PER ROW
C IN DISTANT GRID - 5 CARDS PER ROW
100   FORMAT (8(212,14,I1,X))
101   FORMAT (8(212,14,2X))
      DO 2 I1=1,52
      DO 3 J1=1,52
      READ (105,100),II(I),JJ(I),TEMP1(I),TEMP2(I),I=1,8)
      DO 3I=1,8
      LEVEL(II(I),JJ(I))=TEMP1(I)=LEV(TEMP1(I))
      LEV12(II(I),JJ(I))=TEMP2(I)
3     CONTINUE
      READ (105,100),(II(I),JJ(I),TEMP1(I),TEMP2(I),I=1,8)
      DO 2 I=1,8
C     LEVEL CONTAINS ALTITUDES IN THE IMMEDIATE GRID PLUS
C     THE CORRECTION FACTOR FOR THE TYPE OF VEGETATION AT
C     THAT LOCATION
C     LEV12 CONTAINS THE VEGETATION CODE FOR THE IMMEDIATE GRID
      LEVEL(II(I),JJ(I))=TEMP1(I)+LEV(TEMP2(I),I=1,8)
      LEV12(II(I),JJ(I))=TEMP2(I)
2     CONTINUE
      DO 4 I1=1,32
      READ (105,101),(II(I),JJ(I),TEMP1(I),I=1,8)
      DO 4 I=1,8
      LEVEL2(II(I),JJ(I))=TEMP1(I)
4     CONTINUE
      DO 5 I1=1,50
      READ(105,101),(II(I),JJ(I),TEMP1(I),I=1,8)
      DO 5 I=1,8
      LEVEL3(II(I),JJ(I))=TEMP1(I)
5     CONTINUE
C     ALTITUDES ALL IN
C     DETERMINE VISIBILITY FOR VARIOUS POSITIONS
      DO 1000 JOBS=1,50
```

```
DO 1000 JOBS=1,50
C LEVEL SET TO ACTUAL ALTITUDE BY SUBTRACTING CORRETION
C FACTOR FOR VEGETATION TYPE FOR LOCATION CURRENTLY BEING
C STUDIED.
  LEVEL (IOBS,JOBS)=LEVEL(IOBS,JOBS)-LEV(LEV12(IOBS,JOBS))
C INITIALIZE INCREMENTS FOR END-POINTS OF RAYS FOR EACH GRID
C THEN INITIALIZE THE END-POINTS OF THE RAYS
  K1I=0;K1J=1;K2I=0;K2J=1;K3I=0;K3J=1
  ISTAR1=IOBS+2;JSTAR1=JOBS-1
  IMED=1+IOBS/6.5;JMED=1+JOBS/6.5
  LEVEL2(IMED,JMED)=LEVEL(IOBS,JOBS)
  ISTAR2=IMED+8;JSTAR2=JMED-1
  ISTAR3=30;JSTAR3=0
C ADD INCREMENTS TO END-POINT OF RAY IN IMMEDIATE GRID
C ANGMAXI IS MAXIMUM ANGLE THAT HAS OCCURRED BETWEEN CURRENT
C LOCATION AND SITE CHECKED ALONG RAY. IT IS SET TO A LARGE
C NEGATIVE VALUE SO THAT SITES LOWER THAN THE CURRENT LOCATION
C CAN BE OBSERVED IF THERE ARE NO HIGHER POSITIONS BETWEEN
10  ANGMAX1=-999;ISTAR1=ISTAR1+K1I;JSTAR1=JSTAR1+K1J
6  INCREMENTS FOR END OF RAY IS CHANGED IF CORNER OF GRID IS
C ENCOUNTERED
  IF (JSTAR1.EQ.JOBS=2) K1I=-1;K1J=0
C SLOPE ALONG RAY IN IMMEDIATE GRID IS DETERMINED IF THE
C DENOMENATOR IS NOT ZERO
  IF (IOBS.NE.ISTAR1) SLOPE1=(JOBS-JSTAR1)/(IOBS-ISTAR1);GOTO 15
C SLOPE = 000 IF DENONOMINATOR WAS ZERO
  SLOPE1=999
C VISIBILITY DETERMINED ALONG RAY IN GRID 1 IN SUBROUTINES.
15  CALL GENRAY(IOBS,JOBS,ISTAR1,JSTAR1,IVIS,LEVEL,52,52,ANGMAX1)
C ACTIONS REPEATED FOR INTERMEDIATE GRID
20  ANGMAX2=ANGMAX1;ISTAR2=K2I;JSTAR2=JSTAR2+K2J
  IF (JSTAR2.EQ.JMED+8) K2I=-1;K2J=0
  IF (IMED.NE.ISTAR2) SLOPE2=(JMED-JSTAR2)/(IMED-ISTAR2);GOTO 25
  SLOPE2=999
25  CALL GENRAY(IMED,JMED,ISTAR2,JSTAR2,INVIS,LEVEL2,16.16,ANGMAX2)
C ACTIONS REPEATED FOR DISTANT GRID
30  ANGMAX3=ANGMAX2;JSTAR3=JSTAR3+K3J;ISTAR3=ISTAR3+K3I
  IF (JSTAR3.EQ.40) K3I=-1;K3J=0
  IF (ISTAR3.NE.1) SLOPE3=(1-JSTAR3)/(1-ISTAR3);GOTO 35
  SLOPE3=999
35  CALL GENRAY(1,1,ISTAR3,JSTAR3,DISVIS,LEVEL3,30,40,ANGMAX3)
C THE SEARCH IN THE DISTANT GRID GOES UNTIL THE RAY HAS
C A SLOPE GREATER THAN OR EQUAL THE SLOPE IN THE
C INTERMEDIATE GRID. THE INTERMEDIATE GRID THEN ADVANCES
C AND THE DISTANT GOES AGAIN UNTIL THE INTERMEDIATE GRID
C HAS A SLOPE GREATER THAN OR EQUAL THE IMMEDIATE GRID
C THEN THE IMMEDIATE GRID ADVANCES AND THE PROCESS STARTS
```

