AN ASSESSMENT OF REMOTE SENSING TECHNOLOGY IN VIRGINIA PLANNING AGENCIES

by

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Chapter I

THE SCOPE AND FOCUS OF THIS STUDY

THE RELATIONSHIP OF REMOTE SENSING TO PLANNING

Much has been written about the application of remote sensing techniques to a wide variety of resource and management problems (Clayton and Estes 1980, MacConnell and Niedzwiedz 1979, Minnoch 1974, Mooneyhan 1975 and Parrish 1975). In the broadest sense, remote sensing is the measurement or acquisition of information of some property, object, or phenomenon by a recording device that is not in physical or intimate contact with the object or phenomenon under study (Amer. Soc. Photogram. 1980). Remote sensing of the earth's resources is basic to the wise planning and management of such resources as crops, water, wildlife, forests, open land, soils and urban land. The relationship can be presented in a three-part statement: 1) whether viewed on a local, regional, national, or global level, human demand for most types of resources is rising quickly at a time when the supply of these same resources is rapidly dwindling; 2) dwindling resources mandate the wisest possible management of these resources; and 3) wise planning and management are greatly facilitated if timely, accurate and consistent inventories are made available to planners and managers, thereby increasing their cognizance of their planning/management units (Colwell 1975).

Numerous attempts have been made to define the role of planning in meeting the needs of society. Inherent in all definitions of planning is the concept of process. Few will dispute that all types of planning are process-oriented, with time horizons in the future. The quality of the planning effort is dependent upon the quality of the data input into the process. The availability of quality data does not guarantee, however, parallel quality of planning output. The importance of "good", relevant data is apparent in the large library of literature about the planning profession. (Scott 1975, Hirsch, W.Z. 1966, Whittick, A. 1974, and Schaenman and Muller 1975). Planning is data dependent. For most planning problems, the data required to analyze, select and implement alternatives are substantial. At any level of planning, e.g., local, county, or regional, resources allocated to generate data consume a substantial portion of the agency budget.

THE PROBLEM

Proponents assert that remote sensing techniques can increase the timeliness and resolution of information and reduce manpower and monetary inputs to obtain such information (Heller and Johnson 1979, MacConnell and Niedzwiedz 1979 and Todd et al. 1980). If such claims are fact, then it follows that planners should consider the utilization of remote sensing techniques to meet their needs. In fact, many planners have advocated the adoption of remote sensing techniques (Avery 1970, Heller and Johnson 1979 and Mooneyhan 1975). The degree of adoption and the potential for increased utilization, however, are not known. This study undertakes to assess the current and potential utilization of remote sensing techniques by planning agencies in Virginia. More specifically, this study will:

- establish the utility of remote sensing techniques in a wide spectrum of planning needs;
- document the degree and the characteristics of current remote sensing utilization by Virginia planning agencies;
- attempt to identify the reasons for any lack of use of remote sensing techniques by Virginia planning agencies;
- evaluate the potential for increased utilization of remote sensing techniques by Virginia planning agencies; and

- identify viable means for addressing the above potential.

METHODOLOGY

An extensive literature search was conducted to document sensor capabilities as defined by actual application by past users. The purpose of this literature review was to establish the utility of current, available remote sensing techniques in meeting planning agency data/information requirements.

A profile of planning agencies in Virginia was developed to identify: (1) administrative parameters; (2) staffing characteristics; (3) jurisdiction characteristics; (4) data/information requirements; (5) current data/information sources; and (6) potential for increased remote sensing utilization. The profile was constructed from responses to a mailed questionnaire. The questionnaire was sent to all Virginia town, city, county and district commission planning agencies. Questionnaire design was based upon current state-of-the-art design research methods (Bobbie 1973, Bailey 1978, Blalock 1972, and Moser and Kalton 1972). West Virginia planning agencies served as the survey pre-test population. Responses were stratified according to the following agency identifications:

local planning (towns and cities), county planning, and regional planning (planning district commissions).

Questionnaire responses were analyzed to produce descriptive and inferential statistics concerning the sample and population. Statistical analysis was accomplished through the use of a computerized program designed specifically to meet the requirements of this research. The analytical program utilized the Statistical Package for Social Scientists (SPSS) and Minitab.

Results from the above statistical analysis were interpreted for trends of association concerning the degree of current and potential utilization of remote sensing techniques by Virginia planning agencies . The administrative, personnel, jurisdictional, and information requirement characteristics of those responding agencies also serve as the dependent variables in this analysis.

Associations identified during the interpretive phase were used to identify, assess, and categorize alternative means for increasing the utilization of remote sensing techniques by Virginia planning agencies.

THE QUESTIONNAIRE

The survey questionnaire provides an integral component of the methodology (see Appendix A). Much time and effort were devoted to the design of the survey questionnaire, a factor believed to have contributed to the high response rates experienced. As a pretest, the questionnaire was administered to a group of planning agencies in West Virginia. Results of the pretest indicated no design deficiencies. A questionnaire was mailed to every planning agency within the Commonwealth of Virginia. Returns were catalogued over one month, then a second mailing of questionnaires followed, directed at "non-responding" agencies. Returned questionnaires were stratified by level of planning agency, e.g. town, city, county or planning district commission.

One month after the second mailing, a third distribution of questionnaires was conducted to reach agencies which had not responded. Each mailing of questionnaires was accompanied by a cover letter (see Appendix A) explaining the objectives of the research.

Objectives of the questionnaire were to develop data that would allow an analysis of:

- the basic characteristics of each planning jurisdiction;
- the kinds of data/information required by each planning agency;

- the extent of current remote sensor utilization by agencies to meet their data/information needs;
- the potential for increased utilization of remote sensors within Virginia planning agencies;
- any reasons for a "lack of use" of remote sensing technologies by Virginia planning agencies;
- the level of interest in various operational remote sensors;
- the extent of current computer usage by Virginia planning agencies;
- the potential for increased utilization of automated remote sensing techniques within Virginia planning agencies; and
- basic administrative characteristics about Virginia planning agencies.

Eighty-three questionnaires were returned from the 110 agencies in Virginia, representing an overall response rate of 75.5 percent. Perhaps as important as the absolute level of response is the relative distribution of responses within each planning level category, as shown in Table 1. Clearly, representative samples necessary to allow cross-comparison between agencies have been established for every level of planning agency.

METHOD OF STATISTICAL ANALYSIS

Choice of statistical technique is paramount because available statistical techniques are not always appropriate for data measured at various levels (e.g., nominal, ordinal, interval and ratio). The process of measurement, i.e., of assigning a value to the observed data, has important implications concerning the choice(s) of statistical technique to analyze the data (Nie et al., 1975). Variables being analyzed within this research are nominal in level of measurement. Using the nominal scale requires that variables be classified into two or more groups, of which the members differ with respect to the characteristics being scaled. No assumption of gradation or distance between the groups is made.

Not all statistical techniques may be employed to analyze nominal scale variables. Included in the menu of appropriate techniques are chi-square and its derivatives, phi, Cramer's V and contingency coefficient C. Chi-square is a test of statistical significance. Such tests help determine if a systematic relationship exists between two variables (function of X^2) and the strength of the associa-

Table 1-1. Level and Distribution of Questionnaire Response

	Number of agencies	Responses	Rate
town	14	7	50%
city	32	26	81%
county	42	31	74%
PDC	22	19	86%
total	110	83	75.5%

tion (function of phi, Cramer's V) or "c". Chi-square and Cramer's V were used as measures of association between variables in this research. Further discussion of these statistical techniques is provided in Appendix B. For detailed discussion of chi-square statistical theory and procedure, the reader may refer to Blalock (1972), Moser and Kalton (1972) and/or Bailey (1978).

STRATIFICATION OF SAMPLE DATA FOR STATISTICAL ANALYSIS

The methodological approach designed for this research assumes that differences exist between levels of planning. These differences might include, but are not limited to budgetary, staff, equipment, information input and information source parameters. Because such importance is placed upon the different levels of planning represented by Virginia planning agencies, discussion of levels of planning within Virginia is presented in Appendix C. Appendix C and the following text address the data requirements at different levels of planning and some explicit assumptions concerning data dependency and levels of planning.

DATA REQUIREMENTS AS A FUNCTION OF LEVEL OF PLANNING

When using scale of information required by Virginia planning agencies as the descriptive criteria, three "levels" of planning may be delineated: local (city and town), county, and regional (district commission). Each level represents a jurisdiction where problems may be unique, and often, where the "scale" or level of detail of required information to help solve these problems is different. Certainly, some data/information are of common use to all three planning levels. However, the above planning level distinctions require a hierarchy of information levels, extending from parcel level data and small-cell grid areas of less than one-quarter acre for highly urbanized districts to one-ninth kilometer square cells for regional applications (Giles, et al. 1976 and Jones 1976). Further, as stated in Stearns and Montag (1974), the level of detail to be studied and the size of the planning jurisdiction influence greatly agency staffing requirements, costs and study methodologies used.

As an example, Stearns and Montag point to the different factors affecting siting of major developments (e.g., power plants, airports) within a metropolitan area versus those affecting the siting of small developments (e.g., small shopping center, small apartment complex). Further, there are important differences in the scale of data required to analyze the effect(s) of major land use shifts on primary productivity of forests, grasslands, or weather patterns versus the scale required to analyze the impact of paving in central cities on wild animals, site specific temperatures and soil moisture.

The need for hierarchical analyses and interfaced data bases is well established (Davis, 1974). Development, storage and utilization of data/information in accordance with hierarchical design should help eliminate repetitious searches and storage of data. Establishing hierarchical analyses at three levels (regional, county and city/town) encourages "explicit consideration of proportions at each level and helps maintain an appropriate balance between generality and detail."[1]

Table 1-2 depicts hierarchical levels of information that could be associated with the levels of planning associated with Virginia agencies. The table delineates three levels of planning, their systems capabilities, data banks utilized and suggested staff background. Table content serves only as a primer to understand better the differing scales of data/information needed at each level of planning.

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[1]Stearns, F.W. and J. Montag. 1974. <u>The Urban Ecosystem: A Holistic Approach</u>. Dowden, Hutchinson and Ross, Inc., Stroundsbury, Penn., p. 182

Table 1-2
Organization of a Hierarchical System of Planning Information

		STATE/MULTI-COUNTY AREA
	Systems Capability	Socio-economic, socio-political Land use Ecological Geographical
LEVEL I	Data Bank	Census data Geology, soils, hydrology, forest lands, fisheries and wildlife statistics Land capability Cultural and historical land use trends
	Staff background (5-10 people)	Economics, systems analysis Mathematics, ecology, sociology, engineering, hydrology
		COUNTY/METROPOLITAN AREA
LEVEL II	Data Bank	Land capability and suitability scales of 1:50,000 or 1:25,000 Soils, geography, hydrology, forests, wildlife and recreation statistics Present land use Cultural and historical land use trends
	Staff Background	Environmental extension specialist: science background, design background

	CITY 100,000 OR MORE		CITY LESS THAN 100,000	
LEVEL III	Data Bank	Amenity resources Water quality Noise Vegetation Open space Ground water	Data Bank	Same as city of 100,000 or more
	Staff	Wildlife biologist, environmental scientist or ecologist and environmental designer	Staff	Part-time or professional re-trainer

Table 1-3 represents an extension of the above analysis into some of the issue categories likely addressed at the three levels of planning. Again, although not absolutely definitive, each level points to increasing specificity of issues as level of planning moves from regional to local.

A wide range of remote sensing techniques and procedures have been applied to an even larger array of problems. Successful application of remote sensors can be found for all levels of data specificity, and for problems of interest to practicing planners. Justification of remote sensor utility is not presented here, however, readers interested in the general utility of remote sensors may refer to Appendix D. For in-depth discussion of remote sensor application-case studies, the reader should refer to Appendix E.

ASSUMPTIONS CONCERNING LEVELS OF PLANNING AND DATA DEPENDENCY

The above discussion suggests that data requisites are a function of level of planning: each level having particular needs as defined by issue areas, with scale, temporal aspects, area of jurisdiction, jurisdiction complexity and dynamics and staffing skills as important criteria.

Table 1-3. Issues Addressed at Each Level in the Hierarchical System (modified from Stearns and Montag)

Increasing Specificity of Issues and Detail of Data		
	Level I:	Impact of industrial locational decisions on air, water, waste disposal, transportation systems; impact of/to growth centers; impact of locating major facilities.
	Level II:	Land use controls; zoning, performance standards; subdivision design approval; growth options or directions for urban expansion; site selection for major facilities.
	Level III:	Zoning for environmental effects; subdivision control; setting standards for noise levels, open space and water quality; park location.

Assumptions concerning levels of planning and data requisites include:

- The level of detail required of data/information is highest in urbanized environments (local planning);
- Planning jurisdictions of limited area obviate data collection problems associated with large area analysis and, in effect, may reduce remote sensor utilization;
- Conversely, large planning jurisdictions increase the data collection task and, in effect, may promote remote sensor utilization;
- Urban area dynamics increase the need for data base updating; and,
- Local planning agencies emphasize data/information of the socio-economic type.

TESTING OF ASSUMPTIONS: IDENTIFICATION OF DEPENDENT VARIABLES

Subsequent to development of assumptions concerning levels of planning within Virginia, characteristics of data/information used and the level of remote sensor utilization to meet agency data/information requirements, dependent variables for this research were identified. Dependent variables include:

- type of information required -- land use, transportation, population/demographic, socio-economic, environmental and "all" of the above (each being weighted equally);
- specific information types within the above categories (see appendix -- survey questionnaire);
- planning agency level of remote sensor utilization, and
- type of remote sensor utilization

SUMMARY

This chapter establishes the scope and focus of this research, the methodology applied, the basic parameters delimiting levels of planning and the assumptions concerning levels of planning and data requisites. Subsequent chapters define in detail the various elements of the research. Questionnaire design and results guide the organization and content of the following chapters.

Appendices D and E established the utility of remote sensing techniques to a wide variety of planning-related problems. It is hoped that after exposure to this literature search, the reader will be convinced that remote sensing techniques can be efficiently and effectively applied to a variety of problems.

Chapter II is devoted to a detailed analysis of important agency and agency jurisdiction characteristics, as defined by questionnaire results. Some of these characteristics include information needs and information sources.

Planning agency utilization of available remote sensor technologies per level of planning is also addressed in Chapter II. Survey questions delineating the content of this section address planning agency utilization of remote sensing techniques, the types of applications to which these sensors are applied, agency source of remotely sensed products and factors limiting the use of remotely sensed products by Virginia planning agencies.

Discussion and analysis of survey results concerning demand for increased cognizance of remote sensing applications is also presented in Chapter II. Specific subject categories to be addressed include the role of planning publications, state supported remote sensing planning conferences and general and specific demands concerning remote sensing applications.

The conclusions and summary of the research, along with suggestions regarding extensions of this research, are delineated in the final chapter.

Chapter II

RESEARCH RESULTS: AN ANALYSIS OF REMOTE SENSING POTENTIAL, UTILIZATION & INFORMATION DEMAND BY VIRGINIA PLANNING AGENCIES

Appendices D and E establish the applicability of remote sensing technologies to a broad spectrum of problems. Most of the information/application areas described are relevant to one or more of the levels of town, city, county and district commission planning. Establishing "need" or potential applicability of remote sensors to levels of planning requires an analysis of basic characteristics of each planning level agency and its jurisdiction.

Agency characteristics deemed relevant to this research include agency staff characteristics, size of planning jurisdiction, land-use characteristics of the planning jurisdiction, agency data/information requirements and agency in-house data/information generation capabilities. Research data regarding the above characteristics were developed via questionnaire responses.

Statistical analyses indicate very little association between agency variables and remote sensor use (see Chapter III). Agency characteristics identified on the questionnaire, however, may serve to answer two questions: (1) what agency characteristics affect remote sensor use; and,

(2) what is the potential for increased remote sensor use by Virginia planning agencies? Since no statistical association is indicated between most categories tested, agency characteristics having limited bearing upon the potential use of remote sensing techniques take on less importance. However, summary discussion of agency characteristics which show no or little statistical association with remote sensor use, but which help define the potential for increased use of remote sensors by Virginia planning agencies, is presented here.

PART I: PRIMARY AGENCY CHARACTERISTICS WHICH HELP DEFINE THE POTENTIAL FOR INCREASED USE OF REMOTE SENSORS

The characteristics of data/information requirements and in-house data/information generation capabilities serve to define the potential for increased remote sensor use by Virginia planning agencies. What types of data/information are deemed important by Virginia planners and the source of that data/information define the theme behind a portion of the questionnaire administered to Virginia's planning agencies. Results from the questionnaire are discussed in the following text.

Data/Information Requirements as a Function of Size of Planning Jurisdiction

At any level of jurisdiction, effective, efficient planning requires timely and accurate data/information. Not all data/information are equal in respect to availability, resolution, and costs of generation. Historically, much of the data/information produced addressed the intra-economic, social and activity functions of municipalities (Glasson 1974, Isard and Langford 1971). Lacking have been data reflecting inter-municipal and inter-regional activities, and both local and regional land-use patterns/change.

Cognizance of Virginia planning agency data/information requirements will provide increased understanding of a) the relationship between current data needs and current utilization of remote sensing technologies to meet those needs and b) the potential of remote sensing technologies to meet identified data requirements.

To determine data/information input requirements each Virginia planning agency was requested first to rank its needs using the general categories of land-use, transportation, population and demography, socio-economic, environmental, all of the above (equally weighted) and other (agency specified), and secondly, within each of these broad categories, to rank specific data needs. The detailed list of specific data categories is outlined in

Appendix A--Survey Questionnaire. Direct interpretation of the results is possible. Each respondent could rank the data options using a scale from one to seven (if the "other" category was used). In cases where no rank was given (no response), the fact was tabulated and interpreted as meaning "such information not required by this agency."

Broad Category Requirements

Difficulty is experienced when attempting to analyze town planning agency responses because the town sampling population is small (14 cases -- of which seven returned the questionnaire). Although town agency ranking distribution is depicted in Table 2-1 for reader reference, discussion is not provided.

A simple weighting methodology was used to establish information rank-order for each level of planning. As an example, if five rankings were possible, e.q., one through four plus "no response", the top rank (1) would be given a weight of five (5), the 2nd rank given a weight of four (4)...etc. The summation of the five weighted response totals were then divided by the total number of respondents (per planning level) to determine the relative position of rank.

Table 2-1. Rank-Order of General Information Needs by Level of Planning Agency

	Land-use	Transportation	Population-demographic	Socio-economic	Environmental	All equally valued
Town	5	2	3	1	2	4
City	1	5	3	2	6	4
County	1	5	2	3	4	6
PDC	1	4	2	3	5	6

Table 2-1 displays individual rank order findings for city, county and PDC agencies. City results yield both expected and surprising elements. Land-use data/information was given top priority by city planners. Such results were expected as cities are highly diverse, complex, and often dynamic units. Maintaining current land-use profiles is difficult. Ranked second are socio-economic data, followed by population/demographic data. None of the above defy our perception of problem areas associated with cities. However, transportation, an oft cited area of concern in and about cities, was ranked fifth by respondent agencies. Placed in sixth and last place for required data inputs was environmental data/information. Environmental data placement is not unexpected, especially within the city planning group. However, to forge ahead a bit, environmental data was placed consistently in the lower ranks of importance at all levels of planning. Such overwhelming statistics were unexpected, particularly at the regional level of planning (PDC).

As planning jurisdictions increase in size (area) one would expect those data that defy collection by conventional, centralized approaches to be of premium importance. Such data is exemplified by land-use, environmental and some population/demographic data. County planning agency responses support the above expectations. County agencies ranked land-use data as their primary concern, followed by population and demographic data. As discussed earlier, environmentally based data/information were ranked fourth by county planners. Found in the fifth position is transportation data while the "equally ranked category was ranked sixth."

Planning district commissions follow closely the results displayed by Virginia county agencies. Land-use data were positioned first followed by population /demographic and socio-economic data in rank positions two and three. Remaining data/information categories include transportation (ranked fourth), environmental (ranked fifth) and all categories equally valued (ranked sixth).

Specific Data/Information Requirements

The categories above serve only to identify agency emphasis over the spectrum of data/information offerings. Within these broad categories exist data/information elements that are specific, that often present unique collection problems to planners, and which may vary in their utility (relevance) to planners of different jurisdictions and/or planning levels. The attempt is made here to study these specific data/information elements and the distributional responses (reflecting importance values) assigned to them by the planning agencies included in this study.

Land-use Categories

Land-use categories were broken into nine elements for this study. These categories include residential, commercial, industrial, agricultural, forest, wetland, openspace/vacant, recreational, and other (agency specified). Each agency was requested to rank the above categories according to the relative importance of each as data/information required for "planning" within the agency's jurisdiction. Results of the survey follow. As noted earlier, due to the small size of the town sampling population only tabular results are presented. A distinguishing feature of the city tabulations is the clear demarcation of ranked needs between "urban" associated versus "natural" environmentally associated land uses (Table 2-2). No doubt confounds the analyst upon completing a review of these data. City planners want commercial, residential, and industrial data/information. These categories were ranked in the top three positions by 92.4 percent, 92.3 percent, and 76.9 percent of respondent agencies, respectively.

Table 2-2. Rank-Order of Land-Use Information Per Level of Planning Agency

	Residential	Commercial	Industrial	Agricultural	Forest	Wetland	Open-Space Vacant	Recreation
Town	2*	1	2*	6	5	7	3	4
City	2	1	3	6	7	8	4	5
County	1	2	4	3	5	8	6	7
PDC	1	4	3	2	5	8	6	7

*tie

As expected, relatively low levels of importance were assigned the land-use data categories of agriculture (ranked 6th), forest (7th), and wetlands (8th) by city agencies who chose to participate in this research.

Changing growth-development patterns should change data/information input requirements of planning agencies. Results from county agencies support the above claim (Table 2-2). County data/information rankings of importance are less definitive than those outlined by city agencies. Only the residential land-use category did county agencies clearly define as most important -- 80.6 percent placed this category in positions one through three while 54.8 percent assigned residential data to position one. No definitive proportional land-use assignment was made for the second, third or fourth rank positions, although weighted analysis places commercial, agricultural, and industrial categories into these positions.

Land-use data/information categories given lower importance rankings were forest (5th position), open-space/vacant (6th position), recreation (7th position) and wetlands (8th position). It should be noted that questions addressing specific data/information needs did not include a "data equally ranked" alternative as did the question addressing broad data/information needs. This is considered a design weakness by the author, though one that can be circumvented (i.e. by noting less than definitive, broad distributional responses).

Within the Commonwealth of Virginia the largest (area) planning jurisdictions lie under the authority of planning district commissions. Virginia PDC's have an average jurisdicitonal area of nearly 1500 square miles. As noted above, increasing relative size of planning area can compound the problem of data/information generation. Increased planning area taxes existing staff skills and knowledge, staff time allotment and agency budgets. Historically, accurate and timely land-use data has been available only marginally. The problem is exacerbated as planning areas increase in size.

Data/information requirements for PDC jurisdictions approxmiate those requirements assigned to county planning agencies whereby residential, agricultural and industrial categories were ranked 1st, 2nd, and 3rd, respectively (Table 2-2). These rankings do not portray some of the subtleties associated with the raw frequency tabulations, however. Close inspection of the raw data defines a number of insightful aspects of these data. First, a 3-cell test (summation of proportional responses for the top three ranks) suggest that industrial inputs should be ranked higher than agricultural inputs, when in fact, 52.6 percent of respondent agencies placed agricultural inputs in the top two rank positions versus 31.6 percent for industrial inputs. Secondly, in a 3-cell test forest land-use inputs place nearly as high as commercial inputs (31.5 percent versus 36.8 percent). And thirdly, while wetlands inputs were ranked in the last (8th) position of importance by 26.3 percent of respondent PDC's, over 42 percent of all respondent PDC's stipulated that wetlands data were not required as input for planning of their areas! This represents a startling proportion in light of recent public opinion movement and federal and state legislation (Global 2000 Report 1980, Greenwood and Edwards 1979, Sargent 1976).

Specific Data/Information Requirements: Transportation

Data/information reflecting transportation issues and problems, potential alternatives, constraints and alternative base information inputs are oft requested by those dealing with such problems. Because of changing land-use mix, diversity, density and pattern differentials associated with levels of planning jurisdiction, greater or lesser emphasis upon relevant data/information inputs would seem justified by planners representing their respective planning areas. Emphases of this kind are reflected by the questionnaire results.

Within the transportation category all respondents were allowed to rank among the elements of local route design and location, regional route design and location, mass transit studies, parking facilities studies, bikeway design and location; and, miscellaneous or "other" transportation use category. Again, town responses are tabulated but not analyzed (Table 2-3).

