LANDSCAPE AESTHETICS NUMERICALLY DETERMINED: APPLICATIONS TO HIGHWAY CORRIDOR SELECTION

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Because considerable controversy commonly surrounds testimony concerning environmental effects of highway construction, a quantitative method to evaluate aesthetic factors of a landscape is needed. Such an evaluation will help to separate facts from emotions and to provide a means to hierarchically rank various alternative sites or corridors. The LAND system, which is discussed in this paper, provides a preliminary method to quantify aesthetic factors of a landscape and to visually inspect hierarchically ranked alternatives. The model is an extension of Leopold's (1) concept of landscape uniqueness. Descriptive evaluation numbers for various landscape factors are used to derive indexes, which are then used to evaluate and compare different landscapes. Data are obtained from measurements and observations from topographic maps, aerial photographs, and field work. This type of parametric analysis may find application in the planning stages of many highway engineering projects. However, the system is only an additional tool in a decision-making process involving the selection of alternative routes whose construction would significantly modify existing landscapes.

•CURRENT public laws and public policy require evaluation of existing natural landscape conditions as part of an environmental impact statement. Considerable controversy often surrounds testimony during public hearings on the environmental effects of proposals for highway routing and construction. Therefore, it seems desirable to develop a quantitative method to evaluate aesthetic, scenic, and other factors of a particular landscape. Such an evaluation will help to separate facts from emotions and to provide a means to hierarchically rank various alternative sites or corridors.

As stated by Leopold (1), any scheme for comparing landscapes must rest on some philosophical framework. Leopold noted that factors contributing to aesthetic or other nonmomentary aspects of a landscape are difficult to evaluate whereas aspects that tend to lend themselves to cost-benefit comparison, such as location of dams, roads, and trails, are treated in a routine way. He also determined that, if criteria are sought for comparing different landscapes, factors that constitute relevant features of those landscapes must be defined and evaluated. Those are primarily the factors that influence aesthetic impression and human interest in an area. In his study of quantitative evaluation of wild rivers, Leopold's analysis and measurements considered descriptive categories of 3 types: physical factors, biologic and water quality factors, and human use and interest factors. A total of 46 factors was established, and each factor was ranked on an arbitrary scale of 1 to 5 as evaluation numbers.

Leopold's quantitative approach to landscape evaluation is constrained by the fact that his studies included only river valleys and were understaken at on-site locations. However, the basic system can be expanded, as we are doing, to include parametric measurements of total landscapes, for in all landscapes fluvially derived features are the most significant single physiographic element. The concept basic to our philosophy, as with Leopold's, is that any landscape that is unique, in either a positive or negative way, is more significant to society than a landscape that is commonplace. The evaluation of a landscape initially requires an evaluation of its relative uniqueness, which for practical purposes becomes defined as a measure of the relative difference between

landscapes. Those shown to be unique must then be analyzed to determine why they are unique. That is accomplished by defining what is to be evaluated and then numerically determining what part of the uniqueness is owing to characteristics that are antithetical to the definition. For example, if we define aesthetic rivers as those rivers or sections of rivers that are clear, unpolluted, and unlittered, then a stream that is polluted and cluttered with garbage dumps along the banks would be ranked very low as an aesthetic river even though it may be a relatively unique river for the region. If we are evaluating possible highway corridors, a definition of desirable corridor characteristics can likewise be developed, and various alternative corridors can be analyzed and hierarchically ranked.

THE MODEL

The LAND system (landscape aesthetics numerically determined) is a method that quantifies aesthetic factors of a landscape. Only river valleys have been evaluated to date, but the system can be easily modified to evaluate any point of interest of the landscape. The present, preliminary working model is primarily designed to test our data processing procedure. Improvements on the choice of parameters with consequent improvements of results are expected.

