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Measuring Public Values in Environmental Assessment

With the passage of the National Environmental Policy Act of 1969 and many corresponding state-level acts, environmental assessment has become an important component of environmental planning. A number of assessment techniques have been developed and range from simple matrix analysis of static, direct cause and effect relationships to computer simulations based on grid systems (Lapping 1975). Most of these assessment methodologies are highly technical, but in some of them, the matrix being the foremost example, there is an attempt to weigh technical evaluation of impact with social judgments about the value of the affected environmental features.

This latter approach to environmental assessment presents a number of interesting methodological problems. Most obvious is the problem of determining the value of environmental characteristics. That is, are these values measurable from the subjective perceptions of people about their environment; for example, in comparison to the environmental amenities of other locations (Craik and Zube 1976).

A second problem is the issue of who should make this value choice. Is it a matter of consumer preference, something that can be ascertained through survey or a type of market research, or instead is it the province of the expert, who is usually the project consultant, to make the decision? The latter alternative may be the easier one to use in the course of a project evaluation, but it certainly is questionable whether it can be claimed that the judgments are reflective of community sentiment.

A third problem may be less complex and relevant only if the above two have already been solved. If the value of the environment has been measured according to some scale, then it becomes a matter of combining this data with technical evaluations to provide an overall assessment of the project's impact.

In this paper, the question of using public perceptions in environmental assessment is approached from two perspectives. First, matrix analysis, an approach to the determination of environmental values, is described and other approaches which utilize citizen input are briefly analyzed. In the second part, research findings from a study conducted on a public development project are discussed. The research design was based on a matrix and community responses were employed to measure the value of the environment to local residents.

Problems and Strengths of Matrix Assessment

One of the values of matrix assessment is its simplicity and ease of application. The matrix structure provides a clear and straightforward organization and allows a rudimentary classification of cause-effect relationships. The Leopold *et al.* (1971) model is the best known of these approaches. The matrix is comprised of 100 categories of actions and 88 environmental characteristics that can be affected by these actions. This matrix produces 8,800 cells, each of which identifies an environmental impact. For each cell, two values are assigned. A magnitude estimate is made for the level of impact and this score is weighted by a subjective judgment about the value of the environmental characteristic that is being affected.

It is the latter characteristic of matrix assessment, the assignment of community values to the environment, that is of interest to the social scientist. This methodological approach provides a way to interject community attitudes into the planning process and to integrate technical and social data into a comprehensive summary of a project's impact.

Matrix analysis, however, is not without its shortcomings, especially on the technical side of evaluation. The size of the matrix, 8,800 cells in the Leopold model, can make concise analysis very difficult (Fischer and Davies 1973, p. 211) and often results in nothing more than an inventory of probable impacts (Lapping 1975, p. 125). The analysis is cross-sectional in time so longitudinal or seasonal changes in the environment that might change the nature of the impacts are not analyzed (Fischer and Davies 1973, p. 211). A related problem is the direct cause-effect nature of the analysis. Cumulative, synergistic and higher order impacts are not identified (Lapping 1975, p. 125-126).

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Another area of controversy in matrix assessment, which is more germane to the purposes of this paper, is the assignment of subjective values to environmental characteristics. Leopold (1974, p. 31) has stated that scientists should make the technical and social value judgments in matrix assessment. In the latter role, the scientist has become the surrogate representative of community values. There are two important questions that stem from this role assignment to the scientist. One question is normative, the other empirical. First, should it be the role of the scientist to be an arbitrator of social values? It would seem presumptuous to say yes, since he is not acting as a member of a social community in his role as evaluator, but as a member of a professional community with norms very different from those of the former. McElrath (1973, p. 56) has made this point. His view is that the primary client of the professional is government and the public is a "distant, secondary client dimly viewed through an organizational screen not directly related to their activities."

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The empirical question is not whether the scientist should make the decision, but how he can make it. Even if we accord him the right to make this judgment, can we really expect him to adequately make an assessment of community values? What standard will he use and how will he apply it? Maybe Plato's philosopher king could adequately perform this role, but I am somewhat reluctant to concede that the scientist as consultant has the perspective that Plato gives to his ruler.