Experiencing quickened pace of life, greater urban densities and greater dynamics per se, city planning agencies would seem to emphasize different data/information categories than would town, county and PDC agencies. A high proportion of city agencies (57.7 percent) rated local route design information as their primary requisite (Table 2-3).

The importance of parking as an issue within Virginia cities, a perennial problem of most towns and cities, was supported further by questionnaire results. Parking facilities related information was assigned the second ranked position of importance. Following parking related information in importance are regional route inputs (ranked 3rd), mass transit information (ranked 4th) and bikeway related information (ranked 5th).

Table 2-3. Rank-Order of Transportation Information Per Level of Planning Agency

	Local Route	Regional Route	Mass Transit	Parking Facility	Bike way
Town	2	5	3	1	4
City	1	3	4	2	5
County	1	2	4	3	5
PDC	2	1	3	4	5

As planning jurisdiction increases in area, transportation issues and problems often include both localized and regional characteristics. Counties commonly incorporate several municipalities, each of which harbor specific problems and each of which has contributed to, and will contribute to, county-wide problems. The synergistic relationship(s) among municipalities, and counties for that matter, should not be denied by planners and decision-makers. County planning agency results addressing transportation inputs reflect the above statement and the importance of all levels of information (Table 2-3).

A majority of county agencies (58.1 percent) assigned local route related information to the first rank position. Establishing the importance of regional levels of data/information, county agencies placed regional route related data/information into the second rank position (45.2 percent responded at this level of rank). Following in order of rank were parking facility data/information (3rd), mass transit information (4th), and bikeway route information (5th).

Weighted analysis indicates that respondent Planning District Commissions value regional transportation information over categories of transportation related information (Table 2-3). Local and mass transit information were ranked into the 2nd and 3rd positions, respectively. Parking facilty and bikeway information, most associated at local levels of planning, were ranked 4th and 5th, respectively.

Specific Data/Information Requirements: Population/Demographic

Four categories of population/demographic information were identified on the mailed questionnaire. These include population distribution, housing, population change and "other" population/demographic (specified). Distribution of population has important implications in planning. Where people live affects district representation, service(s) availability, infrastructure capability and decisions affecting same, budget apportionment, and a host of other concerns. Associated with population distribution are housing characteristics. Distribution of housing stock, (e.g. single family, duplex, multiple family and unit developments), the state of this stock and its surrounding environment, and the potential for meeting future demand all serve as important inputs for planning. Data/information collection concerning the above often consumes much time of planners. Correlated with both population distribution and housing characteristics is the parameter of population change. Planners must be able to forecast with reasonable accuracy the dynamics of population for their jurisdiction. Growth or decline of population is often the basic element for a planned action, be it park, school, shopping center or capital facilities expansion, or, a decision to forestall "expansion" because of declining population.

Limited response categories (four) within this survey question temper the weight of the findings. Trends are evident however, and should prove helpful in later analysis. Significantly, all levels of planning agencies, except town, rated population distribution data/information as being the most important within the population/demographic category (Table 2-4). City planning agency rankings of the second and third positions of importance were assigned to housing and population dynamics, respectively.

County planning agencies identifed the same rank list and order as did city agencies. The frequency distribution assigned to population/demographic information is less definitive, however.

Results of the questionnaire pertaining to PDC population/demographic inputs are more clearly defined than those described above. The most important type of population/demographic information within PDC agencies is population distribution (68.4 percent of respondent agencies

Table 2-4. Rank-Order of Population-Demographic Information by Level of Planning Agency

	Population Distribution	Housing	Population Change
Town	2	3	1
City	1	2	3
County	1	2	3
PDC	1	3	2

Table 2-5. Rank-Order of Socio-Economic Information by Level of Planning Agency

	Employment	Income	Sales
Town	1	2	3
City	1	2	3
County	1	2	3
PDC	1	2	3

ranked it first while 94.7 percent ranked it first or second). Absolute ranking suggest that population dynamics information is considered the second-most important type of population/demographic information by PDC planners, while housing data/information is considered the third-most important type of population/demographic information.

Specific Data/Information Requirements: Socio-economic

Much of the data/information collected and analyzed by planners is labeled socio-economic. The import of socio-economic data/information cannot be disregarded or refuted, nor was its position ignored during the design of this survey. The author is well aware of the significant contribution of socio-economic inputs to planning methodologies. However, the author is also aware of the limitations of current remote sensing technologies to address most socio-economic input problems. Recognizing these limits, few socio-economic data/information categories were allowed in the questionnaire. Categories include the following types of socio-economic data/information; employment, income, sales and "other" (agency specified). Statistical analysis suggests that no relationship exists between agency remote sensor use and the above types of information. Because remote sensor applicability to such information categories is limited, no discussion of rankings is presented. Ranked results are delineated in Table 2-5, however.

Specific Data/Information Requirements: Environmental

There exists no dearth of reasons fostering the need for environmental data/information input at all levels of planning. Environmental consciousness spawned by movement during the 1960's and 70's has increased environmental inputs to the planning process. Further, a host of new laws, both federal and state, force inclusion of environmental concerns into the decision-making process. Examples of such "action forcing" legislation include the National Environmental Policy Act, National Clean Air and Water Acts and the Endangered Species Act.

Somewhat surprisingly, no distinguishing features can be identified among the environmental results obtained for each level of planning. Slight shifts of emphasis are noted, although no abberations exist. One might expect significantly different requirements between planning conducted at local levels (town and city) and at near regional/regional levels (county and multi-county). Seven environmental data/information response categories were listed in the questionnaire. These include information concerning; soils, wetlands, hydrology, wildlife, land-forms, vegetation and "other" information (agency specified).

Comparison of environmental data/information categories ranked first through third by agencies of all planning levels indicates that there are few preferential differences. At each planning level except PDC, soils information was ranked first, hydrologic information second and landform information third. Only in the case of district commission level of planning was there a slight difference noted, i.e., landform information was placed into the second position of importance while hydrologic information was ranked third by PDC's (Table 2-6).

Agency In-House Data/Information Generation Capacity

Having identified the relative importance placed upon both broad and specific categories of data/information by Virginia planning agencies, the obvious next step is an identification of agency in-house capabilities to generate or develop these data/information. Known in-house capabilities to produce needed data/information should aid evaluation of the potential for increased utilization of remote sensing techniques by Virginia planning agencies. Such information also will be merged with an assessment of agency in-house remote sensing application skills, as is discussed latter in this document.

Table 2-6. Rank-Order of Environmental Information by Level of Planning Agency

	Soil	Wetland	Hydrology	Wildlife	Landform	Vegetation
Town	1	4	2	6	3	5
City	1	4*	2	5	3	4*
County	1	5	2	6	3	4
PDC	1	6	3	5	2	4

*tie

As applied in the questionnaire, a statement requests the responder to assess his/her agency's estimated in-house capabilities to meet their data/information requirements (per broad category to the nearest percentile). Again, these broad data/information categories are; land-use, transportation, population/demographic, socio-economic, environmental, and "other" (specified by responder).

Land Use Information Generated by In-house Staff

Figure 2-1 summarizes Virginia planning agency in-house information generating capacity. A general trend is common to all levels of agencies sampled: many agency staffs (nearly 50 percent for all levels) produce 80 plus percent of their information needs. A slight dichotomy is noted however. Agencies with larger jurisdictional area, e.g., counties and PDC's are meeting relatively less of their data/information needs than are town and city agencies. Just over 60 percent of all respondent town and city agencies declared that their in-house staffs were meeting over 80 percent of their data/information requirements.

No less important than the above findings, however, is the fact that 26 percent of all respondent agencies produce 50 percent or less of their required data/information inputs. Of these, 3.8 percent of city agencies (1 case),

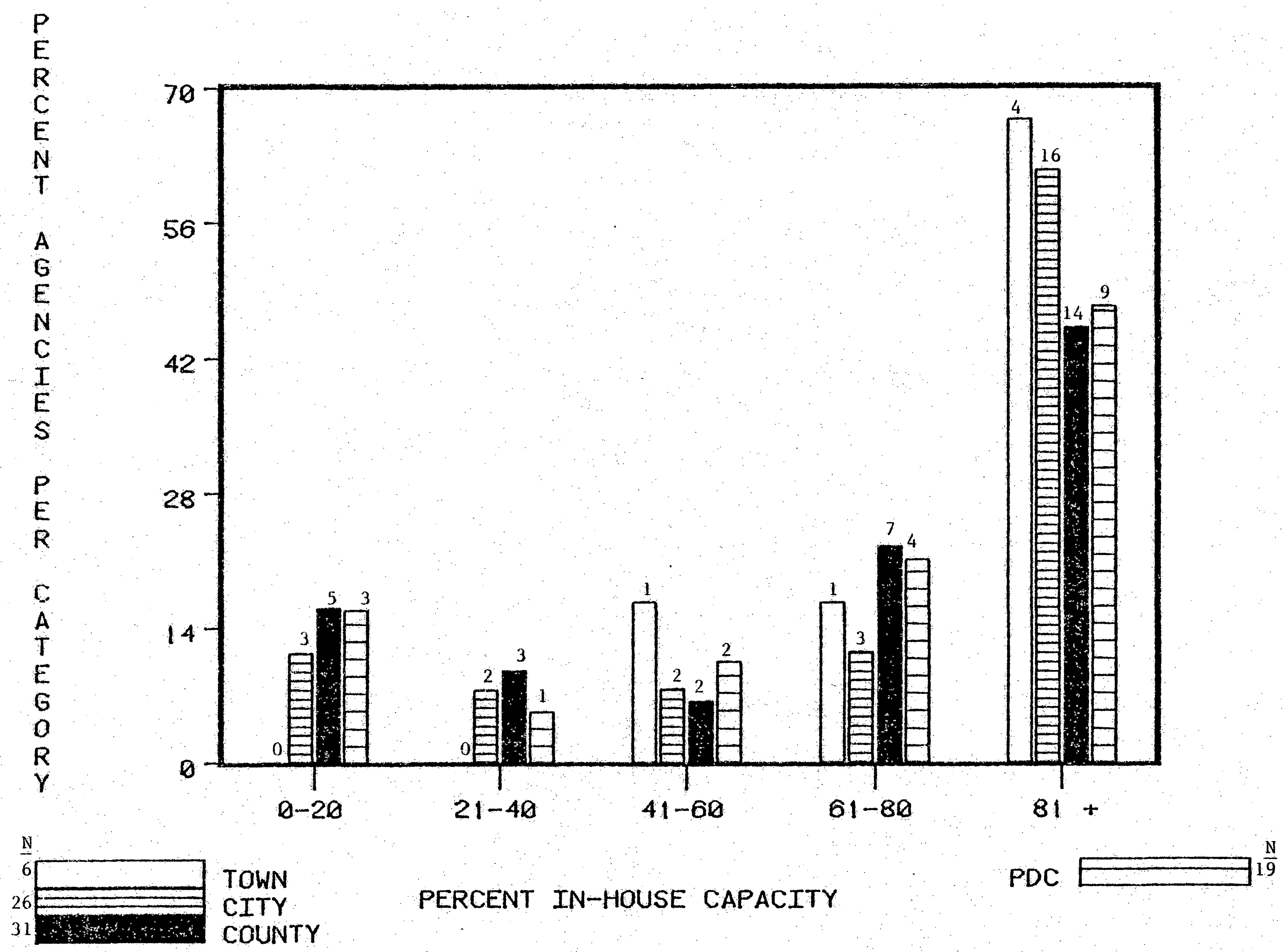

Figure 2-1. Proportaion of Land-Use Information Generated by Staff

9.7 percent of county agencies (3), and 5.3 percent of PDC agencies (1) produce no required data or information. These figures are significant because a) planning may have been conducted within these jurisdictions with little or no quality land-use information, or b) these agencies might be paying premium fees to consultants to produce such data, and c) land-use information at the primary, secondary and tertiary levels can be efficiently and accurately produced via remote sensing techniques. In fact, many remote sensing techniques are highly amenable to land-use problems, a fact that will be used later to assess potential use of remote sensing techniques within Virginia planning agencies.

Transportation Information Generated by In-house Staff

Transportation data/information implies a wide range of possibilities, some of which are existing land-use, critical habitat areas, existing rights-of-way, condition of rights-of-way, and traffic volumes and flow rates. Relative to the capabilities discussed above for land-use information, Virginia planning agencies seem less capable of generating transportation information for planning purposes (Fig. 2-2). Greater than 50 percent of responding town, county and district commission agencies stipulated that they generated 20 percent or less of their required transportation inputs. Of interest is the fact that town and city agencies, that often experience more frequent and complicated transportation problems than do other agencies, tend to generate more of this type of information than do county or district commission agencies.

Referring to the elements outlined above, remote sensing techiques can play an important role in meeting many transportation associated data/information requirements. Not all needs are addressable, e.g., traffic flows, which may be more cost-effectively analyzed via conventional methods, however, many remote sensor-transportation applications have been documented as highly successful.

Population/Demographic Information Generated by In-house Staff

A wide spectrum of information is inherent in population and/or demographic discipline areas. Although not all types of population/demographic data can be accessed with available remote sensing techniques, many applications are possible. The use of remote sensing in the study of population can be of two types: (1) in support of enumeration census-type and sample survey-type activities, and (2) as a basis for developing data directly (Aschmann et al., 1975). Specific application areas include housing counts, distrib-

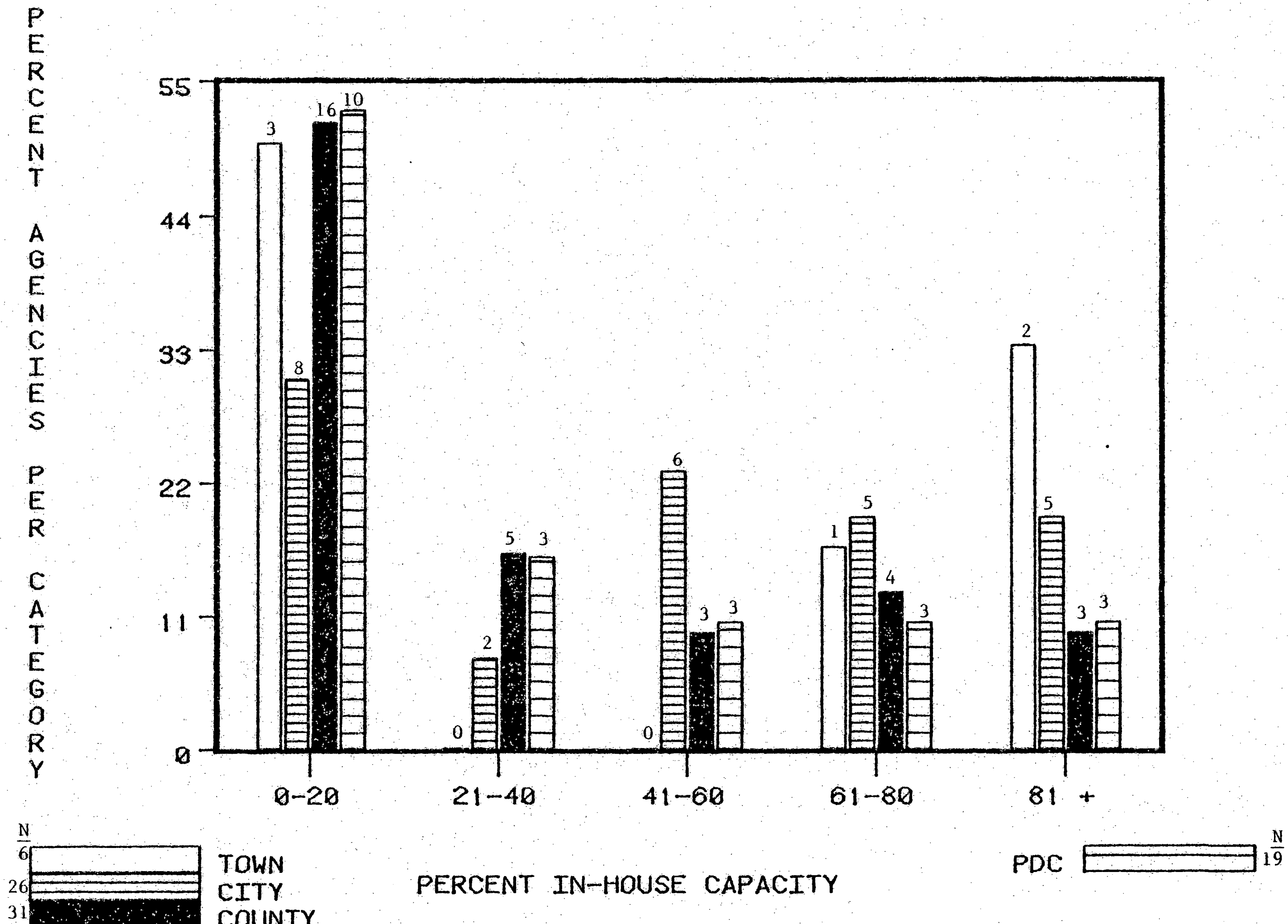

Figure 2-2. Proportion of Transportation Information Generated by Staff

ution of housing stock, its type and condition, updating of existing maps and creation of typologic maps where none exist, and the use of surrogate methods to analyze indirectly problems that are not explicitly obvious. Considerable caution should be exercised with the use of surrogate methods, however. A strong correlation between the surrogate(s) and the item studied must first be established by the researchers lest the means become the end.

Figure 2-3 presents the level of in-house population/demographic information generation capacity of Virginia planning agencies. These results indicate that a large proportion of all Virginia planning agencies produce but a percentage of their required population/demographic information.

Socio-Economic Information Generated by In-house Staff

Many types of social-economic indicators cannot be assessed via remote sensing techniques. Average annual incomes, type of employment and educational background would be members of this group. Surrogates might be used to assess some of these information types but not without the dangers expressed above. Viable and direct remote sensing application(s) to social-economic indices does exist however. Some such application areas include the

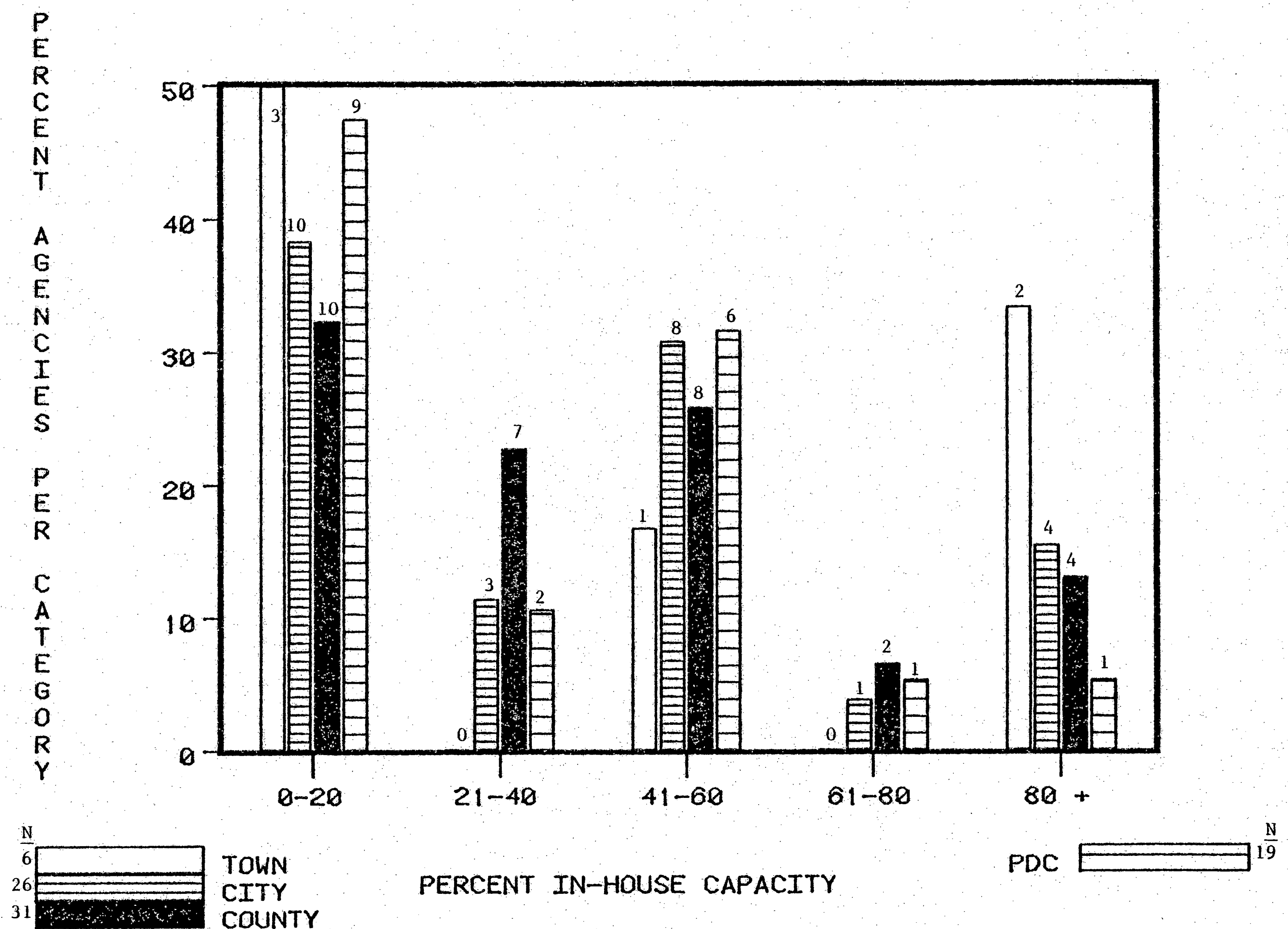

Figure 2-3. Proportion of Population/Demographic Information Generated by Staff

social cost studies associated with development-forced obsolescence interactions, land-house mix studies, sprawl analyses and development-nuisance analysis.

All planning agencies evaluated appear limited in their ability to generate requisite socio-economic data/information (Fig. 2-4). Forty to fifty percent of all responding agencies, representing all levels of planning, produce 20 percent or less of their required socio-economic information.

Environmental Information Generated by In-house Staff

Two factors indicate that the greatest potential for remote sensing induced cost savings and increased availability of higher quality data/information lie in the area of environmental inputs. These factors are: (1) a large proportion of Virginia planning agencies are either not inputting such information into the planning of their jurisdictions (because of unavailability such data or because they do not deem such information as necessary) or they are obtaining environmental information from outside sources, perhaps consultants, and (2) remote sensing techniques have a highly successful record in the area of environmentally based applications.