The factors evaluated are grouped into Leopold's 3 categories: physical, biologic, and human use and interest. The number of factors used within each category depends on what is to be measured and the detail of the evaluation. In our preliminary model, we evaluated 31 factors (Table 1). Our model is an extension of Leopold's (1) system, which evaluates the relative uniqueness at a site. Each factor is assigned an evaluation number, ranging from 1 to 5; the values are derived from measurements and observations obtained from topographic maps, aerial photographs, and field work (Table 1). The evaluation numbers serve a descriptive function only. For example, the evaluation number 1 is not to be interpreted as better or worse than any other evaluation numbers. What is important is how many of the evaluated landscapes have a common evaluation number for the same factor. That is, if all evaluated landscapes contain polluted streams with foamy water (factor 16, Table 1), then that indicates a common occurrence. However, a clear running stream indicates a unique situation, but that does not negate the commonness of pollution in those landscapes.

The uniqueness value for each factor is determined by its uniqueness ratio, defined by Leopold (1) as the reciprocal of the number of sites sharing the same evaluation number. For example, if 5 landscapes are being evaluated and all have foamy streams, the uniqueness ratio is 1 divided by 5, or 0.20. If one stream is clear, then that stream has a uniqueness ratio of 1 divided by 1, or 1.00, and the 4 remaining streams, all foamy, are assigned a uniqueness ratio of 1 divided by 4, or 0.25 for that factor. This procedure is repeated for all evaluated factors for each landscape. The total uniqueness is computed as the sum of all uniqueness ratios for that landscape.

We define uniqueness index, UI, as the percentage of the total possible uniqueness. For example, if for 10 physical factors the total uniqueness is 5.0 out of a possible 10.0, the uniqueness index for physical factors on a 333.3 point scale is $(333.3 \times 5.0)/10.0 = 167.0$. The 333.3 point scale is used so that the entire uniqueness index for the 3 categories of factors will be on a 1,000-point scale. Figures 1, 2, and 3 show evaluation numbers and uniqueness indexes for 5 stream valleys in Indiana.

The next procedure is to evaluate what part of the uniqueness is contrary to a predetermined definition. For example, aesthetic rivers have been arbitrarily and rather broadly defined as rivers or sections of rivers that are clear, unlittered, and unpolluted. Thus, if we wish to derive an aesthetic river index, ARI, the uniqueness ratio for factors contrary to the definition of an aesthetic river are zeroed and the ARI for each landscape is computed from the equation

$$ARI = UI\left(1 - \frac{x}{y}\right)$$

Table 1. Factors and evaluation numbers for preliminary LAND system.

