LANDSCAPE VISIBILITY MAPPING:

THEORY and PRACTICE.

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FORWARD:

An undertaking of this magnitude, covering two and a half part-time years, involves many participants. I would like to thank Dave Harper and John Warbach of the School of Landscape Architecture for their continued support. Students (present and former) who have assisted in this effort, and the Port Bay Visibility Case Study, include: Varda Wilensky, Rick Dumont, Molly Burgess, Pete Jackson, Doug Johnson, Dennis Jud, and Mark Holzman.

In particular, this study owes its existence to the many practicing professionals and academics who have created a new and exciting field out of whole cloth in a very short period.

The logical structures and conclusions which have been developed to organize the material are my own. The data used is primarily from project reports, at best a "secondary" source. I apologize at the outset for occasionally bending square pegs into round holes, and excising information from its context. If it stimulates thought and discussion, the artistic license is worthwhile.

John Felleman

Syracuse, Summer 1979

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I INTRODUCTION

1 INTRODUCTION

Vision plays a central role in man's environmental behavior. It has been estimated that approximately ninety percent of our sensory stimulation is visual. Throughout the evolution of culture, landscape visibility has been a major determinant of the location and physical form of human settlements. Examples include defense fortifications, dominant religious structures, navigational aids, and recreation site development.

The comprehensive management of environmental resources encompasses critical stages of resource analysis, land planning and project design. As illustrated in Figure 1, each of the interfaces between these stages incorporates visibility information. These include: scenic assessment, project location, impact analysis, activity allocations, and performance criteria.

Visibility deals with both the geographic extent of surfaces which can be seen, and the legibility of features which, in composite visibility mapping, provides the basis for human perception and cognition

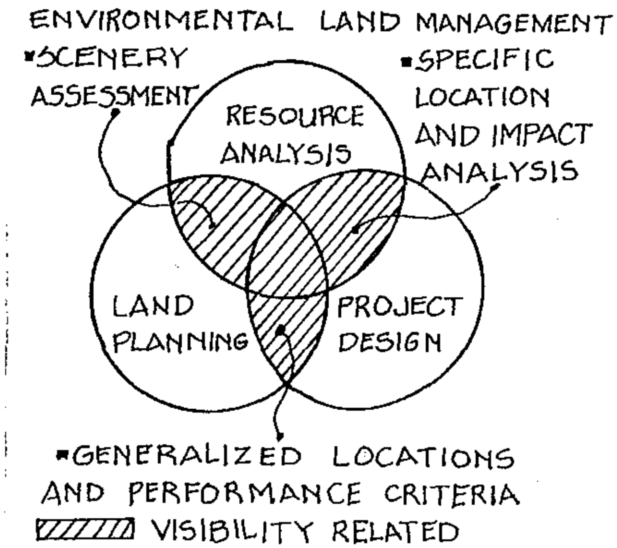


Figure 1: Visibility in Environmental Land Management.

of landscapes. Geographic extent of visibility is the primary emphasis of this monograph.

Historically, development siting and design decisions utilized a limited, intuitive approach to resource analysis. Visibility information was often developed in-situ, by means of direct terrain observations. In the twentieth century, as accurate topographic maps and remote sensing information became available, more sophisticated, off-site methods of visibility mapping evolved. The recent momentum given to environmental studies, particularly aesthetic concerns, by the National Environmental Policy Act (N.E.P.A.) has led to the widespread use of visibility mapping techniques.

In the context of coastal aesthetic research conducted for the New York Sea Grant Program, a wide range of theoretical studies, and project reports were reviewed. The author found that although a variety of methods were apparently being used by design and resource professionals to map visibility, the published documentation exhibited a widespread lack of clarity in both conceptual logic, terminology, and methodological approaches.

Many of these studies appeared to be underfunded, resources expended did not reflect the significance of the information, and some were clearly isolated from or "tacked on" to a more comprehensive study. In contrast, some excellent prototypical state-of-the-art applied visibility analyses are beginning to emerge from the public and private sectors.

The purposes of this report are threefold:

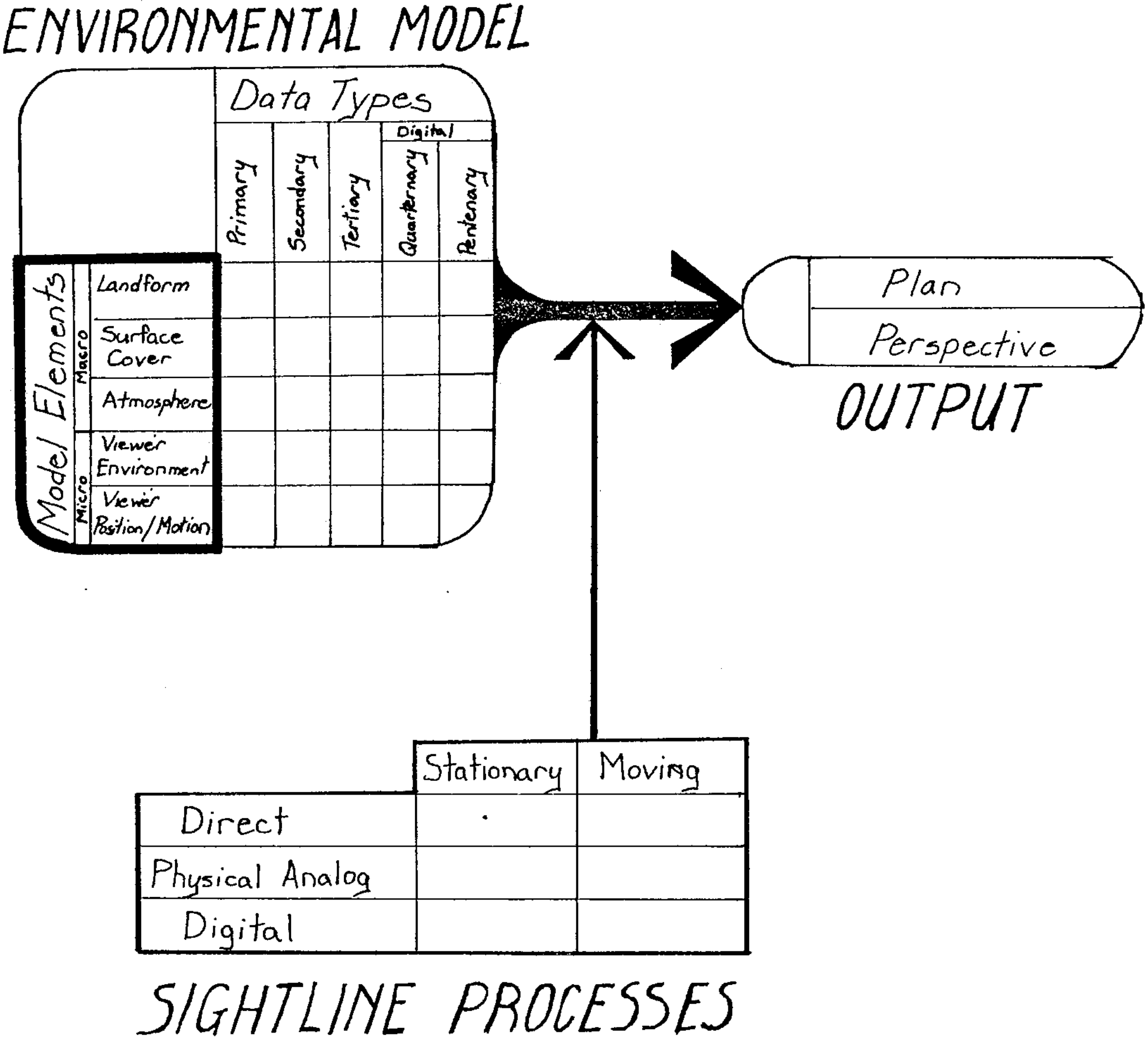
a. To develop a coherent, conceptual construct of landscape visibility mapping;

b. To systematically articulate the alternative methods of data organization, and visibility mapping through the use of selected illustrated examples; and

c. To foster improved integration of visibility information into complex resource planning and project design.

The body of this report is presented in six parts. Section II contains a working definition of a comprehensive visibility model. Section III includes a discussion of data assembly for the elements of the visibility model; while Section IV is focused on line-of-sight processing methods for stationary positions; and Section V for moving observers. Visibility study outputs, plan views and perspectives, are discussed in Sedtion VI, while some brief conclusions are identified in Section VII.

II VISIBILITY MAPPING - A WORKING MODEL



II VISIBILITY MAPPING - A WORKING MODEL

A. INTRODUCTION

Many primitive peoples have conceived of sight as a physical process which emanates from the human eye, as shown in Fig. 2. Although modern physics has shown the reverse is true (light enters the eye from external sources) the primitive approach is ideal for understanding the geographic extent of visibility. (Note: A visibility analysis of a smoke stack could "look" at the stack from the adjacent environment, or "look" from the stack into the environment.)

Consider building a scale three-dimensional model of a real landscape. The model is placed in a dark room, and a tiny light source is placed on the model's surface at the position of an observer. The surfaces which are directly illuminated represent the locus of all visible points, the "viewshed".

In the model, the configuration of the surfaces blocks the light from reaching the dark (hidden) areas. This blocking is called "interposition". If we then project the illuminated viewshed vertically

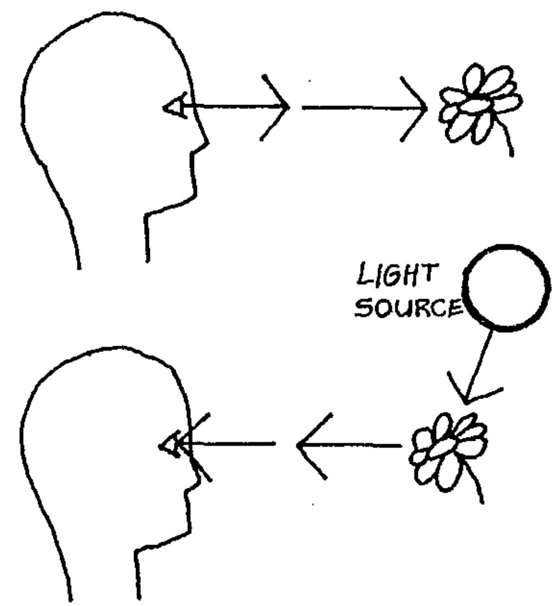


Figure 2: Visual Transmission.

to a horizontal plane, we have constructed a scale "potential visibility map". This is shown in Fig. 3.

The infinite number of light rays in the above example are analogous to "lines of sight" passing from observer to the environment. A major issue in visibility analysis is to selectively reduce the number of such lines investigated to a representative, manageable set.

The word "potential" is used above to clarify the difference between the simulation and the complexities of the real environment. A more comprehensive model of visibility mapping is shown in Fig. 4. Each of the elements is discussed below.

B. MACRO LANDSCAPE

Landforms and surface features are the primary elements of interposition. They also provide the visual content which is the basis for scenery analysis. The role of landforms in the context of scenic evaluations has been extensively explored in previous N.Y. Sea Grant work (Felleman, 1977).