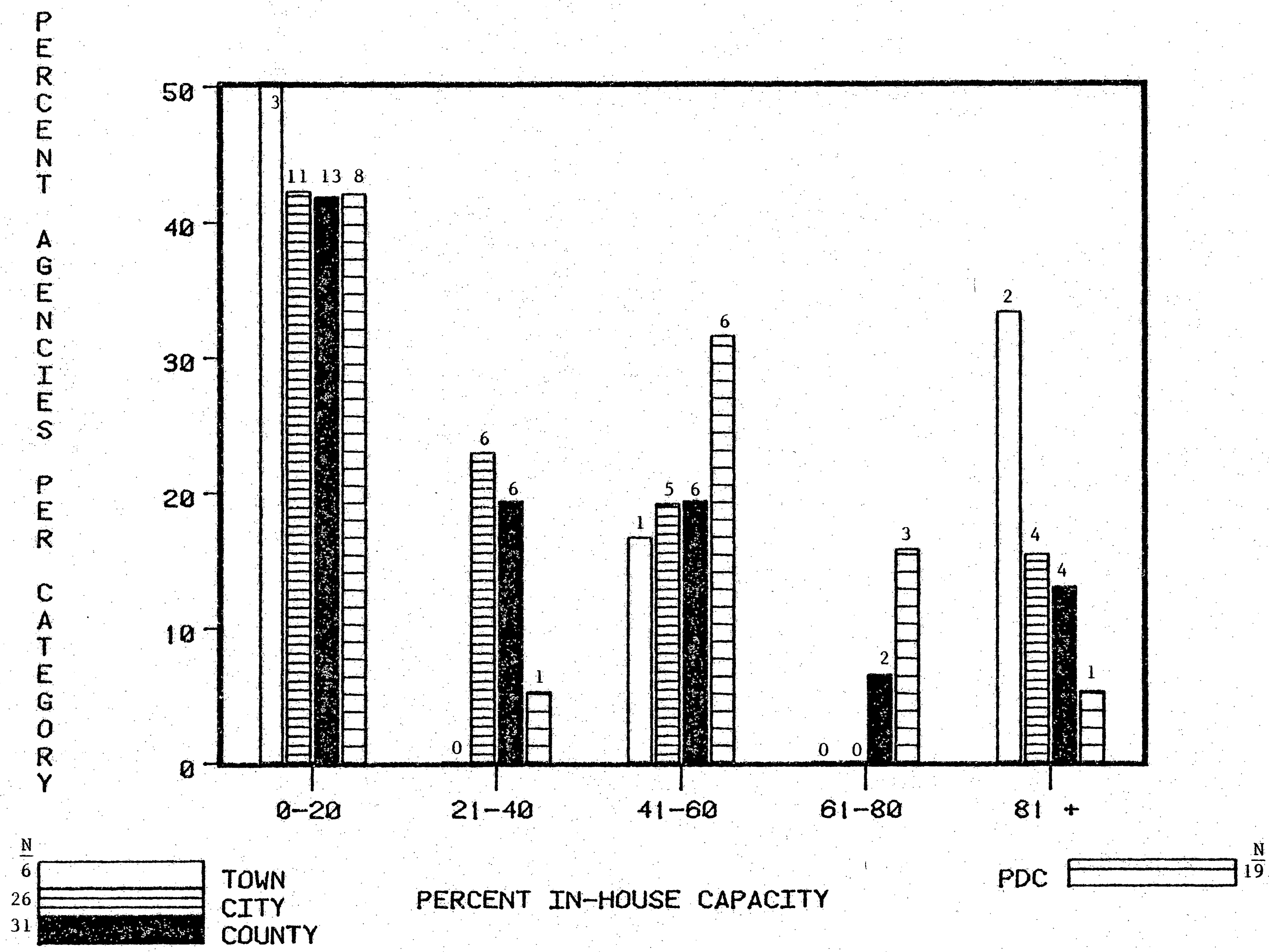

Figure 2-4. Proportion Socio-economic Information Generated by Staff

In reference to item one above, more than one-half of all respondent agencies for all levels of planning stated that they generated 20 percent or less of their requisite environmental information. Fully 83.3 percent of respondent town agencies reported the above while 57.7 percent of city agencies, 51.6 percent of county agencies and 52.6 percent of PDC's reported the same (Fig. 2-5). Fewer than 18 percent of town, 24 percent of city, 13 percent of county and 6 percent of PDC agencies reported generating more than 81 percent of their required environmental information. Clearly, the potential for increased remote sensing applications within Virginia planning agencies is high.

Miscellaneous Information Generated by In-house Staff

The miscellaneous information category was offered to circumvent an oversight of important inputs by particular planning agencies. Such a category is also an integral part of a correctly designed questionnaire survey (Lin, 1976).

Results from returned questionnaires indicate that few agencies have particular information needs not identified on the questionnaire. Only one town agency and two agencies at each level of city, county and PDC planning

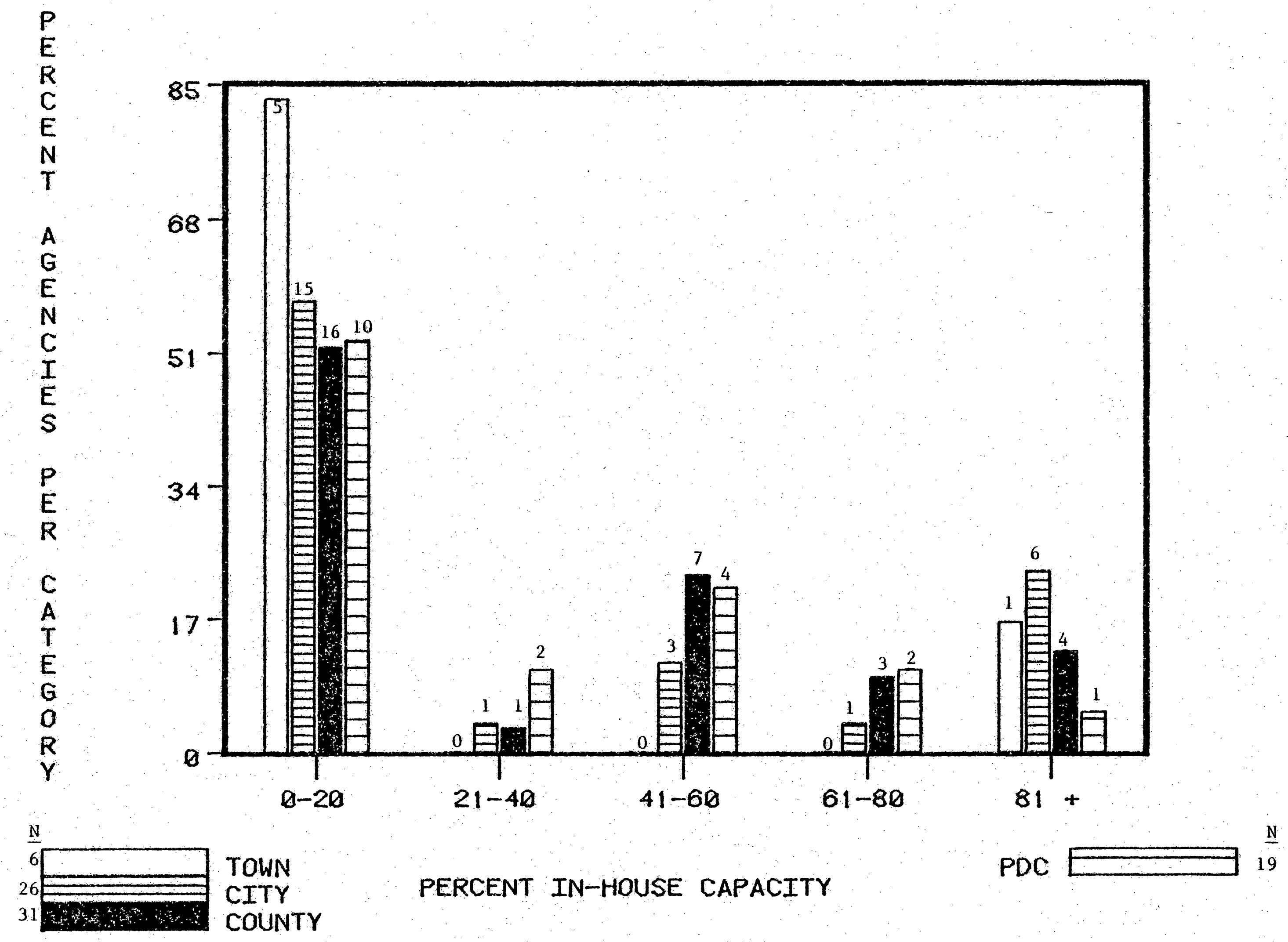

Figure 2-5. Proportion of Environmental Information Generated by Staff

reported specific data/information requirements. Again, unfortunately, no explicit identification was offered by respondents.

Summary: Part I

Results reported in this chapter indicate wide-ranging diversity of the above characteristics for agencies within the same planning level and between levels of planning. Among items of data/information requirements and agency information generation capacities, there is ample evidence that available remote sensing techniques and products can enhance data collection and problem solving within Virginia planning agencies.

Results reported in this chapter will be used to analyze the relationship among remote sensor utilization and the characteristics outlined in the preceding paragraph and the potential for increased utilization of remote sensing techniques. Statistical analysis and discussion is provided in the final chapter.

PART II: PLANNING AGENCY UTILIZATION OF REMOTE SENSING TECHNIQUES

The utility of remote sensors to meet a wide range of data/information needs was established in Appendices D and

E. Distinctly important elements of part one of this chapter are the descriptions of data/information requirements and agency in-house capacities to generate these types of information and the dynamics of change associated with each planning jurisdiction. Because of the successes of remote sensing applications, as described in Appendices D and E and elsewhere, the importance of accurate and timely data/information to the planning process and because of the constraints of time, quantity of staff and budget, it has been hypothesized that many Virginia planning agencies should have incorporated the tool(s) of remote sensing into their planning effort. It has been further hypothesized that the degree of incorporation of remote sensing inputs is a function of planning level.

The following discussion of survey results supports neither of these hypotheses. In fact, the results are highly repetitive, there being no significant differences between levels of planning and the degree of adoption of remote sensing techniques for planning purposes. The most significant finding, and somewhat unexpected, is the very low degree of adoption of most remote sensing techniques at all planning levels.

Four survey questions were developed to generate the information provided within this chapter. These questions provide information regarding planning agency utilization of remote sensing techniques, the types of applications to which these sensors are applied, agency source of remotely sensed products and, factors limiting the use of remotely sensed products by respondent agencies.

Remote Sensor Utilization as a Function of Planning Level

Each planning agency, at all levels of planning, was requested to identify those remote sensors that they have utilized to develop data/information. The menu of remote sensors offered on the questionnaire included:

- black and white aerial photography;
- black and white infrared aerial photography (BIR);
- color aerial photography;
- color infrared aerial photography (CIR);
- radar systems;
- electronic scanners;
- Landsat imagery; and,
- "other" sensor(s) (agency specified).

Use of only three of the above sensors were reported by town planning agencies: black and white aerial photography, color aerial photography and an unidentified sensor (Fig. 2-6). Of sensors used, three respondent agencies reported using black and white aerial photography, while one reported using color aerial photography and an unspecified sensor to obtain data/information.

It should be stated that black and white aerial photography is the oldest, most established and accepted type of remote sensor. Further, towns (and cities) with limited jurisdictional areas present few data/information problems that could not be addressed via conventional sensors. Advanced electronic sensors, then, would seem to have limited utility for local urban applications. Perhaps the salient finding is that only half of Virginia town planning agencies responding to the questionnaire are taking advantage of this proven remote sensing technology.

As described in the introduction to this section, few differences exist between agencies representing different levels of planning and their adoption and utilization of remotely sensed data/information. Products of four sensors were utilized by city planning agencies. These include; black and white aerial photography -- utilized by 22 respondent agencies, color aerial photography -- utilized by three agencies, electronic scanners -- utilized by one agency, and an unspecified sensor -- utilized by one respondent agency. All other sensors were reported as not used by all respondents, or no response was recorded (Fig. 2-7). Perhaps one positive feature among city planning

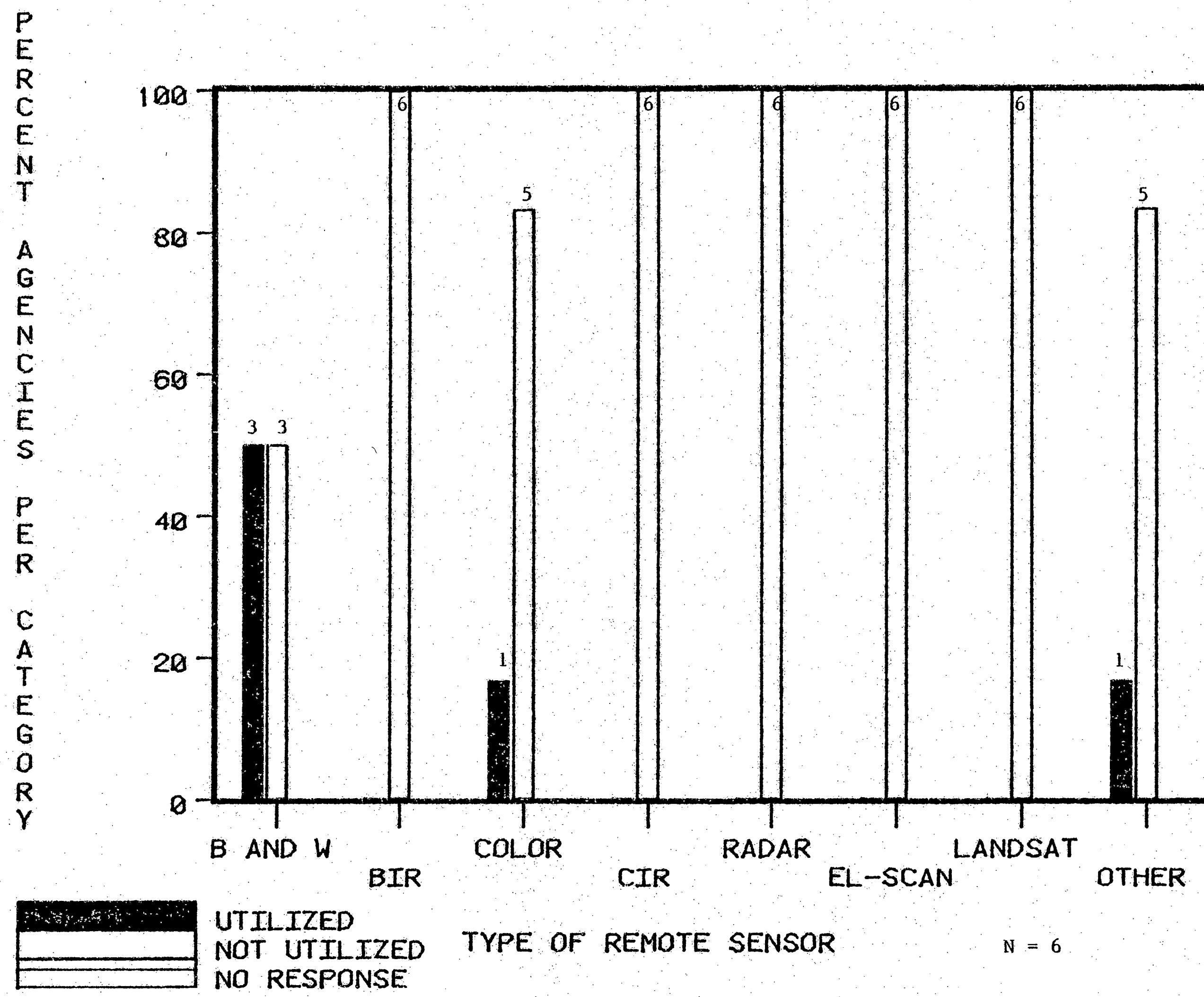

Figure 2-6. Town Planning Agency Utilization of Remote Sensing Techniques

agencies is their relatively higher adoption rate (84.6 percent) of remotely sensed products. Bearing in mind the limited jurisdictional area of most cities, the potential for increased remote sensor utilization appears good in the arena of conventional formats, e.g., BIR, color and CIR.

Likely the most distinguishing difference between local planning and county planning is their respective size of jurisdiction. A hypothesis included in this study stipulates a direct positive relationship between the size of planning jurisdiction and the use of remote sensing technology. The hypothesis applies to all sensors although the relationship should have greater impact on the utilization of the electronic sensors, e.g., radar systems, scanners and particularly satellite systems. Survey results do not support the hypothesis.

The reader will note from Figure 2-8 that four sensors have been utilized by county planning agencies. The sensors are; black and white aerial photography -- utilized by 24 respondent agencies, black and white infrared aerial photography -- utilized by one agency, color aerial photography -- utilized by three agencies, and satellites -- utilized by one respondent agency. All other sensors were reported as "not utilized" by all respondent agencies. A small proportion of agencies did not respond to this survey

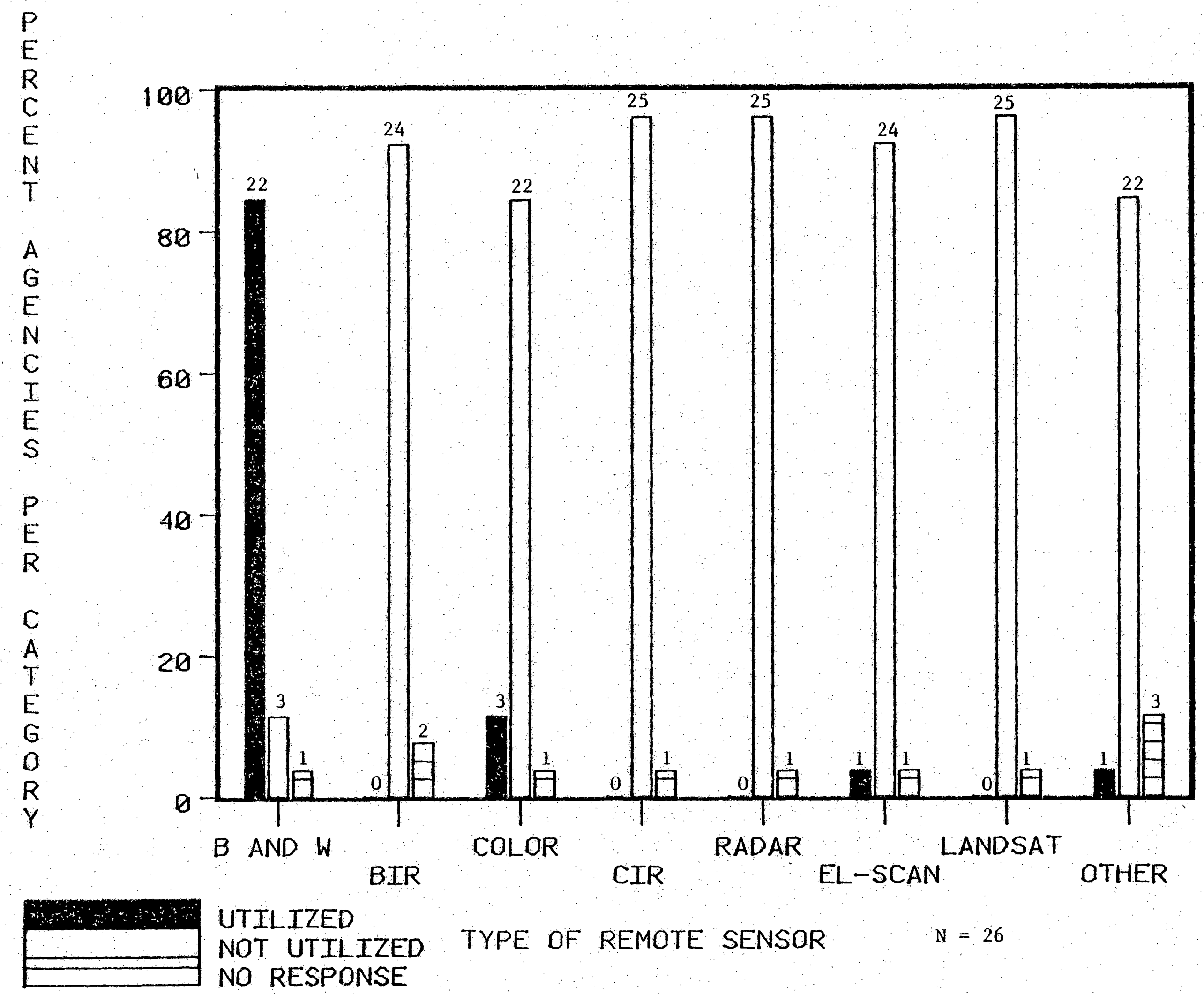

Figure 2-7. City Planning Agency Utilization of Remote Sensing Techniques

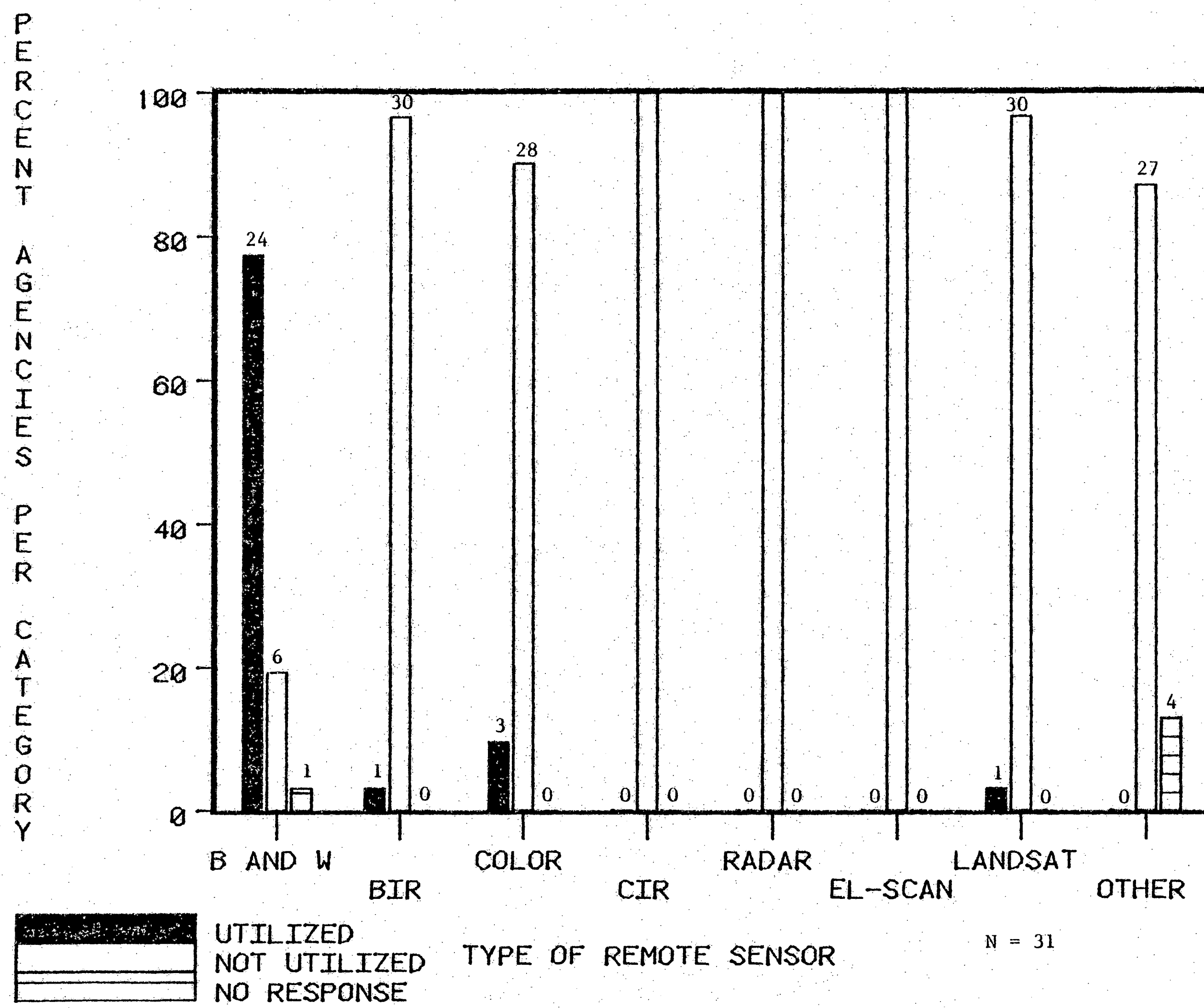

Figure 2-8. County Planning Agency Utilization of Remote Sensing Techniques

question. It was expected that more county planning agencies would have adopted satellite information as a source of input (only one agency reported utilization). As planning jurisdictions increase in size, generating certain kinds of information, land-use is an example, becomes more difficult. Orbiting satellites have proven to be very successful at providing area-wide land-use information. Except for black and white aerial photography which was/is utilized by 77.4 percent of county planning agencies, the level of remote sensor utilization is extremely low, offering a decided opportunity for improvement.

Planning district commissions represent a consolidation of smaller (jurisdictional area) planning agencies (refer to discussion in Appendix C). As such, their planning jurisdiction can represent several hundred square miles of area. The tasks of collecting and analyzing spatially disaggregated data tax the capacities of a regional planning agency. It would seem imperative for regional planning agencies to identify, adopt and utilize data generating tools and methods that are effective and efficient. As discussed in Appendices D and E, many types of data/information important to the regional planning process are obtainable via several remote sensing techniques. Of notable value are the Landsat technologies, capable of providing quality regional level data/information. It has been hypothesized that regional level planning agencies in Virginia are using remote sensing techniques (particularly satellites) to generate information to a greater extent than are other planning agencies within Virginia. Hypothesized reasons for any increased utilization include; greater need derived from larger planning jurisdictions, larger, more skilled staffs and larger budgets. Figure 2-9 summarizes PDC utilization of remote sensing techniques. Although there is a general increase of utilization as compared to town, city and county agency utilization, the degree of increase is surprisingly small. A total of five remote sensors were utilized as sources of planning information by PDC's. Only the utility rate of satellites reflects a notable increase over those associated with other levels of planning, although only four PDC's out of 19 respondents have or are, utilizing satellite inputs.

The above results for all Virginia planning agencies clearly describe the underutilization of proven, operational and available information generating technologies. Although the responses for the lack of remote sensor utilization have yet to be discussed (this discussion is found later within this chapter) the fact remains that considerable potential for increased utilization of remote sensing technologies by Virginia planning agencies does exist.