In contrast to Leopold's attitude toward determination of the importance of environmental characteristics in matrix analysis is the position taken by social scientists working in the area of environmental perception and behavior. Craik and Zube (1976, pp. 3-23) have called for the development of standardized indicators of environmental quality based on human perception, which they refer to as Perceived Environmental Quality Indices (PEQIs). It is their position that the measures can provide a complementary set of indices to physically-based ones, serve to increase our understanding of the relationship between man and his environment, and provide an alternative method of project-related environmental assessment.

Substantial research has been conducted on the development of such indicators and the validity and reliability problems associated with them (Craik and Zube, 1976). The problem of community perception of environmental values in matrix assessment is a related research question and the same type of methodological considerations should apply. Matrix evaluation would not be based on a generally accepted set of indices as exemplified by Craik and Zube's concept of PEQIs, but would be project-specific. The same measurement issues apply, however, and data could be gathered in the same way whether through verbal surveys or graphic simulations of an environment.

Survey techniques have been used in other types of assessment methodologies to measure environmental values. One such methodology has been developed by Burnham, Nealey and Maynard (1975) for the siting of nuclear power plants. This approach employs respondent evaluations of project alternatives as weights to technical judgments on environmental impact. The researchers present the respondents with "mini-environmental impact statements" for hypothetical power plant options. Each statement describes the impact of each alternative according to eight criteria: aesthetic, land use, water, air, economic, cultural/-recreational, health/safety, and animal/plant. Visual representations are also used in areas like aesthetic values where verbal descriptions prove inadequate. In contrast to the matrix approach, respondents are instructed to rate project alternatives according to their level of acceptability.

In matrix assessment, a sample of community residents would only indicate the value of a particular environmental attribute to them. Identification of project alternatives and their impacts would not be a part of a matrix evaluation. In this regard, the matrix approach is much less comprehensive in the level of community input it provides, but highlights basic project-environment relationships that make it easier to communicate information about impacts. In doing so the matrix approach facilitates community involvement in the environmental planning process.

An Exploratory Application of Matrix Assessment to an Airport Development Project

Under a grant from the Environmental Studies Council, University of North Carolina, research was conducted on the application of the Leopold matrix to the Raleigh-Durham airport development project and the

Resident attitudes towards the nearby airport were measured.
Photo by Blair Pollock

use of this information as the basis of a questionnaire measuring environmental preferences. The goal of the research was to determine if it is feasible to derive social rights from a matrix assessment methodology.

The environmental parameters that are focused on in the questionnaire are of three types: resources, problems, and processes. Resources refers to environmental amenities like parks, employment opportunities, health and safety, and forests. General land use patterns are also included in this category. Aircraft noise is an example of a problem. Some processes are soil erosion, compaction and deposition, and aquatic cycles. Air and water quality could be resources, problems, or processes depending upon the pollution level in the area. Individuals respond according to their perceptions of the value or significance of a particular environmental feature of the area. For example, a concern over erosion is likely to be a function of how a person values water and land quality.

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Interviews were conducted with a random sample of local residents to gather this information. Respondents were not asked to estimate the degree of impact they thought the airport would have on the environment. They were simply required to indicate whether they thought an environmental resource was an important one or that a problem was significant. The technical judgment about the level of impact is the decision made by the expert and is a separate evaluatory process. The choices made by local citizens represent the priority or weight that should be given an environmental feature in the planning process, quite apart from the degree of impact that a project alternate could have on it.

This dual definition of environmental quality, impact and value, provides an approach to environmental assessment that is analogous to cost-benefit analysis in economics. For example, a proposed project alternate could result in a significant disruption of an ecological system. Yet if the affected residents do not place high priority on this aspect of their environment, should the alternative be abandoned solely on the basis of the "objective" assessment? A negative decision of this type, while justified on technical grounds, would not be an accurate reflection of community sentiment. Given the low valuation placed by residents on this environmental attribute, a preferable alternative would be to weight the technical assessment with the environmental preferences of the public. This approach would provide an integrated "community-expert" profile of a project's anticipated environmental impact.