Landforms - Landforms include terrain and surface water features. Visually significant characteristics include size, shape, distance from observer, and aspect (orientation relative to solar position and observer location). In large scale, rugged landscapes, landforms tend to provide

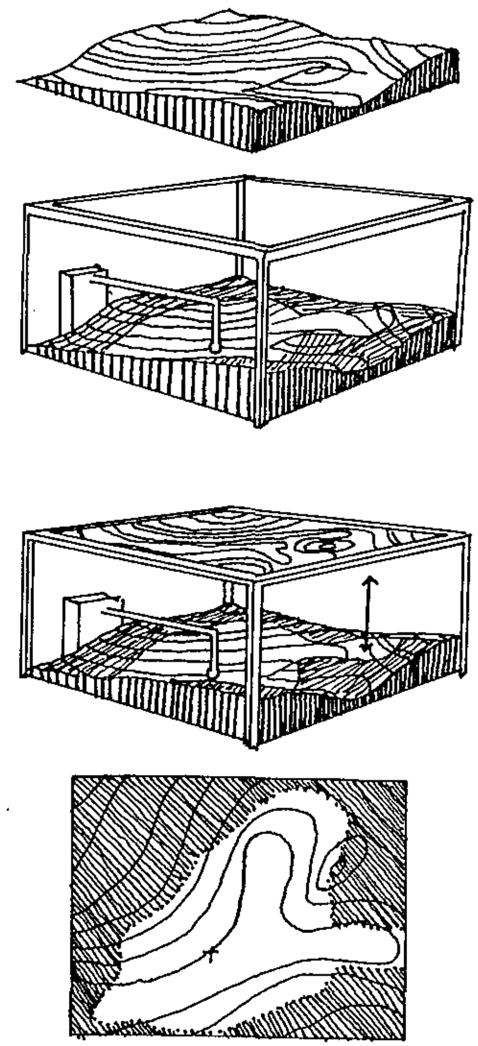


Figure 3: Point Light Source Model.

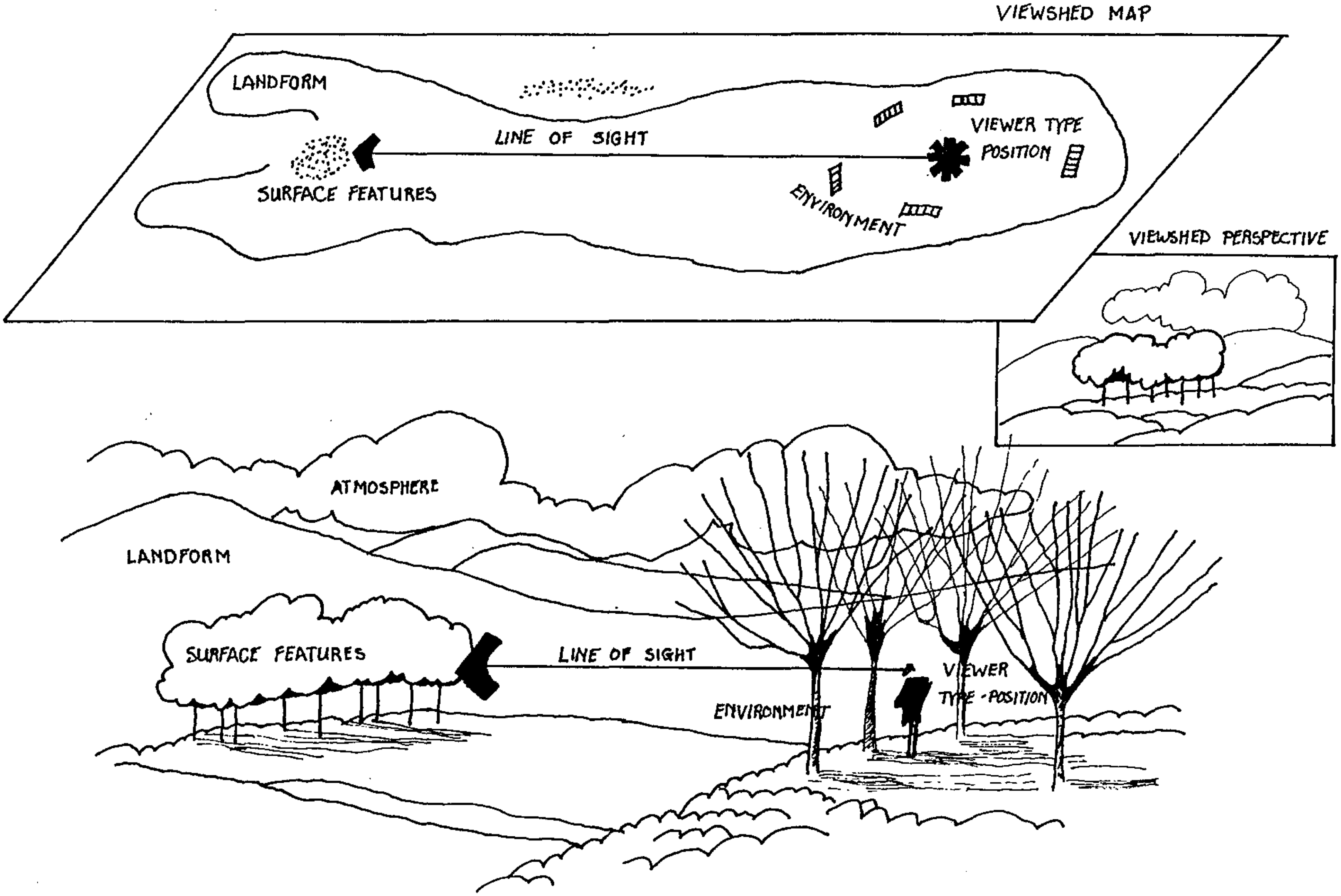


Figure 4: Visibility Model.

the majority of interposition determinants. A frequently used simplification of the visibility model utilizes only landform, observer, lines of sight, and viewshed record. The latter is properly called a "Potential Topographic Viewshed" to clarify its limited scope.

<u>Surface Features</u> - Surface features include vegetation and built forms. Regional scenic studies have developed the general principle that as the scale of landforms decreases, the visual significance of surface features increases (see Figure 5) (Research Planning and Design Associates, 1972, p.N-19).

In addition, field research regarding scale and distance, indicates that the significance of surface features will decrease as sight-line distance increases from foreground, to midground, to background (see Figures 6a, 6b) (Litton, 1968). A New England highway study revealed that land development types could be identified at a maximum of 1 km (0.5 km mean) (Jacobs and Way, 1969).

In a significant water related analysis, the combination of earth curvature and light refraction are shown to reduce the apparent height of water surface objects (See Figure 7) (Roy Mann Associates, July, 1975a, p.293). (See also discussion in Section IV-D).

Landforms are generally static within the time frame of a project oriented visibility study. A major earth moving project would be an

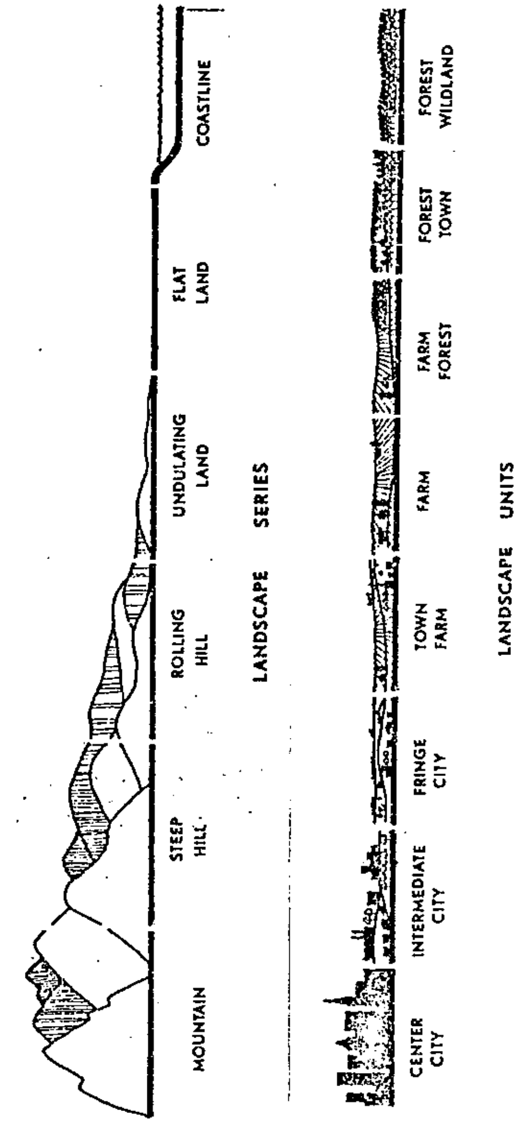


Figure 5: Landscape Continuum.

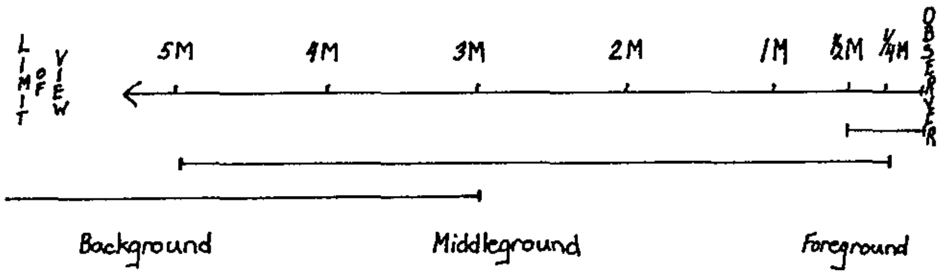


Figure 6a: Distance Zones.

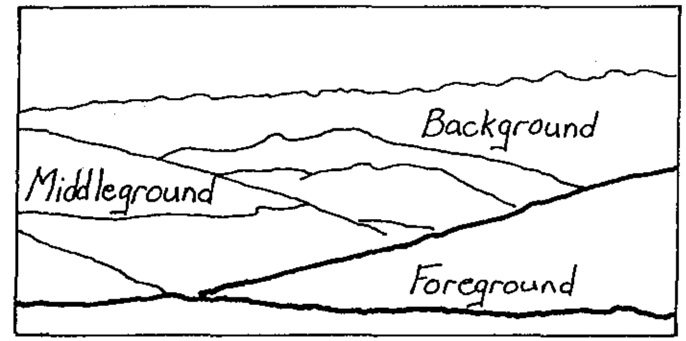


Figure 6b: Distance Zones - Perspective.