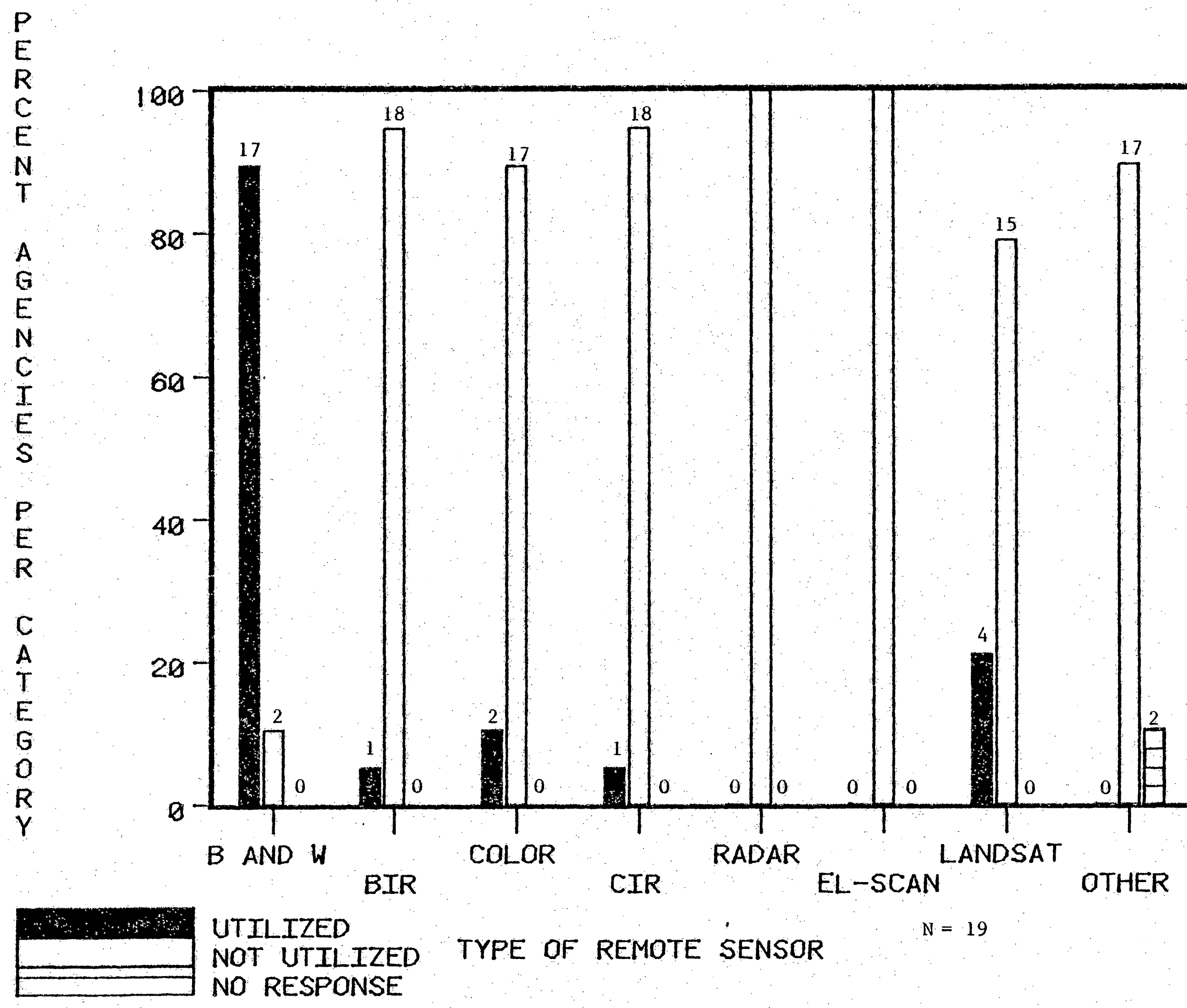

Figure 2-9. Planning District Commission Utilization of Remote Sensing Techniques

An obvious topic for discussion at this juncture is the application of the adopted remote sensing technologies. What types of information are being generated by the adopted remote sensing products is the theme of the immediate text.

Remotely Sensed Information Generation as a Function of Planning Level

Preceding discussion revealed that conventional remote sensors have been utilized by Virginia planning agencies, albeit at low levels, while a few agencies had adopted Landsat information. It might be assumed that each agency representative of a level of planning harbored functional and operational characteristics that are specific to it, or to its level of planning. If this scenario is true, then one would expect to find differences in the type of information requisite at each level of planning, the value placed on each type of information (weighted value) and the application areas of the remote sensors adopted by each agency (see discussion in this chapter). Following is a discussion of categorical types of information being developed with the aid of remote sensing technologies by the planning agencies of Virginia. Information categories identified in the mailed questionnaire are as follows; land-use, transportation, population/demographic, socio-economic, environmental, historical, impact assessment, and "miscellaneous."

Figure 2-10 defines the level of application of remote sensing techniques to the above information categories for town planning agencies. Wishing not to be needlessly redundant, the author would like to note again the limited sampling population from which town inferences are being drawn. Although less pronounced than results representing city, county and district commission agencies, town agency application trends do parallel the above. Generally, town planning agencies have been using remote sensing techniques to enhance the development of land-use (two agencies), transportation (two), population/demographic (one), socio-economic (one), environmental (one), and impact assessment (one) information. These results are tempered further by the high "no response" rates of each information category. A minimum of one-third (two) of all responding agencies failed to supply answers for each application category.

Results for city planning agencies indicate a broad range of remote sensing application areas (Fig. 2-11). City planning agencies have used remote sensing products to enhance data collection and/or analysis of all eight data/information categories. High, or relatively high application rates were registered for the following types of information; land-use -- 22 agencies, transportation -- 18 agencies, population/demographic -- 12 agencies, envi-

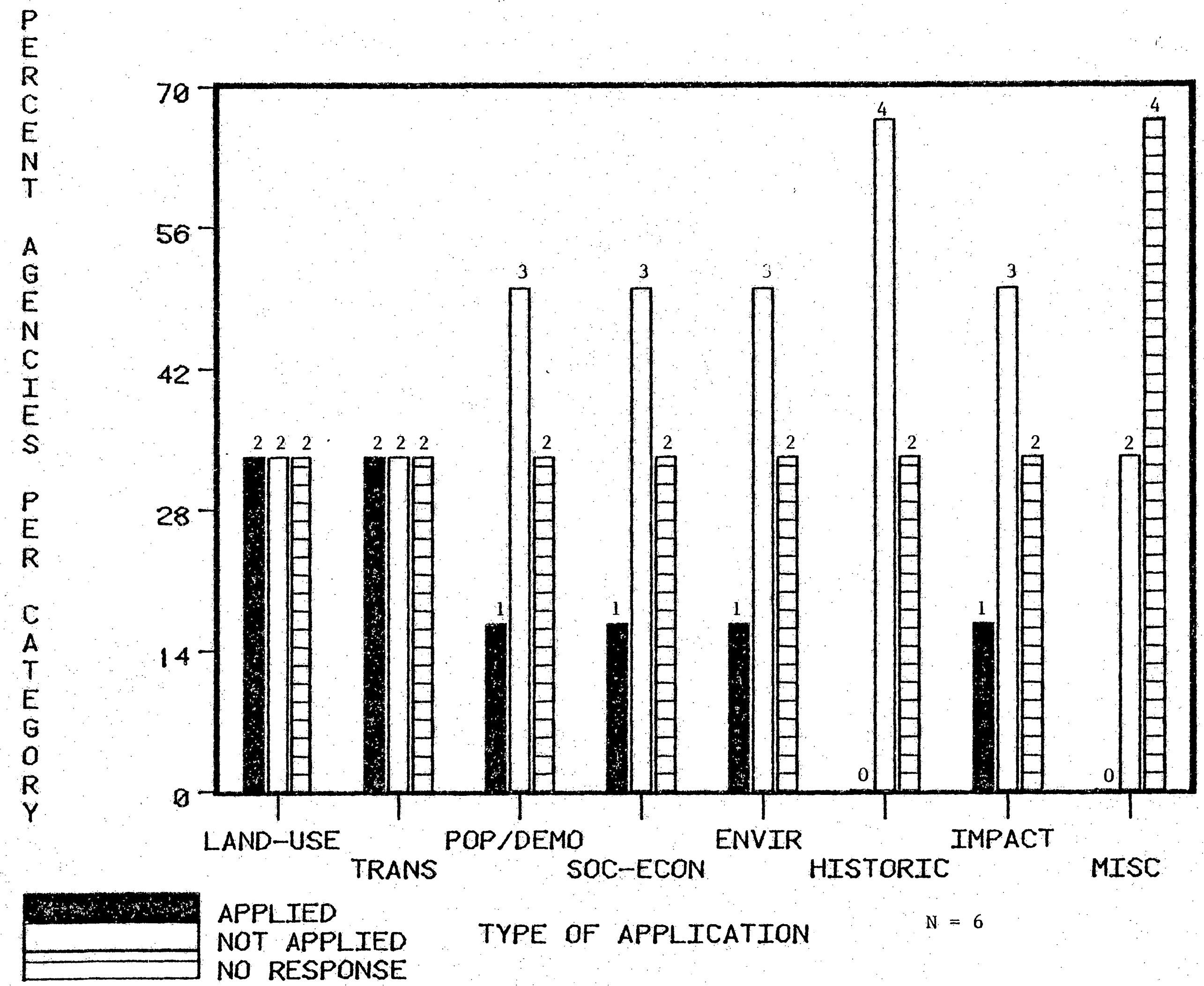

Figure 2-10. Town Planning Agency Application of Remote Sensing Techniques

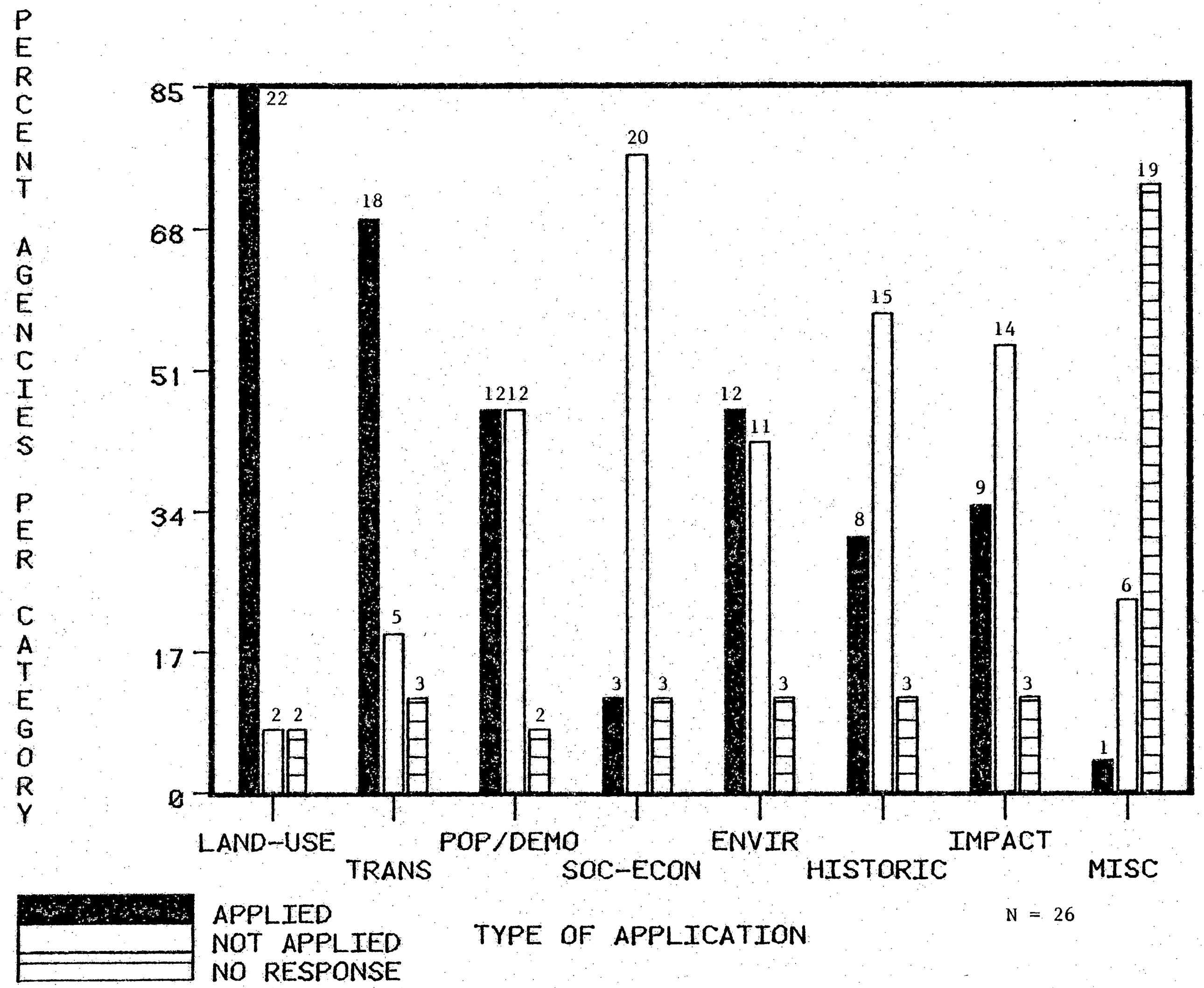

Figure 2-11. City Planning Agency Application of Remote Sensing Techniques

ronmental -- 12 agencies, historical -- nine agencies and impact assessment -- nine agencies. Each of these application areas has been addressed successfully by practitioners of remote sensing, as has been documented in Appendices D and E. Further, many of the problems confronted within each of the application categories can be addressed with conventional remote sensing techniques, e.g., aerial photography. One application category, socio-economics, received little support from remote sensing inputs. Only 11.5 percent of respondent city agencies reported using remote sensing techniques to supply socio-economic data/information.

Although the average jurisdictional area of county planning agencies is considerably larger than for cities, neither the breadth nor the degree of remote sensor application differs significantly (Fig. 2-12). As with city agencies, county planning agencies have applied remote sensing products to all eight information categories. However, in every application except impact assessment, a lower proportion of county agencies applied remote sensing products to their information development problems than did city agencies.

Further comparison and discussion of city/county applications seems appropriate in order to understand bet-

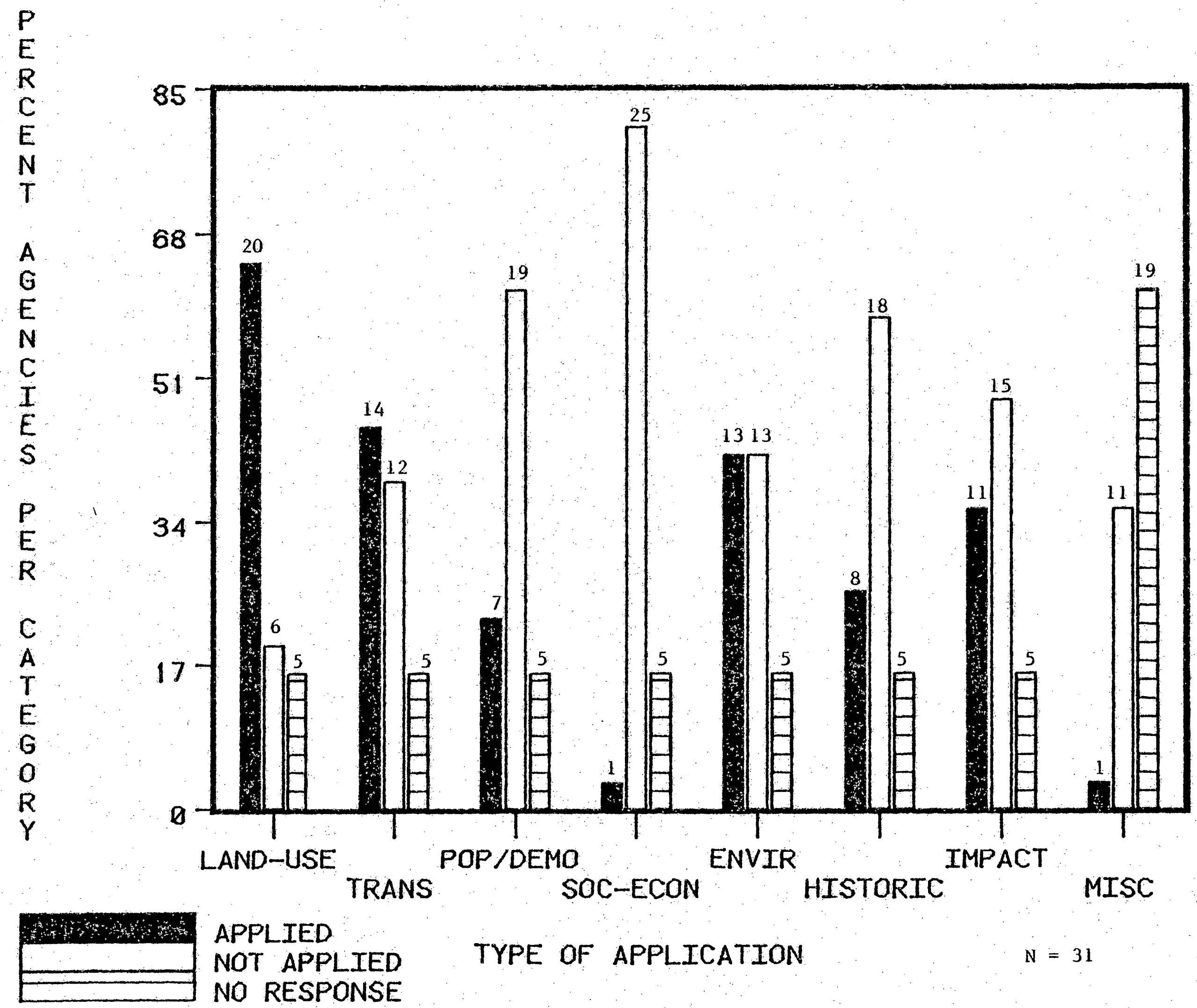

Figure 2-12. County Planning Agency Application of Remote Sensing Techniques

ter the somewhat confounding results. City agencies looked to remote sensing products more often than did county agencies to help solve transportation, population/demographic and socio-economic data/information problems. That fact is understandable and expected. The same trend is true for land-use and environmental information problems, a somewhat unexpected finding primarily because larger jurisdictional areas make development of such data markedly more difficult. A plausible explanation for the above might be found in the greater complexity, diversity and dynamics of urban environments, and the demand for smaller scale data/information.

Planning district commission jurisdictions represent the largest contiguous planned areas within the state of Virginia. As stated above, the problems of data/information development are compounded by large jurisdictional areas. This is so even though the scale of needed information for some regional problems is considerably larger than for smaller planning jurisdictions. Figure 2-13 displays the distribution of PDC agency application of remote sensing techniques per category of information. No significant differences of application are evident when comparing PDC's versus county and/or city planning agencies. However, this fact in and of itself, is significant.

It was expected that the increased size of most PDC jurisdictions would force these agencies to seek effective, efficient methods to develop data/information of the type categories identified.

Survey results show, however, that for land-use information, 84.2 percent (16) of PDC's applied remote sensing techniques as compared to 64.5 percent (20) of county planning agencies. Versus city agency remote sensor application to land-use problems, there is no difference. These statistics hint strongly that staff characteristics, education, experience, skills and budget, influence adoption of remote sensing technologies. Of the applications identified in figure 2-13 only the proportion associated with environmental information is significantly different from those of the same category within city and county planning agencies. City and county agencies having applied remote sensing techniques to environmental problems represent 12 or 46.2 percent and 13 or 41.9 percent of total respondent agencies, respectively. As noted above, 11 or 57.9 percent of respondent PDC's applied remote sensing techniques to environmental problems.

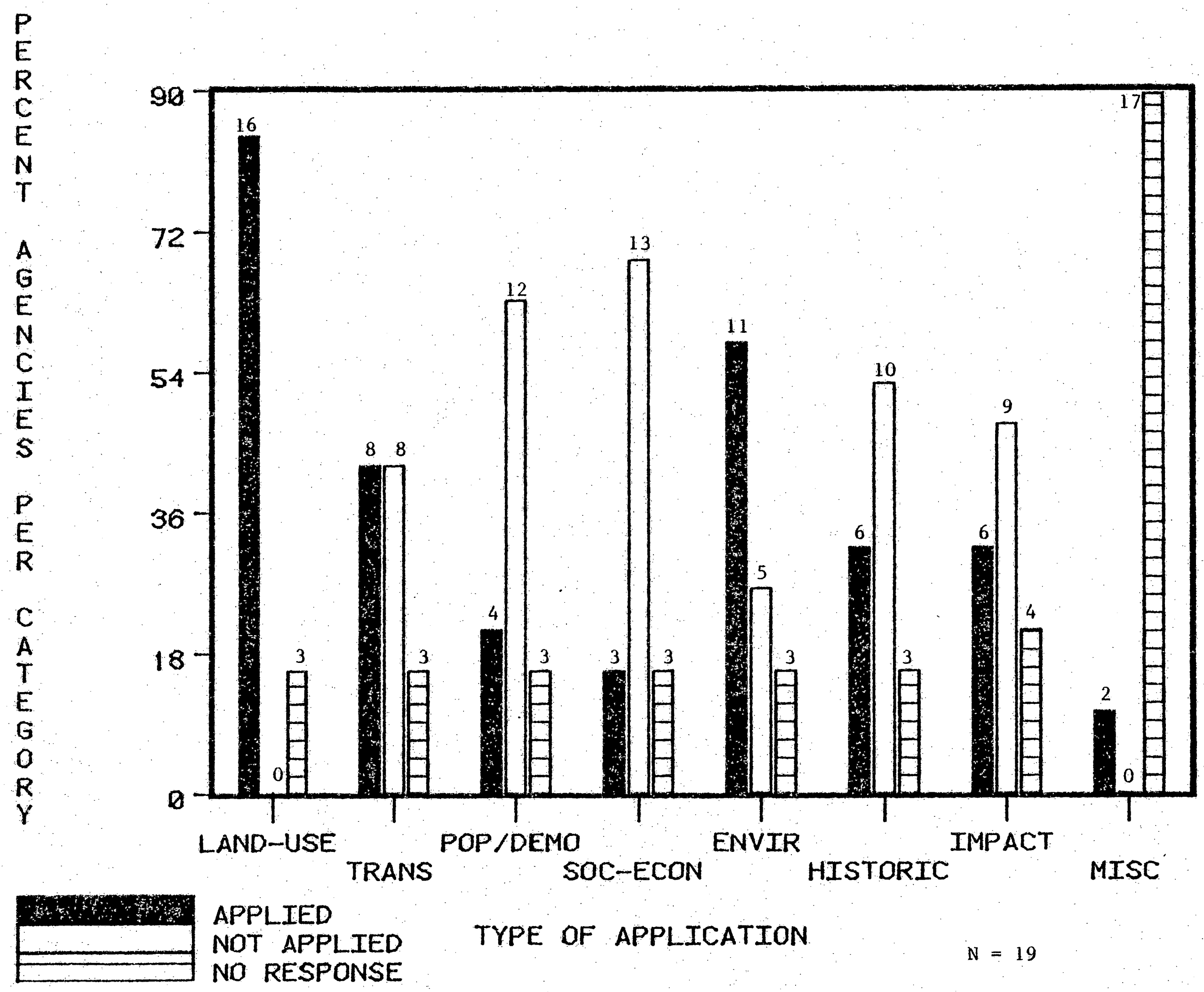

Figure 2-13. Planning District Commission Application of Remote Sensing Techniques

Remotely Sensed Product Source as a Function of Planning Level

Application of remotely sensed information, as defined and discussed above, is quite limited and not fully informative. The preceeding discussion identifies only the remote sensors adopted and used per level of Virginia planning agency, and the types of information/problem categories to which these sensors have been applied. An inherent aspect in the application of remotely sensed products is the source of the information produced from the product. Are planning agencies the primary producers? Or, are planning agencies serving as secondary sources and primary analysts? The difference has real meaning to Virginia planning agencies in terms of functions, operations and budgets. Any agency housing the capacity to obtain "raw" remote sensing products, interpret and analyze those products, and then input any findings into their planning process will likely benefit in three ways: they should receive more timely and relevant information; and, they should achieve the above at a cost-savings.

Having established the types of remote sensors being used by Virginia planning agencies (in this case "not being used" seems more appropriate) and to what problem categories the sensors are being applied, it seems appropriate that each level of planning be assessed regarding its derivation of usable information from remotely sensed products. Accordingly, each agency was requested to answer a question regarding its source of remotely sensed information. Five response categories were represented on the questionnaire; percentage of your remotely sensed information generated by (1) in-house staff, (2) consultants through contract, (3) other state agencies, (4) federal agencies, and (5) "other" sources. Results to this question follow. Analytical discussion will include an assessment of remotely sensed product source first within planning level groupings (e.g. town, city, county and PDC), and secondly, across planning levels for each of the five sources of remotely sensed information.