Factor			Evaluation Number				
Type	Number	Descriptive Category	1	2	3	4	5
Physical	1	Channel width, ft	< 10	10 to 30	30 to 100	100 to 300	> 300
	2	Low flow discharge, ft^3/sec	< 10	10 to 50	50 to 100	100 to 200	> 200
	3	Average discharge, ft^3/sec	< 10	10 to 100	100 to 500	500 to 1,000	> 1,000
	4	Basin area, sq mi	< 10	10 to 100	100 to 500	500 to 1,000	> 1,000
	5	Channel pattern	Sinuous, pool and riffles	Meandering, pool and riffles	Sinuous, without riffles	Meandering, without pool and riffles	Braided
	6	Valley width and height ratio	< 5	5 to 12.5	12.5 to 25	25 to 50	> 50
	7	Bed material[a], percent	A 100	A 75, R 25	A 50, R 50	A 25, R 75	R 100
	8	Bank and valley material[b], percent	U 100	U 75, R 25	U 50, R 50	U 25, R 75	R 100
	9	Bed slope, ft/ft	< 0.0005	0.0005 to 0.001	0.001 to 0.005	0.005 to 0.01	> 0.01
	10	Width of valley flat, ft	< 100	100 to 500	500 to 1,000	1,000 to 5,000	> 5,000
	11	Erosion of banks	Stable	→	Slumping	→	Eroding
	12	Valley slope, x deg	0 to 10	10 to 30	30 to 50	50 to 70	70 to 90
	13	Sinuosity	< 1.25	1.25 to 1.5	1.5 to 1.75	1.75 to 2.0	> 2.0
	14	Number of tributaries	None	1 to 3	3 to 5	5 to 7	> 7
Biologic and water quality	15	Water color	Clear and colorless	→	Green tints	→	Brown
	16	Floating material	None	Vegetation	Foamy	Oily	Variety
	17	Algae	None	Bed and bank partly covered	→	→	Everything covered
	18	Land plants on floodplain	Open	Wooded with brush	Wooded	Cultivated	Mixture cultivated and other
	19	Land plants on hillslope	Open	Wooded with brush	Wooded	Cultivated	Mixture cultivated and other
	20	Water plants	Absent	→	→	→	Abundant
Human use and interest	21	Trash per 100 ft	< 2	2 to 5	6 to 10	11 to 50	> 50
	22	Variability of trash	Equally distributed	→	→	→	Predominantly in localized areas
	23	Artificial control	Free and natural	Partially controlled	Partially channelized	Completely channelized	Dammed
	24	Utilities, bridges, roads	None	< 4	5 to 10	11 to 20	> 20
	25	Urbanization	No buildings	Cabins, trailors, campsites, few farm houses	Farm houses	Mixture of 2 and 3 and urban	Predominantly urban
	26	Historical features	None	1	2	3	> 3
	27	Local scene	Pleasing	→	→	→	Nauseating
	28	View confinement	Open	→	→	→	Closed by hills, cliffs
	29	Rapid and falls	None	→	→	→	Abundant
	30	Land use	Agriculture	Recreation	Urbanization	Recreation and urban	Agriculture and urban
	31	Misfits	None	1	2	3	> 3

[a]A = alluvium, and R = rock. [b]U = unconfined, and R = rock.

Figure 1. Landscape evaluation numbers for 5 selected Indiana stream valleys.

FACTOR	A	B	C	D	E
1 CHANNEL WIDTH	3	3	4	4	3
2 LOW FLOW DISCHARGE	2	2	4	5	2
3 AVERAGE DISCHARGE	3	3	4	5	3
4 BASIN AREA(SQ. MI.)	3	3	4	5	3
5 CHANNEL PATTERN	2	2	1	2	2
6 VALLEY WIDTH/HEIGHT	2	4	5	4	5
7 BED MATERIAL	1	2	1	1	1
8 BANK AND VALLEY MATERIAL	3	2	1	1	1
9 BEDSLOPE	2	3	2	2	1
10 WIDTH OF VALLEY FLAT	3	3	5	4	4
11 EROSION OF BANKS	2	2	1	2	2
12 VALLEY SLOPE	3	2	1	2	1
13 SINUOSITY	3	3	2	3	3
14 NO. OF TRIBUTARIES	5	5	5	5	5
15 WATER COLOR	2	5	2	2	4
16 FLOATING MATERIAL	1	5	2	5	1
17 ALGAE	2	2	1	1	2
18 LANDPLANTS-FLOOD PLAIN	4	5	5	5	5
19 LANDPLANTS-HILLSLOPE	3	2	5	2	2
20 WATER PLANTS	1	1	3	1	2
21 TRASH / 100 FT.	2	3	2	3	3
22 VARIABILITY OF TRASH	5	3	4	2	3
23 ARTIFICIAL CONTROL	1	1	1	5	1
24 UTILITIES, BRIDGES, ROAD	2	3	3	4	3
25 URBANIZATION	2	1	4	4	1
26 HISTORICAL FEATURES	1	1	1	1	2
27 LOCAL SCENE	2	3	3	2	3
28 VIEW CONFINEMENT	3	3	2	2	3
29 RAPID AND FALLS	2	1	1	1	1
30 LAND USE	2	1	1	2	1
31 MISFITS	1	4	2	2	3

LOCATION OF LANDSCAPE

A Big Pine Creek Near Williamsport, Ind
B Deer Creek Near Delphi, Ind
C Eel River Near Logansport, Ind
D Tippecanoe River Near Delphi, Ind
E Wildcat Creek At Owasco, Ind

Figure 2. Uniqueness indexes for the valleys shown in Figure 1.