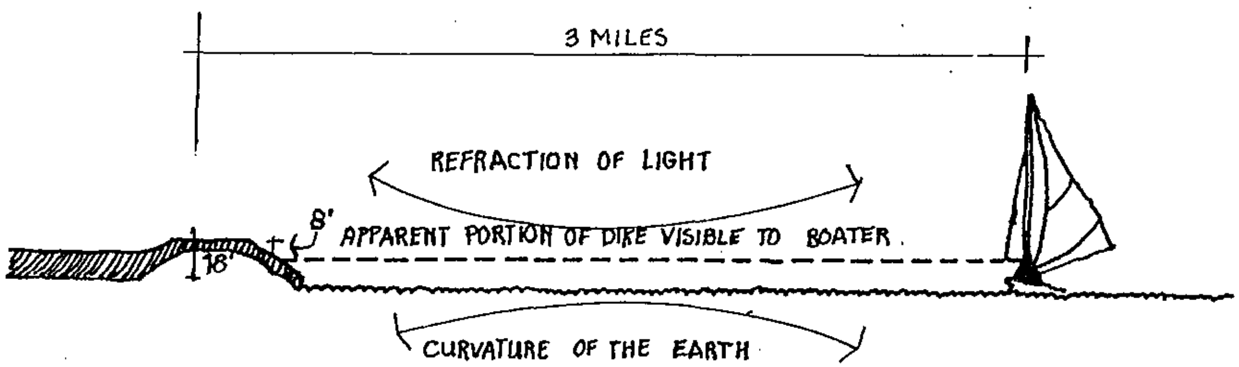


Figure 7: Visibility Factors - Open Water.

example of the exception to this statement. However, the temporal dimension is highly relevant in the treatment of surface features as the seasonal attributes of vegetation and land development changes. A comprehensive visual analysis would include a representative treatment of expected surface feature conditions which are relevant during a project's short-term implementation stage, and its long-term useful life.

Atmosphere - Atmosphere characteristics are a continuously variable element in visibility studies. Lighting conditions, clouds and precipitation can all modify the potential topographic and surface feature visibility. This is important to both viewshed and scenic analyses.

A dramatic visual analysis of Boston from major highways in day and night conditions illustrates an extreme example of variable lighting conditions (Appleyard & Lynch, 1964). The significance of terrain aspect, sun angle, and observer position in viewing surface features is illustrated in Figures 8 and 9 (U.S. Forest Service, 1972, p.12). Aesthetic field research has shown that coastal haze and fog is a frequent factor modifying on-site visibility (Felleman, 1979).

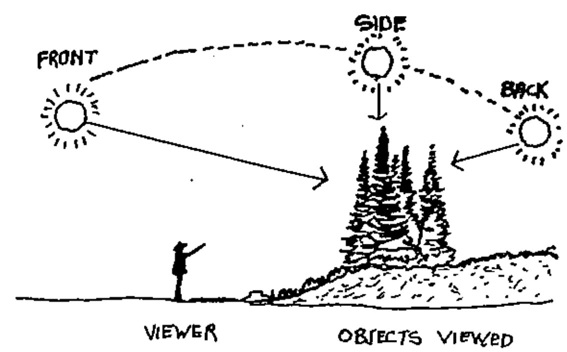


Figure 8: Solar Position.

SEASONAL LIGHT CONDITIONS - GENERAL

	WINTER	transition period SPRING	SUMMER	transition period FALL
Color Hue	Minimum	Maximum	Medium	Potential Maximum
Color Value	Maximum	Medium	Medium	Potential Maximum
Sun Angle	Lowest	Medium Increasing	Highest	Medium Decreasing
Daylight Time	Shortest	Increasing	Longest	Decreasing
Probable Light Variations	Medium	High	Low	High
Mean Shadow Lengths	Maximum	Medium Decreasing	Shortest	Medium Increasing

Figure 9: Seasonal Light Conditions - General.

C. OBSERVER

As noted earlier, a major consideration in designing a visibility study is to effectively select a representative set of lines-of-sight to be investigated. Particular views may be highly significant because of their frequency of occurrence, the unique content of the scene, or a combination of these factors. Frequency of occurrence is typically associated with concentrations of observers. In addition, for projects which will generate new viewers the analysis should include views of the project and from the projects. Figure 10 depicts "views of the road" and "from the road".

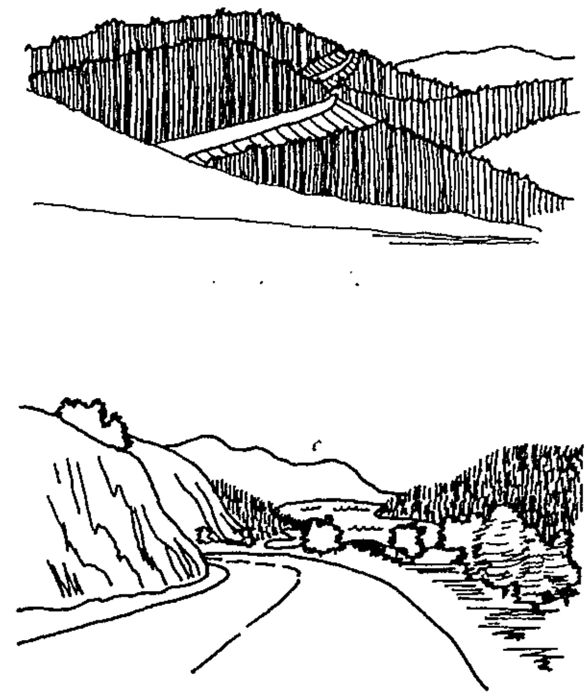


Figure 10: View "Of" and "From" Road.

Type and Quantity - Type and quantity of viewers is often interpreted from activity patterns such as residential clusters, recreation sites, and major vehicular routes. The U.S. Forest Service has identified three functional criteria for analyzing observers: number, view duration, and scenic concern (recreation, residential, other) (U.S. Forest Service, 1974, p.18). In an analysis of proposed cooling tower alternatives for a Hudson River power plant, analysts quantified and weighted residential, auto, rail, and boat viewers within the potential viewshed influence zone (Jones and Jones, 1975). In a transmission line study, the number of observers was factored by ... "An attention analysis, (which) addresses how many of the potential viewers will be preoccupied with other aspects of the landscape ..." (Carruth, et al., 1977, p.32). Attention may also be used as a design principle in providing sequential variety (Pragnell, 1970, p.38).

Unique Scenes - Resource and scenery studies must often deal with the protection of unique and sensitive landscapes. In a remote wilderness area for example, it might be important to protect a view of a unique feature for potential, aesthetically sensitive viewers years or even generations in the future. In this case viewsheds are mapped from significant landscape features to identify potential view influence zones.

Examples of visually significant landscape features include: hilltops and skylines, water features, enclosed valleys, vista points, and unique resources. In one of the earliest visually related guidelines, the Federal Power Commission stated that rights of way should not cross ridgelines parallel to the line-of-sight, and that structures should not be placed at the crest of a hill (Federal Power Commission, 1970). This logic is based on our perceptual use of skylines to provide constant orientation, combined with the high degree of visual contrast given to objects silhouetted against the sky. (See Figure 11).

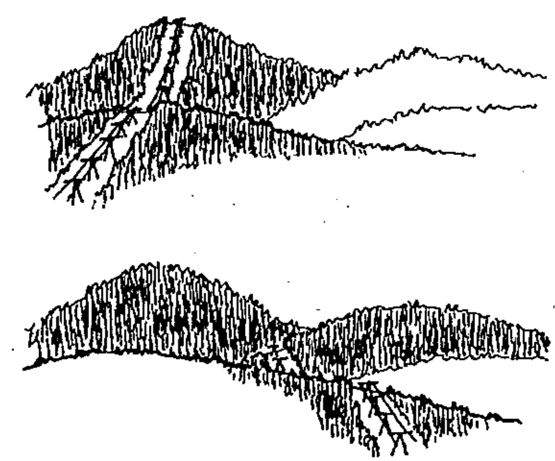


Figure 11: Skylining.

There is a general consensus that the presence of water greatly enhances the scenic quality of a view. In addition, water features often provide opportunities for extended, unobstructed views. In a comprehensive study, a hierarchial classification of water-related features was proposed: the landscape unit, setting unit, and waterscape unit (Litton, et al., 1974). The latter includes the adjacent upland slopes which are visually related to the water surface (see Figure 12).

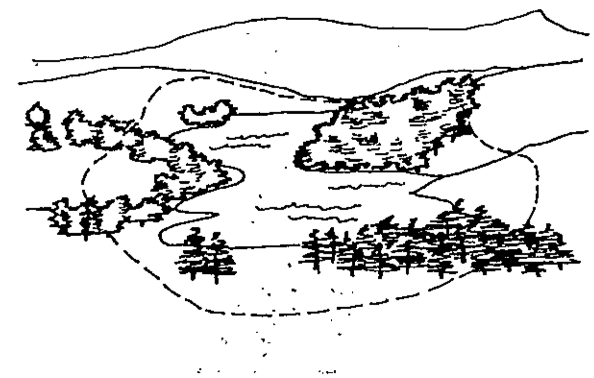


Figure 12: Water Influence Zone.

The pioneering N.Y. Hudson River Valley Commission had a flexible jurisdictional limit based on the water-surface viewshed. This approach has been used in studies of the Potomac and Lake Tahoe, and has been incorporated in federal and state, wild and scenic river legislation.

Enclosure is another scenically positive landscape attribute. Potential for open views within an enclosed valley was a central concept in the classification of Massachusett's scenic highways (see Figure 13). This concept has also been incorporated in studies of the Hudson Valley (see Figure 14a) (Harper, 1978, p.38), and Ross County, Ohio (see Figure 14b) (Kobayashi, 1975, p.160).

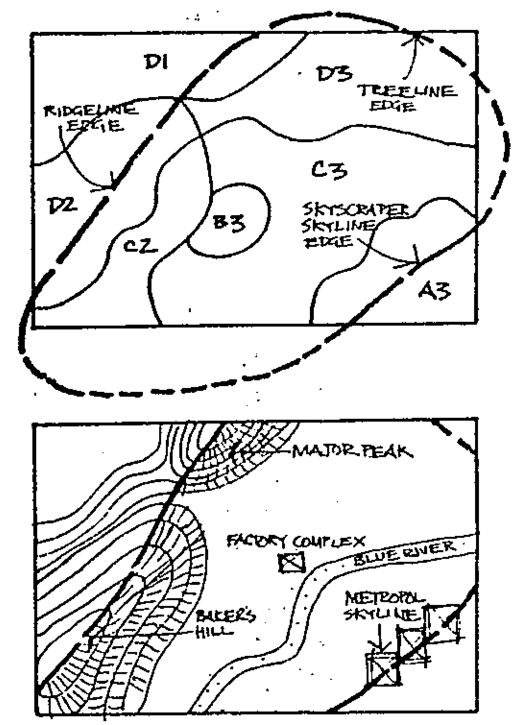


Figure 13: Enclosure - Massachusetts.