It should be noted that the use of citizen perception as the basis of determining environmental value is based on the assumption that the network of costs or benefits that derive from a particular environment are internalized by the public most immediately affected by the proposed project. This assumption, although a necessary one for purposes of this methodology, is questionable for environmental problems, like air or water pollution. Environmental resources generally have a component affecting a larger segment of the population outside the locality. The question of value extends further than the preferences of local residents and places constraints on the applicability of this matrix technique to projects that affect features of the environment that have broad geographic significance.

With these limitations in mind, the Leopold matrix was applied to the Draft Environmental Impact Statement (DEIS) issued by the Federal Aviation Administration on the proposed Raleigh-Durham airport expansion. The approach identified 240 environmental impacts from the 5 project alternates considered in the document.

In Figure 1, the types of impact are identified. The most frequently occurring impact is on physical processes like flooding, soil erosion, deposition, and compaction. Twenty-two percent of the impacts are in this category. Water-related problems are the second most frequent impact. Runway construction will necessitate construction of dams filling some marshes in the area. Aircraft noise, the most publicized environmental impact from airports, accounts for just four percent of the total number of impacts.

A major limitation of the Leopold matrix is the lack of specification of synergistic and secondary environmental impacts. Aircraft noise is an example. It is an effect of airport expansion if air traffic is increased or different flight patterns are adopted due to runway relocation. Residential neighborhoods may be exposed to higher noise levels in either case. Additionally, there is some evidence that aircraft noise can depress residential property values (Gautrin 1974; McClure 1969) and so it can function as a cause or independent variable. Noise from aircraft can also combine with surface traffic noise to produce a synergistic effect on the ambient noise level in a neighborhood.

This example clearly demonstrates the simplified nature of matrix analysis. The technique, however, does allow basic categorization of cause-effect relationships and this could be sufficient in some cases for construction of a questionnaire to measure environmental values. The problem is that if higher order or synergistic causes have not been specified, then all the consequences of the action have not been identified. The questionnaire would not reflect all the features of the environment that might be affected by a project action in this type of multiple cause-effect pattern. The validity of matrix survey questions ultimately depends upon the thoroughness of the determination of the impacts by technical experts. Sorenson's (1972) attempt to develop a matrix which deals with the multiple and interactive causal dimensions of environmental impacts represents a substantial improvement over Leopold's more direct causal model.

A methodological implication for questionnaire design from an approach which identified cause-effect networks is whether a set of questions could be designed to

Figure 1

Matrix Identification of Effects of Raleigh-Durham Airport Expansion

Effects (Changes in . . .)	N	%
Physical Processes	50	21
Water	43	18
Land Use	28	12
Aesthetics	25	10
Fauna	21	9
Flora	20	8
Earth	14	6
Cultural Land Use	11	5
Noise	10	4
Man-Made Factors	9	4
Atmosphere	5	2
Cultural Conditions	4	2
Total Number of Impacts	240	100*

*Percentages do not sum to 100 due to rounding error.

accurately measure environmental preference based on systems of interaction rather than discrete elements. In the Leopold matrix, environmental features are treated as single, unrelated items. If a matrix is employed that merges these phenomena into a system, e.g., ecological or social, is it valid to ask a respondent to assign a value to the entire set of phenomena? With a large number of elements in the system, there would always loom the internal validity problem of "are we measuring what we think we are measuring?" That is, on what basis would the respondent be making his decision: the system in its entirety or a particular element of it that he might think important?

Problems in Questionnaire and Scale Construction

The first problem in constructing the questionnaire was the number of impacts. Two hundred and forty items are too many for any type of sample survey, including a personal interview. Since there were multiple causes for a single effect, it was possible to reduce this to a single item. Pre-testing of the questionnaire also showed that inclusion of the causal action along with the effect tended to confuse the respondent. When a cause was identified, the respondent often tried to make an impact judgment rather than simply estimating the value of the environmental characteristic. This problem did not occur when only effects were listed.

Identification of the location of the impact proved to be a problem. With many physical, air, and water processes, the location of the actual impact could not be isolated to a single place. Therefore, for these processes, it was necessary to include the location of all the probable impacts. In most other cases where a physical process was not involved, only one locational variable was specified since the effect seemed to be isolated to a particular area.

Seventy-three impacts were included in the final version of the questionnaire. They ranged from controversial issues like "aircraft noise over Raleigh and Cary residential neighborhoods" to straightforward items such as "soil composition surrounding runways on airport property."

