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DATA REQUIREMENTS FOR ARMY LAND USE PLANNING AND MANAGEMENT.(U)
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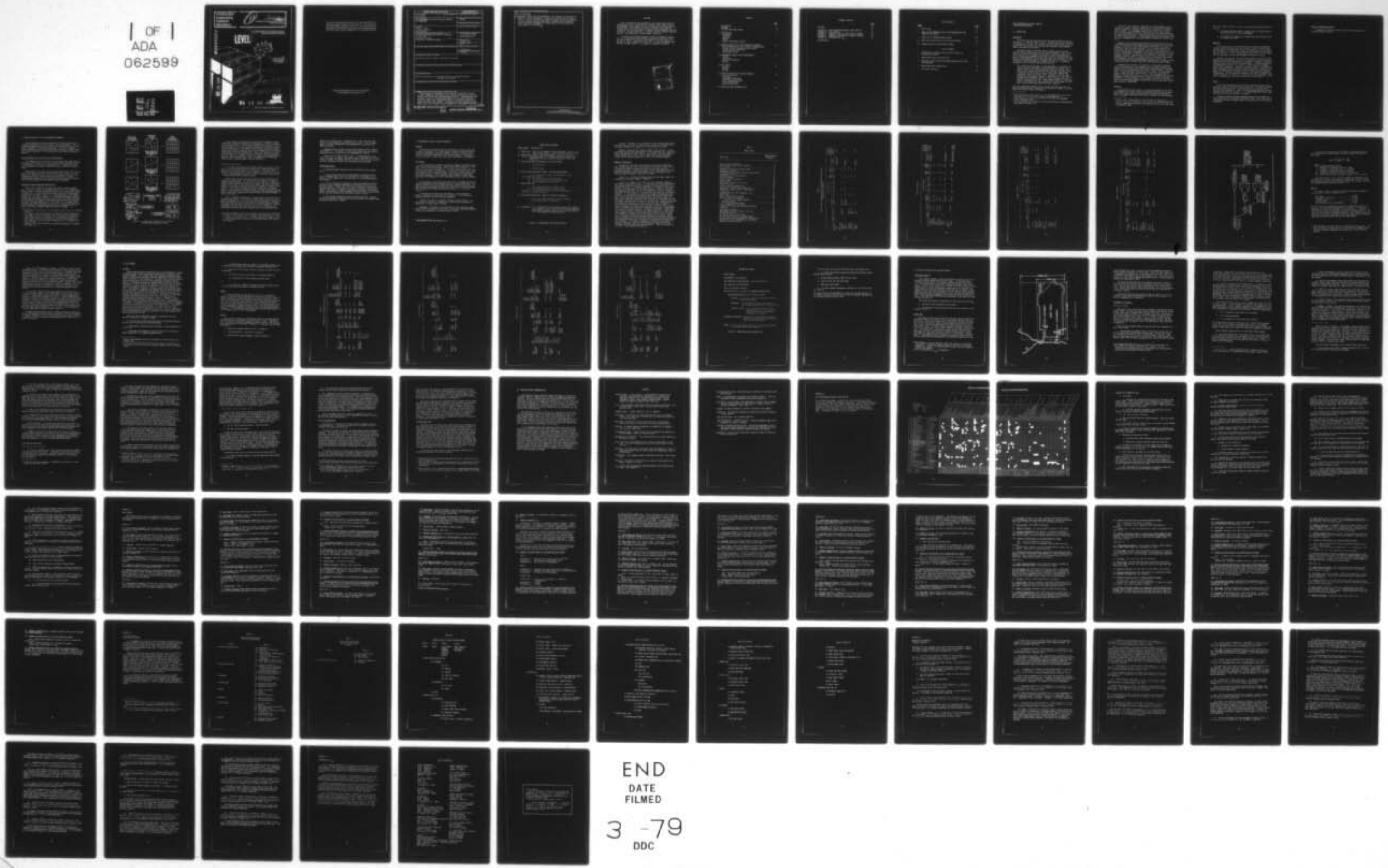

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November 1978
Guidelines for Preserving Natural Resources
and Land Use Planning

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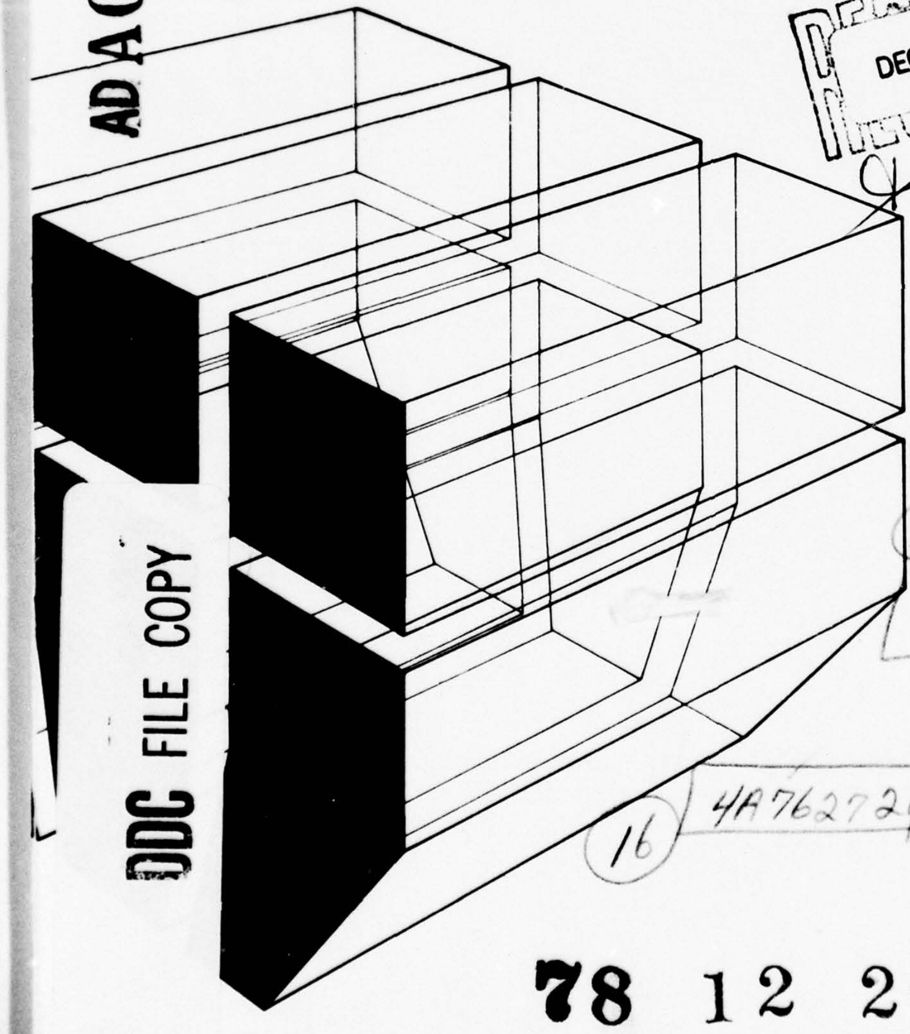

by
⑩ Robert C. Lozar
J. Robert Anderson
Harold Balbach

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Data needed for Department of the Army (DA) installation natural resources management and planning were surveyed and analyzed to aid compliance with existing and projected Army policies. The methodology used included a survey of the data requirements of 32 currently available analytical models and a subsequent survey of existing data sources to supply input into those models. The analytical models surveyed covered areas such as soil erosion, flood susceptibility, groundwater pollution, OVER

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watershed runoff, wildlife management, visual impact, agricultural productivity, forest management, air quality, water quality, and noise levels. Criteria for analytical models and data sources are suggested. Five data sources selected from among 16 surveyed, are reviewed in detail, and their performance as input sources to the surveyed analytical models is evaluated.

FOREWORD

This investigation was performed for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities"; Task 04, "Land Use Planning"; Work Unit 001, "Guidelines for Preserving Natural Resources and Environmental Land Use Planning." The applicable QCR is 1.03.006. The OCE Technical Monitors were Mr. Vance Mays and Mr. Donald Bandel, DAEN-FEB-N.

The work was performed by members of the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (CERL). Dr. Harold Balbach is principal investigator of this work unit. Dr. Ravinder K. Jain is the Chief of EN. COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

More than 5 million hectares within the United States are used primarily for U.S. Army military functions. Because many natural resources are managed on this land, the siting of new activities and facilities on portions of this property has required that hundreds of environmental impact assessments be prepared.

AR 210-20[1] requires that many items of common interest to Army planners and environmental and natural resource managers, such as vegetation and land use, be mapped or plotted on installation base maps. Such listings of environmental and natural resource information are necessary if the Department of the Army (DA) user is to satisfactorily complete the environmental setting and impact prediction sections of an environmental impact assessment or statement (AR 200-1).[2] In addition, paragraph 2-10 of AR 420-74 specifically requires:

> The initial step to be taken in the development of a multiple use natural resources management program requires an inventory and classification of the resources present and their status. The inventory will identify and evaluate the condition and potential of wetland, marine and estuarine areas, fresh water, forest land, grasslands, scenic and natural areas, aesthetics, and any other significant environmental element. Inventories will also identify endangered and threatened species of flora and fauna, and archeological and historical sites. When inhouse capability is not adequate to accomplish this task, maximum use should be made of assistance from the MACOM and cooperating local agencies.[3]

It is an increasingly complex task to assemble and make available for these varied purposes all items which are logically included in environmental and natural resource inventories.

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[1] *Master Planning for Army Installations,* Army Regulations (AR) 210-20 (Department of the Army [DA], January 1970) paragraph 2-2.

[2] *Environmental Protection and Enhancement,* AR 200-1 (DA, December 1973), paragraph 2-12b,d.

[3] *Natural Resources Land, Forest, and Wildlife Management,* AR 420-74 DA, June 1966), paragraph 2-10.

Originally, when agencies responsible for the management of the land and its natural resources needed data to prepare an environmental impact assessment or statement, the data were collected on a project-specific basis. Land management agencies have always required that records be maintained of the basic characteristics of their properties, but large data collections or long-term storage of these data for future use were seldom considered. Land management problems were assumed to be relatively independent of each other and were treated on a case by case basis.

However, public concerns and pressures about the physical and socioeconomic environment have demonstrated that problems are often interrelated. The result is that many complex environmental and resource management issues have been generated. This increased complexity requires more specific data to identify alternative problem solutions. Although the National Environmental Policy Act of 1969 (NEPA) sets forth no direct requirement to maintain large standardized data banks of environmental or natural resource data, such records are necessary if land management agencies expect to prepare timely environmental assessments and statements. Further, ongoing Army-sponsored research into resource/planning/environment/management techniques will require uniform installation data to provide input into the newly-developed systems.

Computers have recently been applied to the storage and manipulation of large masses of environmental data. Computer capability to manage extensive banks of environmentally related data was first developed more or less simultaneously by several research groups in the late 1960s. Private and public universities plus several U.S. Government agencies made significant contributions.[4] Yet to be determined is whether or not the Army can use *any* existing environmental data and data management systems to analyze natural resource and land use related questions on its installations. If such use is possible, the environmental data and data management methods that are most applicable to this Army use must be determined.

Objective

The objective of this report is to provide Department of the Army [DA] command-level natural resources management and planning personnel with an up-to-date survey and evaluation of information necessary to fulfill the goals of AR 420-74 in resource inventory and land management.

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[4] Steinitz, Carl, Timothy Murray, David Sinton, and Douglas Way, *A Comparative Evaluation of Resources Analysis Methods*, prepared under contract No. DACW 33-68-DC-0152 DA, New England Division, U.S. Army Corps of Engineers, 1969).

With that overall objective in view, two supporting subobjectives were pursued:

1. To examine the data needs of common analytical models applicable to Army natural resource management.

2. To determine the adequacy of standardized data sources to fulfill these data needs.

Approach

First, data needs of available analytical models were determined through literature review and direct inquiry. Second, a preliminary list was made of candidate data sources, followed by the actual acquisition of data for one installation from the most promising of the candidate data sources. Finally, recommendations were made as to the adaptation of these data to Army land management and master planning.

Chapter 2 discusses how natural resource data can be used by Army planners and land managers. A listing of potentially useful analytical models and their data requirements is presented in Chapter 3; Chapter 4 examines possible data sources for these models. A detailed evaluation of selected data sources is in Chapter 5; conclusions and recommendations are in Chapter 6. Appendix A contains a table of all analytical models surveyed and their respective data requirements. Appendix B contains information about the different data sources that were surveyed; Appendix C illustrates a potential land use classification system for Army purposes. An annotated bibliography of the models surveyed is presented in Appendix D. Appendix E explains the noise measurement system used. A glossary (pg 43), defines terms used in this report.

Scope

This study investigated only nationally standardized data sources potentially applicable to every Army installation. No local or regional data sources were evaluated. Only those sources with data already available were examined, as opposed to methods detailing how to acquire original data from field surveys. It is acknowledged that lesser known nationwide sources may have been overlooked.

Analytical models and data management methods were screened for their capability to incorporate site-specific data. This study did not investigate macroscale regional models or data sources utilizing broad parameters.

Mode of Technology Transfer

A summary of findings from this report will be issued as an Engineer Technical Letter.

2 CONSIDERATIONS FOR THE DATA MANAGEMENT FRAMEWORK

Massive amounts of data are necessary for the DA installation inventory required by AR 420-74 and other related requirements. The accompanying computational analysis makes almost mandatory the use of computer techniques to store and analyze data. The use of a computer implies important considerations about data uniformity, storage, format, and degree of precision in location-specific environmental evaluation models.

Data Uniformity and Classification Standardization

Environmental evaluation models that are potentially applicable to most Army installations in the United States demand input that exhibits a high degree of uniformity or standardization. Standardized inputs allow the models to be useful repetitively and at different installations.

Many localities may have data bases* of better quality and in more detail than those of national scale included in this study, but available only in that particular locality.** By adopting the most highly standardized national classification system available, the Army increases the probability that information from such localized sources can be used to prepare DA environmental impact assessments.

Formats for Data Storage and Manipulation

Much of the information available on computer-readable magnetic tape is stored in polygon line-segment form.+ This is an inherently efficient means of storing data because only those locations which contain a change (i.e., a corner) need be recorded as opposed to the method of recording all the possibilities (i.e., the points along a line segment or the cells in a grid). However, if an environmental model begins to combine data from several data bases (as do most of the models reviewed in this report), the number of significant intersections can, and usually does, increase geometrically. (See Figure 1.) This means that a slightly more complicated model can result in a significantly more complicated degree of data handling, which implies increased costs; at times, the limit of computer capabilities can be reached.

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* A data base is a collection of a particular type of data in a standard format.

** For example: the Louisiana Office of State Planning is developing a Land Capability Study for Coastal Zone Planning using 28 natural resource data items at a 4-hectare cell size; Resources Information System (IRIS), held by the Northeast Illinois Planning Commission, 400 W. Madison, Chicago, contains information for a six-county area around Chicago.

\+ A polygon is an area inclosed by a series of connected line segments. (See Figure 1.)