Scenic turnouts, recreation trails, and residential sites are all enhanced by location at points in the terrain where broad vistas

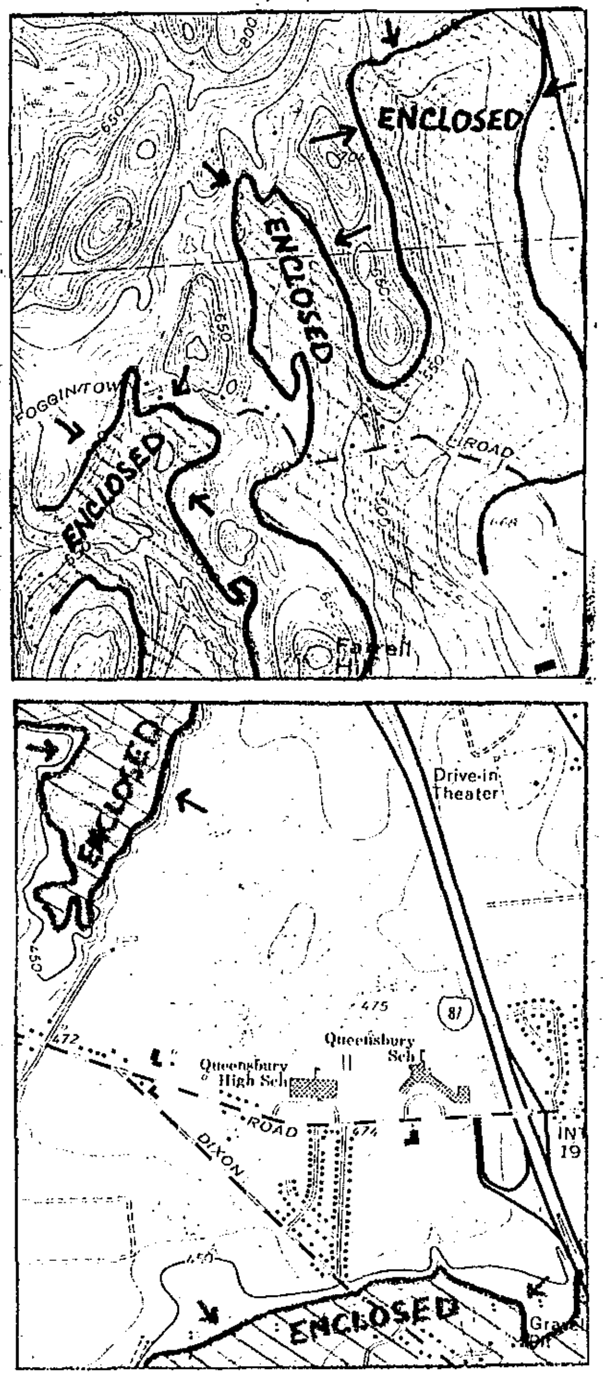


Figure 14a: Enclosure - Hudson Valley.

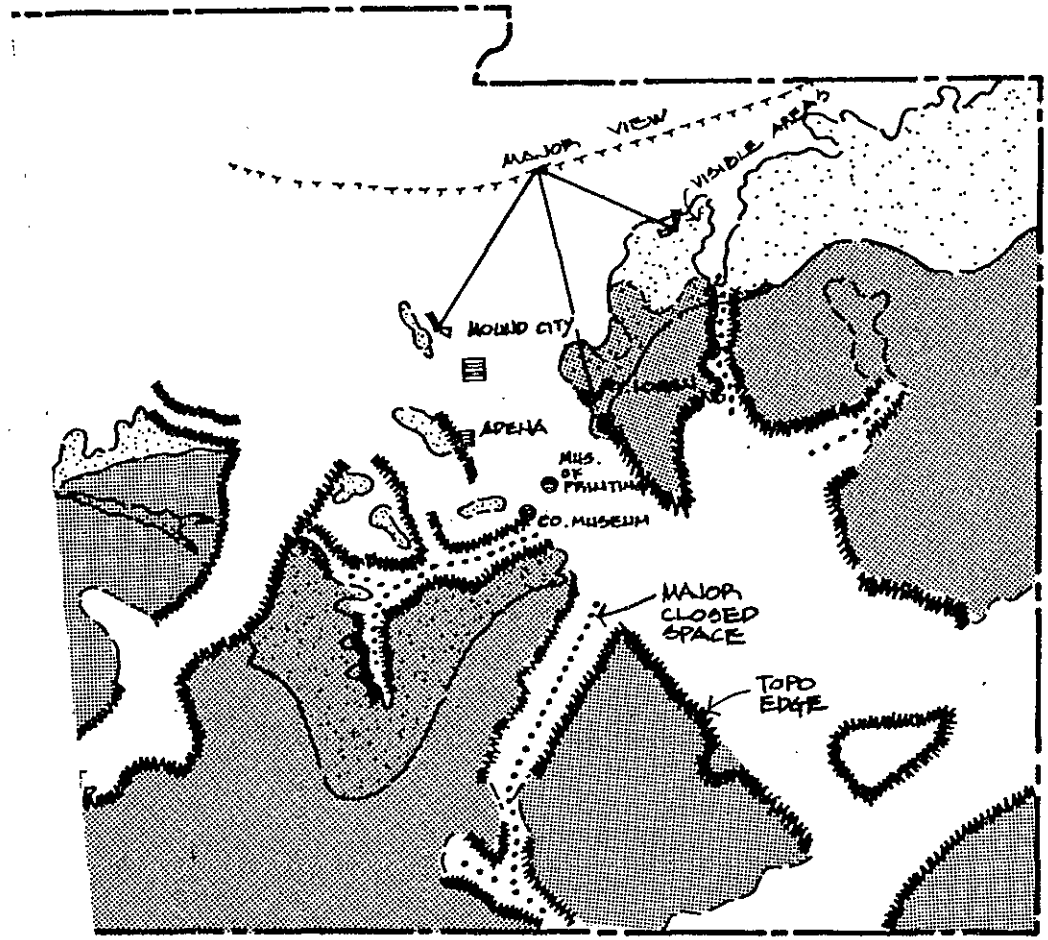


Figure 14b: Ross County - Ohio.

are available. In rugged terrain, peaks and ridgelines often provide maximum views; while in more logically mature land forms, maximum views tend to occur where steep side slopes end at the base of the rounded terraces and crowns. (See Military Crest, Section IV.) (See Figure 15.)

Position and Motion - Viewshed and view content are functions of viewer position and motion. Three prototypical viewer positions relative to the vertical compositon of the scene have been identified: superior (above), normal (intermediate), and inferior (below). (See Figure 16) (Litton, 1968, p.7).

A matrix of viewer postions and distance zones developed to aid in the selection of scenic impact analysis locations, is shown in Figure 17 (Battelle, 1974, p.97).

The relationships of viewer motion and visibility have been extensively studied from the perspectives of ground and air traffic safety. Unlike the stationary position which is typically presumed to have a 360° potential viewshed, medium and high speed motion has been shown to limit the normal cone of vision particularly for the driver. The concept of view cone is discussed in Section V.

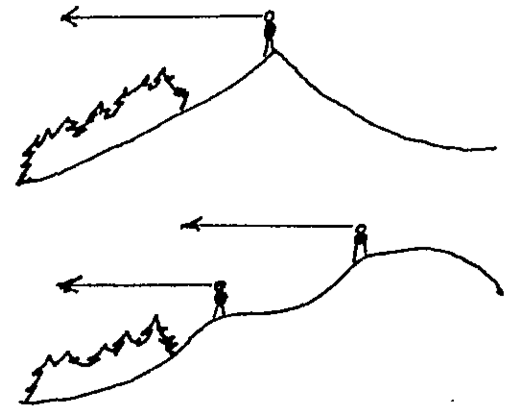


Figure 15: Vista Points.

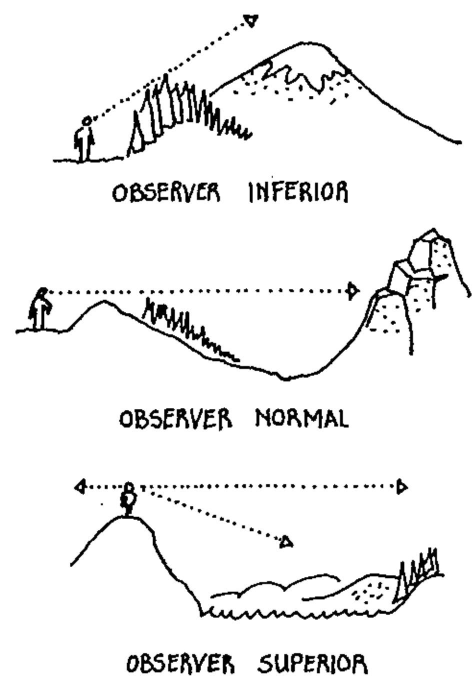


Figure 16: Viewer Positions.

Observer Environment - Observer environment includes both observer container (vehicle, building windows...) if any, and the immediate natural and built landscape. Although conceptually these factors are a localized continuum of the Macro Landscape surface described above, it is analytically useful to differentiate immediate foreground objects.

Both observer containers and immediate landscape are often design variables which may be studied in detail such as window orientation and screening plantings. Because these features may not be visually opaque or continuously solid, view "filtering" as well as interposition may occur. Many impact studies now incorporate seasonal "foliate" and "defoliate" visibility analyses.

In addition, the accuracy and scale of data needs may be very different for immediate and macro landscapes. For example, a forest mass on a topographic map may correctly define a hillside midground sky-line condition while the map may not have any indication of a single roadside hedge which effectively blocks or filters views from the route.

D. PROCESSES

Lines of Sight - All viewshed delineation methods make use of one or more line-of-sight techniques. These may be generally grouped into: field approaches, physical analogs, and numerical simulations. Field

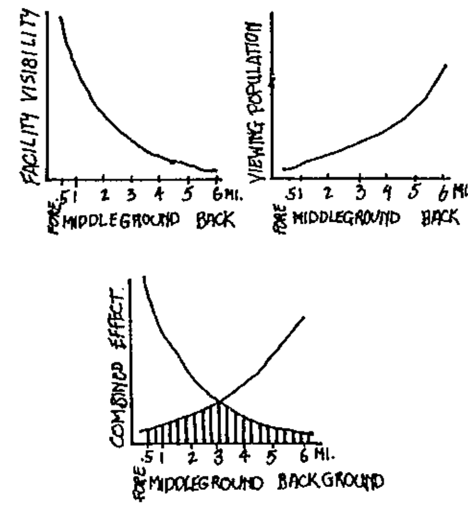


TABLE 15. Idealized Viewpoint Distribution: Natural Draft Cooling Tower Alternative (12 Final Viewscapes Required).

Distance	Observer Inferior	Observer Normal	Observer Superior
Foreground 0-1/2 Miles	1	.	.
Middleground 1/2-5 miles	1	6	1
Background >5 miles	.	2	1

Figure 17: Viewer/Distance Distribution.

approaches are the traditional in-situ "actual views". Modern adaptations include the use of airplanes, helicoptors and balloons, as well as photographic recording techniques to expand the scope and content of the method.

Physical analogs primarily include interpretation of topographic maps by means of cross sections, vertical stereo air photo interpretation, and the use of terrain models utilizing periscope optics (model scope) or point light sources. The latter was briefly described in the introduction (see Figure 3). Numerical simulations utilize digital computers to "pass" line-of-sight vectors from the selected observer positions to intercept a numerical (x,y,z) approximation of the macro landscape.

Recording - The locus of lines-of-sight must be recorded in a format which is compatible with the resource analysis, planning, or design data needs. Limits of visibility may be recorded directly in the landscape by the placement of markers. More typically, plan view maps and perspectives are prepared which depict the viewshed limits and view content, respectively. It is important in processing data to articulate both the type and quality of view limit so that subsequent interpretations are properly founded. For example, recording should differentiate between moving and stationary views, the presence or absence of seasonal vegetation considerations (such as filtering), and the geographic specificity ("hard", "soft","ambiguous") of the viewshed limit delineation. The latter is illustrated in Figure 18.