```
C OVER. THE DISTANT AND INTERMEDIATE GRIDS USE THE MAXIMUM
C ANGLE FROM THE PREVIOUS GRID AS THE STARTING ANGLE IN
C DETERMINING VISIBILITY.
C   IF (SLOPE3.LT.SLOPE2) GOTO 30
C   IF (SLOPE2.LT.SLOPE1) TOTO 20
C   IF (SLOPE1.LT.999) GOTO 10
C   LEV13(IOBS,JOBS)=0
C PUT VISIBILITY CODES IN LEV13 AND LEV12
W
C   DO 70 I1=IOBS,IOBS+2
C   DO 70 J1=JOBS,JOBS+2
70  LEV13(IOBS,JOBS)=LEV13(LOBS,JOBS)+LCOD(LEV12(I1,J1))
C   &*IVIS(I1,J1)
C   LEV12(IOBS,JOBS)=0
C   DO 80 I1=IMED,IMED+8
C   DO 80 J1=JMED,JMED+8
80  LEV12(IOBS,JOBS)=LEV12(IOBS,JOBS)+INVIS(I1,J1)
C   DO 90 I1=1,40
C   DO 90 J1=1,30
90  LEV12(IOBS,JOBS)=LEV12(IOBS,JOBS)+100*IDISVIS(I1,J1)
C WRITE RESULTS FOR THIS LOCATION
C   WRITE (108,99) IOBS,JOBS,LEV12(IOBS,JOBS),LEV13(IOBS,JOBS)
1000 CONTINUE
00  FORMAT (X,12,X,12X,17,X,15)
C   END
C   SUBROUTINE GENRAY(IOBS,JOBS,I,J,INRIM,LEVEL,N1,M1,ANGMAX)
C GENRAY GENERATES A RAY OF CELLS FROM IOBS,JOBS TO EACH I,J ON THE
C CIRCLE. THE RAY CONSISTS OF ALL AND ONLY THOSE CELLS THROUGH
C WHICH A LINE FROM THE OBSERVER TO A RIM POINT PASSES.
C ANGMAX MAXIMAL ANGLE BETWEEN OBSERVER AND ANY CELL ON THE RAY WHICH
C HAS BEEN TESTED FOR VISIBILITY.
C USER MUST CHOOSE INITIAL VALUE OF ANGMAX, SELECT ZERO IF THE CENTER
C CELL IS TREATED AS A PLANE WITH THE OBSERVER FIXED AT ITS CENTER. ALL
C TERRAIN AT A LESSER ELEVATION WILL BE INVISIBLE, OTHERWISE SELECT A
C LARGE NEGATIVE VALUE (EG, -999) WHICH TREATS THE CELL AS A POINT.
C JLEG NUMBER OF CELLS BETWEEN JOBS AND J.
C ILEG NUMBER OF CELLS BETWEEN IOBS AND I.
C   COMMON JLEG,ILEG
C   DIMENSION INRIM(N1,M1)LEVEL(N1,M1)
C   MDTM=1
C   JLEG=IABS(J-JOBS)
C   IF(IOBS.EQ.I) GO TO 35
C   ILEG=IABS(I-IOBS)
C   IF(ILEG.LT.JLEG) GO TO 20
C   I=IOBS
C   DO 10 K=1,ILEG
```