Figure 2-14 indicates the distribution of the sources of remotely sensed information for Virginia town planning agencies. As might be expected, town agencies appear quite limited in the extent of in-house capabilities to produce remote sensing information. Eighty-three percent (six cases) of respondent town agencies indicated that they produced but 0-10 percent of their remote sensing information. A detailed look at the results actually show that the above agencies do not produce any remote sensing information. Because town planning agencies are deficient of both staff and budget, it is surprising to find that

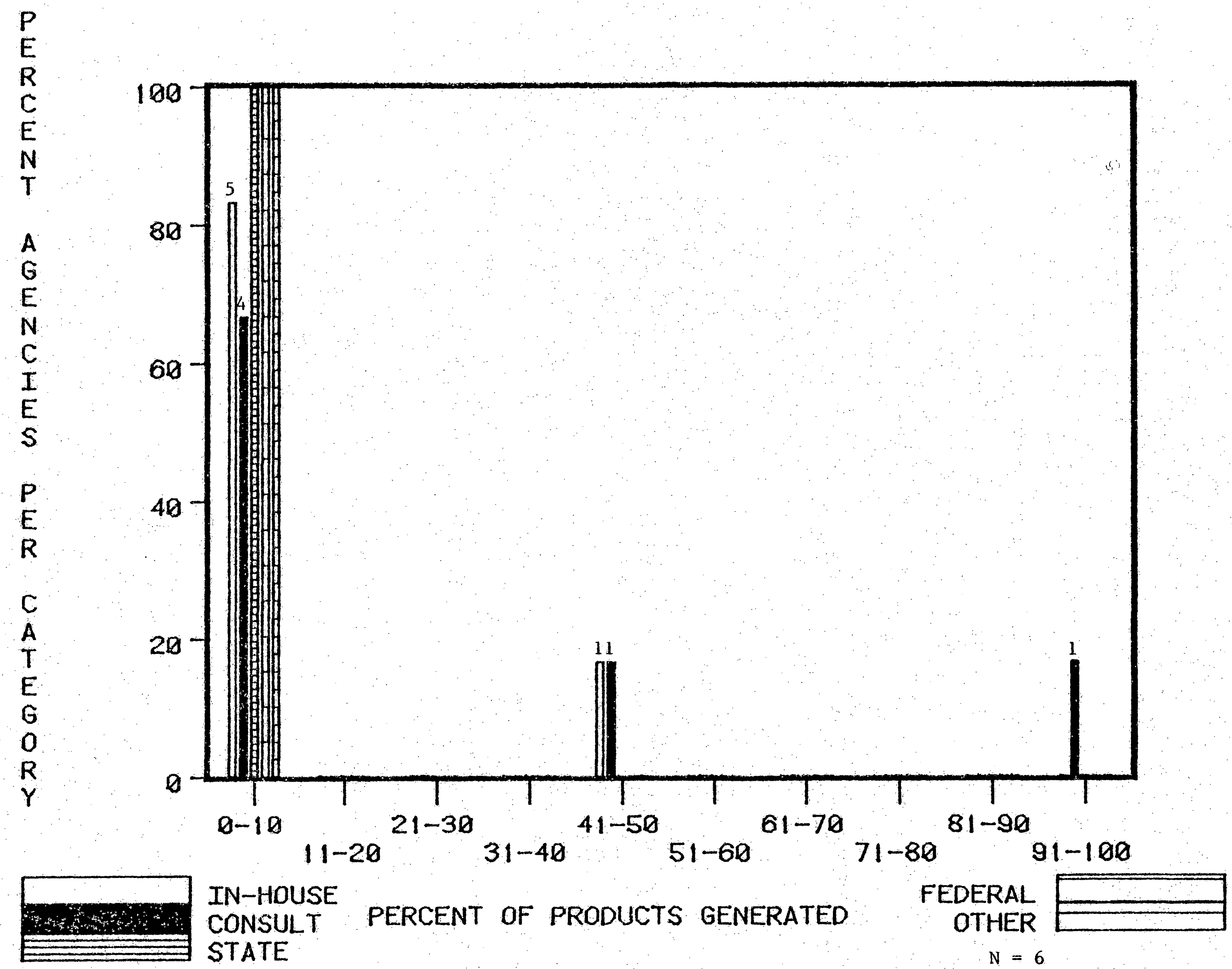

Figure 2-14. Town Agency Source of Remote Sensing Products

few, if any, town agencies tap state or federal sources for remote sensing products/information (100 percent (seven cases) of respondent agencies stated that less that 10 percent of their remote sensing products emanated from federal or state sources, respectively). Private consultants seem to be the primary source (though limited) of remotely sensed information for town planning agencies.

Only modest differences exist between the above town planning agency source trends and those defined by city agency results. Few city agency staffs are capable of producing their remote sensing information. In fact, 88.5 percent -- 23 cases (76.9 percent report no capability) of responding city agencies reported that their in-house capacity to produce such information ranged between 0-10 percent (Fig. 2-15). In the same category, one respondent placed in-house capacity at 11-20 percent while two others identified their capacity at 41-50 percent. Most remote sensing information emanating to city planning agencies is generated by private consultants and state agencies, the latter being the most important source. The above is tempered by the fact that 57.7 percent (15 agencies) of all respondents stated that consultants did not serve them regarding remote sensing products and 50 percent (13 agencies) stated that the same applied to other state agencies.

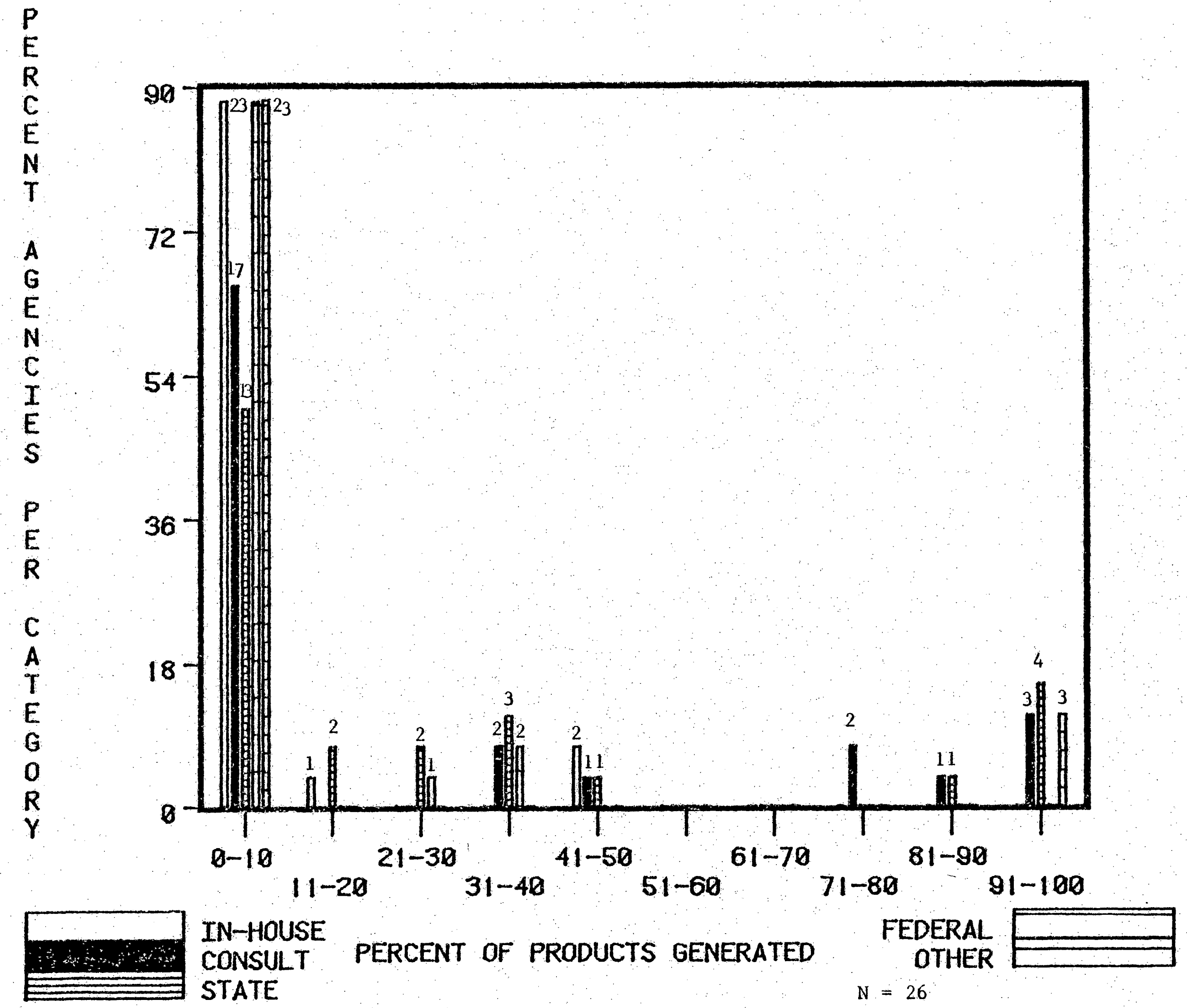

Figure 2-15. City Agency Source of Remote Sensing Products

Federal agencies and miscellaneous sources served few city planning agencies. Sources reported as supplying greater than 70 percent of remotely sensed information to city planning agencies include consultants, state agencies and "miscellaneous" sources.

Results of county planning agency survey responses (Fig. 2-16) indicate that county planning agencies are (1) least capable of producing in-house remote sensing information, and, (2) utilize more sources than town or city planning agencies to obtain remotely sensed information. Detailed response figures show that 30 respondent county agencies (96.8 percent) estimated that their in-house staff produced 0-10 percent of remotely sensed information. A more telling statistic, 28 agencies (90.3 percent) reported that no remote sensing information was produced by their in-house staff.

Of sources contributing to county remote sensing product needs, private consultants, state agencies and federal agencies, in order of input, have contributed most. In a majority of cases, however, the contribution has been marginal.

Virginia's planning district commissions represent the state's largest planning jurisdictions and likely house the largest and most professionally diversified staffs. Such

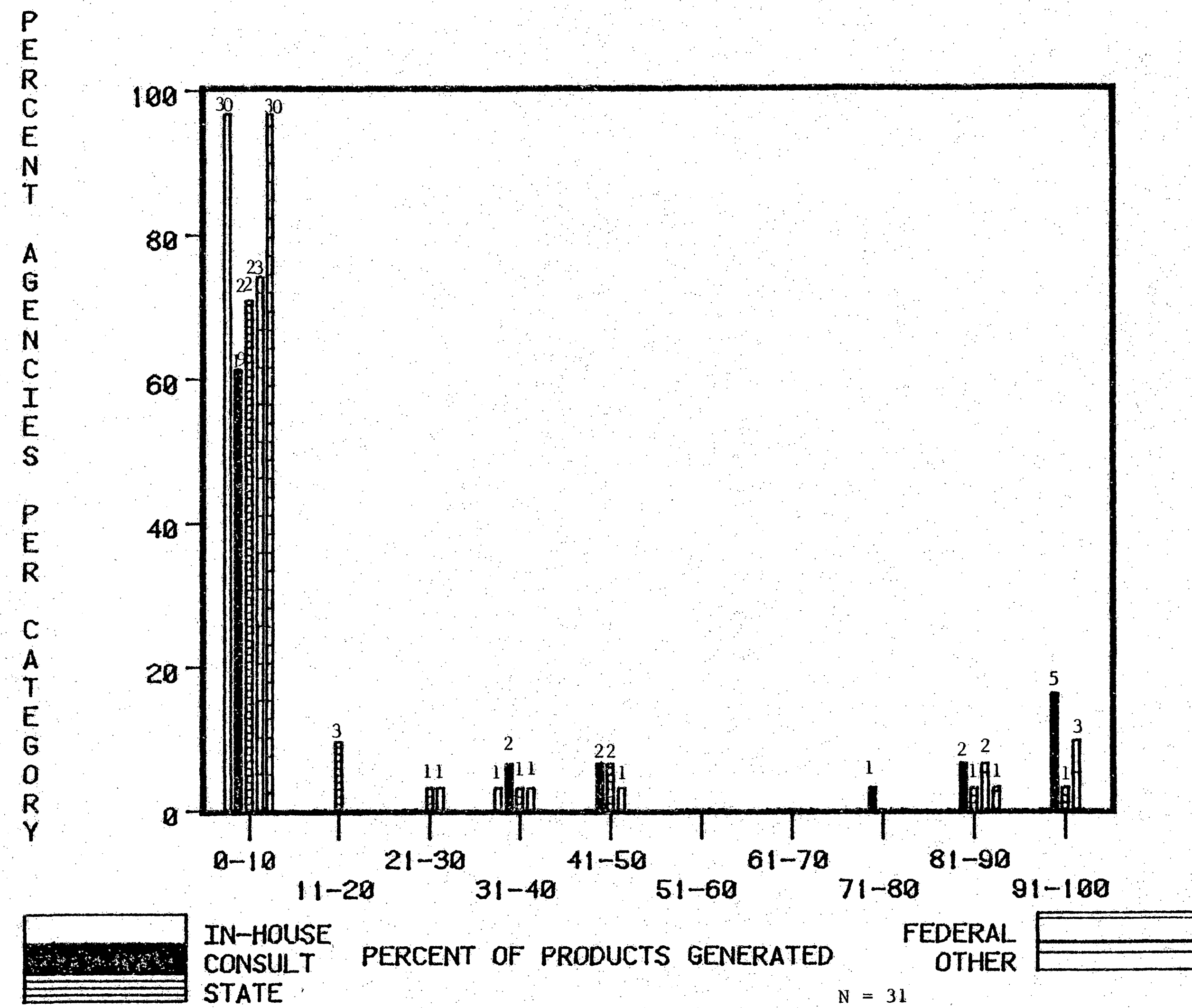

Figure 2-16. County Agency Source of Remote Sensing Products

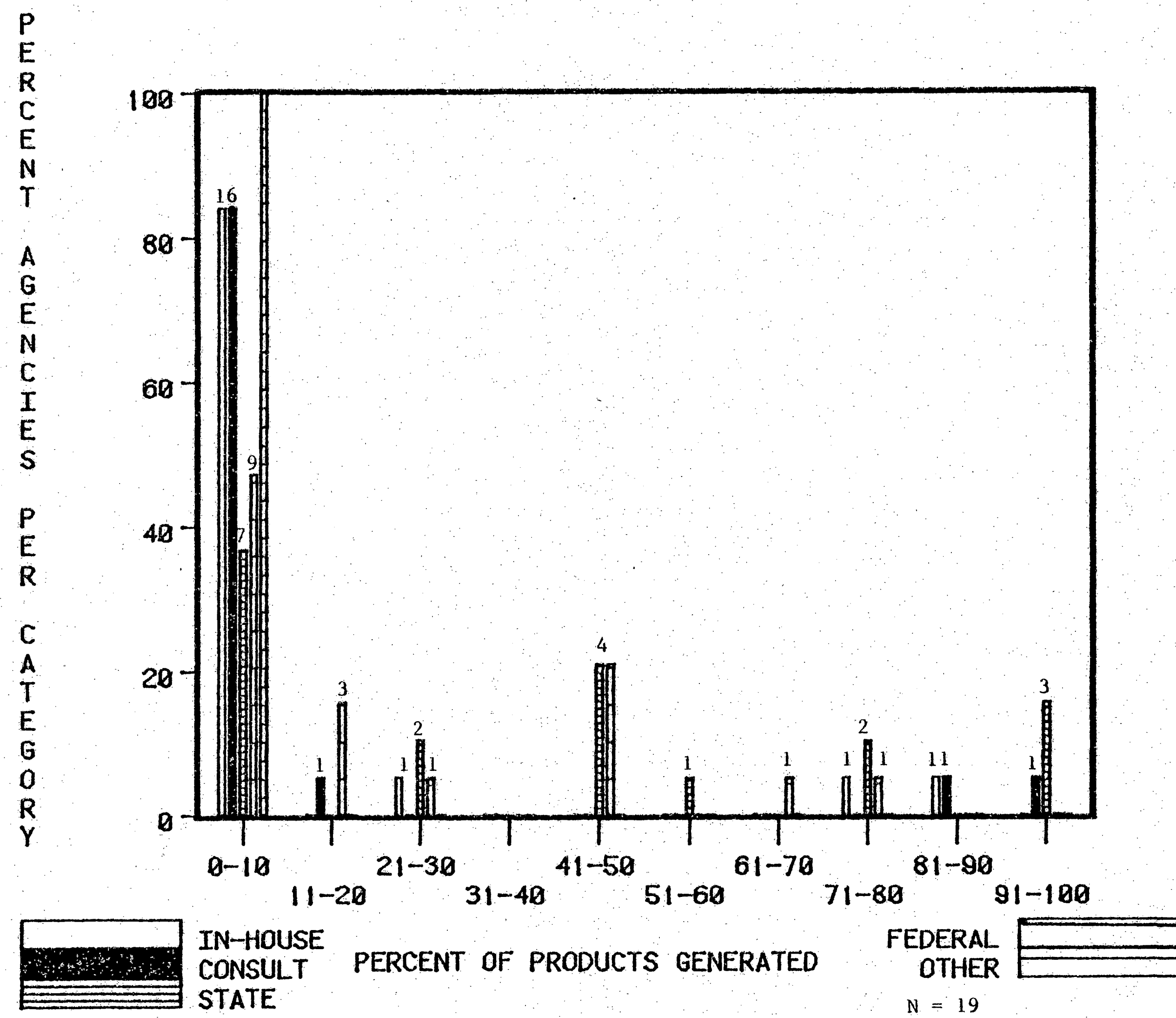

Figure 2-17. District Commission Source of Remote Sensing Products

characteristics foster the expectation that PDC's are capable of producing a large proportion of their remote sensing products. Survey results do not support such an expectation (Fig. 2-17), in fact, 16 respondent PDC's (84.2 percent) stated that no remote sensing products were generated by their in-house staff. Of those PDC's reporting some in-house capability, three agencies, representing 5.3 percent of respondents per percentage category, reported generating 25 percent, 75 percent and 90 percent of agency remote sensing product needs.

Notably, a smaller proportion of PDC's utilized consulting services to obtain remote sensing information than does any other category of agency within Virginia. Only three respondent PDC's (less than 16 percent) reported obtaining greater than 12 percent of their remote sensing products from consulting firms. More strikingly, 14 PDC's (73.7 percent) did not utilize private consultants at all.

District Commission results do indicate, however, an increased reliance upon state and federal sources to obtain remotely sensed information. Thirteen respondent PDC's (68 percent) reported that they utilized state agencies for remote sensing inputs. Eleven respondent PDC's (nearly 58 percent) made the same claim for federal agencies.

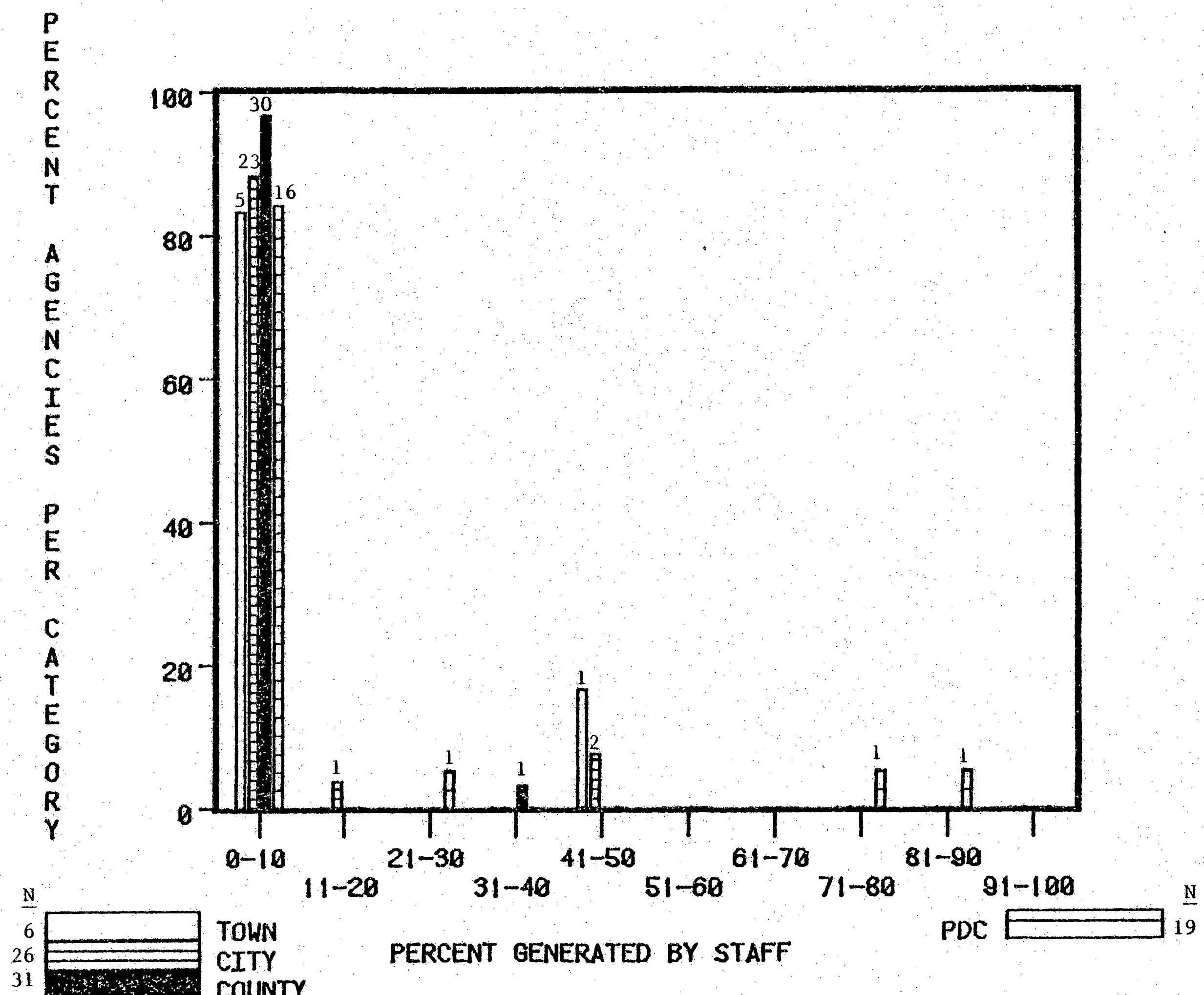

Figure 2-18. In-house Remote Sensing Product Generation Capacities

Inter-Planning Level Comparison of Remote Sensing Product Sources

Figures 2-18 through 2-21 depict aggregate remote sensing source characteristics per level of planning agency within Virginia. Figure 2-18 illustrates the relative in-house capabilities of town, city, county and district commission agencies to generate remote sensing based information. Quite clearly, few agencies at any level of planning are capable of producing information from remotely sensed products. The following represent proportions of respondent agencies that reported generating only 0 to 10 percent of their remote sensing based information; town agencies -- five (83.3 percent), city agencies -- 23 (88.5 percent), county agencies -- 30 (96.8 percent), and PDC's -- 16 (84.2 percent). These results suggest that the elements of jurisdictional size, planning level, area dynamics, agency budget, agency staffing characteristics and area diversity have little affect on agency staff abilities to develop and utilize remote sensing technologies and information.

Relative agency utilization of private consultants as a source of remotely sensed information is portrayed in Figure 2-19. As suggested earlier, the utilization of private consultants as a source of remotely sensed information is low at all levels of planning. Twelve county planning agencies (38.7 percent of respondents), however, contracted consultant firms for such services and products.