Computerized resource studies typically require numerical inputs of visibility. These can range from a single +,- (visible, not visible) to sophisticated geographic matrices of "weighted scores" which incorporate the area of view, distance, slope/aspect, and number and types of observers (see Section IV-D). Although mapped visibility is useful to the interpreter, actual computer format is typically tabulated cards or tapes. Perspectives are highly useful in illustrating the content of scenes due to the ease of reader legibility (see Figure 19) (Roy Mann Associates, Dec., 1975, p.77).

Figure 18: Viewshed Limit Accuracy.

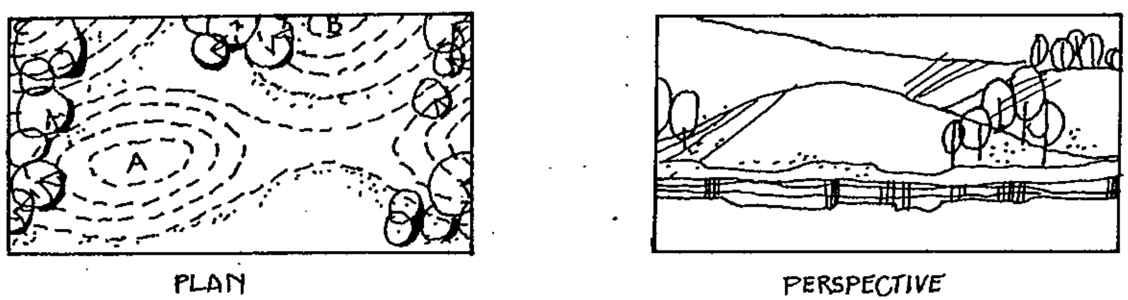
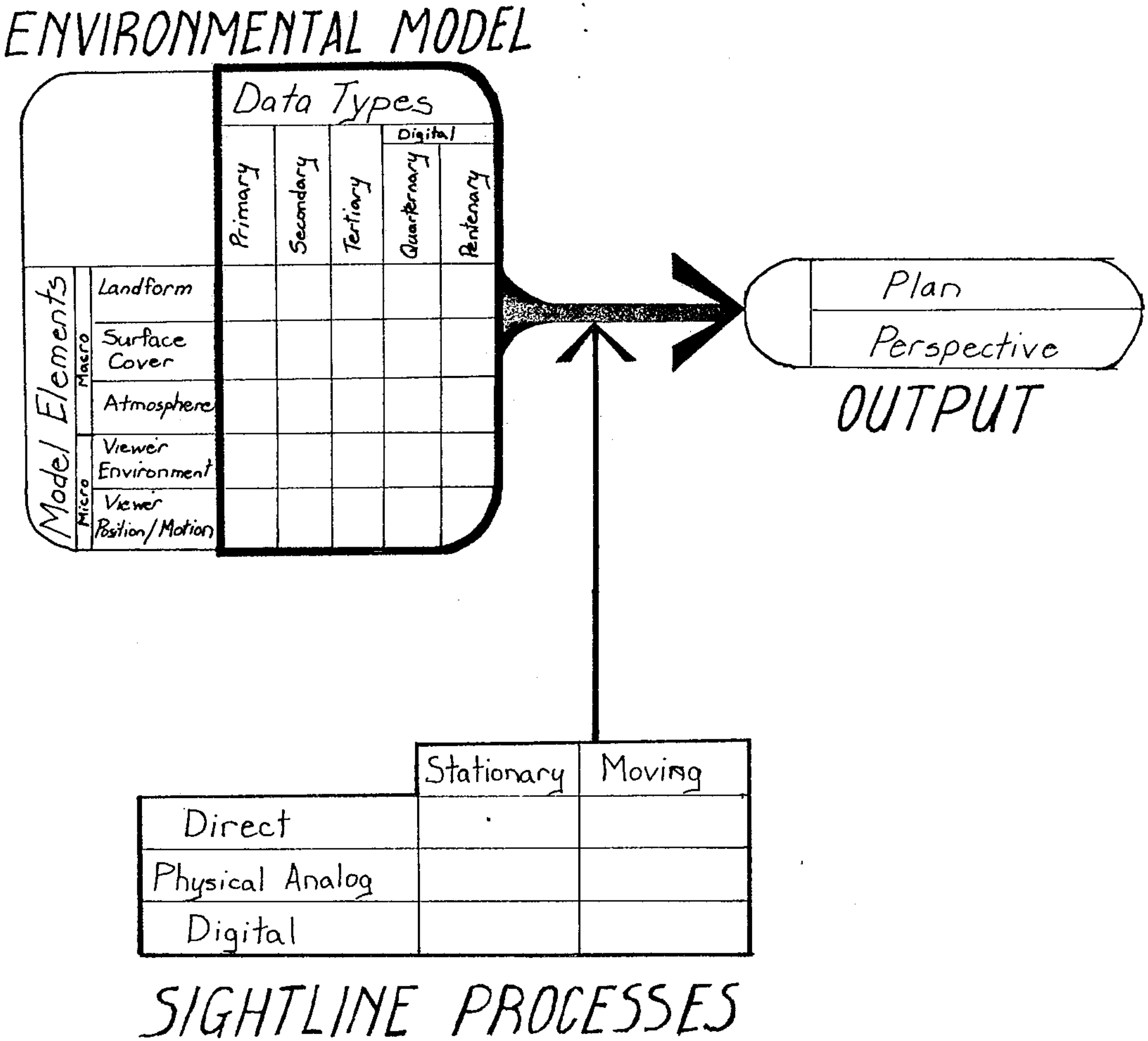


Figure 19: Plan/Perspective.

III DATA ASSEMBLY



III DATA ASSEMBLY

A. INTRODUCTION

The macro landscape and observer components of the visibility model require the collection and synthesis of terrain and surface character data. Careful attention to this stage of study design is important for internal consistency, i.e., that the data is compatible in form and quality with the subsequent line-of-sight process to be utilized. In addition, external consistency is also significant. This includes the sharing of information gathered from other components of the resource analysis project.

It is highly useful in discussing data to clarify its relationship to the actual environment. In this monograph the following functional definitions will be used:

PRIMARY DATA - Data collected in the field. Examples include photographs, sketches, map notes, videotapes, and position marking such as flags and stakes.

SECONDARY DATA - Information, typically mapped, which has been processed expressly for the visual study, or for a direct data need of the study. An example of the former is a forest cover map made from air photos; while the latter would include topographic maps such as the U.S.G.S. 7½ minute quadrangles.

TERTIARY DATA - Mapped geographic information not expressly developed for visual studies. Examples would be soil surveys, wetland designations, and New York's Land Use and Natural Resources Inventory (L.U.N.R.).

QUARTERNARY DATA - Numerically processed secondary and tertiary data. This information has been manipulated for inclusion in digital computer analyses. Examples are the grid cell centroid elevations obtained from topographic base maps, and height and diversity of vegetation interpreted from air photos and stored for ¼ square kilometer cells in the EDAP study (Landscapes Limited, 1973).

PENTENARY DATA - Numerically hybrid quarternary data. Examples include slope and aspect maps generated from grid cell elevations (Travis, et al., 1975), and grid cell elevations developed from "random" point elevations (Sampson, 1978).

In the following brief overview, each Macro Landscape and Observer Environment element of the visibility model will be addressed from the standpoint of primary, secondary, tertiary, and quarternary data considerations. Pentenary discussions are included where appropriate.

B.LANDFORM

Three dimensional physiography is usually the dominant interposition factor in large and medium scale landscapes (e.g.: those that contain views of background and midground distances).

1. Primary

Primary terrain data may include topographic surveys, field sketches, ground level photography and vertical aerial photography. Field sketches were the traditional means of recording land features on maps by exploration parties. An example is shown in Figure 20 (Litton, 1973, p.3). Although viewer position (or object location) photography has largely supplanted the need to manually portray detailed features, field sketches supplemented by notes can be highly useful in highlighting the character of terrain features as experienced and photographed in the field (see Figure 19) (see Figure 21) (Litton, 1973, p.21).

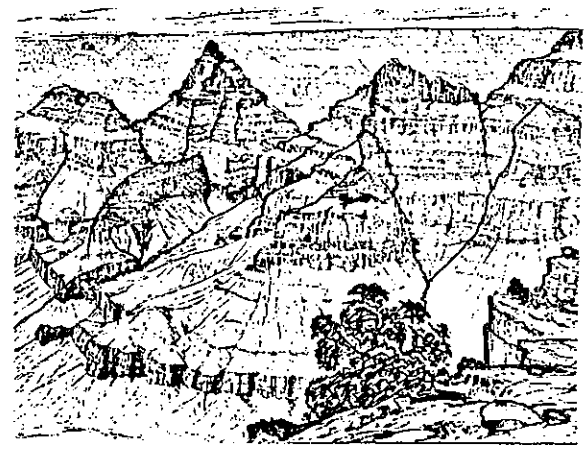


Figure 20: Detailed Field Sketch.