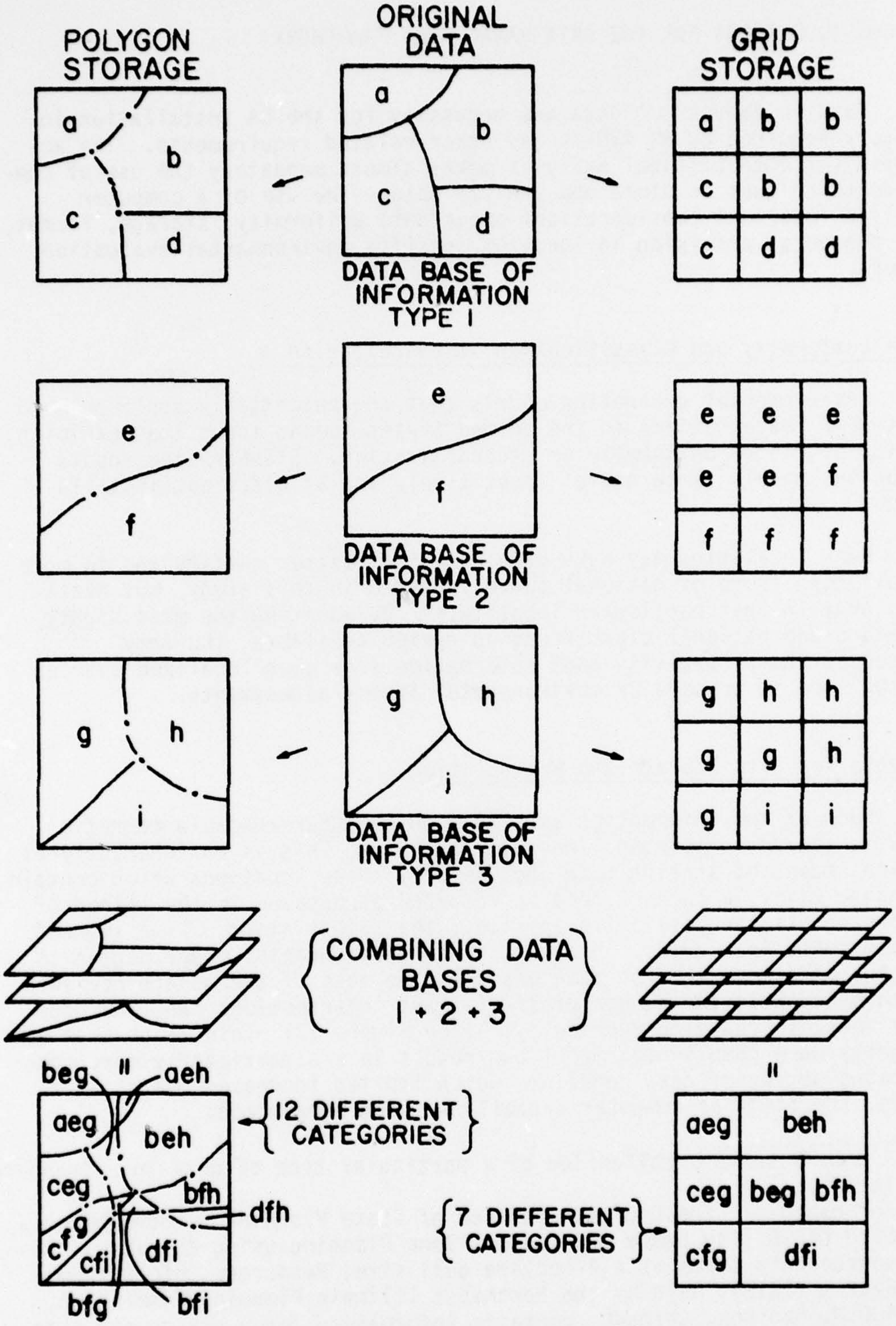

Figure 1. A comparison of polygon and grid data storage and manipulation formats.

A grid* format is often the means by which large amounts of geographically referenced information is manipulated. From its inception, a grid always handles a limited number of data items. Adding a series of grid data bases will imply a constant (arithmetic) increase in unique, location descriptions. The number of these unique descriptions can be large, but will not increase as quickly as the geometrically increasing combinations of polygon-defined areas. Thus, grid storage will allow the manipulation of the same amount of information stored as polygons, but at a lower cost. However, to gain the greater data manipulation capability, the recording of area data in a regular grid (a form that seldom occurs in nature) means a loss of precision.

Accuracy vs Capability

It is often true that the more simple a model is, the less it will cost. It is also often true that simplicity in a model decreases its ability to accurately describe a real situation. But there are important factors of precision, scale, weighting, and ease of use in addition to a straightforward balancing of cost vs accuracy, which the DA user must consider when selecting a model.

A land planner usually must make trade-offs among different environmental considerations. If the results of one model are compared against those of another, the precision of the comparison is necessarily limited to the level of the least precise model. As can be seen from Appendix A, the state of the art for many of the models reviewed varies greatly. Since some of the moderately precise models are the most useful, it is not cost effective to gather increasingly detailed information if that additional information produces little advantage when the model's results are compared and trade-offs made with those of other, less precise models.

Scale is another consideration. In this study, a grid cell area of 4 hectares was adopted. It is useless (often confusing and costly) to gather information on a scale more detailed than necessary. Further, at the several-hectare scale of investigation, a general evaluation model is implied, one that still necessitates on-site confirmation. A complicated model which provides detailed, on-site final information will often provide answers which are inappropriate to the questions being

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* A grid is defined by two sets of parallel lines, each set overlapping the other at right angles. The rectangular area defined by the lines is called a grid cell, or cell. Usually, although not always, a cell in a data base contains one piece of information about that location. (See Figure 1.)

asked at this larger scale. "Comparability" of the resultant information is a requirement determined in part by scale. Thus, a simple model is often as valuable as a considerably more complicated and expensive system.

Weighting values of some sort are often integral parts of models. (See Chapter 3.) If a model is simply constructed, the logic behind a weighting value is usually easier to comprehend and justify.

Simplicity also implies ease of use: a limited number of data inputs for a user to gather, less possibility of submitting an incorrect value or command, and greater ability to confirm that the model has run correctly and then to correct one discovered to be inaccurate.

System Application

A system developed using the criteria discussed in this chapter would:

1. Allow large amounts of environmentally related data such as soils, vegetation type, and slope to be stored at a unique point of access (a single agency) and to be available in a coordinated and uniform format.

2. Aid in evaluating environmental impact by comparing existing conditions with acceptable standards of environmental quality using analytical models. (Models for evaluating environmental quality have been developed to aid in forestry, wildlife, agriculture, grazing management, real estate investment, enhancement of aesthetically desirable values, and protection of environmentally sensitive areas, such as flood plains, aquifer recharge areas, and special natural areas.)

In the following chapters the most desirable data (No. 1, above) are defined through investigating the data requirements of commonly used analytical models (No. 2, above).

3 ENVIRONMENTAL MODELS--DATA REQUIREMENTS

Purpose

No matter how accessible data are, they have no value if they are not used in some way. This investigation, therefore, surveyed several available environmental analytical models in order to obtain a cross-section of the data requirements such analyses demand. In addition, possible sources to supply these data input requirements are suggested.

The Survey

This investigation surveyed 32 analytical models* to determine each model's data-input requirements. Models were selected based on a literature search of published papers and, in some cases, on direct inquiries of the model's developer(s). For this investigation, each model was assigned an identification number. The model's purpose, name, and source were listed. The specific data inputs required by each model were then determined. This information was recorded on a Model Data Evaluation form prepared for this investigation (A,B,C, and D of Figure 2).

As each model's data inputs were identified, an attempt was made to locate an appropriate existing data source for the required input. The agencies which could supply appropriate data, estimated data costs, and when and how data would be available for input into an analytical model were recorded on the Model Data Evaluation form (D, E, F, and G of Figure 2).

A preliminary evaluation was then made as to each analytical model's suitability to Army needs (H of Figure 2). This evaluation grouped each model into one of three categories:

Primary: the model is important to Army land-use planning. Its data inputs are simple and inexpensive to collect and can easily be adapted to a location-specific format.

Secondary: the model is less important, or data inputs are somewhat difficult or expensive to collect, or the model would need moderate changes to be adapted to a location-specific format.

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* See Appendix D for the complete list.

MODEL DATA EVALUATION

Model Number: (Assigned) 22

A. Model Type: (What is the parameter being evaluated?) *EVALUATION OF VEGETATIONAL CHANGE -- TO IMPLY WILDLIFE HABITAT CHANGE*

B. Model Name: (What is the model called?) *Vegetation Diversity*

C. Source: (From what agency is the model available or what is the reference?) *Interaction Between Urbanization and Land, October 1974*

D. What Kind of Data are Necessary to Run the Model?

1. Vegetation type

2. Land Use type

E. Are the Data Available? Where? Can Data be Generated?

1. From cover type, density, and height map of ETL Terrain Analysis Studies
2a. From USGS Land Use/Land Cover maps
2b. Installation Special or Training Area maps
2c. Air photographic interpretation

F. Approximate Cost:

1. About $50/installation to digitize data
2a. About $50/installation to digitize data
2b and 2c. In combination would be much more descriptive; about $150, including digitizing

G. Are Data Available Now? (When will Data be available?)

1. Yes, or it will be within 5 years for FORSCOM and possibly TRADOC installations

2. No

H. Evaluation: (Is it reasonable to get the model going? How important is the model? This is a discussion of relevant important points which the model brings to light plus a rating of it as a DA compatibility planning tool.)

Figure 2. Sample Model Data Evaluation form.

Tertiary: The model is not important, or the necessary data inputs are expensive, difficult, or infeasible to collect, or the model would need major changes to be adapted to a location-specific format.

Appendix A presents the analytical model survey results. In some cases, there may be more than one model of the same type; e.g., there are three "precipitation runoff" models. This repetition allows comparison of the suitability of several similar models which require different inputs, are of varying complexity, or which use different methods.

Method of Evaluation

The specific data types required for each analytical model were then further analyzed; the input frequency of data used in each of the 32 analytical models surveyed was rated, and the data importance weighted by means of a formula prepared for this investigation to determine what data types were of the highest overall importance to the location-specific analyses required by the Army.

Table 1 is a listing of the model types with the model number corresponding to the model number in Appendix A.

Table 2 is a summary of the results of the analytical model and preliminary data source survey. If a data type from those in Appendix A was used more than once (with the exception of the noise levels) it is included in Table 2. The models (numbered as in Appendix A and Table 1) which use that data type are recorded (Column 4). Column 5 lists the corresponding importance ratings (from Appendices A and D) assigned to that model for this survey. If data must be collected, this is noted in Column 2. It is necessary to distinguish between collected data (data which may be retrieved from an agency source) and derived data (that which can be generated from other data after collection); that is, in many cases a new data base need not be collected if information recorded in another (collectable) data base can be relabeled or manipulated to get the desired new data base. If this is the case, the collectable data base from which the new data can be derived is noted in Column 3. (Figure 3 depicts how certain data bases may be derived from collected data.) Derivable data importance frequencies are placed in parentheses in Column 5 to indicate that this is derived information. "Data Source Used in Cost Estimate" (Column 8) and "Approximate Cost to Obtain Computer Readable Information per Installation" (Column 9) are not given for derived data because that would be repetitious or imply a double cost. For those information sources which must be collected, the importance frequencies of the data which must be collected are followed by the importance frequencies (in brackets) of data bases from which they can be derived. For example, topographic elevation has one model of tertiary importance, plus four others which use data derived from elevation (two from slope and two from aspect). These are recorded as "1 + [4]". (See Figure 3 and Table 2.)

Table 1

Model Types

Model Type	Model Number in Appendix A
Small building foundation	1
Septic tank suitability for homesites	2
Soil erosion	3
Rainfall infiltration--percent runoff	4
Groundwater balance	5
Vulnerability to change in surface water quality	6
Groundwater quality	7
Vulnerability to flood potential	8
Wildlife habitat	9
Visual change vulnerability	10
Water quality	11
Agricultural productivity change	12
Visual diversity	13
Visual land use compatibility	14
Simulation of small forest fires, etc.	15
Managing for maximization of forest yield over time	16
Determine optimal deer management, etc.	17
Runoff Model	18
Septic tank suitability, etc.	19
Rainfall runoff infiltration	20
. . . Dissimilarity between adjacent vegetation types	21
. . . Wildlife habitat change	22
Linear (highway) air pollution	23
Evaluation of diversity of possible wildlife habitat	24
Noise quality impacts	25
Development cost for different land uses	26
Stream quality model	27
Air quality from a point source	28
Air and point source air pollution model	29
Surface water quality degradation vulnerability	30
Sunficial aquifer vulnerability to pollution	31
Potential for forest fire	32

Table 2

Types of Data Commonly Used in Environmental/Land Use Compatibility Models

1	2	3	4	5			6	7	8	9
				Frequency of Importance						
Data Base Type	Must be Collected	Can be Derived From	Used in Model Number (see Table 1)	Primary	Secondary	Tertiary	Frequency Usage Total (FUT)	Weighted Importance Rating (WIR)	Data Source Used in Cost Estimation	Approximate Cost to Obtain Computer Readable Information per Installation
Noise Data										
$L_{C_{dn}}$	X		25	1			1	.09	CERL Noise Loudness Survey	$100
Vegetation Data										
Vegetative cover density		Vegetative Type	4,7,10,18,20, 21,32	(4)	(2)	(1)	(7)	(.53)		
Vegetative type	X		8,9,10,16,17, 20,21,22,26, 32	4+[6]	5+[3]	1	10+[9]	.72[1.47]	ETL Terrain Analysis	$ 50
Vegetative fuel type		Vegetative type	15	(1)			(1)	(.09)		
Cover factor		Vegetative type	3,8	(1)	(1)		(2)	(.16)		
Soil Data										
Depth to bedrock		Soil type	19,26	(2)			(2)	(.19)	ETL Terrain Analysis	$100

Table 2 (Cont'd)

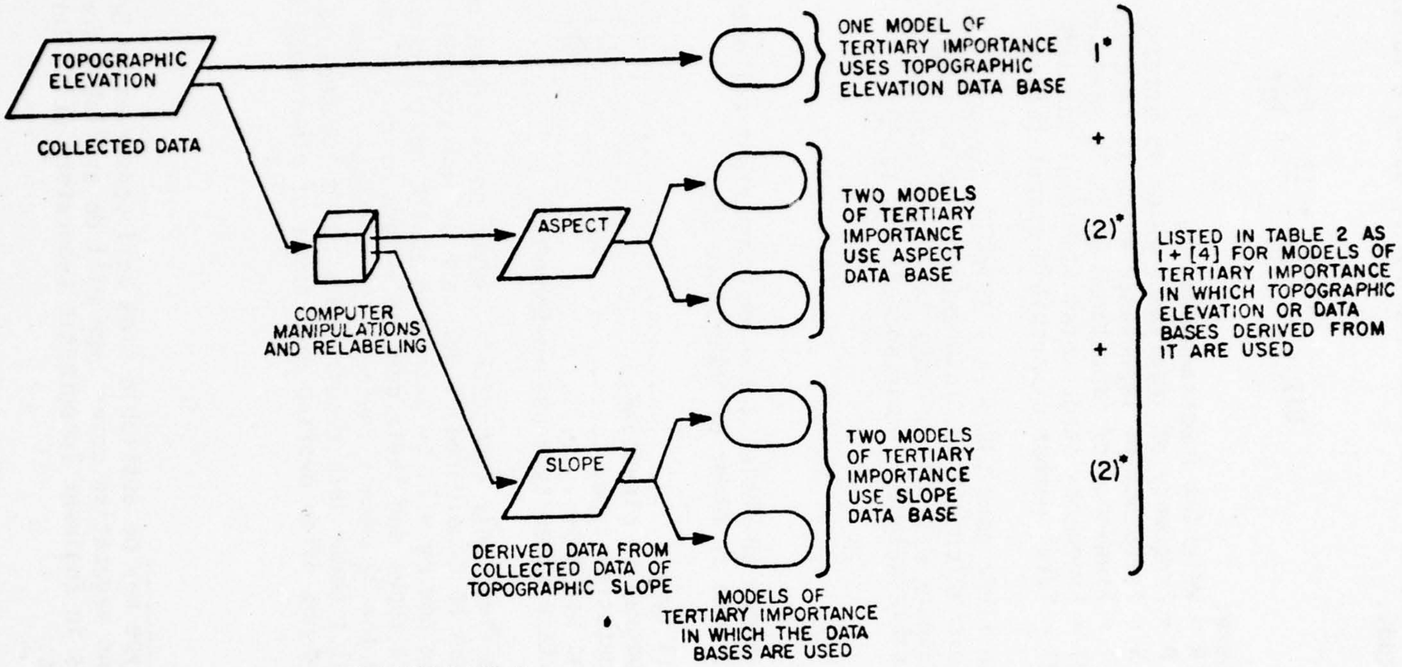
1	2	3	4	5 Frequency of Importance			6	7	8	9
Data Base Type	Must be Collected	Can be Derived From	Used in Model Number (see Table 1)	Primary	Secondary	Tertiary	Frequency Usage Total (FUT)	Weighted Importance Rating (WIR)	Data Source Used in Cost Estimation	Approximate Cost to Obtain Computer Readable Information per Installation
K-factor (inherent erodibility)		Soil type	3,8	(1)	(1)		(2)	(.16)	SCS and its local offices	$5-100
Permeability (infiltration rate)		Soil type	5,7,8,19,20, 26	(4)	(1)	(1)	(6)	(.47)		
Depth to water table		Soil type	7,19,26,31	(4)			(4)	(.38)		
Soil moisture capacity		Soil type	18,20,32	(1)	(1)	(1)	(3)	(.19)		
W-values	X		4,7	2			2	.19		
Soil type	X		1,2,4,6,7,12, 16,26,30	5+[12]	2+[3]	2+[2]	9+[17]	.66[2.03]	SCS generalized soil associations	$50
Topographical Data										
Aspect		Elevation	16,18			(2)	(2)	(.06)		
Elevation	X		10,15,16,25	3+[10]	+[5]	1+[5]	4+[20]	.31[1.69]	DMA Terrain Tapes or DMA Installation maps	$50-1000 or $500-1000