The measurement scale used in the questionnaire was a "Q-sort." Each of the seventy-three environmental parameters were listed on a separate card and the respondents were asked to sort them on a ten-point scale ranging in value from important to unimportant. The cards could be re-sorted any number of times, providing the respondent with flexibility in his ranking of the environmental attributes.

The advantage of a Q-sort is that it allows the respondent to make comparisons between items in assigning them ranks. Scales based on comparative appraisals produce less variability in respondent choice than preferential judgment scales where rankings are made on a single issue-by-issue basis (Craik and Zube 1976, pp. 14-20). The issues themselves are the frame of reference with the Q-sort technique, although the usual procedure in using comparative appraisal scales to study environmental perception has been to ask respondents to evaluate a particular setting against settings that possess different characteristics (Zube 1974). This latter approach is more complicated since many more elements have to be introduced into the research design and thus would limit the ease with which the technique could be applied by planners.

Data Analysis

This exploratory survey was administered in July, 1977, to 130 residents of Cary, North Carolina. This community was chosen as the sampling area because most of the city was within the zone of lowest noise level where land use impacts have been established (Federal Aviation Administration 1971, p. 49).

> "A major limitation of the Leopold matrix is the lack of specification of synergistic and secondary environmental impacts."

To determine the priority of the seventy-three environmental attributes, a coefficient of variation was computed for each item and the attributes were ranked according to this value. This measure is based on the mean and standard deviation, thus allowing the average score for a given item to be weighted by the level of agreement among the respondents on its importance. Using a mean to determine an item's priority is a misleading statistic if there was substantial variance in the distribution of the scores. The importance of an environmental feature should be a function of the level of consensus on its significance as well as the value assigned to it on the ranking scale.

The level of consensus on the value of an environmental dimension has been emphasized in the literature on environmental perception. A higher level of agreement among the public over particular issues or problems provides a more reliable data base on which to make policy decisions (Craik and Zube 1976, p. 18).

There are a number of ways to analyze the data. For the purposes of this paper, the rankings of the issues will be examined according to the type of environmental problem and resource and its location. This type of analysis would be the method employed in matrix assessment. Alternatively, questions can be asked about the pattern of individual responses. Studies indicate that environmental perception is a function of many background variables: political ideology, environmental knowledge, education, and lack of personal efficacy (Arbuthnot 1977); self-confidence and esteem (Kaplan 1977); and occupation or role (Althoff and Grieg 1974; Constantini and Hanf 1972). For example, in this survey did the respondents tend to group certain types of impacts together in that they assigned them all similar scores? A pattern of this type would suggest that they viewed the impacts from perspectives that reflected broader concerns such as conservation, recreation, economic development or even environmental ideology (see Tognacci *et al.* 1972).

Questions comprising nine attitudinal scales were also included in the survey which measured attitudes toward such dimensions as aesthetic values, environmental regulation and utility, business, technology, and ruralism. Responses to the seventy-three environmental issues identified by the matrix can be correlated with these scales to determine whether general attitudes toward the environment and other phenomena affected what issues the respondents thought were important. These questions about background and attitudinal correlates of the matrix responses, although important, will not be discussed in this report on the study's findings. In the subsequent discussion, the emphasis will be placed on analysis of the data in a matrix format.

Individual-Level Environmental Parameters Ratings

In Figure 2, the rankings for the top 25 percent of the issues (ranks 1-18) appear. There is a fairly even mix of issues dealing with the physical and biological dimensions of the environment along with cultural elements, although the latter factors tend to be ranked higher. This combination of issues indicates a concern among the respondents with both the natural and social environment. The social dimension of environmental impact has been increasingly stressed in discussions of environmental assessment. For this reason, the analysis of the rankings will focus on the social factors.

The Federal Aviation Administration in a recent circular (U.S. Department of Transportation 1975) emphasized the importance of estimating cultural impacts from airport development projects. Among the social impacts which were identified as items that should be considered in an Environmental Impact Statement (EIS) were direct effects of surface traffic disruption on community socio-economic structure (roads and highways was ranked 18th in this survey) and indirect impacts such as population movement and growth, and public service demands (waste disposal and public utility use were ranked 2 and 6, respectively).