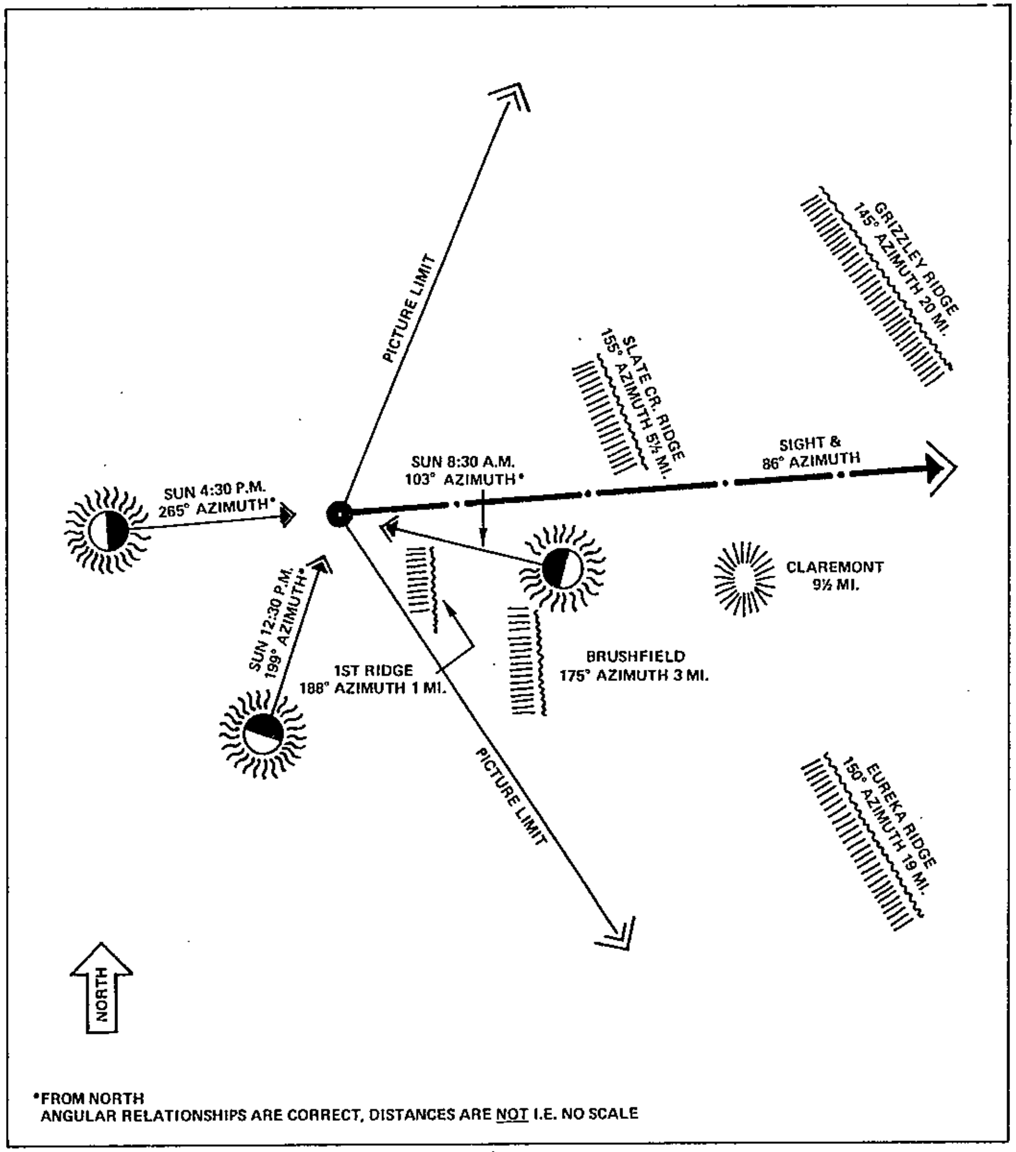
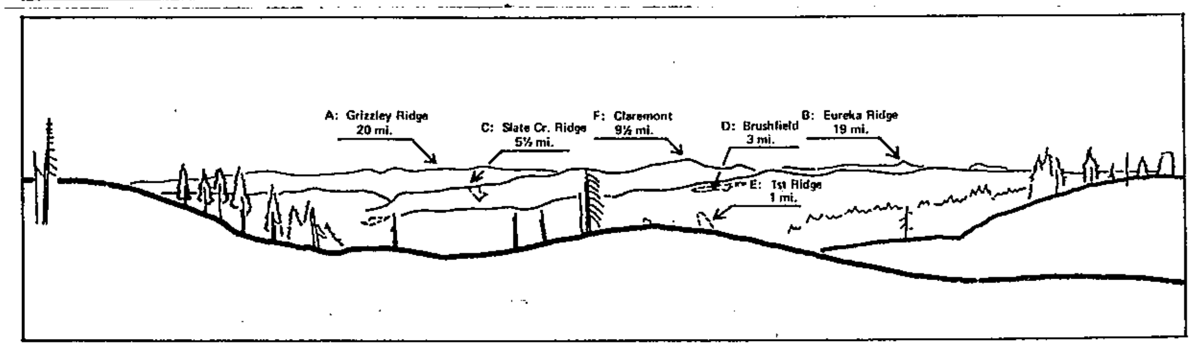


Figure 21: Photo Reference Sketch

Plan diagram

Distance diagram



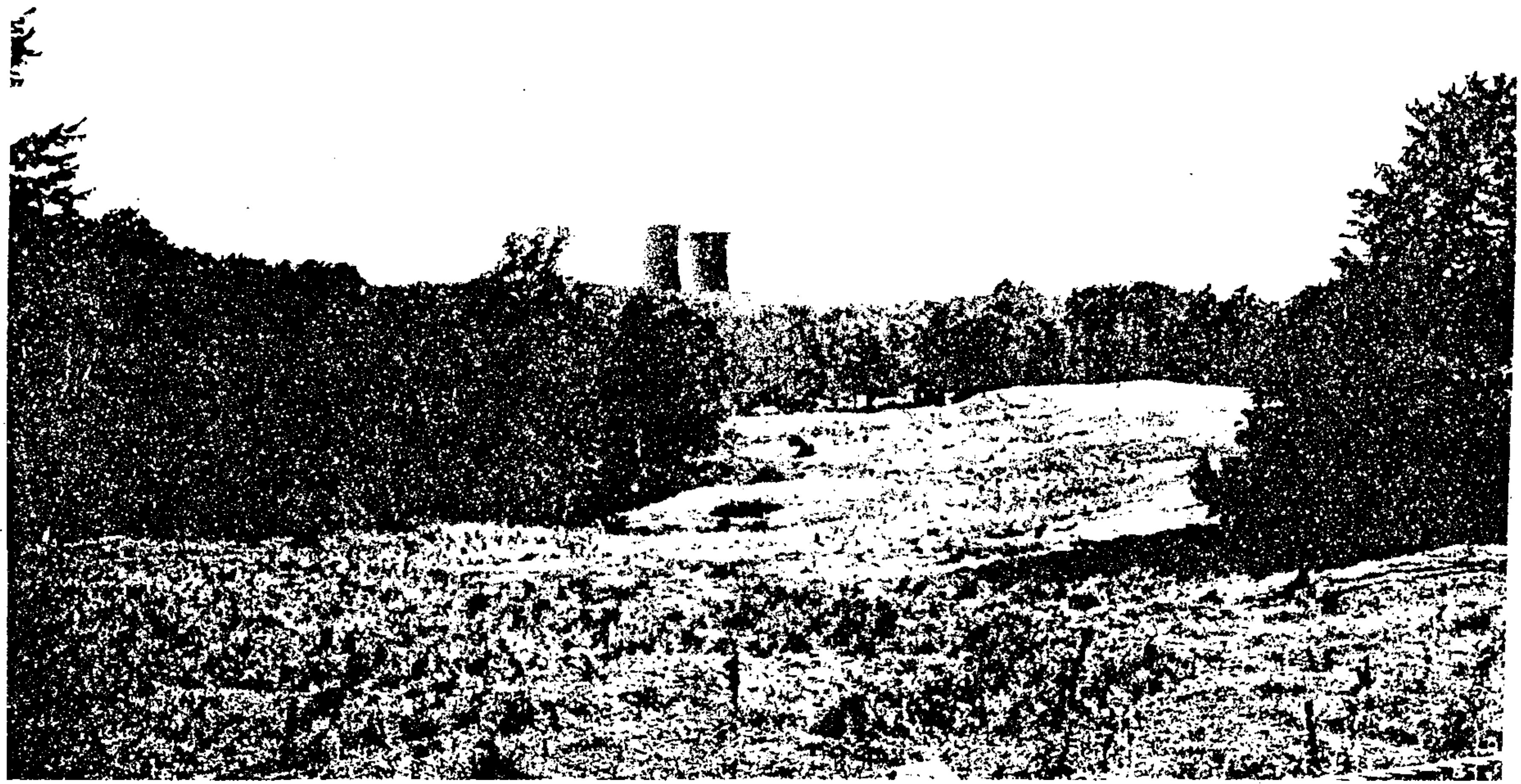
Viewer position (or object location) photography is a major primary terrain data collection technique. Ground photography is particularly useful in the direct analysis of profiles and skylines, and the evaluation of "before and after" scenic impacts using artist renderings (see Figure 22) (U.S. Nuclear Regulatory Commission, 1977) and computer plots (Kunit, Calhoon, 1973; Aerospace Corp., 1977; Penzien, 1978, p.36) (see Section IV).

Vertical aerial photographs in stereo pairs can be used to update major topographic changes such as landslides, reservoir construction and surface mining.

2. Secondary

The U.S.G.S. topographic maps provide analysts with the major source of terrain information. Contours (lines connecting points on the ground surface of identical surface elevation) are plotted to national map standards. Analysts should be sensitive to the dates of the U.S.G.S. photography and interpretation.

In some study locations more detailed topographic maps may be available. For example the New York State Department of Transportation has developed 1" = 20', 50' maps for the vicinity of its project locations. In recent years many advances have taken place in the field of cartography. One of the most promising is the "orthophoto map", the plotting



Projected View of 565-Foot Towers

Figure 22: Artist Photo Rendering.

of pertinent terrain-contours and cultural information on a distortion corrected air photo mosaic. The U.S.G.S. is introducing these maps in its nationwide map series.

3. Tertiary

Where available, surficial geology maps are readily combined with topography to define visually relevant landforms. In contrast bedrock geology, and soil survey maps appear to be of little direct use.

4. Quarternary

With the advent of digital terrain analysis, (see Section IV) considerable research interest has been devoted to the development of digitized data banks of terrain information. Typically these include a matrix of cartesian coordinates with associated elevations for each grid intersection (or cell centroid) (see Figure 23).

At present, the only widely available terrain data is the Defense Mapping Agency's (D.M.A.) tapes which are a digitized grid of the U.S. Geological Survey 1:250,000 generalized topographic maps. Ground cells are 200' square (National Cartographic Information Center).

The suitability of this information for visual analyses is a function of the scale of the project area, and the degree of resolution

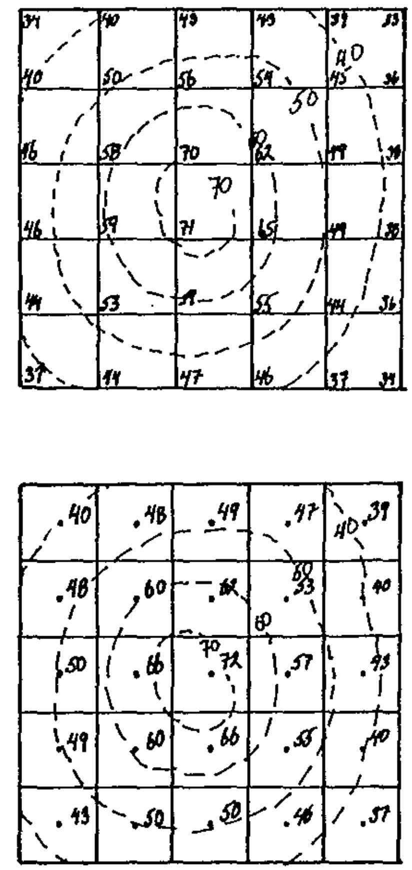


Figure 23: Digitized Elevations.

required. In an innovative scenic river study, the D.M.A. tapes were used to establish the "scenic boundary" for the Upper Missouri. Since the D.M.A. information has a maximum deviation of 400' horizontally and 100' vertically, the study was designed to map 400 acre units (1,320' square). This approach was considered conservative as a "V" shaped valley is approximated by a trapezoid (see Figure 24) (Van Dyke, 1977, p.7). In contrast, the N.Y. Sea Grant Port Bay Case Study found that the vertical relief of the 1:250,000 maps and the D.M.A. tapes were too gross to accurately represent low relief coastal areas (Felleman, 1979).

Figure 24: DMA Landform Truncation.

With the rapid evolution of computer hardware and software, many alternatives are now available to generate data for subsequent analysis with numerical terrain routines. Since most analyses internally utilize numerical grids, decisions must be made regarding accuracy, cost, and whether to input a grid (quarternary) or to generate a grid with a software program from non-grid points (pentenary).