Table 2 (Cont'd)

1	2	3	4	5			6	7	8	9
				Frequency of Importance						
Data Base Type	Must be Collected	Can be Derived From	Used in Model Number (see Table 1)	Primary	Secondary	Tertiary	Frequency Usage Total (FUT)	Weighted Importance Rating (WIR)	Data Source Used in Cost Estimation	Approximate Cost to Obtain Computer Readable Information per Installation
Slope		Elevation	1,2,3,4,6,7, 8,16,18,19,26, 30,31	(8)	(3)	(2)	(13)	(1.00)		
Slope length		Elevation	3,8	(1)	(1)		(2)	(.16)		
Hydrological Data										
Water basin boundaries		Elevation	5,6,8	(1)	(1)	(1)	(3)	.19	USGS standardized hydrological units	$ 50
Surface water type and morphometry	X		2,6,8,9,27, 30	2	4		6	.44	DMA Installation maps	$ 50
Climatological Data										
Air temperature	X		28,29	1		1	2	.12	National Climatic Center or site surveys	$50-1000
R-factor (includes depth and duration of rainstorm)	X		3,8,18,20	2	1	1	4	.28	USDA handbook No. 282	Insignificant
Wind direction	X		15,23,28,29	2	1	1	4	.28	National Climatic Center or site surveys	$50-1000

Table 2 (Cont'd)

1	2	3	4	5 Frequency of Importance			6	7	8	9
Data Base Type	Must be Collected	Can be Derived From	Used in Model Number (see Table 1)	Primary	Secondary	Tertiary	Frequency Usage Total (FUT)	Weighted Importance Rating (WIR)	Data Source Used in Cost Estimation	Approximate Cost to Obtain Computer Readable Information per Installation
Wind speed	X		15,23,28,29	2	1	1	4	.28	National Climatic Center or site surveys	$50-1000
Height of mixing layer	X		23,28,39	1	1	1	3	.19	National Climatic Center or site surveys	$50-1000
Pasquil stability class	X		23,28,29	1	1	1	3	.19	National Climatic Center or site surveys	Insignificant
Land Use Data										
Land use: percent developed or impervious		Land use type	4,7,9,20	(3)	(1)		(4)	(.34)		
Land use type	X		11,12,13,14,17,22,24,25,26,30,31,32	6+[4]	4+[1]	2	12+[5]	.88[1.31]	USGS land use/cover maps or DMA Installation maps	$50-150
Open land and wetland		Land use type	6	(1)				(.09)		
Various Weighting Factors	X		1,2,3,6,8,11,12,14,18,26,30,31,32	5	5	3	13	.88	Most are original research	$300-20,000



*NOTATION USED IN TABLE 2, COLUMNS 5 AND 6

Figure 3. Depiction of how certain data bases may be derived from collected data.

To determine the importance of data types, a Weighted Importance Rating (WIR) was determined (Column 7) using a formula developed for this study.

$$WIR = \frac{3P + 2S + 1T}{FUT} \cdot \frac{FUT}{TOT}$$

where:
WIR = Weighted Importance Rating
P = Frequency of importance which is primary
S = Frequency of importance which is secondary
T = Frequency of importance which is tertiary
FUT = Frequency usage total (subtotal for data type)
TOT = Total number of possible usages (always 32 in this study).

The first term (3P + 2S + 1T)/FUT, averages the importance of all the models which use the information; the second term, FUT/TOT, weighs the frequency with which those data were used in this survey. The highest possible Weighted Importance Rating is "3".

Results

As shown in Table 2, the most important collected (as opposed to derived) data in order of importance are:

Soil type	[2.03]
Topographic elevation	[1.69]
Vegetation type	[1.47]
Land use type	[1.31]
Surface water type and morphometry	0.44

Of these five, only topographic elevation is expensive to collect--the others can be considered of moderate or low expense. All data are available now or will be available in the next 5 years.* Together, the five data types and their derivable data bases are components in all but three of the 32 models reviewed (91 percent). Those three are air quality models; their data requirements rated low because their information needs did not often overlap with those of other models.

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* Soil type may be available from Soil Conservation Service (SCS). Soil type and vegetative cover type will be available for FORSCOM installations in Engineer Topographic Laboratory (ETL) Terrain Analysis Reports.

There is a final category in Column 1 of Table 2, labeled "Various Weighting Factors." During the review process, it became evident that one of the critical inputs into nearly half (13) of the models was some weighting or rating factor which was often based on subjective professional estimates or costly and location-unique survey results. The types of weightings were varied, as were the costs of collecting the information. In such situations, estimating the cost of collecting a model's weighting information is impossible, largely because cost depends on the quality of the information desired. Because such a large proportion of the models reviewed fell into this category, it is to be expected that this type of information is necessary for many of the models which currently qualify for use in Army environmental evaluations.

The five most important data types should be collected first to obtain the highest degree of cost effectiveness, and to insure the most versatile, least expensive data base possible. Although topographic elevation is expensive to obtain, its use in a variety of important applications (WIR of 1.69) strongly suggests that the initial cost will be worthwhile. Further, elevation data does not change significantly with time, so once collected it need never be collected again, making the initial financial outlay small over the projected period of use. Collection of data types other than these five implies less usage and thus more cost over time; nevertheless, other data types will be necessary integral components for models actually adopted.

Weighting factors appear to be an integral component of many analytical environmental/land use compatibility models. The use of weights is commonly accepted as valid in such models; the Army should be able to use them occasionally, provided that the weighting deviations are explicit and logical.

4 DATA SOURCES

Criteria

Modern data manipulation techniques place new requirements on data. Before the advent of such technology, most data were collected in nonstandard formats. These formats make valid computer-aided comparisons among DA installations (and even different study areas within an installation) difficult, if not impossible. The most closely related types of data available before 1970 were those generated for master planning studies. Although these data are standardized by AR 210-20, the standardization is not of a sufficient degree to allow these data to be validly used in computer work due to variations in how the data are collected and stored in practice. Further, a model which evaluates land use or environmental compatibilities demands data not usually included in a master plan. The National Environmental Policy Act of 1969 (NEPA) did not require collection of such data, but computer technology introduced new parameters to data collection. For example, in 1969 NEPA characterized data collection of noise levels for large areas as "presently unquantified environmental...values".[5] However, current state-of-the-art techniques *can* quantify noise data.[6] The advent of modern data storage technology also requires users to record information in new ways. For example, it is not sufficient merely to tell a computer to store as a data point the location of the Mississippi. The computer must also be told that the Mississippi is a river, plus any other characteristic which may be apparent to a human but not to a computer, such as the Mississippi's direction of flow, etc. Clearly, data sources had to be developed that were very different in form and content from those available before 1970.

There are several immediately apparent requirements for data sources if they are to be useful DA-wide.

1. Any data source should provide already collected data because the costs of on-site surveys can be prohibitive.

2. Data must be location specific and have a resolution down to a few hectares.

3. Data which are immediately available must be in a format already standardized in a computer-adaptable form.

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[5] National Environmental Policy Act of 1969, PL 91-190, 83 Stat. 852, 1 January 1970.

[6] *Interaction Between Urbanization and Land: Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

4. If standardized, data must either be in computer-readable form or be easily and inexpensively converted to computer-readable form.

5. Data sources must supply national coverage (at least for DA installations).

6. In order to be most cost-effective, data must either be

(a) necessary to run one primary analytical model

or

(b) useful to a number of important analytical models and be in a form such that they need be collected only once.

Method

To record information regarding data sources in a systematic manner, a standard form was developed for this investigation (Figure 4). Possible data sources were investigated during April and May of 1977. Agencies contacted were well known for their data distribution activity, e.g., the U.S. Geologic Survey (USGS), or were those which would be likely to use these types of data in the course of their own work, such as the Environmental Protection Agency (EPA). Other appropriate agencies or individuals suggested during the course of the survey were also contacted. If literature was available about a possible data source, it was reviewed as part of this investigation.

Results

Data sources thought to be potentially useful in location-specific environmental/land use compatibility modeling are listed in Appendix B. Table 3 presents a comparative summary of these findings. Data sources were then evaluated in more detail (Chapter 5) if they met the following requirements:

1. Relatively standard format (a "yes" in Column 6)
2. Location specific (a "definite" in Column 7)
3. Best choice of those surveyed (a "yes" in Column 9)

Table 3

Comparison of Candidate Data Sources

1 Name	2 Data Type	3 Coverage	4 Date	5 Present Storage Format	6 Is the Format Relatively Standardized?	7 Is it Likely to be Usable for a Location Specific Land Use Format?	8 Estimated Total Computer Compatible Conversion Costs	9 Is it Possibly the Best Choice of Those Surveyed?
CERL Baseline Noise Survey	Noise	Most Army installations	1972-present	Computerized grid	Yes	Definitely	$20-1000/installation	Yes
STORET	Water quality	National--as discreet points	1950's-present	Computerized lists	Yes	Possibly	$50/point	Yes
WATSTORE	Water quality	National--as discreet points	Pre1971-present	Computerized lists	Yes	Possibly	$50/point	Yes
NAWDEX	Water data sources	National--as responsible agencies	Up-to-date	Computerized lists	Yes	No--a source bibliography	$0-300 depending on the amount and type of data desired	No
Army Environmental Hygiene Agency (AEHA)	Solid waste Water qualtiy Noise Chemical Pollution	Spotty	Varies widely	Generally hard copy, computer readible for noise and water	Yes for some water data	Possibly if available	Lack of sufficient standardization makes cost estimates unfeasible	No

Table 3 (Cont'd)

1 Name	2 Data Type	3 Coverage	4 Date	5 Present Storage Format	6 Is the Format Relatively Standardized?	7 Is it Likely to be Usable for a Location Specific Land Use Format?	8 Estimated Total Computer Compatible Conversion Costs	9 Is it Possibly the Best Choice of Those Surveyed
DMA Terrain Analysis studies	Elevation Soils Slope Vegetation Hydrology Transportation	Spotty--mostly TRADOC installations	1975-present	Hard copy	Yes	Possibly (if available)	No cost to Army agencies	No
DMA Terrain Tapes	Elevation	National--complete	Up-to-date	Computer ized tapes	Yes	Definitely	$100-1000/sq degree	Yes
SCS Soils Tapes	Soils	National--not complete	1920-present	Computerized tapes Hard Copy reports	Yes	Definitely	$100-1000/report $50-200/report	Yes

Table 3 (Cont'd)

1 Name	2 Data Type	3 Coverage	4 Date	5 Present Storage Format	6 Is the Format Relatively Standardized?	7 Is it Likely to be Usable for a Location Specific Land Use Format?	8 Estimated Total Computer Compatible Conversion Costs	9 Is it Possibly the Best Choice of Those Surveyed
USGS Land Use/ Cover maps	Land use/ cover Political units Census subdivisions, Hydrological units, Federal land	National--not complete	1972-present--continually updated	Hard copy Computer ized tapes	Yes	Definitely--on gross scale	$250-500/1 sq degree $100-1000/1 sq degree	Yes
DMA Installation maps	Basic topographic map information	All Army installations	1950--present	Hard copy	Yes	Definitely	$40-300/1:50,000 scale map/data item (depending on data type)	Yes
ETL Terrain Analysis Reports	Soils Geology Vegetation Land use	All FORCOM (possibly TRADOC also)--not yet complete	Current (1976-1980)	Hard copy	Yes	Definitely	$50-200/1:50,000 scale map/data item (depending on data type)	Yes
SAROAD	Air quality	National--as discreet points (spotty)	1975-present	Computerized lists	Yes	Marginally as the scale is gross (depends on the type of air quality model used)	$50/point	Yes, because it is the only national standardized source

Table 3 (Cont'd)

1	2	3	4	5	6	7	8	9
Name	Data Type	Coverage	Date	Present Storage Format	Is the Format Relatively Standardized?	Is it Likely to be Usable for a Location Specific Land Use Format?	Estimated Total Computer Compatible Conversion Costs	Is it Possibly the Best Choice of Those Surveyed?
Environmental Protection Agency	Variety of information types	National--spotty	1969-present (if available)	Hard copy--impact statement reports	No--for computer purposes	No	Not usually feasible	No
LANDSAT Satellite Imagery	Land use/cover types	World	1972-present--updated every 18 days	Computer tapes Photo-images	Yes	Marginally-as the scale is gross	$600-700/10,000 sq mi	No
Department of Transportation	Transportation characteristics	National--usually for metropolitan areas of population greater than 50,000	As recent as the local transportation plan--varies greatly	Hard copy or computer readable depending on metropolitan area	No	Possibly (if available)	$300--not feasible	No
Bureau of the Census	Demographic data	National--by enumeration district (varies in size)	1970--much now out-of-date	Computerized tape lists Hard Copy	Yes	No--one or two enumeration districts may cover the whole installation	$50-500/base	No--but may be the main source simply because it is standardized

INFORMATION SOURCES

Source name:

From where is it available?

How extensive is the coverage? *(For Army facilities)*

How recent is the information?

How is it presently stored?

How difficult is it to get into computer-readable form?

How expensive would it be? *(Rough estimates)*

Dollars: *(To procure the initial information from the distribution agency)*

Man-hours: *(To transfer the initial information into gridded form; people's time -- usually labor)*

Length of time: *(To get computer compatible gridded information ready to use as input to a model from the time the initial information is received)*

Personnel evaluation: *(Evaluation of the information source's usefulness in fulfilling the requirements and the stated objectives)*

Source: *(Person who supplied the data to evaluate the information sources for specific purposes)*

Figure 4. Sample data source report form.

The five data sources which fulfilled these requirements were:

1. U.S. Army Construction Engineering Research Laboratory (CERL) Baseline Noise Survey

2. Defense Mapping Agency (DMA) Terrain Tapes

3. USGS Land Use and Land Cover Maps

4. DMA Installation maps

5. U.S. Army Engineer Topographic Laboratory (ETL) Terrain Analysis Reports.

SCS tapes fulfill the requirements, but were not included because (1) ETL studies include soils data, and (2) the SCS computer tape data may not be made available within 5 years.

5 DETAILED EVALUATION OF SELECTED SOURCES

Site and Criteria

This chapter presents a detailed evaluation of each of the five information sources determined to be most useful. To test the effectiveness of data sources, a rectangular area was chosen at Fort Polk, LA. The area was based on Universal Transverse Mercator (UTM)* coordinates. It was 17 600 m north-south by 35 800 m east-west (Figure 5) and divided into 15 752 two hundred meter square cells of 4 hectares each. These dimensions defined a rectangle of 88 rows and 179 columns. Then, examples of Fort Polk data from each of the five sources were requested. Agencies which served as data sources for this test were not aware they were being evaluated as potential data sources for Army-operated facilities. Thus, the request procedure was considered to be a realistic test of data availability.