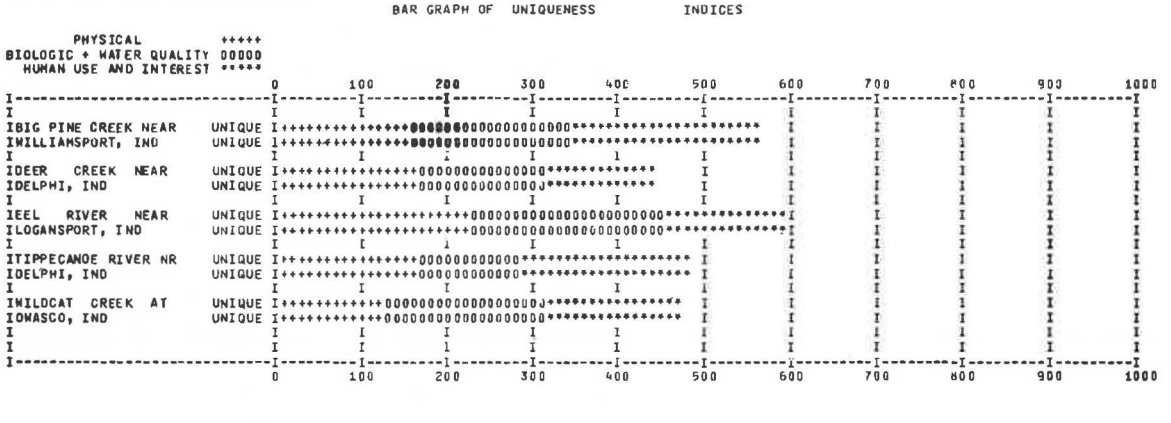
UNIQUENESS MATRIX

			LANDSCAPE LOCATION A	B	C	D	E
		PHYSICAL FACTORS					
	1	CHANNEL WIDTH	.333	.333	.500	.500	.333
	2	LOW FLOW DISCHARGE	.333	.333	1.000	1.000	.333
	3	AVERAGE DISCHARGE	.333	.333	1.000	1.000	.333
	4	BASIN AREA(SQ. MI.)	.333	.333	1.000	1.000	.333
	5	CHANNEL PATTERN	.250	.250	1.000	.250	.250
	6	VALLEY WIDTH/HEIGHT	1.000	.500	.500	.500	.500
	7	BED MATERIAL	.250	1.000	.250	.250	.250
	8	BANK AND VALLEY MATERIAL	1.000	1.000	.333	.333	.333
	9	BEDSLOPE	.333	1.000	.333	.333	1.000
	10	WIDTH OF VALLEY FLAT	.500	.500	1.000	.500	.500
	11	EROSION OF BANKS	.250	.250	1.000	.250	.250
	12	VALLEY SLOPE	1.000	.500	.500	.500	.500
	13	SINUOSITY	.250	.250	1.000	.250	.250
	14	NO. OF TRIBUTARIES	.200	.200	.200	.200	.200
		SUBTOTAL	6.37	6.78	9.62	6.87	5.37
PHYSICAL		UNIQUENESS INDICES	152	162	229	163	128
		BIOLOGIC + WATER QUALITY FACTORS					
	15	WATER COLOR	.333	1.000	.333	.333	1.000
	16	FLOATING MATERIAL	.500	.500	1.000	.500	.500
	17	ALGAE	.333	.333	.500	.500	.333
	18	LANDPLANTS-FLOOD PLAIN	1.000	.250	.250	.250	.250
	19	LANDPLANTS-HILLSLOPE	1.000	.333	1.000	.333	.333
	20	WATER PLANTS	.333	.333	1.000	.333	1.000
		SUBTOTAL	3.50	2.75	4.08	2.25	3.42
BIOLOGIC + WATER QUALITY		UNIQUENESS INDICES	194	153	227	125	190
		HUMAN USE AND INTEREST FACTORS					
	21	TRASH / 100 FT.	.500	.333	.500	.333	.333
	22	VARIABILITY OF TRASH	1.000	.500	1.000	1.000	.500
	23	ARTIFICIAL CONTROL	.250	.250	.250	1.000	.250
	24	UTILITIES, BRIDGES, ROAD	1.000	.333	.333	1.000	.333
	25	URBANIZATION	1.000	.500	.500	.500	.500
	26	HISTORICAL FEATURES	.250	.250	.250	.250	1.000
	27	LOCAL SCENE	.500	.333	.333	.500	.333
	28	VIEW CONFINEMENT	.333	.333	.500	.500	.333
	29	RAPID AND FALLS	1.000	.250	.250	.250	.250
	30	LAND USE	.500	.333	.333	.500	.333
	31	MISFITS	1.000	1.000	.500	.500	1.000
		SUBTOTAL	7.33	4.42	4.75	6.33	5.17
HUMAN USE AND INTEREST		UNIQUENESS INDICES	222	134	144	192	157
		TOTAL	17.20	13.95	18.45	15.45	13.95
TOTAL UNIQUENESS		INDICES	568	448	600	480	474