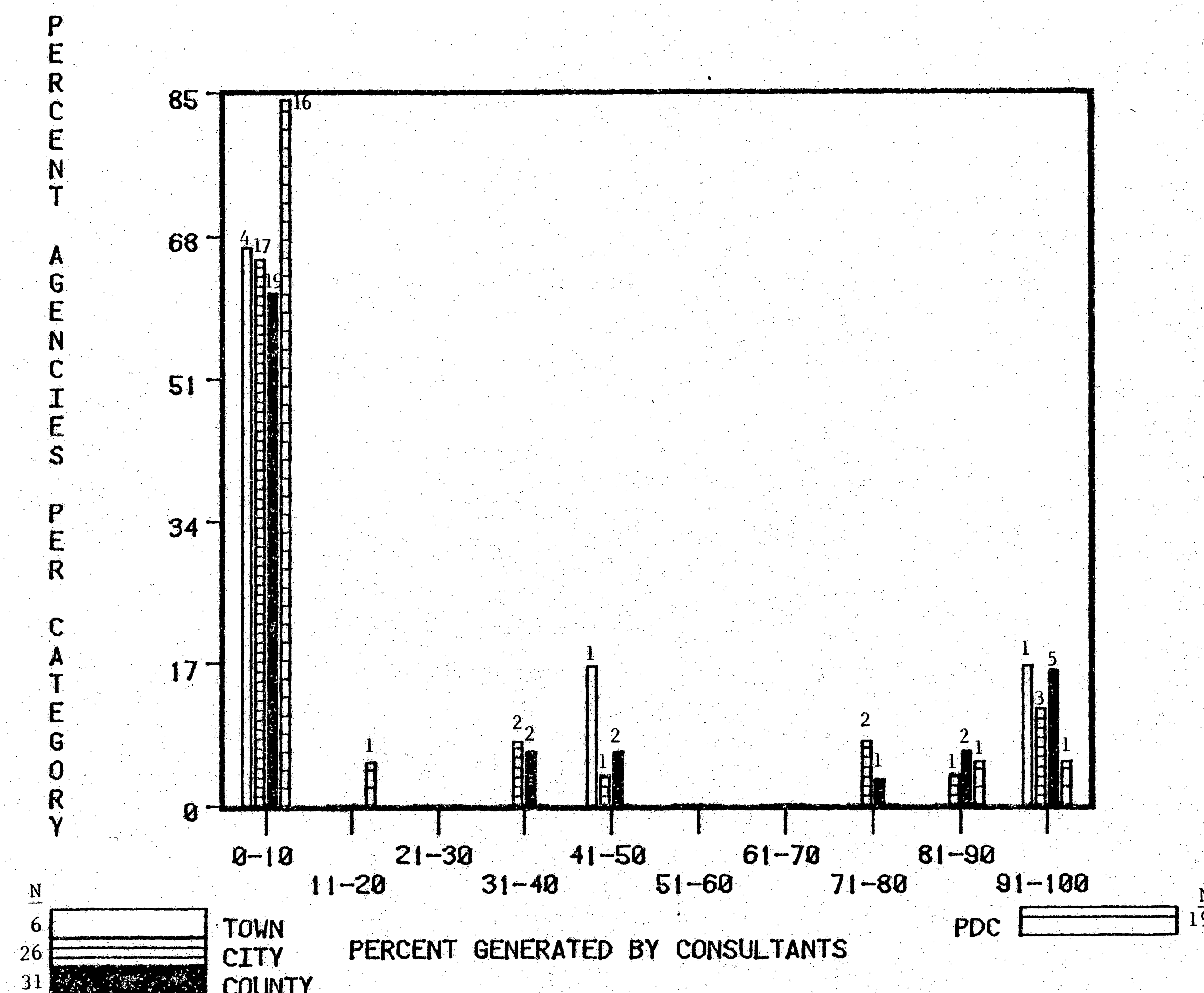

Figure 2-19. Proportion of Remote Sensing Products Generated by Consultants

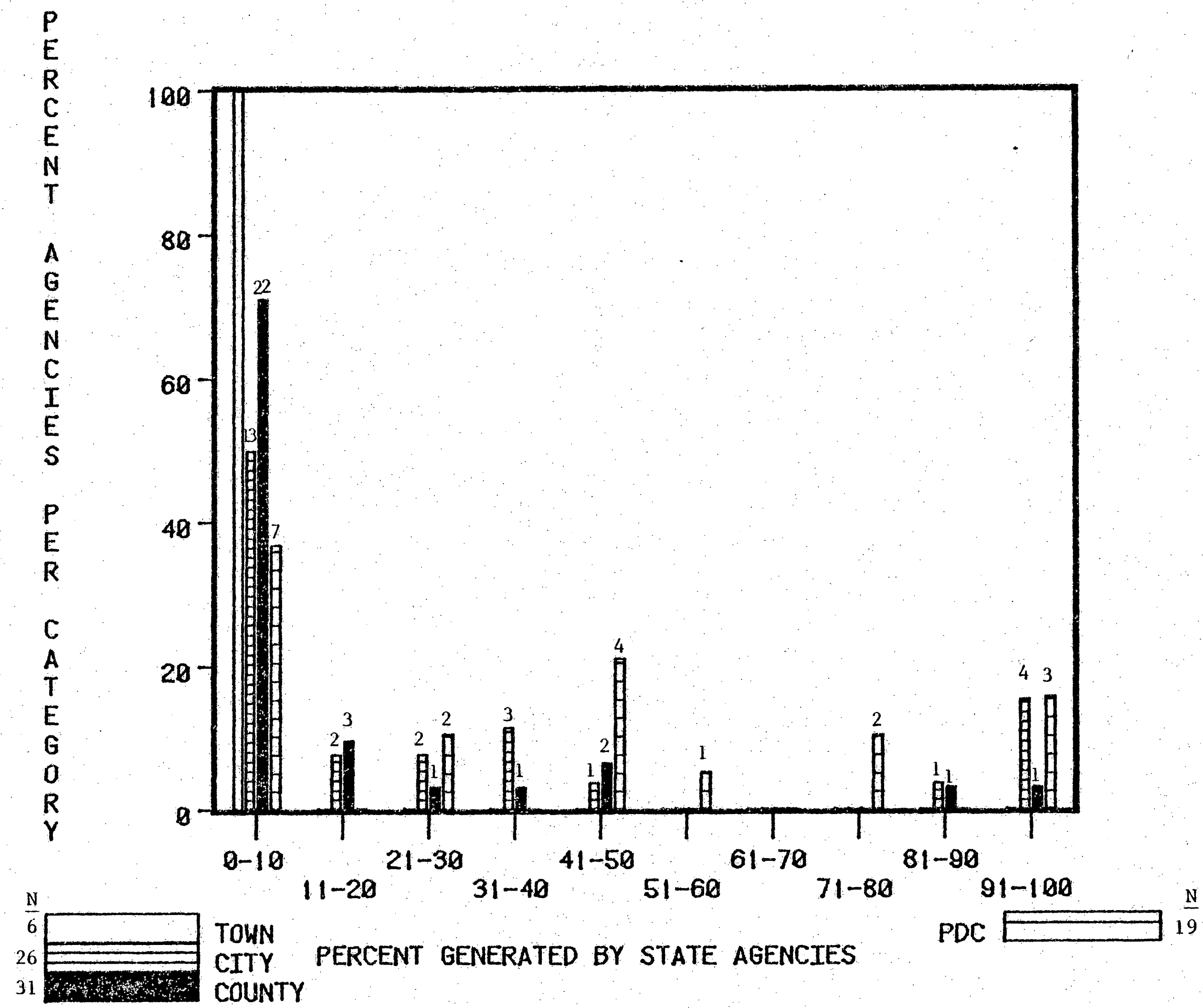

Figure 2-20. Proportion of Remote Sensing Products Generated by State Agencies

Greater diversity of remote sensing product source is apparent when one contrasts level of planning against adoption of state agencies as a source of remotely sensed information (Fig. 2-20). Survey results indicate that all respondent town planning agencies obtain less than 10 percent of their remote sensing based information from state sources while 13 city (50 percent), 22 county (71 percent), and seven PDC (36.8 percent) agencies reported same. Clearly, city and PDC agencies have identified and developed better linkages with state agencies, an operational element that likely benefits them regarding time and budget conservation.

Federal linkages to planning agencies within Virginia that serve to provide remotely sensed materials/information are not strongly developed. Figure 2-21 indicates that fewer agencies at all levels of planning rely upon federal sources than state sources for remote sensing based information. Only PDC's seem to have developed moderately strong linkages with federal sources of remote sensing information (nearly 58 percent of respondent PDC's (11 cases) reported obtaining some of their remote sensing products from federal sources).

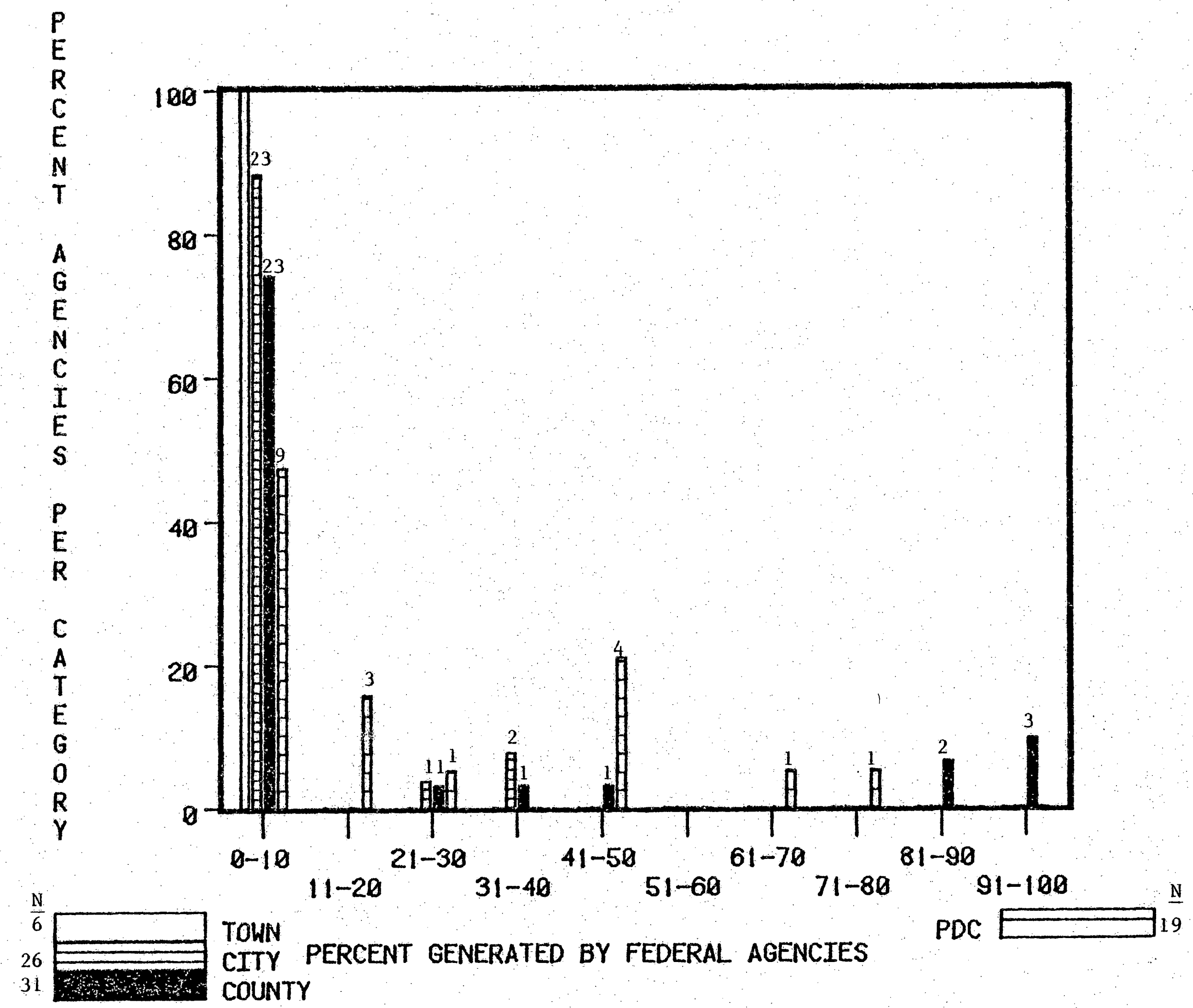

Figure 2-21. Proportion of Remote Sensing Products Generated by Federal Agencies

<u>Factors Limiting the Adoption and Utilization of Remote Sensing Technologies and Products</u>

The development of this research was partly a result of the author's opinion that planning agencies were limited in their use of remote sensing technologies/products as a source of information and that planners as a group were limited in their cognizance of remote sensing technologies in general. The statement concerning lack of utilization has been convincingly supported by survey findings. The latter statement concerning planner's cognizance of remote sensing technologies is at least implicit in the above findings.

During conceptual stages of research design for this study, which included design of the questionnaire, one element defined as important was the reason(s) for any "non-use" of remote sensor technologies by Virginia planning agencies. Considering the degree of "non-use" of remote sensing technologies that has been established by this research, exemplifying a situation far worse than originally assumed by this author, the import of the survey question designed to identify reasons for planning agency non-use of remote sensing techniques seems elevated. The survey question posed to Virginia planners requested information about their agency reasons for any "lack of use" of remote sensing techniques. Response categories available on the questionnaire were; no need, budgetary contraints, lack of remote sensing education and skills among staff, no confidence in remote sensing techniques (based on current knowledge), and "other" reasons (responder specified). Results of this question follow.

Analysis and discussion of questions requiring "ranked" responses have been addressed on the basis of planning level, with comparisons between planning levels brought forth throughout the discussion. Because of the overwhelming similarities of responses to this question, it is felt that no "planning level" breakdown is required. At each planning level, the following rank-order was given for reasons affecting the lack of use of remote sensing techniques:

* first -- budgetary constraints
* second -- lack of remote sensing education and skills among staff
* third -- no need
* fourth -- no confidence in remote sensing techniques (based on current knowledge).

No "other" reasons were given. Planning level differences in the above rankings are merely a matter of emphasis. The methodological approach used to determine information input rank-order was applied to this survey question.

These results are significant, particularly the relatively high ranking given educational deficiencies since such deficiencies could have direct implications for all other response choices. It is the belief of the author that a lack of knowledge of remote sensing techniques, their capabilities, costs and availability might jaundice the responders opinion. In essence, how can the responder meaningfully compare costs of information acquisition using current techniques versus remote sensing techniques with limited understanding of the latter? Further, an expression of confidence in any technology (or lack of it), is a direct function of the responders knowledge of the technology.

<u>Summary</u>: <u>Part II</u>

Meaningful findings concerning Virginia planning agency utilization of remote sensing techniques include the following:

- there is a general lack of use of remote sensing products at all levels of planning;

- only marginal differentiation can be made between remote sensing utilization at the town, city, county and PDC levels of planning;
- utilization is limited primarily to conventional remote sensing techniques although utilization of satellite technology is seen at some PDC's; and,
- there exists considerable potential for increased utilization of remote sensing products within all levels of planning.

In terms of remote sensing application areas, planning level does not appear to dictate significantly implementation of remote sensing techniques to particular problems. Town, city, county and PDC agencies have applied remote sensing techniques to all categories identified in the questionnaire. Most important application areas are land-use, transportation, population/demographic, environmental, historical assessment and impact assessment. Further, agencies responsible for larger jurisdictions, e.g., county and PDC's, do not differ markedly from town or city agencies in their application of remote sensing techniques.

All four levels of planning agency appear to have limited in-house ability to generate requisite data/information from remote sensing techniques; county agencies appearing least capable, while PDC's appear most capable. All levels utilize private consultants as a source for remotely sensed information. Although consultant contributions are limited at all levels of planning, county agencies rely upon consultants more often than do other agencies. Utilization of state and federal sources for remote sensing products is also limited at all levels of planning. Town agencies obtain no remote sensing products from these sources. The strongest state and federal linkages appear to be at the city and PDC levels of planning.

A cross-comparison between levels of planning within Virginia suggests that jurisdictional size, level of planning, planning area dynamics, budget, agency staffing characteristics and planning area diversity have little or no affect on agency in-house capacity to generate information from remotely sensed products.

Factors limiting the adoption and utilization of remote sensing techniques are the same for each level of planning. These reasons, in order of ranked importance, are:

- budgetary constraints;
- lack of remote sensing education and skills among staff;
- no need; and,

- no confidence in remote sensing techniques (based on current knowledge).

The differences of rank as assigned by level of planning are defined by degree of emphasis only. Lack of education concerning remote sensing techniques, applications and costs may have influenced the rank-order results obtained via the survey.

PART III: DEMAND FOR INCREASED COGNIZANCE OF REMOTE SENSING TECHNOLOGIES AND APPLICATIONS

One of the goals of this research is to assess the potential for increased utilization of remote sensing techniques and their products by Virginia planning agencies. An element of any strategy to increase utilization of technology within a particular discipline -- in effect an attempt to transfer technology -- involves the elevation of knowledge of the target population concerning the technology under consideration. NASA has instituted a technology transfer program for nearly 20 years. Program components include elements identified within this research and which serve as important guides to planning agency demand. Explicit discussion of a NASA technology transfer program may be found in Appendix F.

Several survey questions were designed to address the cognizant levels of respondents regarding planning-remote sensing applications, as well as their interest in increasing their knowledge of them. Specifically, the survey attempted to assess general and specific demand for remote sensing-planning applications and the appropriate means for elevating cognizant levels of Virginia planners regarding remote sensing techniques and applications. Discussion of questionnaire results follows.

<u>Virginia Planning Agency Demand for Remote Sensing Information</u>

A portion of this research effort constitutes an attempt to assess the interest of Virginia planners in the elements of general area transfer, as applied to the discipline of remote sensing.

Each planning agency was requested to answer a series of questions designed to establish their "level of demand" for information about remote sensing applications to planning problems. Establishing such a demand above a certain threshold is a requirement for development and successful implementation of any general area transfer program. Questions addressed the topical areas of:

- demand for general literature covering the application of remote sensing techniques to planning related problems. This question defines a link for a central agency to serve as a clearing house. NASA could serve this function;

- demand for additional planning articles devoted to the topic of remote sensing. Results of this question should help define the role of professional planning journals;
- demand for planning conferences devoted to remote sensing applications within the planning discipline. The question defines a role for federal and state agencies, and for Virginia universities in general; and,
- the demand for information concerning specific remote sensing techniques (a list was outlined on the questionnaire).

<u>General Demand for Information of Remote Sensing Applications to Planning Problems</u>

Accepting the above statement that one element of technology transfer is development of a communication or linking process to bolster adoption, and accepting further that inherent in the successful communication process is an interested user population (potential), it seems important that the level of interest of Virginia planning agencies be delineated. Results of the survey suggest that Virginia planning agencies display a high level of interest in the capabilities of remote sensing technologies (Table 2-7). In response to the survey questions concerning demand for additional remote sensing/planning applications, a high proportion of respondents at all levels of planning said that they would like additional information. An average of 84 percent of all respondents stated that they would like additional information about remote sensing/planning applications.

Such results suggest that Virginia planners as a group have been neglected by those responsible for remote sensing information dissemination, the agency most responsible being the National Aeronautic and Space Administration.

The Role of Professional Planning Journals

Results to the question concerning increased frequency of remote sensing articles in professional planning journals again display a high level of interest on the part of Virginia planning agencies, albeit marginally lower than the support reflected for the above question (Table 2-7). The proportion of all respondents agreeing that professional planning journals should increase their frequency of remote sensing articles is 80 percent. Again, the results

Table 2-7. Demand for Remote Sensing Information

		Town	City	County	PDC	Survey Questions Posed
	Yes	83.3	92.3	87.1	73.7	Would you like additional information concerning remote sensing techniques and their applications to planning?
	No	16.7	7.7	12.9	26.3	
Percent Agencies Responding	Yes	83.3	76.9	83.9	73.7	Would you like to see additional remote sensing/planning articles in planning publications?
	No	16.7	23.1	16.1	26.3	
	Yes	83.3	76.9	87.1	84.2	Would you attend a remote sensing/planning conference if it were offered within the state?
	No	16.7	23.1	12.9	15.8	

suggest that a specific need within the planning profession is not now being met by current planning journals.

<u>The Demand for In-state Remote Sensing/Planning Conferences</u>

The third element of a general area transfer program is the development, organization and implementation of conferences and seminars. Although most agencies have delegated funds to be used for purposes of conference attendance, establishing a need or demand for such conferences is important. As part of the survey, each planning agency within Virginia was requested to express its willingness to send a member to an in-state conference(s) devoted to the application of remote sensing techniques to planning problems. Expressions of interest for such a conference(s) are high within all levels of planning associated with Virginia Table 2-7. Results obtained directly from the survey questionnaire show that an average of 83 percent of all respondents would send representatives to an in-state remote sensing/planning conference.

These results define a potentially important role to be played by federal and state agencies and Virginia's system of higher education and state-wide extension program.

Specific Requests for Information of Remote Sensing Application Capabilities

Each agency responding to the questionnaire was requested to identify those remote sensing techniques of which it would like additional information. Having the above information at hand, organizers of general area transfer programs would be aided in at least two important ways: (1) program organizers could use such information to structure program agenda to address areas of cognitive weakness among agency attendees; and (2) organizers could funnel such information via feedback linkages to designers of remote sensing systems. Design information about user needs represents critical input and is an oft-cited weakness of past remote sensor design products.

Table 2-8 represents the proportion of respondent agencies requesting specific information about certain types of remote sensing techniques. Results are presented in matrix format, cross-referencing type of remote sensor versus level of planning agency. Statistics for individual remote sensor types indicate that the levels of demand for information about black and white aerial photography, black and white infrared aerial photography, and color infrared aerial photography are similar, ranging between 40 and 60 percent of respondent agencies at each level of planning (except for a slight aberration among town findings). The

Table 2-8. Demand Levels for Specific Remote Sensor Applications

Type of sensor	Town		City		County		PDC	
	Request	No Request	Request	No Request	Request	No Request	Request	No Request
B and W	50.0	50.0	50	50	45.2	54.8	47.4	52.6
BIR	50	50	50	50	58.1	41.9	42.1	57.9
Color	66.7	33.3	69.2	30.8	35.5	64.5	31.6	68.4
CIR	83.3	16.7	50	50	54.8	45.2	42.1	57.9
Radar	66.7	33.3	46.2	53.8	29	71	21.1	78.9
Electro Scan	66.7	33.3	46.2	53.8	29	71	26.3	73.7
LANDSAT	66.7	33.3	61.5	38.5	51.6	48.4	57.9	42.1
Other	--	100	15.4	84.6	3.2	96.8	--	100

abnormally high positive response of town planning agencies may not be significant. Because of the small sample population of town agencies, a deletion of but one case from the "request" column would represent a proportional loss of 16.7 percent.

Results indicating significant proportional differences between levels of planning were found within the remote sensor types color aerial photography, radar systems, electronic scanners and Landsat systems. The latter type, Landsat, actually represents a finding that is more confounding than significant. Differences noted break along the planning level differentiation local (town and city) versus county and regional (PDC). The factor most likely contributing to the above results is size of planning jurisdiction. Additional discussion of this finding will follow.

Among town, city, county and district commission agencies responding to this survey question, 66.7 percent of town planning agencies and 69.2 percent of city planning agencies reported that they would like additional information concerning color aerial photography. These figures lie in stark contrast to the percentages reflecting county and PDC agency interests in the same remote sensor technology. The proportion of respondent county and PDC agencies requesting additional information regarding color aerial photography is 35.5 percent and 31.6 percent, respectively. Similar findings were noted regarding requests of radar and electronic scanning information. Sixty-seven percent of respondent town planning agencies and 46.2 percent of respondent city agencies requested additional information regarding both of the above sensors. Only 29 percent of respondent county agencies, however, requested information regarding both radar and electronic scanning sensors. Of respondent PDC's, 21.1 percent requested information about radar systems while 26.3 percent stipulated that they would like additional information about electronic scanning systems.

These divergent results may have basis in fact. One characteristic common to all of the above sensors is high cost. It follows that sensors with high application costs will have reduced or low utility values for planning agencies with large jurisdictions. Although the range of potential application is wide for color aerial photography, the same is not true for radar and electronic scanning systems. Radar and scanning systems, then, are usually applied when someone deems a certain type of data/information valuable, thereby justifying the increased cost, and no other "less expensive" alternative was feasible or successful. In cities, information concerning the "condition", state or environment of alleyways might be necessary to assess potential hazardous areas regarding debris, crime, health and safety. Because of the effects of shadow, indices relevant to identify and assess hazardous alleyway areas could not be delineated with conventional remote sensors. Radar and electronic scanning systems, however, could record the necessary information, because they utilize a portion of the electromagnetic spectrum outside of the visible band, and because these systems may be "active", i.e., provide their own source of radiation.

In another application, radar is often used to record land-use information when the area in question is frequently shrouded in rain and/or fog. Such an application is typically addressed by conventional sensors for small areas and satellites for large area analysis, however, radar systems have the ability to "cut through" light rain, fog and haze.

Results reflecting agency requests for additional information regarding satellite sensors are not significant but noteworthy. Landsat technology is best applied, and indeed has been most successful, in relatively large area analysis. For this reason, its highest utility is found within county and regional planning applications. Although a relatively high proportion of respondent county and PDC agencies requested satellite information (51.6 percent and 57.9 percent respectively), town and city planning agencies displayed request proportions of 66.7 percent and 61.5 percent, respectively. Rather than reflecting potential utility, these findings suggest that satellite systems (mis) information has reached more people than other sensor information, and that its 21st century, "Star Wars" countenance has attracted some of these same people.