The highest ranked issue is an example of a broad cultural dimension, health and safety. The respondents most likely perceived this environmental problem in a general sense without special reference to the airport. However, there is a direct impact on community safety that is produced by an airport. Operational malfunctions like an airplane crash can result in a severe disruption of a community. Nevertheless, the probability of such an occurrence is very low, so this issue would be an example of an environmental dimension that would receive a

Figure 2

Ranking of Environmental Parameters (Top 25 Percent)

Rank*/Environmental Parameter**/Type)***

1. HEALTH AND SAFETY OF POPULATION in Wake and Durham Counties (CC)
2. WASTE DISPOSAL in Wake and Durham Counties (MMF)
3. RESIDENTIAL LAND USE in Wake and Durham Counties (LU)
4. AIRCRAFT NOISE in Raleigh and Cary Residential Neighborhoods (N)
5. EMPLOYMENT OPPORTUNITIES in Wake and Durham Counties (CC)
6. PUBLIC UTILITY USE in Wake and Durham (MMF)
7. INDUSTRIAL LAND USE in Wake and Durham Counties (LU)
8. LAND ANIMALS AND THEIR HABITATS on Airport Property, Airport Periphery and in Umstead Park (FA)
9. FLOODING AROUND STREAMS on Airport Property, Airport Periphery and in Umstead Park (P)
10. EROSION ALONG STREAMS on Airport Property, Airport Periphery and in Umstead Park (P)
11. STREAMS in Northwest Raleigh (W)
12. WASHING OF DIRT INTO STREAMS on Airport Property, Airport Periphery and in Umstead Park (P)**
13. COMMERCIAL LAND USE in Wake and Durham Counties (LU)
14. AIR QUALITY over Airport Property, Airport Periphery and Umstead Park (AT)
15. STABLE SOIL CONDITIONS ALONG STREAMS on Airport Property, Airport Periphery and Umstead Park (P)
16. INDUSTRIAL LAND USE in Research Triangle Park (LU)
17. WATER CYCLE (PRECIPITATION, FILTERING AND EVAPORATION) on Airport Property, Airport Periphery and in Umstead Park (W)
18. ROADS AND HIGHWAYS in Airport Property (MMF)

*Coefficients of Variation ranged from 22.9 (rank no. 1) to 40.4 (rank no. 18). The coefficient for the 73rd ranked issue (the lowest rank) was 67.6.

**For many of the environmental parameters relating to physical processes, the terminology was simplified for purposes of the questionnaire.

***The general category of effect for the specific environmental parameter is listed in the parentheses. The abbreviations refer to: (AE) Aesthetics, (AT) Atmosphere, (CC) Cultural Conditions, (CLU) Cultural Land Use, (E) Earth, (FA) Fauna, (FL) Flora, (LU) Land Use, (MMF) Man-Made Factors, (N) Noise, (P) Physical Processes, (W) Water.

high social value weighting, but the impact score, derived from an estimate of the risk and magnitude of the event, would be low. The problem of weighing risk versus magnitude in determination of a single impact score is not simple. As in the case of nuclear power plants, the likelihood of catastrophic event is very small, but its magnitude could be enormous. How this decision might be made is beyond the scope of this paper, but the example serves to illustrate a typical problem encountered in matrix assessment where a single impact score has to be assigned for an environmental parameter that has multiple dimensions.

Among the top eighteen ranked issues (25 percent) are four that deal with land use around an airport. These issues are examples of environmental dimensions that would likely receive high impact along with high value scores although the direction of the impact could be positive or negative.

The relationship between airports and land use in their periphery is a complex, multi-faceted problem. Airports can exert a major economic influence on their environment through direct, indirect and secondary employment (employment opportunities was ranked 5th in the survey), and purchase of goods and service. The economic stimulus provided by airports creates a high demand for commercial land and residential housing in their periphery (U.S. Department of Housing and Urban Development 1972).

In contrast, aircraft noise has an adverse effect on existing residential neighborhoods. Its effects include residential turnover and reduced demand for single-family dwellings (Environmental Studies Board 1971, p. 105), and lower residential property values (Gautrin 1974; McClure 1969). The importance of this environmental dimension of the airport's expansion is clearly shown by the high ranking (4th) given aircraft noise in Raleigh/Cary residential neighborhoods.