LOCATION OF LANDSCAPE

A Big Pine Creek Near Williamsport, Ind
B Deer Creek Near Delphi, Ind
C Eel River Near Logansport, Ind
D Tippecanoe River Near Delphi, Ind
E Wildcat Creek At Owasco, Ind

Figure 3. Uniqueness indexes derived from values shown in Figure 2.



where

x = the total value of uniqueness ratio zeroed, and
y = the total value of uniqueness ratio that could have been zeroed.

This equation is used to compute an ARI for each category; the sum is then the final index. The factors, F, and evaluation numbers, E, given in Table 1 that are antithetical to our definition of an aesthetic river, and, therefore, may be zeroed in the calculation of the ARI are as follows:

F	E
15	3, 4, 5
16	3, 4, 5
17	4, 5
21	3, 4, 5
22	1, 2, 3
27	4, 5
31	3, 4, 5

The following example shows how the uniqueness index and the aesthetic index are computed. The indexes are computed for only biologic factors of Deer Creek (B in Fig. 2). An assumption is made that factors 15, 16, and 17 can be contrary to the definition of an aesthetic river and so may be zeroed. For the UI, the ratios are as follows:

Factor	Uniqueness Ratio
15	1.000
16	0.500
17	0.333
18	0.250
19	0.333
20	0.333
Total	2.75

The uniqueness index = 2.75/6 (333.3) or 153. For the ARI, the ratios are as follows:

Factor	Uniqueness Ratio
15	0.000
16	0.000
17	0.333
18	0.250
19	0.333
20	0.333
Total	1.25

The amount zeroed from factors 15, 16, and 17 is 1.500. The amount that could have been zeroed is 1.833. Then,

$$ARI = UI\left(1 - \frac{x}{y}\right)$$

where x is amount zeroed and y is amount that could be zeroed.

$$ARI = 153\left(1 - \frac{1.500}{1.833}\right) = 28$$

The aesthetic indexes for the 5 evaluated Indiana river valleys are shown in Figures 4 and 5.

Figure 4. Aesthetic indexes for the valleys shown in Figure 1.