Digitizing is the process of converting pictorial information (maps, photos, etc.) to a computer compatible (cards, tapes, etc.) numerical format (U.S. Forest Service, 1978).

In discussing computers, it is useful to incorporate the process sequence: input, analysis, and output. Since geographic information can be grouped into points, lines and areas (polygons), Figure 25 depicts the variety of approaches currently available for developing digital terrain model base data.

Quaternary processing entails superimposing a grid on the data source information and either manually recording, or electronically digitizing corner point (or centroid) elevations.

5. Pentenary

Pentenary data can be developed in various ways. "Random" points (either statistically random or selected) can be digitized in x,y,z coodinates and a numerical surface program run to create grid elevations (Sampson, 1978, p.91). Linear contours can be digitized (x,y coordinates along the contours, one z elevation associated with each linear string) with subsequent transformation into a numerical grid (Aerospace Corp., 1977, p.5-1).

An analytically powerful means of representing a three dimensional surface is to approximate it with a finite number of

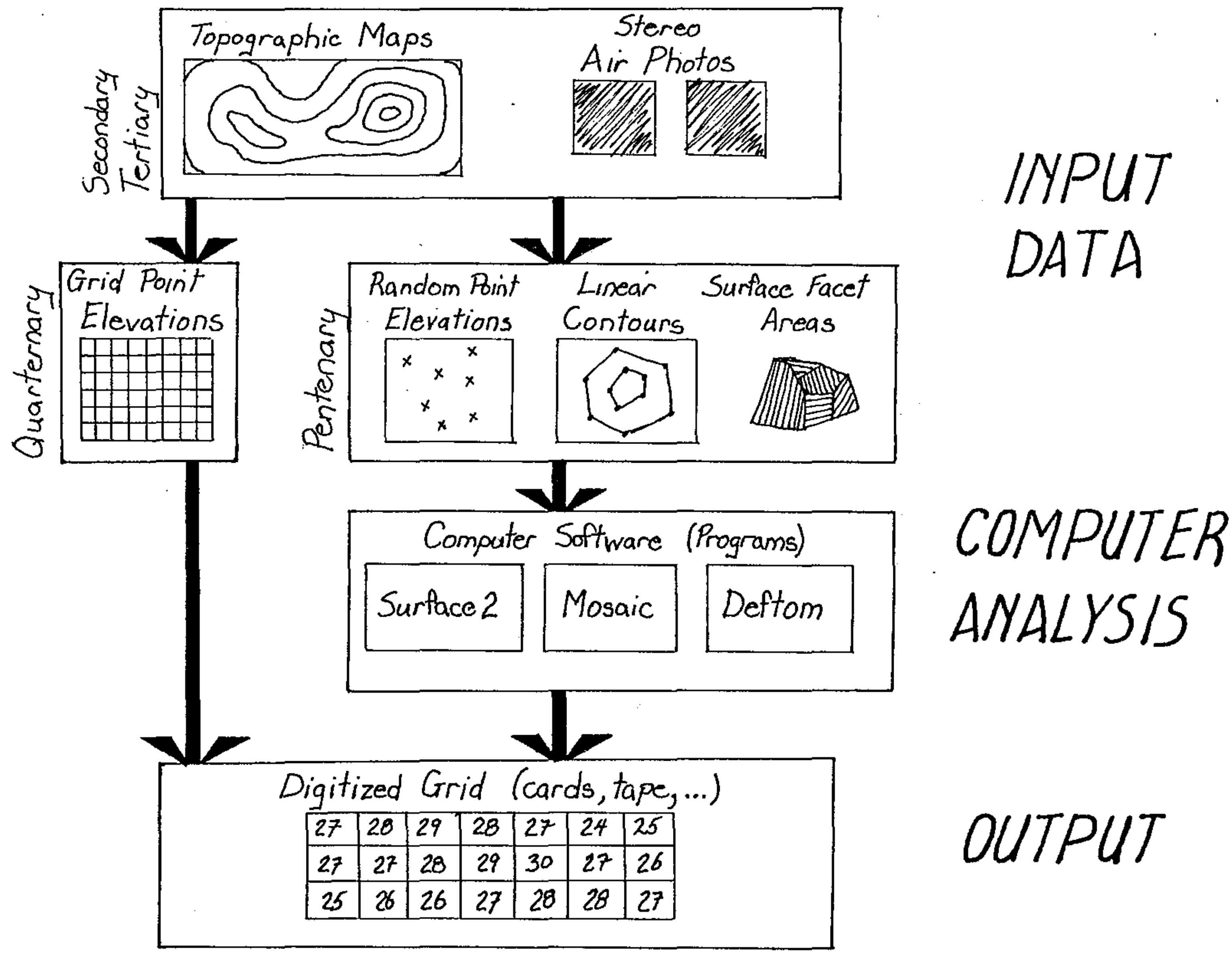


Figure 25: Digitizing Flowchart.

facets, each with internally consistent surface characteristics. This approach is widely used in industrial design (automobile bodies), and computer graphic shading (Newman, Sproull, 1973, part IV). In land form analysis a growing utilization is being made for slope, aspect, and watersheds (see Figure 26). A computer-derived numerical data bank can be made by inputting the polygon or corner outline of facet areas and associating general surface curvature with each area (Wagar, 1977).

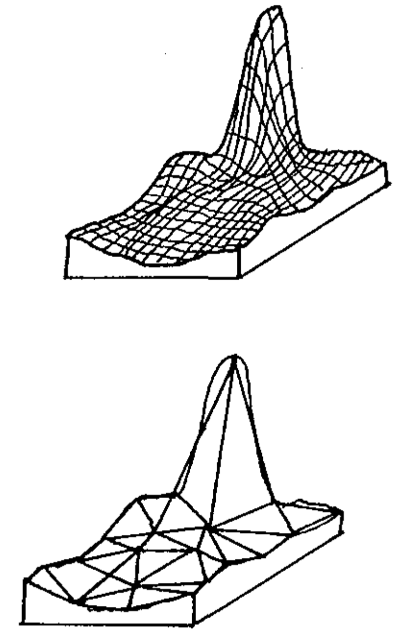


Figure 26: Terrain Facets.

C. SURFACE FEATURES

The significance of terrain surface features, vegetation, and buildings, for interposition in the study area should be carefully considered at the project outset. As the scale of terrain features, and/or the distance to observer positions increase, the significance of surface features in defining macro landscape limits of visibility diminishes.

1. Primary

Field sketching and field photography are generally an inefficient means of assembling comprehensive surface cover information. Major difficulties may be encountered in transcribing such information accurately to a topographic base map.

In contrast, vertical air photos (particularly stereo pairs) provide the most significant data source. Note, however, that field checks

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Unimproved road
- Road under construction, alinement known
- Proposed road
- Dual highway, dividing strip 25 feet or less
- Dual highway, dividing strip exceeding 25 feet
- Trail

- Railroad: single track and multiple track
- Railroads in juxtaposition
- Narrow gage: single track and multiple track
- Railroad in street and carline
- Bridge: road and railroad
- Drawbridge: road and railroad
- Footbridge
- Tunnel: road and railroad
- Overpass and underpass
- Small masonry or concrete dam
- Dam with lock
- Dam with road
- Canal with lock

- Buildings (dwelling, place of employment, etc.)
- School, church, and cemetery — Cem
- Buildings (barn, warehouse, etc.)
- Power transmission line with located metal tower
- Telephone line, pipeline, etc. (labeled as to type)
- Wells other than water (labeled as to type) — Oil ..... Gas
- Tanks: oil, water, etc. (labeled only if water) — Water
- Located or landmark object; windmill
- Open pit, mine, or quarry; prospect
- Shaft and tunnel entrance

Horizontal and vertical control station:

- Tablet, spirit level elevation — BM △ 5653
- Other recoverable mark, spirit level elevation — △ 5455

Horizontal control station: tablet, vertical angle elevation — VABM △ *9519*

- Any recoverable mark, vertical angle or checked elevation — △ *3775*

Vertical control station: tablet, spirit level elevation — BM × 957

- Other recoverable mark, spirit level elevation — × 954

Spot elevation — × *7369* × *7369*

Water elevation — *670* *670*

Boundaries: National

- State
- County, parish, municipio
- Civil township, precinct, town, barrio
- Incorporated city, village, town, hamlet
- Reservation, National or State
- Small park, cemetery, airport, etc.
- Land grant

Township or range line, United States land survey

Township or range line, approximate location

Section line, United States land survey

Section line, approximate location

Township line, not United States land survey

Section line, not United States land survey

Found corner: section and closing

Boundary monument: land grant and other

Fence or field line

- Index contour
- Intermediate contour
- Supplementary contour
- Depression contours
- Fill
- Cut
- Levee
- Levee with road
- Mine dump
- Wash
- Tailings
- Tailings pond
- Shifting sand or dunes
- Intricate surface
- Sand area
- Gravel beach

- Perennial streams
- Intermittent streams
- Elevated aqueduct
- Aqueduct tunnel
- Water well and spring
- Glacier
- Small rapids
- Small falls
- Large rapids
- Large falls
- Intermittent lake
- Dry lake bed
- Foreshore flat
- Rock or coral reef
- Sounding, depth curve — *10*
- Piling or dolphin
- Exposed wreck
- Sunken wreck
- Rock, bare or awash; dangerous to navigation

- Marsh (swamp)
- Submerged marsh
- Wooded marsh
- Mangrove
- Woods or brushwood
- Orchard
- Vineyard
- Scrub
- Land subject to controlled inundation
- Urban area

Figure 27: U.S.G.S. Legend.

are highly useful in developing a correct photo interpretation "key" for categories such as vegetation type and height (Reeves, 1975). An important use of stereo photos in New York is to update the L.U.N.R. map interpretations (see C3 below).

2. Secondary

The U.S.G.S. topographic maps contain a rich spectrum of cultural and natural features. An example is shown in Figure 27 (U.S.G.S., 1972). The user should be cautioned as to the date and accuracy of this information which is noted in the map legend.

In New York State the Department of Transportation has made a statewide update of political and cultural features at the identical U.S.G.S. 7 1/2 minute map series. Maps are available as planimetric or as overprints on the original U.S.G.S. topography from the Department's Map Information Unit in Albany.

3. Tertiary

The New York State L.U.N.R. system is an excellent example of a rich surface feature data source that is increasingly available to the visibility analyst. L.U.N.R. is an automated data bank that was constructed in the late 1960's to provide an information base for multipurpose local, regional and state planning. 1968 and 1969 air photos were interpreted for categories of land use and natural resources. The interpretations were manually transcribed to transparent overlays which fit the U.S.G.S. quads. However, visibility and visual character were not one of the system's application objectives.

The L.U.N.R. overlays contain the outlines of photo interpretation for point, linear and aerial information types (see Figure 28) (N.Y.S. Office of Planning Services, 1974). This mapped data is available in print or overlay form at the U.S.G.S. quad sheet scale. Both mapped data and numerical grid data are available to analysts. The former, although dated, continues to represent a major data source for many current impact assessments.

The L.U.N.R. categories mapped were not developed for visual analysis. Thus, there may be a range of visual character types encountered in a single land use type such as single family residential. Study area field checks may be necessary to clarify this situation.