```
I=I+1
J=JOBS+1*JLEG*K/ILEG
RSPAN=IABS (IOBS-1)
CALL VISTRY (I,J,IOBS,ANGMAX,INRIM,LEVEL,RSPAN,JOBS,N1,M1)
CONTINUE
GO TO 40
J=JOBS
DO 30 K+1,JLEG
J=J+1
I=IOBS+1,*ILEG*K/JLEG
RSPAN=IABS (JOBS-J)
CALL VISTRY (I,J,IOBS,ANGMAX,INRIM,LEVEL,RSPAN,JOBS,N1,M1)
CONTINUE
GO TO 40
SPECIAL CASE (VERTICAL RAY) AVOIDING DIVISION BY ZERO
KF=1
J=JOBS
DO 38 K=1,JLEG
J=J+KF
RSPAN=IABS (JOBS=J)
CALL VISTRY (K,J,IOBS,ANGMAX,INRIM,LEVEL,RSPAN,JOBS,N1,M1)
CONTINUE
RETURN
END
SUBROUTINE VISTRY (I,J,IOBS,ANGMAX,INRIM,LEVEL,RSPAN,JOBS,N1,M1)
VISTRY DETERMINES VISIBILITY OF SUCCESSIVE CELLS ALONG THE RAY.
ANGNEX ANGLE BETWEEN OBSERVER AND I,J.
DIMENSION INRIM (N1,M1),LEVEL (N1,M1)
ANGEX=(LEVEL (I,J)-LEVEL (IOBS,JOBS))/RSPAN
IF (ANGNEX, .GE. ANGMAX) GO TO 10
INRIM (I,J)=0
GO TO 20
INRIM (I,J)=1
ANGMAX=ANGNEX
RETURN
END
```

APPENDIX III

OVERLAY PROGRAM

```

1.     DIMENSION N(50),L(50,50),K(50,50),M(4,4)
2. 100 FORMAT(4X,'0000000001111111112222222222333333333344444444445')
3. 101 FORMAT(4X,'12345678901234567890123456789012345678901234567890')
4. 102 FORMAT(3X,'-----')
5. 103 FORMAT(1X,12,'+',50A1)
6. 104 FORMAT(1X,12,X,12,X,17,X,15)
7. 105 FORMAT('1')
8.     DO 1 I = 1,2500
9.     READ (105,104) I1,J1,ITEMP1,ITEMP2
10.    L(I1,J1) = ITEMP1
11. 1  K(I1,J1) = ITEMP2
12.    M(1,1) = 1H1:M(1,2) = 1H:M(1,3) = 1H:M(1,4) = 1H
13.    M(2,1) = H:M(2,2) = 1H2:M(2,3) = 1H:M(2,4) = 1H
14.    M(3,1) = 1H:M(3,2) = 1H:m(3,3) = 1H3:M(3,4) = 1H
15.    M(4,1) = 1H:M(4,2) = 1H:M(4,3) = 1H:M(4,4) = 1H4
16.    DO 10 MAP = 1,4
17.    WRITE (108,105)
18.    WRITE (108,100)
19.    WRITE (108,101)
20.    WRITE (108,102)
21.    DO 10 I = 1,50
22.    DO 5 J = 1,50
23.    ITEMP1 = L(I,J)/100
24.    ITEMP2 = L(I,J) = 100 * ITEMP1
25.    IF ((ITEMP1.LE.5).AND.1(ITEMP2.EQ.0))N(J)=M(MAP,1);GOTO5
26.    IF ((ITEMP1.LE.5).AND.(ITEMPS.GT.0))N(J)=M(MAP,2);GOTO 5
27.    IF (ITEMP2.EQ.0) N(J)=M(MAP,3);GOTO 5
28.    N(J) = M(MAP,4)
29. 5  CONTINUE
30.    WRITE (108,103) I,N
31. 10 CONTINUE
32.    END

```

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