AESTHETIC MATRIX

			LANDSCAPE LOCATION A	B	C	D	E
		PHYSICAL FACTORS					
	1	CHANNEL WIDTH	.333	.333	.500	.500	.333
	2	LOW FLOW DISCHARGE	.333	.333	1.000	1.000	.333
	3	AVERAGE DISCHARGE	.333	.333	1.000	1.000	.333
	4	BASIN AREA(SQ. MI.)	.333	.333	1.000	1.000	.333
	5	CHANNEL PATTERN	.250	.250	1.000	.250	.250
	6	VALLEY WIDTH/HEIGHT	1.000	.500	.500	.500	.500
	7	BED MATERIAL	.250	1.000	.250	.250	.250
	8	BANK AND VALLEY MATERIAL	1.000	1.000	.333	.333	.333
	9	BEDSLOPE	.333	1.000	.333	.333	1.000
	10	WIDTH OF VALLEY FLAT	.500	.500	1.000	.500	.500
	11	EROSION OF BANKS	.250	.250	1.000	.250	.250
	12	VALLEY SLOPE	1.000	.500	.500	.500	.500
	13	SINUOSITY	.250	.250	1.000	.250	.250
	14	NO. OF TRIBUTARIES	.200	.200	.200	.200	.200
		SUBTOTAL	6.37	6.78	9.62	6.87	5.37
PHYSICAL		AESTHETIC INDICES	152	162	229	163	128
		BIOLOGIC + WATER QUALITY FACTORS					
	15	WATER COLOR	.333	0.000	.333	.333	0.000
	16	FLOATING MATERIAL	.500	0.000	1.000	0.000	.500
	17	ALGAE	.333	.333	.500	.500	.333
	18	LANDPLANTS-FLOOD PLAIN	1.000	.250	.250	.250	.250
	19	LANDPLANTS-HILLSLOPE	1.000	.333	1.000	.333	.333
	20	WATER PLANTS	.333	.333	1.000	.333	1.000
		SUBTOTAL	3.50	1.25	4.08	1.75	2.42
BIOLOGIC + WATER QUALITY AESTHETIC		INDICES	194	28	227	78	86
		HUMAN USE AND INTEREST FACTORS					
	21	TRASH / 100 FT.	.500	0.000	.500	0.000	0.000
	22	VARIABILITY OF TRASH	1.000	0.000	1.000	0.000	0.000
	23	ARTIFICIAL CONTROL	.250	.250	.250	1.000	.250
	24	UTILITIES, BRIDGES, ROAD	1.000	.333	.333	1.000	.333
	25	URBANIZATION	1.000	.500	.500	.500	.500
	26	HISTORICAL FEATURES	.250	.250	.250	.250	1.000
	27	LOCAL SCENE	.500	.333	.333	.500	.333
	28	VIEW CONFINEMENT	.333	.333	.500	.500	.333
	29	RAPID AND FALLS	1.000	.250	.250	.250	.250
	30	LAND USE	.500	.333	.333	.500	.333
	31	MISFITS	1.000	0.000	.500	.500	0.000
		SUBTOTAL	7.33	2.58	4.75	5.00	3.33
HUMAN USE AND INTEREST AESTHETIC		INDICES	222	21	144	82	24
		TOTAL	17.20	10.62	18.45	13.62	11.12
TOTAL AESTHETIC		INDICES	568	210	600	324	238