Numerous surface type classifications are developed for national, state, and local planning and project purposes. The advent of a national land use and land cover system keyed to the U.S. Geological Survey base maps will set the framework for future analyses (9 general, 37 specific categories) (U.S. Geological Survey, 1978).

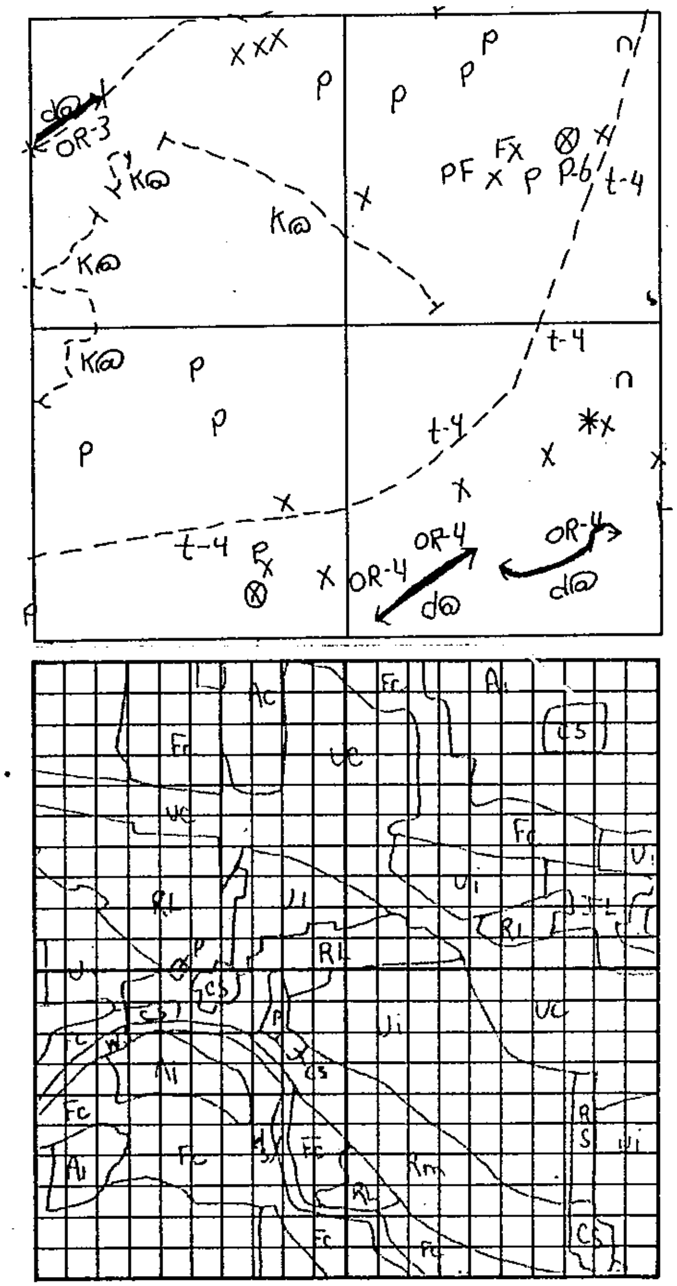


Figure 28: L.U.N.R. - Area and Point Data.

4. Quarternary

The L.U.N.R. system described above was designed to provide fully automated data and analysis assembly. A statewide 1 kilometer square grid system was superimposed on this mapped data and quantitative information was stored for each cell, by area, length, or number (Figure 28).

In contrast, some recent projects have incorporated in a multi-purpose data bank, land use and surface cover categories that are integrally related to scenic analysis. Applied research conducted at the University of Massachusetts (Fabos, 1976) and Harvard (Steinitz, 1978) utilized prior field and photography preference tests in assembling data, and building interpretive models.

The Harvard work is noteworthy in its dynamic synthesis of surface types and viewing distance (see previous discussion Section II-Surface Features). The 267 land use and landscape types which are potentially visible in foreground (200 meters) are aggregated into 30 types in the midground (300 meters +), and 13 groups at "far" distances (Steinitz, 1978, p.29).

D. ATMOSPHERE

This is one of the most complex elements of the visibility model due to the rapid rates of change inherent in climate.

1. Primary

Field observations can be made under varying day/night, and weather conditions to gauge generalized visibility distances associated with a predefined set of significant climatic conditions.

2. Secondary

Charts and tables of solar position can be used to map seasonal, potential sunlight. The U.S. Environmental Protection Agency keeps visibility (haze, smog tables...) information for metropolitan areas and major industrial regions.

3. Tertiary

Weather bureau and airport and coastguard data is highly site-specific. Extreme care should be taken in extrapolation of cloud cover and visibility data to remote sites.

E. OBSERVER TYPE AND QUANTITY

The importance of visual features may vary among observer types. As noted above, the U.S. Forest Service, in its Visual Management System, differentiates between recreation and nonrecreation travellers. The quantity of viewers is used by analysts to select important line-of-sight locations, and to weigh the relative importance of various views.

1. <u>Primary</u>

Field surveys are a frequent method used by recreation and transportation analysts to characterize and quantify user groups. These approaches (surveys, questionnaires...) can be directly applied to visual studies. Most public parks maintain visitor count records. Recreation, (Shafer, 1966), land planning (Zube et al, 1975) and other researchers have developed scenery evaluation approaches which involve direct field (or photo) evaluations.

2. <u>Secondary</u>

Frequent use is made of highway traffic counts to quantify potential numbers of views from the road. This is done by multiplying vehicle counts (such as computed Average Annual Daily Traffic, A.A.D.T.) by a selected occupancy rate, such as 2.5 people per car, and factoring for daylight hours. Such an approach does not deal directly with user types, except where special counts are available. State, county, and some municipal highway departments maintain traffic count data for facilities under their jurisdiction. Where data for precise numbers of travellers is not available or necessary, the Federal Aid Highway Program's Functional Classification System is a useful (and comprehensive) proxy. All routes in the country have been classified for both urban and rural areas (Bureau of Public Roads, 1969). In New York, the State Department of

Transportation has mapped these classifications on the 7 1/2 minute (1" = 2000') planimetric base (Figure 29).

A Federally mandated scenic highway evaluation was conducted by each state in the early 1970's. (Federal Highway Admin., 1973.) In addition, many counties and municipalities have designed scenic routes. These play an important role in developing impact hierarchies. (Wirth Associates, 1976, p.7-16).

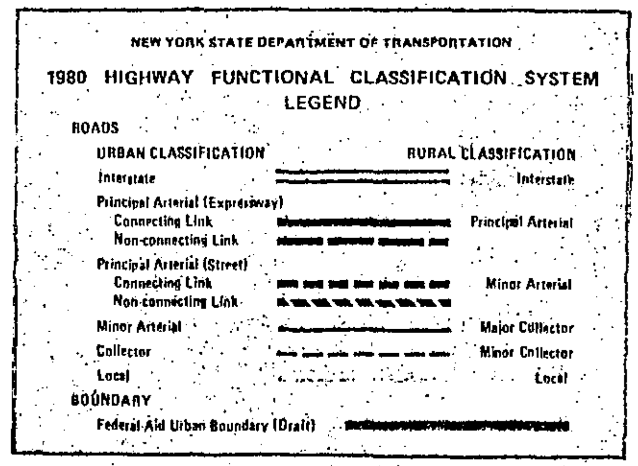


Figure 29: N.Y.S. Functional Highway Classification.

3. Tertiary

For urbanized areas, land use maps, census data, master plans, and zoning may be utilized to approximate existing and future number and type of viewers. Metropolitan transportation studies include industrial and commercial square footage which can be extrapolated to estimate users. This information is, at best, approximate and should be presented with clear explanatory notes. A common problem with quantification of viewer data is the misuse of significant figures, and the lack of provision of an expected statistical range.

4. Quarternary

Land use and transportation computer models are frequently used in simulating future conditions to assist resource managers in decision making. These tools can be adapted to provide gross viewer type and quantity data for a geographic study area such as an urban traffic zone.

F. OBSERVER POSITION AND MOTION

The selection of a finite number of viewing conditions, from the virtually unlimited number of possible views is a major challenge of study design. Studies may contain important stationary observation points and movement paths, as well as "proxy" positions from scenic elements.

View analysis positions may be functionally selected, regularly spaced, random or continuous (see Figure 30). "Landscape Control Points" (a concept researched by Litton and utilized by Jones and Jones, Zube and others) incorporates a few selected viewing positions which provide spatially extensive, representative views of a variety of landscape types (Litton, 1973). Regularly spaced positions are frequently used in a grid format for computer analysis of areas, and in evenly spaced (distance or time) points along roadway and travel corridors such as scenic rivers. Randomly generated points have been used to assess "typical" views in a landscape for areawide (Boster, 1976,p.92) and roadway contexts (Viohl, 1977) (Figure 30). The approach of "continuous" view positions is often used in the analysis of views along movement paths (Figure 30).

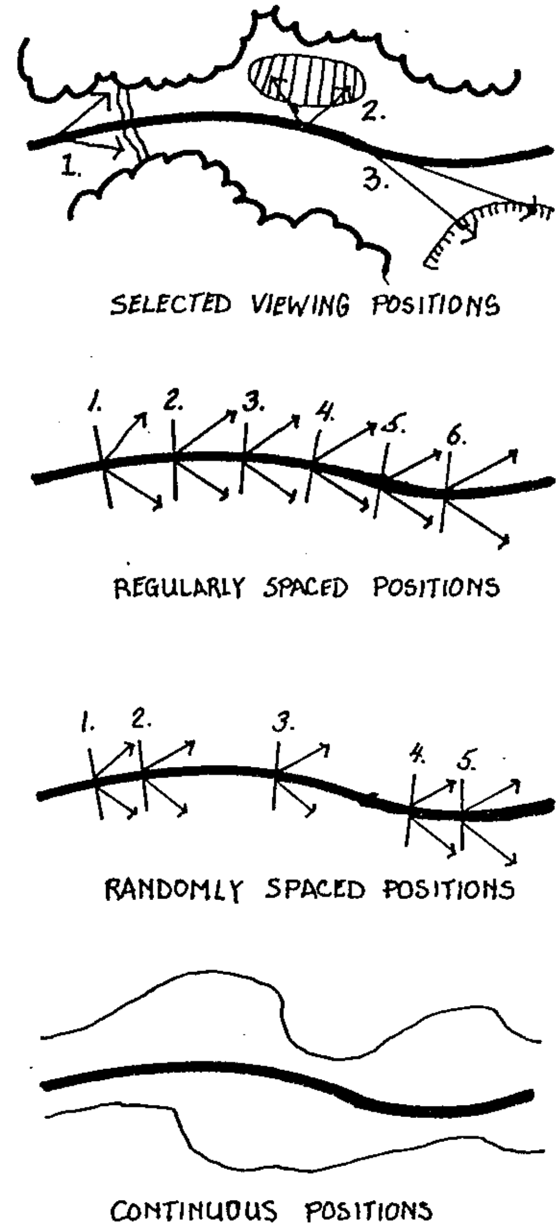


Figure 30: View Position Types.