There were two primary considerations in this section of the study:

1. The cost of data acquisition to the Army.

2. The adequacy of data received to describe the situation at the 4-hectare scale.

Noise Data

CERL Baseline Noise Survey data were developed during research into characterization and reduction of noise associated with major military facilities. Blast noise contours were used because they were available for Fort Polk and because impulsive noise-generating activities (artillery, armor, explosive ordnance demolition [EOD]) are major sources of noise at Fort Polk. The CERL computer program--PUDDLEGRID--resulted in a listing, in map form, of the $L_{C_{dn}}$** values of the center of each grid cell. The values are in tenths of a decibel and were generated from data which are less location specific than a 4-hectare grid. Because the human ear cannot easily distinguish such a fine change in loudness level, it was determined that the degree of accuracy of these data was entirely sufficient for the purposes of an analytical model with a 200 m

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* The Universal Transverse Mercator (UTM) grid system is a world-wide geographical referencing system analogous to latitude and longitude referencing. However, it uses the metric system in place of degrees, minutes, and seconds.

**For an explanation of $L_{C_{dn}}$ see Appendix E.

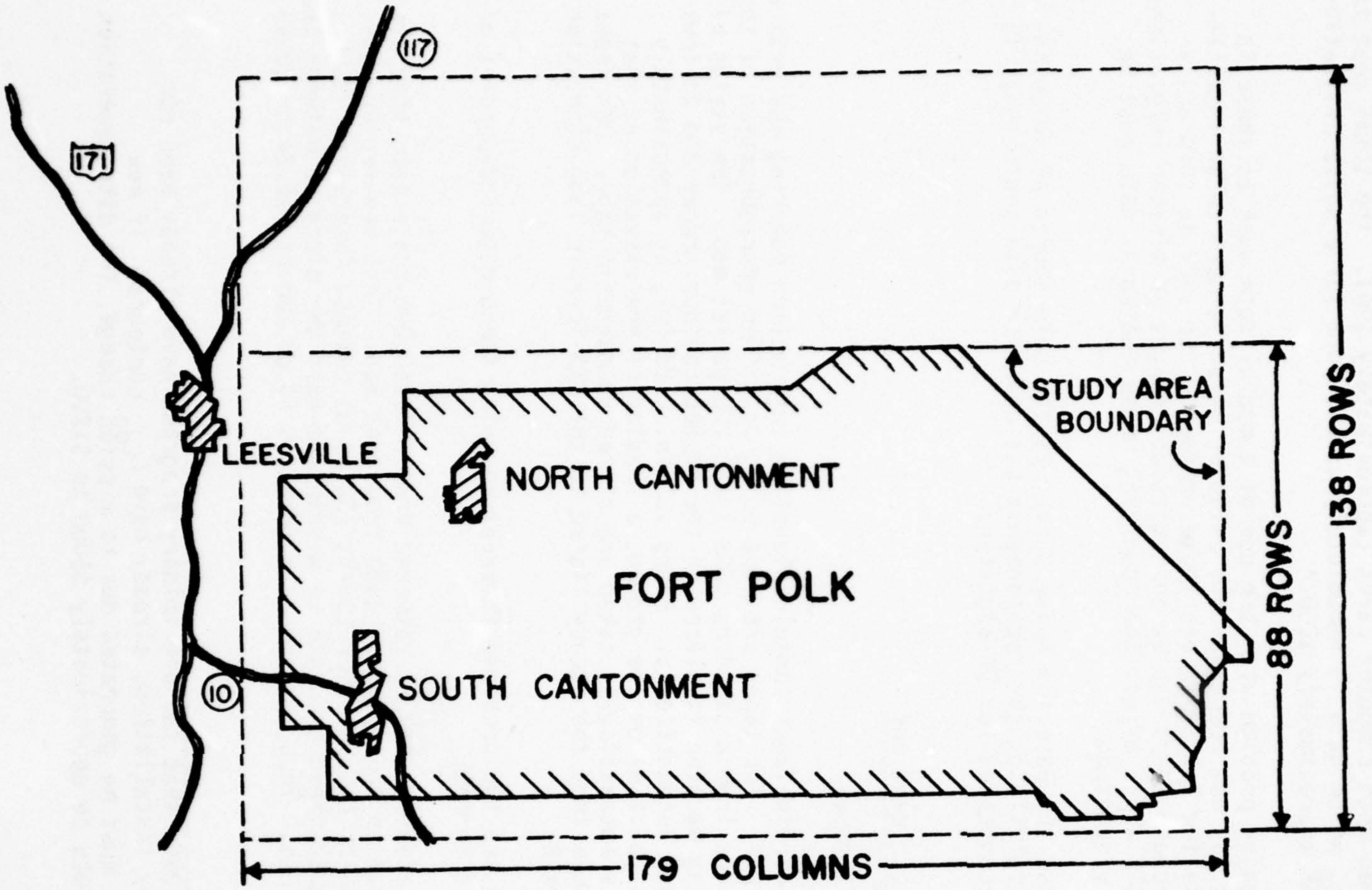

Figure 5. Fort Polk study area.

on-an-edge grid cell size. The cost to run the PUDDLEGRID program to obtain gridded information was $20 to $50. These data were transferred to computer coding sheets by a single technician in 12 hours ($80), and then punched onto computer cards (approximately $90). The total cost to obtain LC_{dn} noise data in immediately usable form for a noise evaluation program was approximately $200.*

The major problem with the use of temporal data such as these is that these may not represent the existing noise pattern on an installation. Data for Fort Polk are those projected for 1977 to 1978 activities. Because there may be some mission changes or mission relocations at Fort Polk which affect the resulting noise contours, data must be continually updated.

Because the Baseline Noise Survey is the sole source of noise information fulfilling the requirements set down for data sources, it is the one recommended for DA adoption.

Topographic Elevations

DMA Terrain Tapes

DMA Terrain Tapes contain elevation information covering the entire United States. The tapes are made using an etched representation of the contour lines from a standard USGS 1:250,000 series map. The stylus of a digitizing machine is placed in the etched contour groove and follows that contour automatically. Every .01 in. (.25 mm), or approximately 208-1/3 ft (63.5 m) on the ground, a reading of the elevation at that location is automatically taken and stored on magnetic tape. DMA Tapes are available from the agency listed in the DMA Terrain Tape discussion in Appendix B.

There are two problems inherent to using these data independent of their taped format.

1. Because data are gathered from a 1:250,000-scale map, they are only as good as the original data from that map. This map series usually has 50-ft (15.24-m) or 100-ft (30.48-m) contour intervals. USGS maps are guaranteed accurate to within one-half the distance between the contour lines. Thus, an error as great as 50 or 100 ft (15.24 or 30.48 m)

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* This assumes that the preliminary programs have already been run. Many Army installations already have $L_{C_{dn}}$ contours. If new contours must be generated due to mission change, the data generation costs would be approximately $1000 to $1200.

is possible. Better maps are available (the 15 minute or 7-1/2 minute series using 5, 10, or 25 ft (1.5, 3.05, or 7.6 m) contour intervals), but these are not necessarily nationally available and would have to be hand digitized. Because the data are intended to be used initially in a visibility model where 5 to 7 ft (1.5 to 2 m) is the critical scale, there may be a real need for a greater degree of precision.

2. A cell of 4 hectares has limitations as to its ability to adequately describe topography because data on the topography in the cell are summarized as a single value. This problem is inherent to the size of the grid cell, not the data source, but it can be significant. Grid translation describes topography least satisfactorily in areas where the drainage pattern is poorly developed and there are irregularly varying topographic aspects and a quickly changing degree of slope. Grid translation best describes topography of smoothly changing surfaces, either flat or steep. (For an evaluation of this problem, see the discussion for the DMA Installation maps in this chapter.)

With these problems in mind, several attempts were made to use the DMA Terrain Tapes. It was necessary to translate the polygon data into a gridded format. For this purpose, permission was requested to use the TOPAS (Topographic Analysis System) computer programs developed by the U.S. Forest Service, Department of Agriculture. TOPAS was used because

1. It is a nationally applicable set of programs
2. It is already developed
3. It is documented by a published user's manual.[7]

The system necessitates the consecutive use of several TOPAS programs (LIST, COPY, PRINT, SCANDTIS, and ARRAY) which result in a gridded Project Terrain Data File of the desired cell size, number of rows, and columns in which each cell contains an individual topographic elevation.

Major problems became evident in using these TOPAS programs.

1. The TOPAS manipulation should have resulted in a gridded area of 138 rows by 179 columns (this corresponds to six 7-1/2 minute USGS maps which TOPAS handles more easily than 88 rows by 179 columns). Instead it generated an area with 141 rows and 176 columns. It was not evident how this happened.

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[7] *TOPAS User's Guide*, Second Edition,EM-7140-1 (Geometrics Division, U.S. Forest Service, U.S. Department of Agriculture, January 1976).

2. After hand mapping a portion of the resulting data and overlaying this onto a 1:50,000 scale topographic map, it was not possible to confirm that this was indeed the correct data for the portion of the map checked.

3. Some of the programs (particularly ARRAY) are very expensive. A simple, though labor intensive, hand digitizing method might be comparable in cost and more accurate. Total costs for the final program output were greater than $500, plus about 20 hours of scientist's time.

4. TOPAS is limited in the amount of area it can handle at one time. Larger areas require major internal changes for the program to handle the data correctly. Fort Polk is such an area. Because Fort Polk is an average-sized installation, similar problems can be expected in the handling of those installations which are still larger.

5. Several delays (in one case more than a month), occurred before the data became available. The system was judged unacceptable because of such delay and uncertainty.

In summary, a number of problems concerning the use of DMA Terrain Tapes and TOPAS application packages were identified. The original DMA data were not precise. Use of the TOPAS program would involve (1) relatively high expense, (2) some changes in its own basic program, (3) an inability to guarantee a completion date, and (4) resulting data that cannot be guaranteed to be an accurate representation of the topography. There is some possibility that the DMA Terrain Tapes themselves could be used if another translation package could be found. The use of TOPAS is not now recommended for Army applications.

DMA Installation Maps

After the work with TOPAS, it was decided to pursue another means of acquiring elevation information. The DMA Installation maps have been compiled for most installations at 1:50,000 scale and are analogous to standard USGS 15-minute series maps (1:62,500). A 200-m grid was overlaid on the Installation map. While one worker determined the elevation at the cell center, another recorded this value on a computer coding sheet. Sixty hours (30/worker) were spent recording the 15,752 points in the study area over a period of 1-1/2 weeks. Key punching required another 15 hours. At the end of 2 weeks, the data were in a form immediately usable for computer model input.

There are several advantages to this simple, manual technique.

1. The availability of data in computer-readable form at the end of a defined period of time can be guaranteed.

2. The data are known to be in the correct location. It is easy to check the "reasonableness" of data by computer printing them as a gray scale map. Points that differ drastically from their neighbors are immediately obvious. It is simple to update the information by changing a value on a card.

3. Though it is a labor-intensive method, the resulting cost is comparable to the TOPAS method. With TOPAS, the cost was $500 for computer time plus 20 hours of professional time ($360) for a total of at least $860 (because the final steps were never carried through); the cost of hand digitizing was 30 hours each for two scientists plus 15 hours for key punching, or $780 and $105 respectively, totalling $885. Because the recording function could in practice be done by less-skilled persons, the operational cost would normally be about $700.

4. There is no limitation on the area that can be digitized (although the evaluation model might have a data input limitation).

5. Because the Fort Polk Installation map was done with a contour interval of 20 ft (6.1 m), manual digitizing, using a 1:50,000 scale map, will result in a much higher degree of precision opposed to the DMA Terrain Tapes/TOPAS method which uses a base scale of 1:250,000.

Using this method, it was found that over most of Fort Polk a 4-hectare cell size could describe the topography reasonably well. A cell usually included little sharply changing topography and the resulting data adequately described the situation for a visibility model.

In summary, data resulting from digitizing elevations from an installation map were found to be simple to set up, easy to understand and confirm, more accurate in describing the topography, and versatile in size capability. This resulted in a more predictably usable product which was comparable in cost to the DMA Tapes/TOPAS method.

Land Use/Land Cover Maps

USGS Land Use/Land Cover Maps

A set of the 1:250,000 scale Land Use/Land Cover maps and computer tapes was ordered from the USGS.[8] Taped data covering the study area had been digitized as polygons. Taped data required 4 months for delivery indicating the computer data delivery systems are not presently working smoothly.

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[8] Alexandria Louisiana Quadrangle, 1:250,000 scale series (U.S. Geological Survey [USGS], 1972).

To evaluate the quality of the mapped hard copy land use data, the section of the 1:250,000 scale map covering Fort Polk was enlarged 5 times to 1:500,000 scale (to coordinate with the elevation data, Installation map, and grid). When this was overlaid on the Installation map, several problems were immediately apparent.

1. Boundaries of land uses did not coordinate well with those apparent from the Installation map or from recent aerial photographs (also at the 1:50,000 scale). This is probably a result of the original map's large scale, which made it difficult for the original photographic interpreter to accurately draw edges on a small area. (On a 1:250,000 scale, the thickness of an inked line can cover 100 m or half the 200-m cell.)

2. The original interpreter's capability to distinguish land use types, especially Army-related uses, from high altitude photographs was limited. In many cases--particularly for the land use categories of Commercial Services, Transportation, Communications and Utilities, and Mixed Urban or Built-up Land--areas immediately distinguishable by investigation reference to the Installation map or aerial photography were incorrectly labeled. Land cover types were more accurate, but many ponds and reservoirs on the installation were not indicated on the enlarged USGS Land Use/Land Cover map. Water bodies are large and contrasting areas, usually easy to pick out with aerial photography.

3. The purpose of the USGS land use classification system[9] is to provide general labels for common land use situations easily distinguishable at high altitudes. Attempts to adapt the USGS system directly to DA installations could result not only in inaccurate labeling of Army land use situations, but could cause projected impacts to DA installations to be overlooked because of this mislabeling. For example, artillery firing points on Fort Polk were labeled "institutional" under the USGS land use classification system in use in 1972.[10]

In summary, the USGS data available in map form were too gross and inaccurate to be useful; in computerized form, the support programs were not developed adequately to be reliable (particularly for deadline-lim-

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[9] Anderson, James R. et al., *A Land Use and Land Cover Classification System for Use for Remote Sensor Data,* Geological Survey Professional Paper 964 (U.S. Government Printing Office, 1976), pp 8-22.

[10] Anderson, James R. et al., *A Land Use Classification System for Use With Remote-Sensor Data,* Geological Survey Circular 671 (U.S. Government Printing Office, 1971), pp 8-22.

ited projects). However, it is recommended that any land use classification system adopted for DA use be coordinated with that used in these land use maps. Although the USGS system is not adequately descriptive now, a modification of it (see Appendix C as an example) could eventually be useful since the USGS system is a standardized nationwide system of land use classification coordinated with the only existing national data bank of land uses. Although the data may not be adequate for this study's immediate needs, any future large scale or regional analysis by the DA or other agencies probably relate in some way to this USGS classification system or to its data bank, since the system is designed for adoption nationally for use by many agencies.[11]

Land Use/Land Cover From Several Sources

Since the USGS maps did not prove to be adequate to describe land uses at Fort Polk, it was decided to determine how difficult it would be to generate a land use map which *would* be adequate at a resolution of 4 hectares. This decision necessitated the combination of several sources by the following procedure. A land use classification scheme similar to that suggested in Appendix C (consisting of 50 categories) was used to categorize the land uses. Data from two major sources were used.

1. The ETL Terrain Analysis Report: Urban Area maps.

2. The DMA Installation maps.

A detailed study of the cantonment areas of Fort Polk was made from the ETL maps at the scale of 1 in. (25.4 mm) = 800 ft (243 m) to allow a more accurate location of the complex land use patterns in the cantonment areas than the 1:50,000 scale Installation maps would allow. A 200-m transparent grid was placed over the two cantonment area maps of Fort Polk. Land uses were manually classified cell-by-cell using the standard land use classification scheme. The digitized cantonment areas were then transferred onto the 1:50,000 scale grid. The DMA Installation map for Fort Polk was used to add other land uses not covered by the cantonment area maps (landfills, cemeteries, drop zones, firing ranges, and water bodies).