LOCATION OF LANDSCAPE

A Big Pine Creek Near Williamsport, Ind
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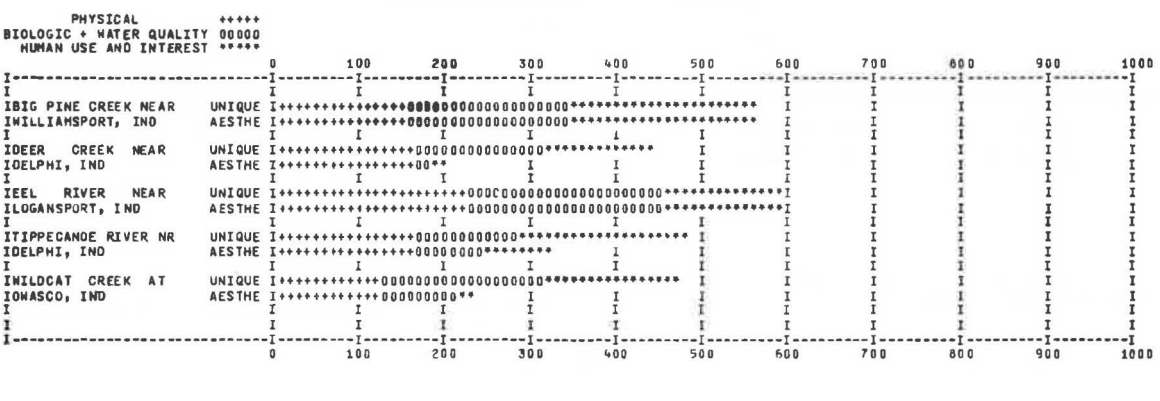
D Tippecanoe River Near Delphi, Ind
E Wildcat Creek At Owasco, Ind

Figure 5. Aesthetic river indexes and uniqueness indexes derived from values shown in Figures 2 and 4.



In connection with the current study, other riverine indexes have been derived and can be similarly computed. Unlike the working definitions for uniqueness index and aesthetic river index already cited, statutory definitions of wild river, scenic river, and recreational river are contained in Public Law 90-542, thus simplifying development of appropriate indexes to fit these definitions. Examples of the measurement and computation involved are, however, omitted from this paper.

METHODOLOGY AND DATA REQUIREMENTS

Information concerning many physical and some biological factors and factors involving land uses and human interest is commonly best obtained from topographic maps and aerial photography. The remaining data are obtained from field observations. Table 2 gives information on how evaluation numbers were obtained for the 31 factors used.

The best currently available topographic maps are the 1:24,000 ($7\frac{1}{2}$-min) USGS map series. Typically, those maps supply information on slope, topography, and human use and interest. However, maps are not yet available for many areas. Therefore, aerial photographs are a very important data source. We have used undodged black-and-white aerial photos at 1:20,000 scale obtained from government agencies. Larger scale photos and color or color-IR films are potentially useful for more detailed studies. The photos normally supply much basic data on vegetation, land use, and human use and interest. Many factors given in Table 2, cited as being obtained from field observation or map measurements, might easily be obtained from aerial photographs. In our preliminary model, we have emphasized field observations as a necessary step to test the validity of the evaluation categories; in developing future models, data obtained from aerial photography analysis will become increasingly important.

Our preliminary model evaluates a length of stream valley 500 times the stream channel width. For example, a stream 100 ft wide would be evaluated for a reach of about 9.5 miles. The decision to evaluate a valley reach 500 times the channel width is completely arbitrary. What is desired in choosing a study reach is to base the length of valley evaluated on some standard parameter that varies directly with the evaluated reach. Thus, a short valley reach is evaluated for small streams, and a longer reach is evaluated as the channel width increases. The only other qualification is that there be sufficient stream gauge data (generally 10 years) to determine flow duration and average discharge. The procedure in evaluating a given river valley is as follows:

1. Measure the channel width on a topographic map or aerial photograph to determine the length of valley reach to be evaluated;
2. Divide the study reach into 10 equally spaced stations;
3. Record measurements and observations in terms of evaluation numbers (Table 1); and
4. Evaluate and hierarchically rank the landscape with other river valleys similarly analyzed.

The data are analyzed by computer. Output includes tables and graphs that list and hierarchically rank the evaluated landscapes in terms of desired indexes. Figures 1, 2, 3, 4, and 5 show examples of the output.