"The importance of an environmental feature should be a function of the level of consensus on its significance as well as the value assigned to it on the ranking scale."

The evaluation of the actual impact of the airport's expansion, as described above, can be problematic. The difficulty is not always estimating the actual magnitude of impact, but in determining in which cases (e.g., project alternates) it is negative or positive. Most matrix systems use a plus or minus value to indicate the direction of impact. The dilemma posed by the airport's land use impacts, for instance, is that positive and negative land use impacts often occur in the same section of a community. It may not be possible to empirically separate these effects so the analytic requirement in the Leopold matrix that they be treated separately may not adequately summarize the nature of the impact.

Besides aircraft noise in Raleigh and Cary residential neighborhoods, there are six other environmental

Citizen perceptions are used to help determine the environmental value of natural areas like this one near the Raleigh Durham Airport.

Photo by Blair Pollock

parameters that deal with aircraft noise. For these remaining issues the problem is perceived as not particularly important. Surprisingly, aircraft noise in a state park (Umstead) located adjacent to the airport is considered even less of a problem than noise over airport property. One reason is the high variance among the respondents on its priority. It has the third highest standard deviation for the seventy-three environmental dimensions. If the mean alone were used to rank the issue, its position would be 49.5, somewhat higher. To some degree, the low level of concern evidenced by the respondents over the noise problem in the park may be a result of the present noise levels, which are substantial in some parts of the facility. Local residents may consider this noise level as a "natural" characteristic of the park, since it is located next to an airport and is unlikely to be relocated.

In contrast, the high rank of aircraft noise in Raleigh and Cary residential neighborhoods probably reflects more of a concern about the future than an assessment of the present noise level. Residents value quiet neighborhoods and the level of exposure to noise under current operating conditions is minimal. Hence, the high ranking given this environmental dimension likely reflects a concern with conserving an existing resource, residential peace.

Aircraft noise in another residential area, Durham, is ranked much lower. This ranking is predictable since the survey, due to its exploratory nature, was restricted to a community in the Raleigh area. If a representative cross-section of citizens from the Raleigh-Durham metropolitan area were used, this issue would likely be ranked much higher.

In terms of physical attributes of the environment, the respondents expressed substantial concern over flooding and erosion problems and related water dimensions. Stream and runoff problems have been a major environmental issue in the Raleigh area since two major floods occurred in 1973. The issues, although important to residents, would probably receive low impact scores. For all the project alternates, the airport has proposed extensive sedimentation pools and dams to prevent many of these problems.

Group-Level (Effect and Location) Rankings

An alternative way to analyze the data is to group the environmental parameters according to two dimensions: category of effect, and location. In Figure 3, the data are summarized utilizing this format. There are twelve categories of effects (or impacts) ranging from a general value dimension, aesthetics, to physical processes of air, water, and earth. Location of these effects are divided into two parameters: single and multiple. A multiple location refers to an action that has an impact on a number of different geographic areas. Multiple locational impacts are common in regard to actions that affect natural processes although it is also true for some types of social impacts like land use. The location of the effects or impacts are almost equally divided between single and multiple sites.

Figure 3 indicates that most of the impacts of the airport's expansion, when the effects of the project alternates are aggregated, are predictably within the facility's boundaries. But it is clear that none of these category effects are highly ranked by the respondents. The rankings for the groups range from 48 to 67, with the average rank for airport property (across the 12 groups) being 58.

In contrast, the grouped impacts that were identified for Wake and Durham counties receive the highest ranking, 13. These issues deal primarily with social rather than natural dimensions of the environment, e.g., residential land use, density of housing, employment and health and safety. This finding again suggests that area residents are more concerned with the broad, social dimensions of their environment. In Figure 3, the mean ranks for the categories of effect are presented without reference to location. Although atmosphere (14) and water (21) are ranked first and second, the next highest ranked groups, cultural conditions (22) and land uses (26), also include many social factors.

Figure 3, although a useful way to summarize the data, is based on a number of questionable assumptions that also pertain to matrix assessment in general. For each project alternate in a matrix analysis, the total number of cause and effect relationships are identified; each relationship then receives an impact and social value score; and finally these scores are summed to give an aggregate impact score for the project. However, as done in Figure 3, it is assumed that the scores for different environmental dimensions can be added to form an aggregate or combined index.