Undeveloped grounds were classified using two primary sources:

1. ETL Terrain Analysis Report, using the vegetation map to determine forest type.

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[11] Anderson, James R. et al., *A Land Use and Land Cover Classification System for Use for Remote Sensor Data*, Geological Survey Professional Paper 964 (U.S. Government Printing Office, 1976), p 3.

2. Fort Polk Range Location map (obtained from the Facility Engineer at Fort Polk) to determine training area designation.

As a supplement to these two primary sources, a 1:50,000 scale aerial photographic mosaic was used to confirm the location and extent of the training areas for tracked vehicles. These land use/land cover classes were located on the 1:50,000 scale grid. Upon completion of the map, the assigned land use classes were transferred onto computer coding forms for keypunching. The time necessary to complete this process was 2 weeks of professional interpretation time (approximately $1000) and 12-1/2 hours each digitizing time for two people (one scientist, one technician--approximately $250*). Two further days of keypunching costing $110 were necessary. Total cost to develop computer-compatible digitized land use data was about $1360.**

It was concluded that such a method was adequately accurate. It was expensive largely because no single standardized source of land use data of sufficient quality exists.

Soils and Vegetation

Draft copies of the Fort Polk Terrain Analysis Report[12] were obtained through ETL. The package included soils and vegetation maps at 1:50,000 scale which were digitized.

In terms of content and format, the data presented were considered adequate. The soils map is equivalent to the standard SCS Soil Association maps (or General Soils map) and is derived in part from the Vernon Parish SCS Soil Association map.[13] Such a map is more general than might be desirable for a study using a 4-hectare grid cell size, but it is useful because the Soil Association types are correlated with the Unified Soils Engineering Classification and several other soil quality, capability, hydrologic, and geologic characteristics. The vegetation map defined community associations, height, and density. These parameters are useful both for classical planning and for environmental purposes.

Two methods were used to convert these data to a computer-readable format. The first method used an automatic Summagraphics Digitizer pen and tablet in conjunction with a digitizing program. The production of one map (88 rows by 179 columns) took one person approximately 3 days.

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* This process could be done by two technicians for $180.

** This could cost $1290 if the digitizing were done by two technicians.

[12] To be published in 1978 as *Fort Polk, Louisiana Terrain Analysis* (U.S. Army Engineer Topographic Laboratories, 1978).

[13] Soil Conservation Service, *General Soils, Vernon Parish, Louisiana*, (U.S. Department of Agriculture, June 1971).

Another half day was required to retrieve results in order to verify their accuracy. The resulting computer output, compared with a sample section of the original soils map, revealed that approximately 10 percent of the grid cells were stored incorrectly (far above the amount that might have been mistakenly recorded). It was concluded that the degree of accuracy this method provided was not acceptable.

The second method manually digitized data on computer coding sheets which had been photographically reduced so the coding position could be directly overlaid onto the 1:50,000 scale map and grid. Using this method, the soils map was digitized in 4 hours. Another 4 hours were necessary for key punching.* So in a single day, soils data were converted to a computer-readable format. The same was found to be true of the vegetation map, which also contained large areas of a single data type. Maps with large areas of a single data type are considerably easier to digitize than continuously changing point data such as elevation. It was concluded that this method was entirely satisfactory for digitizing these types of data.

Surface Water Type

The source used for surface water type data was the 1:50,000 scale DMA Installation map. An overlay map of the water features in the Fort Polk study area was made on clear acetate (requiring about 4 hours) showing the location of streams and impoundments and the order[14] of the streams. A transparent copy of the 200-m interval grid map was placed upon this map and labeled along the edges with the computer card number and column in which each cell was to be placed. Once the stream map data were digitized onto the gridded overlay using this technique, the overlay could be given directly to a keypunch operator in place of the normal coding forms. This was done with only one digitizer (rather than the normal two). Since it was not necessary to record the cells on the map which contained no surface water feature, the digitizing time for this stage was decreased from an estimated 22 to 2-1/2 hours. Further, the keypunch operator felt this technique was faster.**

It was felt that the quality of the information acquired by this method was adequate and the cost acceptable.

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* Cost was $52 for a professional employee (or $28 for a technician) plus $28 for keypunching.

** Cost was $52 for surface water feature mapping by a professional, $32 for digitizing by a professional (or $17.50 for a technician), and $28 for keypunching.

[14] After Strahler, A. N., "Quantitative Analysis of Watershed Geomorphology," *Transactions of the American Geophysical Union*, 38(6) (1957), pp 213-220.

6 CONCLUSIONS AND RECOMMENDATIONS

Data needs of common analytical models applicable to military installation natural resource and environmental management purposes were examined. The data elements required to operate each model were analyzed and the most useful elements determined to be: (1) soil type, (2) topographic elevation, (3) vegetation, (4) land use type, and (5) surface water type and morphometry. Potential sources of these five elements were further examined using the following criteria: uniformity of coverage, model adaptability, location specificity, data availability, and multiplicity of application.

When compared with these criteria, most candidate sources of potentially usable data did not prove economically feasible for input into available management models. No single source examined for the five data elements, above, fulfilled criteria for both accuracy and uniformity with respect to all Army installations. Many potentially useful data sources which meet most criteria have incomplete coverage at this time. Thus, current requirements of AR 420-74, AR 210-20, and AR 200-1 for information of this type cannot be fully met.

It is recommended that these potentially useful data sources continue to be surveyed annually for their progress in extending coverage and availability of data. Several government agencies should have completed their data production programs by the 1980 to 1982 time frame, at which time it is logical to resume Army-related examination of universally applicable, site-specific natural resources-related analytical models of the type surveyed. Emphasis in the interim should focus, within limitations directed by available personnel and funds, on acquisition of installation-specific data shown to be widely applicable and/or basically necessary. Conversion of such mapped data to any one computer-compatible form is neither required nor recommended at this time. Availability of the basic mapped factors would, however, greatly aid the Army-wide implementation of any of the several environmental resource models currently being developed and tested.

GLOSSARY

analytic model: In this report, a representation of reality which identifies the characteristic components of a situation and describes changes in the situation through changes in those components, usually using algebraic manipulations. Implies predictive capability whereas "model" does not.

cell: The rectangular area defined within two sets of overlapping lines at right angles to each other, each set containing only two parallel lines.

computer model: A model adapted to run on a computer.

data base: A collection of a particular type of data in a standard format. Soils type data collected over an installation would be a soils type data base.

data item: A particular classification unit within a data base. Hinkley soil type is a data item in the soils type data base.

digitize: To convert mapped information into numerical or alphabetic units to form a data base.

environmental model: A model describing (a) particular attribute(s) of the environment. (Also see "analytic model".)

geographically referenced: To be associated with a discrete location on the earth's surface.

grid: Two sets of overlapping parallel lines at right angles to each other. A single rectangular area defined by the lines is called a grid cell.

hard copy: A printed map or other paper copy representation of data, as opposed to magnetic tape or other records not immediately visually interpretable.

installation: Real property owned or operated by the Army, such as Fort Polk.

land use: The general classification of a piece of land based on the manner in which it is used.

$L_{C_{dn}}$: Noise levels weighted for human perceptions during both day and night. (See Appendix E.)

location-specific data: Data relating to a particular, relatively small area of land.

model: A representation of reality (see "analytic model"). Does not necessarily imply a mathematical predictive capability.

overlaying: In this report, the combination of several types of mapped data and the manipulation of those data in a model to give resultant information. (See Figure 1.)

polygon: An area enclosed by a series of connected line segments.

resolution: The smallest increment for which one has data (4 hectares in this report).

site-specific data: See "location-specific."

taped information: Information which is stored on magnetic tape and intended to be read by a computer.

Universal Transverse Mercator (UTM): A world-wide geographical referencing grid system analogous to latitude and longitude, but using the metric system instead of degrees, minutes, and seconds.

weighting: the rating of an attribute relative to others for the purposes of comparison.

APPENDIX A:

DATA REQUIREMENTS/SOURCES CHART AND KEY

This appendix catalogues, in chart form, the availability of data sources for the models reviewed by this report. The numbers for the row at the bottom of the chart, labeled "Major Data Source: Refers to Data Sources as Numbered in Appendix B," coordinate with those on pp 55 through 68. The numbers for the rows labeled "Major Data Source: Refers to Numbered Statements on the Following pages" and "Available Now?" coordinate with those on pp 51 through 54.

MODEL DATA REQUIREMENTS/S

*Data Availability Categories are
Y Army wide data is available
N Data not available for Army Installations
Numbers correspond to numbered statements following this table

** In categories as follows

A	$0	19	Insignificant
B	$20	99	Slight
C	$100	499	Moderate
D	$500	1599	Expensive
E	$1600	up	Prohibitive

				LAND USE								SOILS							VEGETATION								TOPOGRAPHY									
		MODEL NAME	MODEL TYPE	Land Use Type	Open Land and Wetland	Per Cent Covered by Impervious Material	Percent Developed Land Per Cell	Noise Levels Associated with Land Use Types	Proposed Street Length	Distance to a Quarry	Land Use Ratings (Weighting Factor)	Soil Type	K Factor (Inherent Erodibility)	W Values	Permeability (Infiltration Rate)	Depth to Water Table	Soil Moisture Capacity	Depth to Bedrock	Vegetation Type	Tree Type	Vegetative Density	Cover Factor (Weighting Factor)	Moisture Content (Vegetative Fuel Factor)	Fuel Type	Burn Probabilities	Vegetative Height	Slope	Slope Length	Elevation	Aspect	Landform	Surface Water Type	Water Basin Boundaries	Human Water Use	Man-Made	
MODELS	1	Suitability for Homesite Foundation	Small Buildings Foundations									■															■									
	2	Septic Tank Suitability	Septic Tank Suitability for Homesites									■															■					■				
	3	Vulnerability to Soil Erosion	Soil Erosion										■									■					■	■								
	4	Sigma W Method	Infiltration/Runoff			■						■		■							■						■									
	5	Groundwater Balance	Groundwater Availability												■																		■	■		
	6	Vulnerability to Surface Water Pollution	Surface Water Quality		■							■															■					■	■			
	7	Vulnerability to Groundwater Pollution	Groundwater Quality			■						■		■	■	■					■						■									
	8	Vulnerability to Flood Potential	Flood Potential										■		■				■			■					■	■				■	■			
	9	Vulnerability of Woodland & Water related Wildlife	Wildlife Habitat				■												■													■				
	10	Vulnerability to Visual Change	Visual Change																■		■								■							
	11	Water Quality	Water Quality	■							■																									
	12	Agricultural Productivity Change	Agricultural Productivity	■								■																								
	13	Visual Land Use Complexity	Visual Diversity	■																																
	14	Visual Land Use Compatibility	*Land Use Compatibility*	■																																
	15	Small Forest Fire Model	Forest Fire																				■	■	■				■							
	16	Simultaneous Determination of Optimal Thinning Schedule and Rotation for an Even Aged Forest	Forest Yield Maximization									■								■							■		■	■						
	17	Dynamic Programming for Deer Management Planning	Deer Management	■															■																	
	18	Mathematical Model for Simulating the Hydrological Response of a Watershed	Runoff														■				■						■			■						
	19	Suitability for Septic Tank Leaching Fields	Residential Septic Tank Suitability												■	■		■									■									
	20	Model for Runoff/Infiltration	Rainfall Infiltration/Runoff			■									■		■		■		■														■	
	21	Vegetation Edge Model	Vegetation Type Dissimilarity																■		■					■										
	22	Vegetation Diversity	Vegetation Change (Wildlife Habitat Change)	■															■																	
	23	HIWAY	Linear (Highway) Air Pollution																																	
	24	Wildlife Diversity	Wildlife Habitat	■																																
	25	NOISENS NOISPAT NOISIMP	Noise Quality	■				■																					■							
	26	Development Cost	Land Use Development	■					■	■		■			■	■		■	■								■									
	27	DOSAG 1	Stream Quality																																	■
	28	P T M T P	Point Source Air Pollution																																	
	29	Climatological Dispersion Model (CDM)	Area & Point Source Air Pollution for Particulates & SO(X)																																	
	30	Vulnerability to Pollution of Surface Water System	Surface Water Quality	■								■															■					■				
	31	Surficial Aquifer Vulnerability to Pollution	Surficial Aquifer Quality	■												■											■				■					
	32	Potential for Forest Fires	Forest Fire	■													■		■		■															
DATA		Major Data Source Refers to data sources as numbered in Appendix B		5,7	5,7	5	5,7,12		5,12	12		10,12			10,12	10, 2		10,12	12		12	12		12		12		5,14	5,14	5,14	10,12	5,12	7		5	5,12
		Refers to numbered statements on the following pages*				12	20	33			22	1	5	11			42			27		8	25	8	26		3	9		3				15		
		Available Now?*		21	Y	13	19	33	Y	10	N	2	6	Y	10	2	N	10	10	N	10	10	Y	Y	N	10	Y	Y	Y	Y	10	Y	Y	16	Y	Y
		Approximate Cost**		B to C	B	C	B to E	D	B	B	D to E	B	A to B	A	B	B	C to E	B	B	D to E	B	B	A	B	C	B	C	C	D	C	C to E	B	B	B to E	B	B

MODEL DATA REQUIREMENTS/SOURCES

SOILS	VEGETATION								TOPOGRAPHY					HYDROLOGY									CLIMATOLOGY							WILDLIFE			NOISE		AIR POLLUTION								WEIGHTING FACTORS					
Depth to Bedrock	Vegetation Type	Tree Type	Vegetative Density	Cover Factor (Weighting Factor)	Moisture Content (Vegetative Fuel Factor)	Fuel Type	Burn Probabilities	Vegetative Height	Slope	Slope Length	Elevation	Aspect	Landform	Surface Water Type	Water Basin Boundaries	Human Water Use	Man Made Drainage Systems	Numbers & Lengthof Tributaries to Each Stream	River Length Between Points of River Inflow	Velocity & Depth Discharge – Tributary & Main	Mean BOD & DO – Upstream End & Incremental Runoff	Location, Mean Flow & BOD of Inputs and of Withdrawals	Depth & Duration of Design Rainstorm (Used in R Factor)	Annual Precipitation (In Inches)	Annual Evaporation (In Inches)	Wind Direction	Wind Speed	Height of Mixing Layer and Hourly Mixing Height	Hourly Air Temperature	Indicator Species & Habitat Requirements	Beginning Deer Population	Acreage of Useable Habitat	Noise Levels	Permissible Noise Levels	Pasquill Stability Class	Pollution Strength for Each Stack	Height and Diameter of Stack	Stack Temperature	Stack Locations	Sensor Location Height and Above Ground	Emissions Factors	Actual Receptor Readings for Calibration	Relative Vulnerability Rates	Suitability & Detractor Classes	Land Uses Relative Impact	Additional Weighting Factors of Various Types	Site Independent Cost Factors	Importance Ratings
									■																																					■		2
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	12		12	12		12		12		5,14	5,14	5,14	10,12	5,12	7		5	5,12	5,12	11,16	11	11										12	2							9		9						
		27		8	25	8	26		3	9		3				15					37	41	7	14	14	14	14	14	43	18	17	8		34	32	39	39	39	39	39	30	40	17	23	35	4	35	
	10	N	10	10	Y	Y	N	10	Y	Y	Y	Y	10	Y	Y	16	Y	Y	Y	36	36	36	Y	Y	Y	Y	Y	Y	N	19	28	29	Y	Y	Y	38	Y	38	39	39	31	N	N	24	N	N	Y	
	B	D to E	B	B	A	B	C	B	C	C	D	C	C or E	B	B	B or E	B	B	B	C to E	C to E	A or E	A	A	A	B	B	B	A or D	D to E	C to E	C to E	C	A	B	A or D	A	A or D	A	A	C to E	A or E	B or E	E	D to E	A to E	A	

2

AVAILABILITY CATEGORIES (KEY)

1. Soil Type:

a. From the Soil Conservation Service (SCS); for most of the United States. Those surveys which are finished will be in digitized form on tape in the next 20 years. Areas of high priority will be available sooner, particularly in urbanizing areas. (Army installations are not usually located in such areas.)

b. From the Engineer Topographic Laboratory (ETL) Terrain Analysis Studies for certain Army installations.