Summary: Part III

The degree of interest expressed by respondent town, city, county and PDC agencies for information regarding remote sensing techniques and their potential to meet planning needs is high. Survey results suggest that important roles could be played by federal agencies, particularly NASA, professional planning journals and Virginia state agencies, including the system of higher education and extension.

Chapter III

SUMMARY AND CONCLUSIONS

RESTATEMENT OF ASSUMPTIONS AND HYPOTHESES

The scope and focus of this research, as stated in Chapter I, have included a number of assumptions concerning levels of planning within Virginia, the agencies identified at each level, their characteristics regarding data/information requirements, data/information sources, their utilization of available remote sensing techniques, and the potential for increased utilization of remote sensing techniques by these same agencies. Emerging from the assumptions, and explicitly stated elsewhere in this thesis, are the following hypotheses:

- The adoption and use of remote sensing techniques is low among Virginia planning agencies;

- The degree of adoption and utilization of remote sensing techniques is a function of level of planning;

- Staff size, diversity, educational and skill levels influence the utilization of remote sensing techniques in the planning process;

- Increased planning area (size of jurisdiction) increases remote sensing utilization;
- Rapidly changing population/demographic conditions will increase remote sensor utilization; and
- Increasing diversity of information requirements will increase the utilization of remote sensing techniques.

Developing data and a methodological approach to test the above hypotheses formed the major task of this research. Previous detailed discussion has shown that utilization of remote sensing techniques by Virginia planning agencies is low, regardless of planning level (refer to Chapter II). Descriptive statistics provided within Chapter II strongly support this statement, which imply that the above cited agency characteristics (e.g., staff size, planning area, demographic change, and information requirements, etc.) do not influence the utilization of remote sensing techniques by Virginia planning agencies. To test further these implications, more powerful statistical analysis were performed on the data (refer to Chapter I and Appendix B). Results of the analysis follow.

ANALYSIS OF STATISTICAL ASSOCIATION

Levels of Planning Versus Utilization of Remote Sensing Techniques

Chi-square tests were performed to establish the degree of association between level of planning and utilization of survey identified remote sensing techniques. Each individual sensor (e.g., black ahd white aerial photography, color aerial photography, Landsat) was assessed against planning level in 2x3 matrices (town agencies were not included in the analyses because of the limited sample size). Cramer's V was applied to establish the strength of association if the Chi-square test indicated a systematic relationship between the variables tested.

Results of this analysis indicate that, except for Landsat, there is no association between levels of planning and utilization of remote sensing techniques at the .05 level of significance. Landsat utilization appears associated to planning level when judged against the .05 level of significance. The strength of association, however, is moderate, yielding a value of V=.59. An explanation of this apparent association lies in the increased adoption of Landsat technology by PDC's. As noted earlier, however, only 4 of 19 respondent PDC's reported adoption of Landsat techniques.

Intra-planning Level Characteristics Versus Utilization of Remote Sensing Techniques

Having found marginal association between levels of planning and remote sensor utilization, an intra-planning level, agency characteristics/remote sensor adoption analysis was conducted. Agency remote sensor adoption responses per planning level were weighed against agency characteristics (e.g., budget, jurisdictional area, staff size and rank-order of land-use information) to determine if such important agency characteristics have an influence upon utilization of remote sensing techniques. Tests of chi-square, Cramer's V and phi were used to determine association and strength of association.

City planning agency characteristics were tested against agency remote sensor utilization using chi-square and phi. At the .05 level of significance no agency characteristics appear associated with remote sensor utilization.

Most county agency characteristics tested against remote sensor utilization appear not significantly associated at the .05 level. Two exceptions were found, however. The utilization of color aerial photography appears associated with both agency budget and agency staff size at the .05 level of signficance. The strength of these relationships, as measured by phi, appears moderate (phi=.56 for agency budget and .61 for agency staff size). The reader is emphatically cautioned against inferring too much from these findings. Comparison of observed cell frequencies indicate that the tested criteria are highly sensitive. In fact, an observed cell-frequency change of two would eliminate the above combinations from significance.

Planning district commission responses were administered the same series of statistical tests as were county and city agencies. In all cases of interaction, no relationship was found at the .05 level of significance.

THE POTENTIAL OF INCREASED REMOTE SENSOR USE BY VIRGINIA PLANNING AGENCIES

Appendices D and E established the utility of currently available remote sensing techniques to a wide spectrum of planning-related problems. Levels and types of remote sensor utilization by Virginia planning agencies and agency demand for increased cognizance of remote sensing capabilities and applications were discussed in Chapter II.

Findings from the above chapters, along with materials developed in Appendices D and E allow for the assessment of the potential for increased utilization of remote sensing techniques by Virginia planning agencies. Establishment of such potential is based upon the following criteria:

- the rank-order and type of information required for planning;
- the in-house capacities of agencies to generate requisite information;
- the current level of remote sensor utilization by agencies;
- the types of remote sensing applications being made;
- the source of current remote sensing products; and
- the expressed demand for remote sensing/planning applications information.

Each of the criteria will be discussed below.

<u>Increased Remote Sensor Utilization as Defined by Agency Information Rank-Order</u>

Agency information rank-order is delineated in Table 2-1. The greatest utility of remote sensors has been established in applications to land-use, environmental, agricultural and transportation related problems. Rank-order findings suggest that Virginia planning agencies lack adequate land-use, socio-economic and population/demographic information. In fact, land-use information appears most important to county agencies and planning district commissions and second most important to city agencies. Also of note is the fact that town, city and PDC agencies ranked third the category giving equal weight to all types of information. These findings suggest that there is a high degree of potential for increased utilization of remote sensors by Virginia planning agencies regarding their requisite information.

<u>Increased Remote Sensor Utilization as Defined by Agency In-house Capabilities to Generate Requisite Information</u>

Figures 2-1 through 2-5 display Virginia planning agency in-house information generation capabilities. Except for land-use information, capabilities of which are marginal, most Virginia planning agencies appear incapable of producing much of the information they require. These findings suggest that: (a) important information is not being employed in the planning process and/or (b) other sources may be supplying such information (no survey question directly addressed information source). If Virginia planning agencies are engaging other sources for necessary information, particularly private consultants, then data acquisition costs might be unnecessarily high.

Increased utilization of remote sensors by in-house staff could: (a) provide more timely and relevant information and (b) conserve financial resources. The mechanisms to address this potential are presented later in this chapter.

Increased Remote Sensor Utilization as Defined by Current Agency Utilization

Figures 2-6 through 2-9 depict current remote sensor utilization by Virginia planning agencies. It is quite clear that utilization is minimal at all planning levels. Black and white aerial photography appears to be the only sensor being consistently applied to planning problems. These low utilization proportions support the contention that substantial improvement is possible. Improvement of remote sensor utilization is a function of increased knowledge regarding remote sensor application capabilities. Addressing the cognitive weaknesses of planners regarding remote sensing technologies and applications constitutes a prerequisite of increased remote sensor utilization. Alternatives to meet this need are discussed later in this chapter.

Increased Remote Sensor Utilization as Defined by Current Agency Remote Sensor Applications

Virginia planning agency applications of remote sensing technologies are displayed in figures 2-10 through

2-13. It is important to note that the diversity of applications is surprisingly broad at all levels of planning. Survey produced information does not allow for individual sensor-application identification. It may be surmised, however, that because sensor adoption is minimal, some of the agency applications are ill-advised. No remote sensor can be applied to all planning problems. Important factors in the decision to choose a remote sensor for a particular application include format (e.g., black and white versus color photography, radar, Landsat), season-of-year of photography or imagery, and scale of remotely sensed product. As an example, a planner not familiar with remote sensor capabilities might select black and white photography at a photo-scale of 1:20,000, taken during the summer season, to analyze area wetlands. Information produced from such photography would be inaccurate because: (a) the scale is too small to resolve small wetland areas, (b) BIR, color or CIR photography are capable of capturing more wetland information than can black and white photography (allowing better class separation), and (c) growing season or "leaves-on" photography masks or "hides" much wetland acreage. This problem is potentially important, since planners may be placing undue credence on the quality and validity of the data/information produced. Increased cognizance of remote sensor capabilities and requirements would substantially reduce this problem.

Knowledge of remote sensor applications allows only partial assessment of the potential for increased utilization of remote sensors by Virginia planning agencies. Remote sensor product source is an important aspect of remote sensor applications.

Increased Remote Sensor Utilization as Defined by Agency Source of Remote Sensing Products

Where Virginia planning agencies are obtaining their remote sensing products has important financial meaning. Figures 2-14 through 2-17 portray agency product source. It is evident that most Virginia planning agencies have limited capacities to generate remote sensing based products. At all levels of planning, most agencies generate 10 percent or less of their products. Other sources include state and federal agencies and private consultants, the latter being used more often as a product source. Clearly, as agency in-house capacity increases, reduced reliance upon other sources can be expected. Again, increasing agency in-house capabilities is highly associated with increased remote sensing education and skills among practicing planners.

Increased Remote Sensor Utilization as Defined by Agency Demand for Remote Sensor/Planning Applications Information

Perhaps most indicative of the potential for increased remote sensor utilization by Virginia planning agencies is their concerted demand for remote sensor-planning related information. Table 2-7 summarizes Virginia planning agency demand for remote sensing-planning information. An overwhelming proportion of agencies at all levels of planning (PDC's registered the lowest proportion at 73.7 percent) stated that they would like additional remote sensing-planning information. Specific requests are displayed in Table 2-8. Survey findings that corroborate the expressed demand include: a minimum of 73.7 percent of agencies at any planning level would like to see additional remote sensing-planning articles in planning publications; and, at least 76.9 percent of agencies at any planning level would send a representative(s) to an in-state conference devoted to remote sensing-planning subjects.

Clearly, planner interest in remote sensing technologies is high and is a prerequisite to increased remote sensor utilization.

<u>Increased Remote Sensor Utilization as Defined by Expressed Reasons for Non-Use</u>

Inherently associated with the demand for remote sensor education, as outlined in the preceding section, are the ranked reasons for agency lack of remote sensor use. Educational deficiencies was ranked second at all levels of planning, and this fact makes an important positive statement concerning the potential for increased remote sensor utilization by Virginia planning agencies. For detailed discussion of these rankings refer to Chapter II.

ASSESSMENT OF THE PROBLEM

Communication with practicing planners contributed to the development of this research and fostered the assumption that planners in general are not cognizant of the field of remote sensing. An often heard comment from planners in response to an inquiry regarding remote sensing is: "You mean satellites?" The major conclusion of this research is that planners are not being exposed to the field of remote sensing and the currently available remote sensing technologies that might enhance the collection of planning related data/information.

No survey questions addressed specific factors of planner educational background beyond the identification of planning focus, e.g., urban, transportation, environmental, etc. Since no statistical correlation could be shown between other staff characteristics and remote sensor utilization, and since it has been shown that remote sensor utilization is low at all planning levels, it is reasonable to assume that all planners, regardless of planning focus, lack the educational exposure to remote sensing techniques that would foster their adoption and use.

A survey of American universities offering graduate programs in planning was conducted in an attempt to substantiate the above assumption. Using information developed by the Association of Collegiate Schools of Planning and the American Society of Planning Officials (Hamlin, 1978), 46 graduate school curricula were analyzed regarding their required coursework and special course offerings. Of the 46 curricula studied, only <u>one</u> required a remote sensing related course. Such findings strongly corroborate the assumption that students of planning are not receiving remote sensing/planning education and skills.

Another problem related to the lack of remote sensing education/skills of recent graduates of planning schools concerns the education of the "old guard" planners who likely direct many planning agencies. Adoption of new technology by those schooled years before the technological innovation may be quite difficult.

The problem defined, then, is how to educate practicing planners and future planners regarding the use of remote sensing techniques as planning tools. Programs to solve the problem must be concerted and both short and long-term.

Educating Planners About Remote Sensing Technology and Applications: Short and Long-Term Approaches

Three problems must be addressed to solve the remote sensing educational weakness identified by this research:

1. Practicing planners must be reached and their cognitive levels and operational skills regarding remote sensing techniques and applications must be elevated.

2. Collegiate planning curricula at the undergraduate and graduate level must be revised to reflect the important contribution(s) that remote sensing techniques can make as planning tools.

3. Continuing educational programs should be developed to upgrade the practical planner's remote sensing knowledge and skills as state-of-the-art improvements are made.

Remote Sensing/Planning Conferences

Addressing the problem of educating practicing planners regarding remote sensing technologies will require several short-term approaches. As Doctors has stated, short-term educational programs regarding remote sensing applications should include conferences and increased exposure to remote sensing/planning literature. Conferences may be sponsored by state-wide extension programs, state agencies, federal agencies or university planning and/or remote sensing departments.

Results from the mailed questionnaire have established the demand for such conferences. Programs designed to offer remote sensing/planning conferences should be developed to meet the expressed demand.

Journal Support

Increasing the frequency of journal articles devoted to the topical area of remote sensing applications in the field of planning should accomplish several goals. It should increase the knowledge of planners regarding remote sensing applications, increase the demand for remote sensing/planning conferences, increase the demand for extension programs devoted to remote sensing/planning applications, and help maintain the knowledge of planners regarding remote sensing applications.

Extension Programs

The Commonwealth of Virginia has a strong and well-developed extension program. Armed with evidence of strong demand for remote sensing/planning related education, program directors, working through university linkages and state field offices, could develop and implement relevant educational programs.

Program development should be coordinated with the planning agencies involved, perhaps stratified to reflect level of planning, and with university departments housing demonstrated expertise in the area of remote sensor application.

College Undergraduate and Graduate Curricula

College planning departments within the state should revise their curricula to reflect added emphasis upon remote sensing technologies as a planning tool. Course requirements should be established which reflect the information requirements of the Virginia planning agencies to be served.

It is suggested that undergraduate requisites be established, requiring perhaps one course each of introductory remote sensing, introductory airphoto interpretation and introductory cartography. Graduate course prerequisites should include the above undergraduate courses. Required graduate courses might include course work in advanced airphoto interpretation, advanced remote sensing with automated satellite systems, and advanced cartography for those students whose major focus warrants such coursework.

Maintenance of remote sensing education and skills of students graduating from such a rigorous curricula could include those short-term alternatives of extension courses, conferences and professional journal articles discussed above.

FUTURE RESEARCH

This research has substantiated the utility of remote sensors to address a wide spectrum of planning related problems. The low proportion of utilization of remote sensing techniques by Virginia planning agencies, the need for increased cognizance of remote sensing/planning applications by Virginia planners, and the need to increase remote sensor adoption and utilization by Virginia planners has also been documented. Extension of this research might address several problems highlighted by these findings. Complete assessment of agency remote sensor application and staff educational backgrounds was not possible with data collected via the mailed questionnaire. Inadequacy of the questionnaire is partially the result of design constraints. As discussed in Chapter I, questionnaire length dictates the number and complexity of questions posed. Future research might address weaknesses inherent in the survey used for this research. Questions need to be posed to Virginia planning agencies regarding:

- detailed educational background of the planning staff;

- specific sensors used and for what problems. An explicit survey question directed at remote sensor application was included in the current survey. This question required, however, a written response. As a result, few responses were made. Future questions should provide comprehensive lists of application possibilities for "check off" by the respondents; and

- actions needed to increase remote sensor utilization by planning agencies. Such questions would allow planner input into the development of any alternatives selected.

Financial constraints pose another obstacle to the increased utilization of remote sensing technologies by

Virginia planning agencies. Locating additional monies to support agency staff training and equipment purchases, and to develop local and/or state-wide educational conferences define an additional future research/program development effort that should be undertaken.

Revising collegiate curricula will require considerable time, effort, research and coordination. Any revision should be a concerted effort between state planning school representatives and planning agency representatives. A process for curricula revision and development is identified as an important extension of this research.

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Appendix A

PLANNING AGENCY/REMOTE SENSING UTILIZATION SURVEY

COLLEGE OF ARCHITECTURE AND URBAN STUDIES

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

ENVIRONMENTAL AND URBAN SYSTEMS—URBAN AND REGIONAL PLANNING

July 2, 1980

Mr. Danny G. Fore
Executive Director
Radco Planning District Commission
Post Office Box 863
Fredericksburg, VA 22401

Dear Mr. Fore:

The Division of Environmental and Urban Systems at Virginia Tech is attempting to analyze information needs and remote sensing capabilities of Virginia planning agencies. Much has been written about the potential of remote sensing techniques to meet the data needs of various users, including planners and land managers. If the claims of better resolution, time and monetary savings have been realized by past users, it follows that planners should consider remote sensing techniques to meet their informational needs.

The enclosed survey is an attempt to identify which Virginia agencies are currently utilizing remote sensing techniques; to what problems they are being applied; and the potential for increased utilization of remote sensing techniques. If results indicate a high potential for increased utilization of remote sensing techniques within Virginia planning agencies, educational programs (e.g. extension courses, conferences, etc.) will be assessed, and hopefully developed and offered, for meeting this potential.

Your prompt and thorough completion of this questionnaire is necessary for our analysis. All responses are confidential. No release of individual survey results will be made unless we have prior written consent from a representative of the original responding agency.

If you have any questions, please feel free to call
. We thank you for your cooperation.

Sincerely,

Ann D. Watts
Chairman, Urban and Regional
Planning Program

ADW/jab

This Line For Official Use Only
Questionnaire No. ____

Information provided in this survey is confidential. Requests for individual survey results will be granted only if specifically approved via letter by a respondent agency representative.

Questions 1-6 are designed to identify basic characteristics of your planning area and the kinds of information that your planning agency requires. This information will be used to assess the applicability of remote sensing techniques to your agency.

1. What is the approximate size (area in square miles) of your planning jurisdiction? ____________sq. miles

2. What percentage of your planning area lies in the following uses? (approximations are acceptable)
   - urban residential _____%
   - urban commercial _____%
   - industrial _____%
   - agricultural _____%
   - forest _____%
   - recreational _____%
   - open space-vacant _____%
   - other _____%

3. Please answer the following questions concerning the population of your area.
   - current population? ______________
   - population in 1970? ______________
   - population in 1960? ______________
   - estimated rate of population growth or decline, 1980-1990 (to the nearest percentile) ____________%

4. Rank your data/information needs within these broad categories. (Rank #1 for most needed.)
   - land use ____
   - transportation ____
   - population and demographic ____
   - socio-economic ____
   - environmental ____
   - all (approximately the same weight ____
   - other (specify) ____

5. Within each separate category, rank your data/information needs (rank #1 for most needed).
   a. land use
      - residential ____
      - commercial ____
      - industrial ____
      - agricultural ____
      - forest ____
      - wetland ____
      - open space/vacant ____
      - recreation ____
      - other (specify) ____

b. transportation
- local route design & location ____
- regional route design & location ____
- mass transit studies ____
- parking facilities studies ____
- bikeway design and location ____
- other (specify) ____

c. population/demographic
- pop. distribution ____
- housing studies ____
- population change ____
- other (specify) ____

d. socio-economic
- employment ____
- income ____
- sales ____
- other (specify) ____

e. environmental
- soils classification ____
- wetlands analysis ____
- hydrologic studies ____
- wildlife habitat ____
- landform analysis ____
- vegetation classification ____
- other (specify) ____

6. How do you meet the above data/information needs? Please indicate estimated percentage generated by in-house staff (to the nearest percentile).

land use	________%
transportation	________%
population/demographic	________%
socio-economic	________%
environmental	________%
other (specify)	________%

Questions 7-9 identify the extent to which your agency currently utilizes remote sensing techniques to meet its information needs. Remote sensing refers to any device used to gather (record) information about an object(s) or area. Such devices include conventional aerial cameras (photography) and range to satellite imagery. Replies to these questions will be analyzed against current viable remote sensing applications to determine the potential for increased utilization of remote sensing techniques within Virginia planning agencies.

7. Which of the following remote sensing techniques do you utilize to develop data/information?
   1 = do utilize, 2 = do not utilize
   ____ black and white aerial photography
   ____ black and white infrared aerial photography
   ____ color aerial photography
   ____ color infrared aerial photography
   ____ radar systems
   ____ electronic scanners
   ____ LANDSAT (satellite) imagery
   ____ other (specify)
   ____ none (if none, skip to question 10)

8a. To what categories of data needs do you apply the above remote sensing techniques?
1 = apply, 2 = do not apply

land use data	____
transportation	____
population studies	____
socio-economic studies	____
environmental analysis	____
historical data	____
impact analysis	____
other (specify)	____

b. Of the above general categories that you identified as remote sensing application areas, please list specific applications within each.

9. What percentage (to the nearest percentile) of remote sensing products are generated by:

your in-house staff	____%
consultants through contract	____%
other state agencies	____%
federal agencies	____%
other (specify)	____%

Questions 10-12 are designed to identify the reasons for a lack of use of remote sensing techniques to develop planning information and to assess the level of interest in various remote sensing techniques.

10. If you do not utilize remote sensing techniques, to what do you attribute this lack of use? (Please rank if more than one - #1 being primary reason.)

    _____ no need
    _____ budgetary contraints
    _____ lack of remote sensing education and skills among staff
    _____ no confidence in remote sensing techniques (based on current knowledge)
    _____ other (specify, list and rank)

11. Would you:

    a. like additional information concerning remote sensing techniques and their application(s) to planning?
    _____yes _____no
    b. like to see additional remote sensing/planning articles in planning publications? _____yes _____no
    c. attend a remote sensing/planning conference if it were offered within the state? _____yes _____no

12. Are there any specific remote sensing techniques about which you would like additional information/education? (Check all that apply)
    _____ black and white aerial photography
    _____ black and white infrared aerial photography
    _____ color aerial photography
    _____ color infrared aerial photography
    _____ radar systems
    _____ electronic scanners
    _____ LANDSAT (satellite) imagery
    _____ other (specify)

Questions 13-16 identify the extent of computer usage by your planning agency. Answers to these questions will allow the researcher to assess the potential for automated remote sensing applications within Virginia planning agencies.

13. Does your agency have access to computer facilities? _____yes _____no (If no, skip to question #16.)

14. Are these computer facilities: (check all that apply)
    _____ in-house (i.e. all components located in your agency)
    _____ shared with other departments
    _____ agency owned
    _____ rented
    _____ other (specify)

15. If you have access to computer facilities, what peripheral equipment is also available to your agency? (Check all that apply)
_____ line printer
_____ cathode ray tube (CRT) - black and white
_____ raster scan display - black and white
_____ raster scan display - color
_____ digitizer
_____ graphics plotter
_____ other (specify)

16. Who else on the staff is knowledgeable about:
a. remote sensing techniques and applications
person's title _____________________
area of formal training _____________
b. computer techniques and applications
person's title _____________________
area of formal training _____________
c. no person __________

Responses to questions 17-22 will provide basic administrative and logistic information about your agency. Information provided will be analyzed against information developed in responses to the above questions. Question 22 gives you an opportunity to critique this survey and to identify problematic areas not addressed.

17a. Agency name ___________________________
b. Address ______________________________
____
____
c. Telephone ____________________________
d. Respondent's name ____________________
e. Respondent's present position _________
f. How long have you held this position _____

18a. What is the 1980-81 budget of your agency?
____
b. What percentage of this budget (to the nearest percentile) is:
locally funded _____%
state funded _____%
federally funded _____%

19. What is the size of your office staff?

Professional staff	Support staff (in-house)
____ 1-3 (members)	____ 1-3 (members)
____ 4-6	____ 4-6
____ 7-9	____ 7-9
____ 10-12	____ 10-12
____ 13+	____ 13+

20. Specialization background of office staff. Please indicate total number for:

a. Professional staff		b. Support staff
____	Urban Planning	____
____	Regional Planning	____
____	Environmental Planning	____
____	Transportation Planning	____
____	Economic Planning	____
____	Urban Design	____
____	Landscape Architecture	____
____	Architecture	____
____	Engineering	____
____	Other (specify)	____

21. In a few words, please characterize the mission of your agency.

22. In your opinion are there areas of importance or interest concerning the profession of planning and remote sensing which were omitted from this survey? If so, please take this time to identify and briefly discuss them.

Appendix B

METHOD OF STATISTICAL ANALYSIS

Choice of statistical technique is paramount because available statistical techniques are not always appropriate for data measured at various levels (e.g. nominal, ordinal, interval, and ratio). The process of measurement, i.e. of assigning a value to the observed data, has important implications concerning the choice(s) of statistical technique to analyze the data (Nie et. al., 1975). Variables being analyzed within this research are nominal in level of measurement. Using the nominal scale requires that variables be classified into two or more groups, of which the members differ with respect to the characteristics being scaled. No assumption of gradation or distance between the group is made.