DISCUSSION AND CONCLUSIONS

We have discussed only one example of how the LAND system can be currently used as a simple tool in a decision-making process involving evaluation of alternative river valley sites or reaches. It can just as easily evaluate possible or existing highway corridors, for stream valleys are naturally occurring corridors and network systems that are analogous to highway corridors and regional or areal transportation networks. The 3 descriptive categories of factors are still applicable, and the inherently flexible model allows for additional categories or factors to be included as needed. The number and designation of factors and the number of data collection stations will obviously differ from those used to evaluate stream valleys, but the analysis procedure will not change. Examples of other factors currently under study for possible inclusion in a

Table 2. How evaluation numbers were obtained for preliminary LAND system.

Data Source	Factor	Descriptive Category	Basis for Evaluation Number
Field measurement and observation	5	Channel pattern	General observation for entire study reach
	7	Bed material	Closest fit based on observations at 10 stations
	8	Bank and valley material	Closest fit based on observations at 10 stations
	11	Erosion of banks	Closest fit based on observations at 10 stations
	15	Water color	Closest fit based on observations at 10 stations
	16	Floating material	Closest fit based on observations at 10 stations
	17	Algae	Avg of 10 stations
	18	Land plants on floodplain	General observation for entire study reach
	19	Land plants on hillslope	General observation for entire study reach
	20	Water plants	Closest fit based on observations at 10 stations
	21	Trash per 100 ft	Avg of 10 stations
	22	Variability of trash	Closest fit based on observations at 10 stations
	23	Artificial control	General observation for entire study reach
	24	Utilities, bridges, roads	Count of occurrences over entire study reach
	25	Urbanization	General observation for entire study reach
	26	Historical features	Count of occurrences over entire study reach
	27	Local scene	Avg of 10 stations
	28	View confinement	Avg of 10 stations
	29	Rapids and falls	Count of occurrences over entire study reach
	30	Land use	General observation for entire study reach
	31	Misfits	Count of occurrences over entire study reach
Air-photo measurement and observation	1	Channel width	Avg of 10 stations
	13	Sinuosity	
	14	Number of tributaries	Count of occurrences over entire study reach
	18	Land plants on floodplain	General observation for entire study reach
	19	Land plants on hillslope	General observation for entire study reach
	23	Artificial control	General observation for entire study reach
	24	Utilities, bridges, roads	Count of occurrences over entire study reach
	25	Urbanization	General observation for entire study reach
	29	Rapids and falls	Count of occurrences over entire study reach
	30	Land use	General observation for entire study reach
Map measurement and observation	1	Channel width	Avg of 10 stations
	6	Valley width and height ratio	Avg of 10 stations
	9	Bed slope	Avg of 10 stations
	10	Width of valley flat	Avg of 10 stations
	12	Valley slope	Avg of 10 stations
	13	Sinuosity	
	14	Number of tributaries	Count of occurrences over entire study reach
	23	Artificial control	General observation for entire study reach
	25	Urbanization	General observation for entire study reach
	26	Historical features	Count of occurrences over entire study reach
	30	Land use	General observation for entire study reach
Gauge station records	2	Low flow discharge (90 percent flow duration)	
	3	Avg discharge	
	4	Basin area	

Note: Many factors listed as obtained from field or map observations might easier be obtained from aerial photographs. The information here represents how we obtained data in our preliminary model.

total landscape evaluation system include the following: in the physical category, drainage frequency, drainage density, amount and type of surficial dissection, and soil-rock material types; in the biologic category, percentage and type of vegetation; and in the human use and interest category, land use, population density, transportation network density, and historical-archeological features. The LAND system allows quantification of what previously was not easily quantifiable and provides for visual inspection of hierarchically ranked alternatives. We believe that this type of parametric analysis can be applied to many highway engineering projects, particularly in the planning and land aquisition phases prior to construction. The LAND system is primarily a potentially valuable, additional tool in the decision-making process where the impact of engineering projects that involve landscape modification must be determined by legal statute or public policy.

ACKNOWLEDGMENTS

This research is in part supported by the Office of Water Resources Research, Purdue University Water Resources Research Center.

REFERENCE

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