2. Soil Type and Depth to Bedrock:

a. May be available from SCS; a major drawback. May not be available for years.

b. ETL Terrain Analysis Studies will be available for many FORSCOM installations within the next 5 years.

3. Slope and aspect can be adequately generated from Defense Mapping Agency (DMA) elevation tapes using the ZONIT subroutine in TOPAS or other similar programs.

4. Weighting factors may be either

a. Available after some literature research and estimates

b. Nonexistent, needing separate studies for each one.

5. K-factors are available on an individual basis through published soil reports, or for all soils on a computer tape listing from from the Washington, DC, SCS office.

6. The K-factor is available for all soil series.

7. These data are available from published accounts (often a single value will cover an entire installation). See Walter H. Wischmeir and Dwight D. Smith, *Predicting Rainfall Erosion Loses from Cropland East of the Rocky Mountains*, USDA Agricultural Handbook No. 282, USDA Agriculture Research Service and Purdue Agriculture Experiment Station (Government Printing Office, 1965).

8. This information can be generated from vegetation type and cover density (data from ETL Terrain Analysis Studies).

9. Slope length can be generated by a computer program using a slope data base.

10. These data are available now, or will be in the next 5 years for certain FORSCOM installations.

11. W-values are published in *Handbook of Applied Hydrology* (McGraw-Hill Book Company 1964).

12. USGS Land Use/Land Cover maps for the United States will provide categories from which cover percentages can be roughly estimated. The actual values should be derived from more specific land use maps, and using the USGS categories as suggested in Appendix C.

13. Impervious area can be obtained by assigning a value, "characteristic percent of area impervious for each land use type." Then a land use type data base could be used to describe the percent of impervious land.

14. Climatic data for specific areas in the country are available from the National Climatic Center, Ashville, NC.

15. Water use can be determined by on-site survey or printed material from local water supplies or operators of local reservoirs.

16. If these data are not available through a local planning agency, they would be prohibitively expensive to obtain.

17. Amounts can be obtained by:

a. Estimates by a qualified scientist

b. Direct studies of actual numbers.

18. Published reports, local colleges and universities, wildlife associations are likely sources for these data.

19. Information on indicator species is probably locally available, but must be gathered.

20. Percent developed land is not available and it may not be possible to generate it. Because wildlife habitat areas on an installation are used, and change readily, this quality is not as directly descriptive of habitat as it is of most other (civilian) open land.

21. USGS Land Use/Land Cover Maps are either currently available or will be by 1982.

22. Fabos arrived at the ratings using a questionnaire. (*Metropolitan Landscape Planning Model* [*METLAND*] [University of Massachusetts, June 1973].) Since many of his study-area land use ratings depend on people being present to perceive the changes; this is not a viable technique for this study. Other Fabos' models which also require such data are also unusable under the restrictions of this study.

23. Data for use in Fabos's models are not readily available.

24. Suitability and detractor classes are judgmental; they are not difficult to derive using expert consideration but difficult to define objectively in quantitative terms.

25. Beall, H. W. *Forest Fire Danger Tables,* Note 12 (Canadian Department of Mines and Resources; Lands, Parks Forest Branch; Forest Fire Research, 1946), p. 55; Gisborne, H. T. *Measuring Forest Fire Danger in Northern Idaho,* Publication 29 (U.S. Department of Agriculture, 1978), p. 63; Nelson, R. M., *The National Fire Danger Rating System Derivation of Spread Index for the Eastern and Southern States,* U.S. Forest Research Paper SE-13 (Southeast Forest Experiment Station, 1964), p. 44.

26. Burn probabilities are generated by running the model several times with different fuel grids.

27. The ETL data are not of adequate detail for the model.

28. Deer population statistics are available if field surveys have been completed by state agencies or installation wildlife managers.

29. If the area of habitat is clearly described on a map, the information may be available. Most of the time this is not the case, so:

a. A habitat model may have to be developed and run

b. The appropriate area may be determined by knowledgeable personnel in state and local conservation agencies or installation wildlife managers.

30. These data are determined from traffic volumes expected and emission factors *(Compilation of Air Pollutant Emission Factors,* [Environmental Protection Agency, 1973]).

31. Traffic volume field readings have to be done for each study. They cost approximately $2000 per study. Traffic volume estimates can be made for around $200. Costs for determining emissions factors are insignificant (although the EPA report [statement 30] may not have the data for Army-unique vehicles).

32. Utilizing a particular Pasquil stability class designation is a user option. For engineering predictions, the worst condition is usually assumed (Level E or worst level expected).

33. CERL personnel state that noise levels for some land uses can be easy and inexpensive to estimate professionally. Noise level estimates can be made using (a) traffic volume figures, (b) population density (in cities), and (c) proximity to airports. Some specific land uses (e.g., industry) must be done on a case-by-case basis.

34. Permissible noise levels are published in *Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, EPA 550/9-74-04 (EPA, March, 1974).

35. These data are available from *Building Cost Calculator* (Dodge, 1972); *A Land Use Plan Design Model* (S. W. Wisconsin Regional Planning Commission, 1968); *Building Construction Cost Data* (R. S. Means Co., 1976).

36. These parameters may be available for some installations. A survey of all installations is necessary to determine which ones have these data.

37. *Pollution Estimation Factors*, Technical Report N-12/ADA033753 (CERL, November 1976) characterizes wastes based on different land uses in Army. Note: STORET has many data categories including BOD and DO runoff, but some files presently do not contain data.

38. There is no universal source, but measurements are available from existing stacks similar to those proposed.

39. These variables are user input options.

40. Local testing data may be available through SAROAD.

41. STORET has some of this information, as do Army installation records. The data from the latter are likely to be insufficiently accurate to be usable.

42. Soil moisture capacity is not available directly from any source, though by using a series of assumptions it may be roughly estimated for the purpose of these models using SCS soils information.

43. a. Not available, must do original research

b. Can be estimated from data available from the National Climatic Center, Ashville, NC.

APPENDIX B:

DATA SOURCES

The following data sources are numbered as referenced in the Model Data Requirements/Sources Chart in Appendix A, and in the main text of this report.

SOURCE NO. 1

(A) Source Name and Address: Army Environmental Hygiene Agency (AEHA), Commander, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Grounds, MD 21010

(B) Data Types: Various types depending on study. Data usually associated with the following categories: pollution monitoring and evaluation, drinking water quality, pesticide levels, waste handling, general water quality, noise from the general environment or occupational surroundings, etc.

(C) Coverage: Spotty at best; available if already requested.

(D) Date of Data: Varies; 1941 to present.

(E) Manner of Storage: Written; hard copies, some water and noise in computer-readable form.

(F) Computer Compatibility: Would have to be standardized (if possible), formatted, and digitized. Not easy to computer-adapt at present. Drinking water and permits for actions impacting water quality are on computer.

(G) Expense of Putting Data in a Location-Specific Format: Lack of standardization makes cost estimates infeasible.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Most data in these programs are coded by installation and cover most DARCOM problem areas. Yet lack of standardization and lack of universal availability preclude use of these data for Army-wide land use environmental analytical modeling.

SOURCE NO. 2

(A) Source Name and Address: Baseline Noise Survey Simulating Human Response to Noise (L_{Cdn}), Acoustics Team, Construction Engineering Research Laboratory (CERL), P. O. Box 4005, Champaign, IL 61820

(B) Data Types: Noise contour maps of Army installations.

(C) Coverage: Noise pattern isobars for many Army installations (and adjoining areas) are being developed.

(D) Date of Data: The first data were gathered in 1972; initial data gathering program is to be finished in 1977, after which program refinements will be made.

(E) Manner of Storage: On computer as points of loudness which are generated onto noise contour maps. After the development phase is finished, data will be housed elsewhere.

(F) Computer Compatibility: Utility programs define areas for a number of different grid sizes.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: computer time approximately $100/regular sized installation
Labor: 2 weeks of programmer's time
Elapsed Time: approximately 1 month.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Purpose of data is to predict a community's degree of annoyance for impulsive (blast) noise sources over the installation, weighted over a 24-hour period. Initial description of system is included in Army Training Manual (TM) 5-803-2, *Environmental Protection: Planning in the Noise Environment* (DA, 15 June 1978). An important and unique source of noise data.

SOURCE NO. 3

(A) Source Name and Address: Bureau of Census, Data Users Service Division, Bureau of the Census, Washington, DC 20233

(B) Data Types: Basic demographic data including population, age, income, and occupation.

(C) Coverage: National, but varies depending on population density. In Standard Metropolitan Areas all categories of data are stored. In less populated areas, fewer categories--mainly population- and density-related data--are stored. (Army installations often fall into the latter category.)

(D) Date of Data: 1970.

(E) Manner of Storage: DIME computer tapes by enumeration district; vary in size but include population of 100 to 800 people.

(F) Computer Compatibility: Presently computer readable, but not in a location-specific format which can easily be translated to small standardized grid-cell format.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: tape data with application programs--$80, computer costs--$150
Labor: 20 hours to set up correct storage spaces
Elapsed Time: 2 weeks

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Types of data available, lack of standardization or location referencing in a map format, and need (as suggested by results of Chapter 3) indicate this data source is not worth pursuing at this time.

SOURCE NO. 4

(A) Source Name and Address: Environmental Protection Agency (EPA), Waterside Mall, Rm. 3821, R.D. 682, 401 N. Street, S.W., Washington, DC 20460

(B) Data Types: This source covers data gathered for specific studies, usually environmental impact statements. For specific data bases housed by EPA, see other sources in this appendix. Standard areas of data are air, water, solid wastes, economic and sociological impacts.

(C) Coverage: National; collection spotty.

(D) Date of Data: Collected continuously.

(E) Manner of Storage: Reports, lists, and maps.

(F) Computer Compatibility: Data usually generated due to environmental impact statement or other type of specific project study. Thus, data are not compatible, continuous, or concurrent. No standardization of data collection or storage.

(G) Expense of Putting Data in a Location-Specific Format: Could not be estimated.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Although EPA holds a huge mass of good environmental data, it is not in a standardized form that can easily be translated into a useful national computerized system.

SOURCE NO. 5

(A) Source Name and Address: U.S. Army Installation or Installation Special maps (1:50,000 scale), Defense Mapping Agency, Topographic Center, 6500 Brookes Lane, Washington, DC 20315

(B) Data Types: Standard topographic data including topography, general vegetation cover, hydrology, cultural features, and especially Army training areas and firing ranges on most maps.

(C) Coverage: Installation maps for most Army installations. (Special maps available for Fort Huachuca, Cibola Range, Fort Hunter-Ligget, 29 Palms East & West Marine Corps Base, Fort Carson, Fort Riley, Camp Ripley, Camp Drum, West Point, Fort Sill, Fort Jackson, Fort Campbell, Fort Hood, Fort Lewis, and Camp McCoy.)

(D) Date of Data: 1950 to present; highly variable.

(E) Manner of Storage: Paper maps.

(F) Computer Compatibility: Grid must be overlaid and data digitized.

(G) Expense of Putting Data in a Location-Specific Format: Maps are free to all DOD agencies.

Labor: continuous area data 4 hours/data type*; Noncontinuous point data--2 hours/data type*; continuous point data (topography)--40 hours/data type*.

Elapsed time: 1 week.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Excellent data source covering many larger Army installations over the United States.

SOURCE NO. 6

(A) Source Name and Address: LANDSAT Satellite Imagery, Earth Resources Observation Systems (EROS), Data Center, Sioux Falls, South Dakota 57198

(B) Data Types: Satellite (SKYLAB-LANDSAT) and aerial photography (high- and mid-altitude) of different spectral scales using different spectral bands. Also computer utility programs which visually display images and simple programs to recombine spectral types using color-coded images.

(C) Coverage: Worldwide.

(D) Date of Data: Entire earth every 18 days (if clouds do not obscure areas).

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* Plus 4 to 20 hours for keypunching.

(E) Manner of Storage: As photographic images or on magnetic tapes as data bits.

(F) Computer Compatibility:

Alternative 1--Tape data are presently computer readable. However, data are unrefined. Groundtruth field surveys are necessary to obtain usable categories and to determine a land use's spectral classification, a collimation procedure which is expensive and time consuming.

Alternative 2--Center's automatic programs identify spectral classification of several areas and allow separation of 6 to 12 spectral groups. Human user then identifies areas as to use (concrete, water, corn fields). Major drawback is that resultant groups are not always useful, critical groups may be indistinguishable from others. (Wheat fields and rye fields are not as environmentally different as concrete and gun emplacements.)

Alternative 3--Visual satellite-photo interpretation coupled with standardized maps; may not have the resolution to distinguish all the critical land use divisions; would have to be hand digitized.

(G) Expense of Putting Data in a Location-Specific Format:

Cost:

Alternative 1 -- \$50,000/frame/10,000 sq miles (2589 km^2)
Alternative 2 -- \$200/tape plus \$50 computer time
Alternative 3 -- \$12 to \$100 for photographs.

Labor:

Alternative 1 -- 160 hours for collimation and field testing.
Alternative 2 -- Computer programmer (\$200) plus interpreter (\$200)
Alternative 3 -- 80 hours for an interpreter.

Elapsed Time:

Alternative 1 -- 3 to 4 months preparation; 1 month for interpretation
Alternative 2 -- 1 month
Alternative 3 -- 1 month.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Land cover is best distinguished. (Soybeans vs wheat are easy to distinguish; asphalt areas vs buildings are more difficult; road vs airplane runway is indistinguishable.) Very good in distinguishing areas of broad ecologic communities. "Point" land uses are lost and there is much distortion and blurring due to the way data are stored in the satellite and sent back to ground. Even Alternative 1 is inexpensive over large areas once collimation studies are made. The major problem is the inability to distinguish land uses according to a standard classification scheme. Although future advances may decrease problems associated with LANDSAT data, it is apparent that they are not adequate at the present time to distinguish all pertinent land uses without help of other methods.

SOURCE NO. 7

(A) Source Name and Address: Land Use and Land Cover Maps and Tapes, National Cartographic Information Center, U.S. Geological Survey, Mail Stop 507, 12201 Sunrise Valley Drive, Reston, VA 22092

(B) Data Types: There are a group of maps in this series: land use and land cover, political units, census county subdivisions, hydrologic units, and Federal land ownership.

(C) Coverage: Entire United States.

(D) Date of Data: High altitude air photographs and satellite imagery no greater than 2 years old. The first entire set for the United States to be finished by 1982 with continual updating thereafter.

(E) Manner of Storage: In polygon form on computer tapes, stable base film positive or paper diazo prints.

(F) Computer Compatibility: Tapes in computer form. Utility programs are being developed for graphics display, evaluation manipulations, and polygon-to-gridded data transformations.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: (1) hard copy paper to film -- $2 to $22; (2) tape -- $50/1 sq degree

Labor: (1) digitizing hard copy--20 hours; (2) computer programmer for tape--4 hours.

Elapsed Time: (1) from hard copy to computer cards--2 weeks; (2) from tape to usable form--2 weeks.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Two major problems exist: (1) the scale (1:250,000) is large due to use of high altitude photography (although units as small as 4 hectares are defined on maps), (2) land uses are divided into only 37 land use categories which must cover all possible situations in the United States. These categories are too broad and cannot include

Army-specific activities, even though these may have great impacts. Any use of this source would have to be accompanied by a revision of the classification scheme for Army purposes. However, this is a data source worth investigating.

SOURCE NO. 8

(A) Source Name and Address: National Water Data Exchange (NAWDEX), U.S. Geologic Survey, National Center, Mail Stop 421, Reston, VA 22092

(B) Data Types: NAWDEX is an index of sources, not a source in itself. It includes water data sources at Federal, state, and local levels, and often provides data desired if those data are stored in STORET or WATSTORE.

(C) Coverage: National; includes Federal, state, and local sources (discontinued hydrological stations are also available).