A valid question is whether such a multi-dimensional index has any meaning since it is multi- and not unidimensional. Unlike an air or water quality index, there is no standard interpretation that can be assigned to a project alternate's score. In one case, a high score may represent mostly aesthetic impacts. For another alternative, the score may be due to impacts on physical processes. In an air quality index, a high value represents high pollution levels. Different combinations of pollutants may produce the score, but there is general agreement on the meaning of the index values. This is not the case for an index value in matrix assessment. An aggregate score does not identify the specific impact: aesthetic, physical, or combination of both. In the latter case, which one contributes more to the score? An alternative approach would be to give a project alternate a separate score on each of the twelve categories of environmental parameters listed in Figure 3. Summary interpretation would be more difficult, but the validity of the technique would be higher. It would not be necessary to make the highly questionable assumption that

Figure 3

Category of Effect by Locational Parameter Rankings

	Single Locational Parameter			Multiple Locational Parameter			
Category of Effect	(A)*	(B)	(C)	(D)	(E)	(F)	Mean Category Rank
Aesthetic	64(5)**	48(5)		21(2)			50(12)
Atmosphere						14(1)	14(1)
Cultural Conditions		28(1)			21(4)		22(5)
Earth				42(4)			42(4)
Cultural Land Use	56(1)					46(1)	51(2)
Fauna	48(3)					26(2)	39(5)
Flora	62(4)	49(3)					56(7)
Land Use	48(1)	36(4)	16(1)	24(1)	8(3)		26(10)
Man-Made Factors	55(3)	18(1)			4(2)		32(6)
Noise	67(1)	37(1)	27(3)	68(1)			42(6)
Physical Processes	56(3)					21(7)	32(10)
Water			11(1)			24(4)	21(5)
Mean Location Rank	58(21)	41(15)	22(5)	38(8)	13(9)	24(15)	

*Definition of Locational Parameters: (A) Airport Property, (B) Airport Periphery, (C) Durham or Raleigh or Research Triangle Park, (D) Umstead Park, (E) Wake and Durham Counties, (F) Airport Property and/or Airport Periphery and/or Umstead Park and/or Northwest Raleigh.

**Figures represent the rank and number of cases, e.g. 64(5), for a category of effects, e.g., Aesthetics, for a particular location, e.g., Airport Property.

the twelve dimensions measure the same phenomenon, which is required if the scores are added together to form a composite index.

Conclusion

In the discussion of the application of survey research methods in matrix assessment in this paper, a generally critical posture was taken toward the validity of the approach. The criticisms made, however, should not be taken as rejection of the approach. It can play a valuable role in environmental planning, but its limitations cannot be ignored.

Matrix assessment represents an "approach, not an arrival," to borrow a quote from Merton (1957, p. 9). Leopold *et al.* (1971, p. 6) make essentially the same point in evaluating the role that a matrix can play in preparation of an Environmental Impact Statement (EIS). They state: "The matrix is, in fact, the abstract for the text of the environmental assessment."

Some of the possible roles that a matrix can perform were outlined in earlier sections of the paper. By relating causes and effects in one comprehensive scheme, it provides a useful vehicle for data reduction and summary. The lack of integration in EISs has been noted by many observers (Ditton and Goodale 1972; Dickert and Domeny 1974), so matrices can provide an approach to this problem.

Secondly, when a social weighting scheme based on survey research is employed in matrix assessment, a method to facilitate the input of citizen concerns into planning is provided. The importance of this element has been stressed in a report prepared for the Federal Aviation Administration. It is emphasized that a public hearing, while a useful means to obtain citizen input, is just a first step. The suggestion is made that the next step be for the "airport operators to weight affected communities' attitudes in their own planning process" (Federal Aviation Administration 1972, p. 32). Survey-based matrix assessment provides such a weighting system and arrays the information in a form that can be combined with technical information on environmental impact. The resulting analysis, although far from definitive, introduces the citizen component into environmental planning and assessment in a systematic and representative fashion—something often missing in the public hearings and other formats that are used in an attempt to produce a process more responsive and accountable to citizen needs and perceptions.

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