(D) Date of Data: Data varies depending on pertinent legal requirements and type of material collected (daily to yearly). Data collected in 1800's are available; computer system initiated in 1976.

(E) Manner of Storage: As listing (in computer form) of all agencies holding water quality data. System began in 1976, will contain approximately 400,000 source entires by end of 1977 (at least 400,000 more, eventually).

(F) Computer Compatibility: Data necessary to run water quality models may be in a variety of forms, depending on the holding agency. It is likely standard parameters will be available; they can be found via NAWDEX.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: $0 to $300 (small jobs are done gratis)
Labor: NAWDEX technicians do input work
Elapsed Time: one day turnaround.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): NAWDEX is excellent for locating water quality model data; it will be connected to STORET and WATSTORE water quality data files during 1977.

SOURCE NO. 9

(A) Source Name and Address: Storage and Retrieval of Aerometric Data (SAROAD), Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC 27711

(B) Data Types: Air quality data including suspended particulates, settled particulates (dust), sulfation rates, gas concentrations, wind speed and direction along with methods of collection and analysis.

(C) Coverage: National coverage, but spotty. (4000 actively reporting locations in January 1976; these are too few for Army-wide applications.)

(D) Date of Data: States must submit on-site test data every 3 months, but many observations taken during that time are allowed for each location. Data are from 1957 nationally; from 1972 locally.

(E) Manner of Storage: As lists in computer storage.

(F) Computer Compatibility: Presently computer readable, but how data are recorded depends on the computer program for which data were collected.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: usually less than $500 (most expensive for raw data); summary $100 to $200
Labor: SAROAD personnel are responsible for running programs
Elapsed Time: 1 week for most data requests.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): A good source of air quality pollution levels, but on a larger scale than concerns this study. Data are most often available for more industrialized locations. For those Army installations which are in rural settings, necessary data may not be available.

SOURCE NO. 10

(A) Source Name and Address: Soils Information Tapes, United States Department of Agriculture, Soil Conservation Service, P. O. Box 2890, Washington, DC 20013

(B) Data Types: Soils maps on tape.

(C) Coverage: National. Standard SCS soils maps are being digitized onto computer tapes in polygon form. It is in its initial phase (April 1977) with only parts of Arkansas and Oklahoma finished (plus other counties, mainly in the Southeast). Approximately 100 counties are digitized per year (newly completed surveys are digitized immediately). Roughly one-third to one-half of available surveys will be completed by 1982. If a hard copy soils survey is not already available (a not uncommon situation), one will not be available on tape. All soils surveys should be completed in approximately 25 years.

(D) Manner of Storage: As recent as the most up-to-date soils survey; varies greatly.

(E) Manner of Storage: Published maps beginning to be stored as digitized polygons on computer tapes.

(F) Computer Compatibility:

1. Hard copy must be hand digitized.

2. Tape copy must be translated into gridded form. Some application programs are being developed (or it may be possible to adapt similar ones being developed by the USGS for use with their Land Use/Land Cover Data).

(G) Expense of Putting Data in a Location-Specific Format:

Cost: (1) hard copy--$15 for general soil association map and making a grid, (2) tape--$50 to $80.
Labor: (1) hard copy--20 hours digitizing and card punching, (2) tape -- 20 hours or less of programmer's time.
Elapsed Time: (1) hard copy--2 weeks, (2) tape -- 1 week to 1 month.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): An excellent source, if data are available either in hard copy or tape. The fact that they may not be available for several years is a real problem. Some areas, particularly in the south-central United States, are presently available in grid cell form. (Oklahoma, Arkansas are complete; Texas is partly done.) Utility programs to manipulate data are being developed but are not now (1977) completed.

SOURCE NO. 11

(A) Source Name and Address: Storage and Retrieval of Water Quality Data (STORET), U.S. Environmental Protection Agency, Office of Water and Hazardous Materials, Washington, DC.

(B) Data Types: Output covers a wide variety of parameters, but includes BOD, DO, chemical composition, micro-organisms, flow, and physical properties.

(C) Coverage: National, but as spot readings from 200,000 collection points on streams, lakes, and other water bodies. Collection points are more common in areas of higher rainfall and population density.

(D) Date of Data: Late 1950's to present.

(E) Manner of Storage: As location-specific points in list format.

(F) Computer Compatibility: Now stored in a computer, accessible through remote terminals. The problem in running a location-specific water quality model is obtaining enough sample points on a water body.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: $2 to $20 depending on size of job

Labor: 6 hours or less if programmer already knows how to use system

Elapsed Time: usually 1 day on telephone-terminal connect jobs; up to 2 weeks if results are to be mailed to user.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): STORET is worth more investigation as a source of water quality model data input, though the number of collection points may limit its usefulness. Output options appear to be varied.

SOURCE NO. 12

(A) Source Name and Address: Terrain Analysis Reports, Engineering Topographic Laboratory (ETL), Fort Belvoir, VA 22060

(B) Data Types: Maps and tables include surface water, ground water amounts, engineering soils location and characteristics, engineering geology location and characteristics, vegetation type and height, climate, cross-country movement capability, lines of transportation and communication, cantonment areas, cultural and off-post features.

(C) Coverage: Studies of many FORSCOM bases in progress.

(D) Date of Data: Usually a gathering of existing planning data for an installation plus those pieces of basic data which have not previously been done. Updated to time of the ETL study (started in 1977).

(E) Manner of Storage: Presently as maps or tables on hard copy.

(F) Computer Compatibility: Most of the maps are at 1:50,000 scale; format is standardized over wide range of important planning types. All that is necessary is to make a grid at the appropriate scale to cover the installation, then hand digitize data for keypunching.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: expenditure for reports is minimal
Labor: area data (soils, vegetation) take approximately 4 hours/map
Elapsed Time: 2 days from digitizing to return of keypunched computer cards.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Terrain analysis reports contain important standardized planning data, inexpensive and easy to translate into computer format. A prime source of data.

SOURCE NO. 13

(A) Source Name and Address: Terrain Analysis Studies, Defense Mapping Agency (DMA), 6500 Brooks Lane, Washington, DC 20315

(B) Data Types: Includes land planning data; elevation, soils (according to the Unified Classification System), slope categories, vegetation and its characteristics, inland hydrology, and transportation characteristics.

(C) Coverage: Very spotty and often not available.

(D) Date of Data: The most important Army installations have recent maps (since 1965) but many less important installations have maps made from 1940 to 1965.

(E) Manner of Storage: Hard copy maps for some TRADOC installations.

(F) Computer Compatibility: Data would have to be digitized, but DMA has equipment and capability (see "Expense").

(G) Expense of Putting Data in a Location-Specific Format:

Cost and Labor: No cost for DOD functions.
Elapsed Time: Depends on where project falls in terms of assigned priorities; 3 to 6 month turnaround is common.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Data are spotty; DMA's real usefulness would be as digitizers of other data collected and then given to them, (as long as there is no time limit). AR 115-11 describes how DMA assistance may be requested.

SOURCE NO. 14

(A) Source Name and Address: Terrain Tapes (DMA Tapes), Defense Mapping Agency, 6500 Brooks Lane, Washington, DC 20315

(B) Data Types: Elevations in feet above sea level.

(C) Coverage: National, every 208 ft (63 m) over the entire United States.

(D) Date of Data: Taken from 1:250,000 series USGS Topographic maps, so taped data are as recent as the maps. (Elevation data does not change significantly over time as do other data types.)

(E) Manner of Storage: As lists on computer.

(F) Computer Compatibility: In computer-readable form; program needs to be written to obtain data in gridded format. Topographic Analysis System [TOPAS] can do this and is available from the U.S. Forest Service.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: (1) tapes--$15/1 sq degree block, (2) computer time--$100 to $1000.
Labor: 10 to 40 hours.
Elapsed Time: depends on computer priority (1 day to 30 days).

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Easy and inexpensive means of developing gridded topographic data. Since original data are taken from 1:250,000 scale map which has 50 or 100 ft (15 or 31 m) contour intervals, and since USGS guarantees these contours to be within a half contour interval, data may be inaccurate by as much as 50 or 100 ft (15 or 31 m). May be too great an error for use in a visibility model.

SOURCE NO. 15

(A) Source Name and Address: Department of Transportation, Federal Highway Administration, Urban Planning Division, 400 7th Street, S.W., Washington, DC 20590

(B) Data Types: Standard transportation data including location, capacity, peak flows, and often condition of pavement and future proposals.

(C) Coverage: Metropolitan areas in the United States. (To qualify for Federal funds, all metropolitan areas of a population greater than 50,000 must have a set of Federally required data.)

(D) Date of Data: Data are as recent as transportation plan of metropolitan area, thus vary greatly. Since transportation planning is an ongoing process, data are often updated.

(E) Manner of Storage: In computer form as point data. Usually, individual metropolitan areas collect and store the data. Data are often computer readable, but usually not standardized since collection is for use in transportation models of a particular local area.

(F) Computer Compatibility: Data varies. One locality may not collect a certain data type if its local needs do not demand it, thus data are not necessarily complete.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: tape copying--$40 (no charge to government agencies) plus the cost of computer tape.

Labor: since data are not standardized, it is not feasible to estimate labor.

Elapsed Time: will vary depending on source and data.

(H) General Evaluation of Data as a Source for Location-Specific Data Base(s): Since data are on such a low level of standardization, it would likely be difficult and expensive (if not impossible) to adapt them to a standard Army model. Further, Army installations are often located in less populated areas so data may not be available.

SOURCE NO. 16

(A) Source Name and Address: Water Data Storage and Retrieval System (WATSTORE), Chief Hydrologist, U. S. Geological Survey, 437 National Center, Reston, VA 22092

(B) Data Types: Water data includes: stream flow (taken daily), water quality (taken weekly), ground water quality and depth to water table (taken occasionally).

(C) Coverage: National; there are 100,000 data gathering stations--implies a station every 10 to 100 miles (16 to 160 km) (possibly a couple of points per Army installation).

(D) Date of Data: Data are as recent as transportation plan of metropolitan area, thus vary greatly. Since transportation planning is an ongoing process, data are often updated. System established in 1971 but contains data from 1900 to present.

(E) Manner of Storage: In computer form as point data; lists.

(F) Computer Compatibility: In computer-readable form; can be accessed from remote terminals.

(G) Expense of Putting Data in a Location-Specific Format:

Cost: about $1/run; depends on priority (1 hour to 1 week turnaround time).
Labor: WATSTORE personnel will do input for request.
Elapsed Time: approximately 1 week.

(H) General Evaluation of Data as a Source for Location-Specific Base(s): Need is great for more test sites. WATSTORE is most likely to be useful as a source for background data to run water resources models. It is a logical place to access water resource data for a wide variety of water parameters.

APPENDIX C:

SUGGESTED LAND USE CLASSIFICATION SCHEME

It is recommended in Chapter 5 that any system of land use classification eventually adopted for Army use coordinate with the system used by the USGS in their Land Use/Land Cover maps of the United States.[15] The USGS system is designed to use space and high altitude imagery to distinguish different units on the land. Existing USGS classification is shown in Table C1.

Army activities often cause impacts that are unique to the Army or of a different degree than would be experienced in civilian areas. In Table C2, an example of an appropriately modified USGS system is presented. Table C2 is to be considered an example only, and as such is neither complete nor final. Category "0" was added to deal with Army-unique activities. Land uses are classified such that environmental impacts associated with a particular category are similar. Further, instead of just two levels of specificity, as in the USGS system, Table C2 shows four. The first two levels are those of the USGS. The third level coordinates with the U.S. Urban Renewal Standard Land Use Classification Coding Manual.[16] A fourth level insures that the required level of detail in land use classification is available.

It is recognized that this classification provides for greater detail than currently required by most existing Army regulations. Forthcoming development of systematic land management and integrated environmental planning systems will, however, require that installation-related land uses be recorded at a level of detail approaching that suggested.

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[15] Anderson, James R. et al., *A Land Use and Land Cover Classification System for Use for Remote Sensor Data*, Geological Survey Professional Paper 964 (U.S. Government Printing Office, 1976), pp 8-22.

[16] *U.S. Urban Renewal Administration and Bureau of Public Roads, Standard Land Use Coding Manual* (Bureau of Public Roads, 1965), pp 29-31.

Table C1

USGS Land Use/Land Cover Classification System

Level 1		Level 11	
1	Urban or Build-up Land	11	Residential.
		12	Commerical and Services
		13	Industrial.
		14	Transportation, Communications, and Utilities.
		15	Industrial and Commerical Complexes.
		16	Mixed Urban or Built-up Land.
		17	Other Urban or Built-up Land.
2	Agricultural Land	21	Cropland and Pasture.
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas.
		23	Confined Feeding Operations.
		24	Other Agricultural Land.
3	Rangeland	31	Herbaceous Rangeland.
		32	Shrub and Brush Rangeland.
		33	Mixed Rangeland.
4	Forest Land	41	Deciduous Forest Land.
		42	Evergreen Forest Land.
		43	Mixed Forest Land.
5	Water	51	Streams and Canals.
		52	Lakes.
		53	Reservoirs
		54	Bays and Estuaries.
6	Wetland	61	Forested Wetland.
		62	Nonforested Wetland.
7	Barren Land	71	Dry Salt Flats.
		72	Beaches.
		73	Sandy Areas other than Beaches.
		74	Bare Exposed Rock.
		75	Strip Mines. Quarries, and Gravel Gravel Pits.
		76	Transitional Areas.
		77	Mixed Barren Land.
8	Tundra	81	Shrub and Brush Tundra.
		82	Herbaceous Tundra.

Table C1

USGS Land Use/Land Cover Classification System (Cont)

Level 1	Level 11
	83 Bare Ground Tundra.
	84 Wet Tundra.
	85 Mixed Tundra.
9 Perennial Snow or Ice	91 Perennial Snowfields.
	92 Glaciers.

Table C2

Example Land Use Classification Scheme

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
(USGS)	(USGS)	(U.S. URBAN RENEWAL STANDARD LAND USE CLASSIFICATION)	(MORE SPECIFIC DIVISION IF NECESSARY)
0 ARMY SPECIFIC ACTIVITIES			
	01 TRAINING:		
		010 FOOT	
		011 WHEELED	
		012 TRACKED	
		013 CHEMICAL TRAINING	
		014 DROP ZONE	
	02 EXPLOSIVES		
		020 USE AREAS	
		021 TARGET	
	03 BUFFER		
1 URBAN OR BUILT-UP			
	11 RESIDENTIAL		
		110 HOUSEHOLD UNITS	
		111 GROUP QUARTERS	
		112 MOBILE HOME PARKS OR COURTS	
		113 TRANSIENT LODGINGS	
	12 COMMERCIAL AND SERVICES		
		120 RETAIL TRADE - GENERAL MERCHANDISE	

Table C2 (Cont'd)

- 121 RETAIL TRADE - FOOD
- 122 RETAIL TRADE - APPAREL AND ACCESSORIES
- 123 RETAIL TRADE - EATING AND DRINKING
- 124 PERSONAL SERVICES
- 125 REPAIR AND MAINTENANCE SERVICES
- 126 PROFESSIONAL SERVICES
- 127 GOVERNMENTAL SERVICES
- 128 EDUCATIONAL SERVICES
- 129 MEDICAL, SAFETY, OTHER

13 INDUSTRIAL

- 131 APPAREL & OTHER FINISHED PRODUCTS MADE FROM FABRICS, LEATHER & SIMILAR MATERIALS - MANUFACTURING
- 132 LUMBER & WOOD PRODUCTS - MANUFACTURING
- 133 PRINTING, PUBLISHING & ALLIED INDUSTRIES
- 134 CHEMICALS & ALLIED PRODUCTS - MANUFACTURING
- 135 STONE, CLAY & GLASS PRODUCTS - MANUFACTURING
- 136 FABRICATED METAL PRODUCTS - MANUFACTURING
- 137 PROFESSIONAL, SCIENTIFIC & CONTROLLING INSTRUMENTS; PHOTOGRAPHIC & OPTICAL GOODS; WATCHES & CLOCKS - MANUFACTURING
- 138 STORAGE
  - 1381 INERT MATERIALS
  - 1382 CHEMICALS, PERISHABLES, DISTRIBUTION & STORAGE

Table C2 (Cont'd)

- 14 TRANSPORTATION, COMMUNICATIONS AND UTILITIES
  - 140 RAILROAD, RAPID RAIL TRANSIT, STREET RAILWAY TRANSPORT, DISTRIBUTION & STORAGE
  - 141 MOTOR VEHICLE ROADS (INTERSECTIONS, MAJOR ROAD USES)
  - 142 AIRCRAFT TRANSPORTATION
  - 143 MARINE CRAFT TRANSPORTATION, DISTRIBUTION & STORAGE
  - 144 GATE
  - 145 COMMUNICATION
  - 146 UTILITIES
    - 1460 UTILITIES
    - 1461 DISTRIBUTION
  - 147 SEWERAGE
    - 1470 PLANT
    - 1471 DISTRIBUTION
  - 148 OTHER TRANSPORTATION COMMUNICATION & UTILITIES
- 15 INDUSTRIAL AND COMMERCIAL COMPLEXES
- 16 MIXED URBAN OR BUILT-UP LAND
- 17 OTHER URBAN OR BUILT-UP LAND
  - 170 PUBLIC ASSEMBLY (LAND EXTENSIVE AREAS)
  - 171 RECREATIONAL ACTIVITIES
  - 172 PARKS

2 AGRICULTURAL LAND

- 21 CROPLAND AND PASTURE

Table C2 (Cont'd)

- 22 ORCHARDS, GROVES, VINEYARDS, NURSERIES & ORNAMENTAL HORTICULTURAL AREAS
- 23 CONFINED FEEDING OPERATIONS
- 24 OTHER AGRICULTURAL LAND
- 25 UNUSED, DISTURBED OR POTENTIAL AGRICULTURAL LAND

3 RANGE LAND

- 31 HERBACEOUS RANGE LAND
- 32 SHRUB AND BRUSH RANGELAND
- 33 MIXED RANGELAND

4 FOREST LAND

- 41 DECIDUOUS FOREST LAND
- 42 EVERGREEN FOREST LAND
- 43 MIXED FOREST LAND

5 WATER

- 51 STREAM AND CANALS
- 52 LAKES
- 53 RESERVOIRS
- 54 BAYS AND ESTUARIES

6 WETLANDS

- 61 FORESTED WETLAND
- 62 NONFORESTED WETLAND

7 BARREN LAND

- 71 DRY SALT FLATS

Table C2 (Cont'd)

- 72 BEACHES
- 73 SANDY AREAS OTHER THAN BEACHES
- 74 BARE EXPOSED ROCK
- 75 STRIP MINES, QUARRIES, AND GRAVEL PITS
- 76 TRANSITIONAL AREAS
- 77 MIXED BARREN LAND

8 TUNDRA

- 81 SHRUB AND BRUSH TUNDRA
- 82 HERBACEOUS TUNDRA
- 83 BARE GROUND TUNDRA
- 84 WET TUNDRA
- 85 MIXED TUNDRA

9 PERENNIAL SNOW AND ICE

- 91 PERENNIAL SNOWFIELDS
- 92 GLACIERS

APPENDIX D:

ANNOTATED BIBLIOGRAPHY
OF MODELS SURVEYED

Annotations in this appendix indicate the problems of adapting a particular model to Army use under the criteria used in this report. Numbers are those assigned to each model throughout this report.

1. "Suitability for Homesite Foundation," from Frederick, C. J., and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

It is reasonable to get this model running. The data sources are (or soon will be) available if:

a. ETL data for soils can be hand digitized. (DMA will digitize data free of charge; however, turnaround time is contingent on a project's priority within DA.)

b. The slope generating program in TOPAS (or other similar program) is obtained.

This model is of secondary importance.

2. "Septic Tank Suitability," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

It is reasonable to get this model running. (See discussion for Model 1.) This model is of secondary importance.

3. "Soil Erosion," from Frederick, C. J., and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

If the K-values are available, then it is reasonable that this model can be run on available (or soon to be available) data. This, or a similar model, is of primary importance for land management purposes.

4. "Sigma W Method," by J. L. Cook and M. M. Culp, from Frederick, C. J. and Luty J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

All data are or will be available soon, either in the required format, or in a form readily adaptable to the required format. The model is of primary importance.

5. "Groundwater Balance," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

Most data are available. Data regarding water withdrawal by man from individual drainage basins are likely to be available, but not from a single source. The groundwater model was designed to describe urban areas that are covered with large amounts of impervious material. Because large areas of pervious land cover most Army bases, this model is not particularly useful to the Army; it is of tertiary importance.

6. "Vulnerability to Change in Surface Water Quality," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

Most of the data needed to run this model are available, with the exception of the weighting factors. Weighting estimates can be obtained from local water quality authorities. Generation of data specifically for this model is expensive. This model is of primary importance.

7. "Groundwater Quality," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

This model predicts the vulnerability of a site to groundwater pollution, but not the degree of pollution. It is a simple model with easily obtainable data. The model is useful in a comparative analysis. It is reasonable to get it running. The model is of primary importance.

8. "Vulnerability to Flood Potential," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

This model is applicable to land uses on which a major portion of the soil surface is covered with a nonporous material, particularly near stream courses. Usually, large areas need to be covered, so for most Army installations this model has limited usefulness. It uses inputs from several other models, each of which are difficult to develop because of the data inputs required. This model is of secondary importance.

9. "Woodland and Water-Related Wildlife," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

There is a great deal of possible variation depending on the geography of the area of the country where it is to be used. The model is also limited because it cannot be generally applied to all wildlife. Although this limitation can be mitigated by identifying "indicator species" which can suggest what is happening within a community, the use of "indicator species" would require that a model be developed for each DA installation, depending on that installation's native wildlife. Because it was not feasible to suggest data which would be applicable Army-wide for this model, as required by this study, this model was judged to be of secondary importance.

10. "Vulnerability to Visual Change," from Frederick, C. J. and Luty, J. J., *Problem Recognition Study: Central New Hampshire Planning Region* (Harvard Graduate School of Design, 1972).

The data needed to develop this model are available and relatively inexpensive. It is reasonable to get this model running. It is of primary importance.

11. "Water Quality," from Fabos, J., *Model for Landscape Resource Assessment: Part I of the Metropolitan Landscape Planning Model* (METLAND) (University of Massachusetts, June 1973).

METLAND techniques are difficult to adopt to a generalized evaluation model. Since adequate results can be more easily obtained through other methods, this model is of tertiary importance.

Note: Although Fabos defines each cell with smaller divisions within it, the same methodology can be applied to summing linear distances along cell boundaries.

12. "Agricultural Productivity Change," from Fabos, J., *Model for Landscape Resource Assessment: Part I of the Metropolitan Landscape Planning Model* (METLAND) (University of Massachusetts, June 1973).

Most data for this model are available, so it is a reasonable model to setup and run. It is not an important model since property values do not change freely on an Army base and it is not generally applicable to DA installations. It is of tertiary importance.

13. "Visual Land Use Complexity," from Fabos, J., *Model for Landscape Resource Assessment: Part I of the Metropolitan Landscape Planning Model* (METLAND) (University of Massachusetts, June 1973).

This model is easy to program and data for it are readily available, although the usefulness of an evaluation program for visual diversity on an Army installation is questionable. It is of secondary importance.

14. "Visual Land Use Compatibility," from Fabos, J., *Model for Landscape Resource Assessment: Part I of the Metropolitan Landscape Planning Model* (METLAND) (University of Massachusetts, June 1973).

This model may be too broad to be of use since it only asks a blanket question: "Are these land uses compatible?" Other models investigate the individual attributes of land use compatibility. It does, however, consider visual compatibility, a factor which can be important to some DA analyses. Fabos' model is simple to operate. It is of secondary importance.

15. "A Model for a Small Forest Fire. . .To Simulate Burned and Burning Areas for Use in a Detection Model," from Kourtz, P. H. and O'Regan, W. G., *Forest Science*, Vol 17 (1971), pp 163-169.

This is not a classical land use evaluation model although data are generally available, inexpensive, and in a grid cell format. This model is of primary importance.

16. "The Simultaneous Determination of Optimal Thinning Schedule and Rotation for an Even Aged Forest," by Schrender, Gerard F., *Forest Science*, Vol 17 (1971), pp 333-339.

This model is not directly adaptable to Army use; it adds forest management costs over time, while the type of models surveyed for this report usually evaluate impacts at a single point in time. It is reviewed here to illustrate another approach to location-specific planning. In some cases, data are available and the model is easy to setup. However, because it does not fit the qualifications for a primary or standard model as indicated in Chapter 3 of this report, it is of tertiary importance.

17. "Dynamic Programming for Deer Management Planning," Davis, L. S., *Journal of Wildlife Management*, Vol 31 (1967), pp 667-679.

This model determines optimal deer management criteria based on interactively accessing other site activities (mainly timber harvesting). It would be necessary to collect a great deal of data to get this model running; data often are available only locally. It would be expensive to develop this model. It is reviewed here for two reasons:

a. To illustrate the data inputs necessary for a sophisticated land management model

b. To demonstrate how a more sophisticated model can make use of output from a less sophisticated model (Model 9)

Because of the difficulty of obtaining the necessary input data, this model is of secondary importance.

18. "A Mathematical Model for Simulating the Hydrological Response of a Watershed," Huggins, L. F. and Monke, E. J., *Water Resources Research*, Vol 4, No. 3 (American Geophysical Union), pp 529-39.

It should be noted that this model predicts the effects of an individual storm instead of a yearly or monthly average of storm effects--important because averages can be misleading. There are several parameters to this model which must be field estimated, in particular, the severity of the storm (this is actually an advantage as the degree of impact can be estimated based on the severity of the storm [i.e., 1- or 20-year frequency] to find an acceptable upper limit). One of this model's major advantages is that it is based on a grid cell format. This model is important, but would require expensive field surveys and estimated information to run. Thus it is not recommended for adoption. This model is of tertiary importance.

20. "Runoff/Infiltration," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

This model is much more adaptable than either of the previous runoff models reviewed here (Model 4 and 18), particularly if soil moisture capacity data can be obtained from other soil type information. If such data are available, it can be a useful and important model of primary importance.

21. "Vegetation Edge Model," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

This model assesses the degree of dissimilarity between adjacent vegetation types. Data to run it are easily available and inexpensive. For Army considerations, however, it is of secondary importance.

22. "Vegetation Diversity to Imply Wildlife Habitat Change," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

This is a simple model to setup and run. It could be important to Army cantonment area planning, but would be of little use in the planning of Army training areas. This model and the Vegetation Edge model (Model 21) are conceptually similar to Fabos' Visual Land Use Complexity (Model 13) and Land Use Compatibility (Model 14). It is of primary importance.

23. *HIWAY (A Linear Air Pollution Model)* EPA-650/4-74-008 from the Environmental Protection Agency, Office of Research and Development (Environmental Monitoring Series, February 1975).

HIWAY is a reasonably easy air quality model to implement. Most data are available and it fits conceptually into the location-specific format required in this report. Its usefulness to the Army is questionable because large highways seldom cross an installation. However, with additional research, it might be useful for evaluating the activity of heavy armored vehicles. It is considered to be of secondary importance.

24. "Wildlife Possibility Based on Areas of Best Habitat Combination," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

This model, for which data are readily available, is easy to operate and useful to the Army. It requires only uncomplicated programming to setup and run. It is of primary importance.

25. "NOISENS NOISPAT NOISIMP (Noise Quality Impacts)," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

As CERL Baseline Noise data become available, this model will become less expensive to run. The model framework can be expanded with elevation or vegetation data to make it more accurate. It is reasonable to get the model running; it is of primary importance.

26. "Development Cost for Different Land Uses," from *Interaction Between Urbanization and Land; Quality and Quantity in Environmental Planning and Design* (Harvard Graduate School of Design, 1974).

All data for this model are available and can be easily and inexpensively converted to the required format. It is of primary importance.

27. *Simulation of Water Quality in Streams and Canals: Program Documentation and User Manual for DOSAG-1*, Systems Engineering Division, Texas Water Development Board (Texas Department of Water Resources, February 1976).

Although DOSAG-1 is well suited to a grid format, the data it uses:

a. May or may not be available in STORET and WATSTORE

b. May not be accurate enough for the model, if recorded by Army personnel

c. May be only available at the state agency level in a variety of different formats

d. May not be available at all.

The possibilities of retrieving quality data for water quality models are good. Although formats may vary, the computer program NAWDEX will be able to quickly tell the DA user what national, state, or local agencies have data. Occasionally NAWDEX will supply data directly through STORET or WATSTORE. This model is of secondary importance because of the uncertainties associated with the availability of its necessary inputs.

28. "PTMTP (Air Quality from a Point Source)," from Turner, D. and Busse, A., *User's Guides to the Interactive Versions of Three Point Source Dispersion Programs* (Meteorology Laboratory, Office of Research and Monitoring (U.S. Environmental Protection Agency, June 1973).

This is a standard, widely available model. Some of the input data are user options, but many are gathered on-site. The model illustrates how sources and sensors are referenced with a coordinate grid which could be easily adapted to a location-specific program. It is expensive to collect necessary data instead of using "best judgment" inputs. The model's usefulness is limited to a few land uses that occur only occasionally on Army installations. It is of teritiary importance.

29. *User's Guide for the Climatological Dispersion Model*, Busse, A., and Zimmerman, J., EPA-R4-73-024 Office of Research and Development (Environmental Protection Agency, December 1973).

The Climatological Dispersion Model (CDM) can deal with area and point source air pollution for particulates and SO(x). It is versatile and most data necessary to run it are available or inexpensive to generate. It also uses a gridded data system that is easily adapted to location-specific models. It is an important model and reasonable to develop; it is of primary importance.

30. "Vulnerability to Pollution of Surface Water Systems," from Murry, Timothy, *Honey Hill: Systems Analysis for Planning Multiple Use of Controlled Water Areas*, Office of Research, Department of Landscape Architecture (Harvard Graduate School of Design, October 1971).

This model is easy to develop and most data are available. However, it uses many state-of-the-art estimates rather than objective, quantifiable data. It is useful to the Army and relatively easy to setup and run. It is of primary importance.

31. "Surficial Aquifer Vulnerability to Pollution," from Murry, Timothy, *Honey Hill: Systems Analysis for Planning Multiple Use of Controlled Water Areas*, Office of Research, Department of Landscape Architecture (Harvard Graduate School of Design, October 1971).

The same problems associated with Vulnerability to Surface Water Pollution (Model 30) apply to this model. For the same reasons it is considered of primary importance.

32. "Forest Fires Potential," from Murry, Timothy, *Honey Hill: Systems Analysis for Planning Multiple Use of Controlled Water Areas*, Office of Research, Department of Landscape Architecture (Harvard Graduate School of Design, October 1971).

The same problems associated with Models 30 and 31 apply to this model, with the additional problem of deriving soil moisture data. This model is considered of secondary importance.

APPENDIX E:

EXPLANATION OF $L_{C_{dn}}$

This C-weighted measure is an outgrowth of the Day-Night Equivalent Level (L_{dn}). The two are numerically equivalent with respect to their interpretation. "C" weighting is a frequency weighting system which is used to simulate the response of the human ear to high levels of noise exposure.

L_{dn} was developed to provide a single-number measure of time varying noise for a 24-hour time period. In other words, L_{dn} uses the energy equivalent concept, which represents a fluctuating noise level in terms of steady state noise having the same amount of total energy.

Because nighttime operations cause greater disturbance than daytime operations, the noise of each night event is penalized in the calculation procedure by 10 dB. That is, for the same average number of operations per hour during the day and night periods, the L_{dn} value for nighttime operations is 10 dB higher than for daytime operations.

The Environmental Protection Agency (EPA) has chosen, and DOD has accepted, L_{dn} as the best measure for situations where people are affected by noise for extended periods of time. However, L_{dn} is not necessarily the best measure for impulsive noise. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* (EPA, 1970), commonly known as the "EPA Levels Document," provides more information on L_{dn} and how it is used.

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