Not all statistical techniques may be employed to analyze nominal scale variables. Included in the menu of appropriate techniques is chi-square and its derivatives, Cramer's V and contingency coefficient C. Chi-square is a test of statistical significance. Such tests help determine if a systematic relationship exists between two variables. Such a determination is accomplished by computing the cell frequencies that would be expected if a relationship exists between the variables, given the existing row and column totals. Actual values are then compared to expected cell frequencies according to the following formula:

$$X^2 = \Sigma(\frac{(f_o^i - f_e^i)^2}{f_o^i}$$

Where f_o^i equals the observed frequency in each cell, and f_e^i equals the expected frequency as calculated from

$$f_e^i = (\frac{c_i r_i}{N})$$

where c_i equals the frequency in a respective column total, r_i equals the frequency in a respective row total, and N equals the total number of valid cases (Nie et. al., 1975).

If an assumption of no relationsihp between variables is true, then any deviations between expected and actual values are caused by chance. Most researchers agree that randomly caused deviations will likely be small and that large deviations, i.e., large values of chi-square, are not likely. Because the researcher is not cognizant of actual relationships of the populations under study, he or she interprets small values of chi-square as indicating the absence of a relationship while interpreting large chi-square values as indicative of the existance of some type of systematic relationship between two variables. For detailed discussion of chi-square statistical theory and procedure, the reader should refer to Blalock (1972), Moser and Kalton (1972) and/or Bailey (1978).

Though helpful, chi-square values only imply whether variables are independent or related. If related, chi-square does not indicate the strength of the relationship. Fortunately, chi-square techniques may be adjusted to accomodate analysis for the strength of relationsihp between two variables. Two such applications are:

Cramer's V - Cramer's V is used when contingency tables are greater than 2x2 variables [2x2 tables are normally analyzed by phi (Φ).] Phi corrects for the fact that chi-square is directly proportioned to the number of cases N by adjusting the X^2 value. The formula for phi is

$$\Phi = \left(\frac{X^2}{N}\right)^{\frac{1}{2}}$$

A phi value of zero (0) means that no relationship exists while the value of +1 means that a perfect relationship exists.

Cramer's V represents a minor modification of phi, one that adjusts for either the number of rows or colums in a table, depending on which of the two is smaller. The formula for Cramer's V is

$$V = \left(\frac{\Phi^2}{\min(r-1),(c-1)}\right)^{\frac{1}{2}}$$

V also ranges from 0 to +1, signifying the degree of association that exists.

Contingency Coefficient - Contingency coefficient C represents another measure of association that is based upon chi-square. The formula for C is

$$C = \left(\frac{X^2}{X^2+N}\right)^{\frac{1}{2}}$$

Applicable to any size contingency table, coefficient C has a minimum value of zero. Maximum values for C, however, depend upon the size of the table, requiring that comparison be made only between tables of the same dimensions.

Specific application of the above statistical alternatives for this study will depend upon the variables selected for comparison and the contingency table that they define.

Appendix C

THE BASIS OF PLANNING WITHIN VIRGINIA

THE GENERAL PLANNING MODEL

This study does not attempt to define innovatively, or to advocate change in, the planning process. As noted in Chapter I, this study is concerned with the application of the planning process at three levels, town/city, county, and region, and the particular data requirements and degree of remote sensing utilization found at each level. It seems appropriate, therefore, to establish first the general characteristics of each of these levels of planning, and then to discuss the general characteristics of each level within Virginia.

Authors of planning literature have expended considerable energies discussing pointedly the process that defines urban/local (town and city), rural (town and county), county (often a mix of urban and rural), and regional (large-scale urban and rural) planning (Friedman, 1967, Cowan 1973, Chadwick 1978 and Sargent 1976). Although wording and phraseology differ, the context of each discussion is similar, and is summarized by Glasson (1974):

> ... all planning involves a sequential process which can be conceptualized into a number of stages, such as:
> the identification of the problem;
> the formulation of general goals and more

specific and measurable objectives relating to the problem;
the identification of possible constraints;
the projection of the future situation;
the generation and evaluation of alternative courses of action;
and the production of a preferred plan ...[2]

Glasson also states that the above process is relevant to the whole spectrum of planning problems and quotes Friedman's (Friedman and Alonso 1964) words:

> ... planning is primarily a way of thinking about social and economic problems, planning is oriented predominantly toward the future, is deeply concerned with the relation of goals to collective decisions and strives for comprehensiveness in policy and program. Wherever these modes of thought are applied, there is a presumption that planning is being done.[3]

LEVELS OF PLANNING

Since all levels of planning can be identified with the same process and typology, wherein lies the distincition? Planning in western developed countries can be most clearly identified at the national and local levels (Glasson 1974). In part, this reflects their governmental and administrative systems. Planning at the national level tends to be strongly economic in context. National level planning often is subdivided into short-run allocative

[2]Glasson, H. 1974. An Introduction to Regional Planning. Hutchinson Educational. London. p. 5.

[3]Friedman, J. and W. Alonso. 1964. in Glasson, J. 1974. Ibid., p. 5.

planning — concerned with the stabilization of the "ups and downs" of the economy, and long-run innovative planning -- concerned with achieving certain rates of growth.

Effective national planning is important to, and somewhat dependent upon, effective planning at lower levels. National planning often provides the "incentives" for effective lower level planning, e.g., through financial "carrots" and/or imperative plans. Since many national plans are implemented at local levels, their rate of success is tied closely to plan sympathies, understanding and personnel skills at the local level.

Local planning efforts, as suggested above, have a vested interest in national planning objectives. Local authorities, usually hampered by insufficient funding, often look to national programs for sources of revenue. Such sources do not come without strings attached however, specific regulations concerning time horizons, targets and allocations commonly accompany financial support.

Local planning (urban) is most associated with physical rather than economic planning. This type of local planning often manifests itself in land-use approaches, e.g., land-use controls, zoning, recreation plans, etc.

Administrators have identified the need for an intermediate level of planning between the national-local interface. Regional planning straddles this gap. Regional planning is concerned with planning for an area having distinctive economic and social characteristics, opportunities and problems. Economic factors have consistently led the list of regional planning objectives, although recent environmental concerns have led to "action forcing" legislation[4] -- which often translate into planning objectives -- that has elevated non-economic concerns into regional planning objectives.

Pressure for governmental action at the regional level was spawned from a variety of sources. Originally, regional planning may have been a response to regionalism resulting from areas separated by cultural and/or political identities. New England and the Appalachian states serve as good examples of culturally and economically defined regions (Rothblatt 1971). More recently, however, serious functional problems facing society have boosted the need for regional planning. These functional problems include rising urban growth and congestion (new estimates place 80 percent of the world's population in cities by the year 2000); rising standards of living and population mobility;

---

[4]The National Environmental Policy Act of 1969 has been referred to as "action forcing" legislation. Others might include the Endangered Species Act, National Wetland Protection Act, Water Pollution Control Act and the Air Pollution Control Act of 1972.

growing depressed industrial and rural regions; and increasing consciousness that world-wide resources are limited and environmental problems are serious (Sargent 1976).

Although the primary role of regional planning is to deal directly with the functional problems of a particular region, the methodologies used often incorporate intra-regional (local) and inter-regional (supra-regional or national) goals and objectives. The former might be exemplified by the movement and distribution of population and/or employment; the interaction of social and economic problems; and the provision of communications. Inter-regional goals and objectives might include the <u>inter</u>-regional flows of population and employment; the availability and use of resources; and, the consideration of environmental issues that are not confined within regional boundaries (Isard 1975 and Lassey 1977).

As was discussed earlier, more than any other level of planning, regional planning is likely to incorporate a mixture of planning approaches in order to meet its objectives.

The real distinctions between the levels of planning are not to be found in the process used to solve problems, but in the types of problems faced; the scale of these problems; the size of the planning jurisdiction; the kinds and quantities of data required to analyze the problems; the temporal nature of the problems; and the size and skills of the planning staffs at each level (Kraemer _et al_. 1979, Robinson 1972 and Whittaker 1974). Some of the elements have already been introduced and some attempt is made in the literature to characterize functional problems associated with, and the data requirements of, various levels of planning. Although these are an integral part of this study, no detailed discussion will be presented at this point. A critical analysis of these elements is provided in the sections devoted to the analysis of questionnaire results.

One assumption underlying this study is that effective planning requires relevant, timely data. Because data extraction and input command such a high proportion of the time and money budgeted for planning, and because some of these data are highly accessible via remote sensing techniques, it is assumed that remote sensing techniques can aid planners in their mission(s). A discussion of remote sensing utility and application follows in Appendices D and E.

LEVELS OF PLANNING WITHIN VIRGINIA

Local Planning

Legislation governs or mandates planning within the Commonwealth of Virginia. Local governments (defined as towns, cities, or counties) are obligated under the Code of Virginia, Title 15.5, Chapter 11, Article 1, to establish a local planning commission (Va. Dept. Housing and Com. Development (DHCD), 1979). Local planning commissions must organize, develop and recommend a comprehensive plan of their jurisdiction for adoption by their governing body. Further, such commissions must develop subdivision regulations, prepare zoning ordinances and serve generally as a public source of information and advice. Under the Code of Virginia, Title 15.1, Chapter 11, Article 4, it is stipulated that each local planning commission shall prepare a plan for the "development of the territory under its jurisdiction and recommend it to the governing body for their adoption by June 1, 1980" (Va. DHCD 1979). The Code requires that the above plan address long-range recommendations for the general development of the jurisdiction. As stated by the Virginia DHCD, the plan may designate:

- Areas for various types of public and private development and use, such as residential, commercial, industrial, agricultural, conservation, recreation, public service, flood plain, and drainage;

- A comprehensive system of transportation facilities, such as streets, roads, highways, parkways, railways, bridges, viaducts, waterways, airports, ports, terminals;

- A system of commumnity service facilities, such as parks, forests, schools, playgrounds, public buildings and institutions, hospitals, community centers, waterworks and wastewater treatment facilities;

- Areas of historical significance, renewal, or development projects; and,

- An official map, a capital improvements program, a subdivision ordinance, and zoning ordinance and zoning district maps.

Further, the Code stipulates that the plan show the approximate "location, character and extent of each feature described in the plan" and "where lands or existing facilities are proposed to be extended, widened, renewed, relocated, vacated, or otherwise changed."

Means to guide land usage are found in local zoning and subdivision ordinances. Both zoning and subdivision control ordinances play an integral role in the implementation of local plans and both are defined by state enabling legislation. Title 15.1, Chapter II, Article, 8 of the Virginia Code authorizes local governing bodies, or their representatives, to "divide the territory under its jurisdiction into districts to regulate, restrict, permit, prohibit and determine":

- The use of land, buildings, structures and other premises for agricultural, commercial, industrial, residential, floodplain and other specific uses;

- The size, height, area, bulk, location, erection, construction, reconstruction, alteration, repair, maintenance, razing or removal of structures;

- The areas and dimensions of land, water, and air space to be occupied by buildings, structures and uses, and of courts, yards and other open spaces to be left unoccupied by uses and structures, including the variations in the sizes of lots based on whether a public or community water supply or sewer system is available and used; and

- The excavation or mining of soil or other natural resources.

Regarding subdivision regulation, Title 15.1, Chapter II, Article 7 of the Code of Virginia stipulates that local governing bodies adopt a subdivision ordinance "to assure the orderly subdivision and development of land." Local subdivision ordinances should include regulations and provisions that provide for:

- size, scale and other plat details, and the coordination of streets;
- Drainage and flood control and other public purposes such as water, storm and sanitary sewer; and
- The dedication of public rights-of-ways and the financing of improvements thereon.

Regional Planning

"Local" planning, as depicted above, may encompass a wide spectrum of planning jurisdictions (areas). County jurisdictions, representing the largest planning units within the "local" designation fail to incorporate a broad, regional perspective required for the solution of many problems. Addressing this fact, the Virginia state legislature passed legislation enabling local governments to "bind together" into larger regional planning units. Under

Title 15.1, Chapter II, Article 2 of the <u>Code of Virginia</u> (the Virginia Area Development Act), local governments are given authority to organize planning district commissions. As stipulated in the Code, any time after the establishment of the geographic boundaries of the planning district, the governmental subdivisions which constitute at least 45 percent of the district population may, by written agreement, organize a planning district commission. Towns, cities and counties of 3,500 or more population are eligible for commission membership (Va. DHCD 1979).

The DHCD describes a planning district commission as a body politic, incorporated, "with the general powers of such bodies, including the right to adopt a common seal, sue and be sued, adopt by-laws, make and enter into contracts, or agreements, apply for and accept loans and grants of money or material or property from any private source..., exercise any power usually possessed by private corporations, employ personnel as deemed necessary, and carry out its responsibilities as prescribed by the Code."

Planning district commissions function "to promote orderly physical, social and economic development by planning and by encouraging and assisting local governments to plan for the future." However, commissions do not have vested in them the power to implement plans. Further, no action of a planning district commission supercedes the powers and duties provided to local planning commissions by law.

Each planning district commission is to prepare a comprehensive plan to guide development in the district. These plans reflect issues that are important to more than one of the governmental units within the district. Comprehensive plans are developed in cooperation with local governments and then submitted to local planning commissions for review. After a regional public hearing, the planning district commission approves or disapproves the plan. If approved, the planning district commission submits the plan to the governing body of each member government for final adoption. Adoption by a majority of the member governments effectuates the comprehensive plan with respect to all actions involving the planning district commission (Va. DHCD 1979).

Status of local planning agencies within Virginia is depicted in Tables C-1 and C-2. Each agency at the level of town, city and county may be categorized via the following criteria: planning district commission membership, adoption of subdivision regulations, adoption of zoning regulations, submission of a comprehensive plan, availability of a professional staff (defined as employees whose

Table C-1

Status of Planning: Virginia Counties and Cities

COUNTIES	1 COMMISSION	2 STAFF	3 COMPREHENSIVE PLAN	4 ZONING	5 SUBDIVISION	6 PDC MEMBER	7 PLANNING DISTRICT NO.
Accomack	●			●	●	●	22
Albemarle	●	●	●	●	●	●	10
Alleghany	●			●	●	●	5
Amelia	●		●	●	●	●	14
Amherst	●		●	●	●	●	11
Appomattox	●		●		●	●	11
Arlington	●	●	●	●	●	●	8
Augusta	●	●	●	●	●	●	6
Bath	●		●	●	●	●	6
Bedford	●		●		●	●	11
Bland	●		●		●	●	3
Botetourt	●		●	●	●	●	5
Brunswick	●		●		●	●	13
Buchanan	●		●			●	2
Buckingham	●		●		●	●	14
Campbell	●				●	●	11
Caroline	●		●	●	●	●	16
Carroll	●		●		●	●	3
Charles City	●	●	●	●	●	●	15
Charlotte	●		●		●	●	14
Chesterfield	●	●	●	●	●	●	15
Clarke	●	●	●	●	●	●	7
Craig	●			●	●	●	5
Culpeper	●	●	●	●	●	●	9
Cumberland	●		●	●	●	●	14
Dickenson	●					●	2
Dinwiddie	●	●	●	●	●	●	19
Essex	●		●	●	●	●	18
Fairfax	●	●	●	●	●	●	8
Fauquier	●	●	●	●	●	●	9
Floyd	●		●		●	●	4
Fluvanna	●		●	●	●	●	10
Franklin	●		●		●	●	12
Frederick	●	●	●	●	●	●	7
Giles	●	●	●		●	●	4
Gloucester	●		●		●	●	18
Goochland	●	●	●	●	●	●	15
Grayson	●				●	●	3
Greene	●	●	●	●	●	●	10
Greensville	●	●	●		●	●	19
Halifax	●	●	●	●	●	●	13
Hanover	●	●	●	●	●	●	15
Henrico	●	●	●	●	●	●	15
Henry	●	●	●		●	●	12
Highland	●			●	●	●	6
Isle of Wight	●	●	●	●	●	●	20
James City	●	●	●	●	●	●	21
King George	●		●	●	●	●	16
King and Queen	●				●	●	18
King William	●		●	●	●	●	18
Lancaster	●		●	●	●	●	17
Lee	●	●		●	●	●	1
Loudoun	●	●	●	●	●	●	8
Louisa	●			●	●	●	10
Lunenburg	●		●		●	●	14
Madison	●		●	●	●	●	9
Mathews	●		●		●	●	18
Mecklenburg	●		●		●	●	13

COUNTIES	1 COMMISSION	2 STAFF	3 COMPREHENSIVE PLAN	4 ZONING	5 SUBDIVISION	6 PDC MEMBER	7 PLANNING DISTRICT NO.
Middlesex	●		●		●	●	18
Montgomery	●	●	●	●	●	●	4
Nelson	●		●	●	●	●	10
New Kent	●	●	●	●	●	●	15
Northampton	●	●	●	●	●	●	22
Northumberland	●		●	●	●	●	17
Nottoway	●		●	●	●	●	14
Orange	●		●	●	●	●	9
Page	●		●		●	●	7
Patrick	●		●		●	●	12
Pittsylvania	●		●		●	●	12
Powhatan	●	●	●	●	●	●	15
Prince Edward	●		●		●	●	14
Prince George	●	●	●	●	●	●	19
Prince William	●	●	●	●	●	●	8
Pulaski	●	●	●		●	●	4
Rappahannock	●			●	●	●	9
Richmond	●		●		●	●	17
Roanoke	●	●	●	●	●	●	5
Rockbridge	●	●	●	●	●	●	6
Rockingham	●	●	●	●	●	●	6
Russell	●		●		●	●	2
Scott	●	●	●		●	●	1
Shenandoah	●		●	●	●	●	7
Smyth	●		●		●	●	3
Southampton	●	●	●	●	●	●	20
Spotsylvania	●	●	●	●	●	●	16
Stafford	●	●	●	●	●	●	16
Surry	●	●	●	●	●	●	19
Sussex	●		●		●	●	19
Tazewell	●		●		●	●	2
Warren	●		●	●	●	●	7
Washington	●		●	●	●	●	3
Westmoreland	●		●	●	●	●	17
Wise	●	●			●	●	1
Wythe	●	●	●		●	●	3
York	●	●	●	●	●	●	21

CITIES	1 COMMISSION	2 STAFF	3 COMPREHENSIVE PLAN	4 ZONING	5 SUBDIVISION	6 PDC MEMBER	7 PLANNING DISTRICT NO.
Alexandria	●	●	●	●	●	●	8
Bedford	●		●	●	●	●	11
Bristol	●	●	●	●	●	●	3
Buena Vista	●		●	●	●	●	6
Charlottesville	●	●	●	●	●	●	10
Chesapeake	●	●	●	●	●	●	20
Clifton Forge	●		●	●	●	●	5
Colonial Heights	●	●	●	●	●	●	19
Covington	●		●	●	●	●	5
Danville	●	●	●	●	●	●	12
Emporia	●		●	●	●	●	19
Fairfax	●	●	●	●	●	●	8
Falls Church	●	●	●	●	●	●	8
Franklin	●	●	●	●	●	●	20
Fredericksburg	●	●	●	●	●	●	16
Galax	●		●	●	●	●	3
Hampton	●	●	●	●	●	●	21
Harrisonburg	●	●	●	●	●	●	6
Hopewell	●	●	●	●	●	●	19
Lexington	●		●	●	●	●	6
Lynchburg	●	●	●	●	●	●	11
Manassas	●	●	●	●	●	●	8
Manassas Park	●	●	●	●	●	●	8
Martinsville	●	●	●	●	●	●	12
Newport News	●	●	●	●	●	●	21
Norfolk	●	●	●	●	●	●	20
Norton	●	●	●	●	●	●	1
Petersburg	●	●	●	●	●	●	19
Poquoson	●		●	●	●	●	21
Portsmouth	●	●	●	●	●	●	20
Radford	●	●	●	●	●	●	4
Richmond	●	●	●	●	●	●	15
Roanoke	●	●	●	●	●	●	5
Salem	●	●	●	●	●	●	5
South Boston	●		●	●	●	●	13
Staunton	●	●	●	●	●	●	6
Suffolk	●	●	●	●	●	●	20
Virginia Beach	●	●	●	●	●	●	20
Waynesboro	●		●	●	●	●	6
Williamsburg	●	●	●	●	●	●	21
Winchester	●	●	●	●	●	●	7

Table C-2

Status of Planning: Virginia Towns

TOWNS	1 COMMISSION	2 STAFF	3 COMPREHENSIVE PLAN	4 ZONING	5 SUBDIVISION	6 PDC MEMBER	7 PLANNING DISTRICT NO.
Abingdon	●			●	●	●	3
Accomac				●			22
Alberta	●		●		●		13
Altavista	●		●	●	●		11
Amherst	●		●	●	●		11
Appalachia	●		●	●	●		1
Appomattox	●		●	●	●		11
Ashland	●		●	●	●	●	15
Belle Haven	●			●			22
Berryville	●		●	●	●		7
Big Stone Gap	●	●	●	●	●	●	1
Blacksburg	●	●		●	●	●	4
Blackstone	●			●	●	●	14
Bloxom							22
Bluefield	●		●	●	●	●	2
Boones Mill							12
Bowling Green	●		●	●	●		16
Boyce	●		●		●		7
Boydton	●		●	●	●		13
Boykins	●			●	●		20
Branchville							20
Bridgewater	●		●	●	●		6
Broadway	●			●	●		6
Brodnax	●		●		●		13
Brookneal	●			●	●		11
Buchanan	●		●	●	●		5
Burkeville	●						14
Cape Charles	●			●	●		22
Capron	●			●			20
Cedar Bluff	●		●				2
Charlotte C. H.	●				●		14
Chase City	●			●	●		13
Chatham	●			●	●		12
Cheriton	●	●					22
Chilhowie	●		●	●	●		3
Chincoteague	●			●			22
Christiansburg	●		●	●	●	●	4
Claremont	●			●	●		19
Clarksville	●		●	●	●		13
Cleveland			●				2
Clifton				●	●		8
Clinchport							1
Clintwood							2
Clover	●				●		13
Coeburn	●			●	●		1
Colonial Beach	●		●	●	●		17
Columbia				●			10
Courtland	●			●			20
Craigsville				●			6
Crewe	●		●	●	●		14
Culpeper	●	●	●	●	●		9
Damascus	●				●		3
Dayton	●	●	●	●			6
Dendron	●				●		19
Dillwyn	●		●	●	●		14
Drake's Branch	●						14
Draper							4
Dublin				●			4
Duffield							1
Dumfries	●			●	●		8
Dungannon							1
Eastville	●	●					22
Edinburg	●		●		●		7
Elkton	●			●	●		6
Exmore	●	●					22
Farmville	●		●	●	●	●	14
Fincastle	●						5
Floyd	●		●		●		4
Fries	●				●		3
Front Royal	●		●	●	●	●	7
Gate City							1
Glade Spring	●		●	●	●		3
Glasgow	●		●	●	●		6
Glen Lyn							4
Gordonsville	●		●	●	●		9
Goshen							6
Gretna	●		●	●			12
Grottoes	●		●	●			6
Grundy	●		●				2
Halifax	●		●	●	●		13
Hallwood							22
Hamilton	●		●	●	●		8
Haymarket	●			●	●		8
Haysi							2
Herndon	●	●	●	●	●	●	8
Hillsboro	●			●			8
Hillsville	●		●		●		3
Honaker			●				2
Hurt	●		●	●			12
Independence	●		●	●	●		3
Iron Gate	●			●			5
Irvington	●		●	●	●		17
Ivor	●						20
Jarratt	●		●	●	●		19
Jonesville	●			●	●		1
Keller							22
Kenbridge	●		●	●			14
Keysville	●			●	●		14
Kilmarnock	●		●	●	●		17
LaCrosse	●			●	●		13
Lawrenceville	●			●	●		13
Lebanon			●				2
Leesburg	●	●	●	●	●	●	8
Louisa	●			●	●		10
Lovettsville	●		●	●	●		8
Luray	●		●	●	●	●	7
Madison	●			●			9
Marion	●		●	●	●	●	3
McKenney	●			●	●		19
Melfa							22
Middleburg	●		●	●	●		8
Middletown	●		●	●	●		7
Mineral	●			●			10
Monterey			●	●	●		5
Montross	●			●			17
Mount Crawford	●	●		●	●		6
Mount Jackson	●		●		●		7
Narrows	●			●	●		4
Nassawadox	●	●					22
New Castle					●		5
New Market	●		●	●	●		7
Newsoms	●			●			20
Nickelsville	●						1
Occoquan	●			●	●		8
Onancock	●			●			22
Onley	●			●			22
Orange	●		●	●	●	●	9
Painter	●						22
Pamplin City	●		●				11
Parksley	●			●			22
Pearisburg	●			●	●		4
Pembroke	●			●			4
Pennington Gap							1
Phenix	●				●		14
Pocahontas			●				2
Port Royal	●		●				16
Pound	●			●	●		1
Pulaski	●		●	●	●	●	4
Purcellville	●		●	●	●		8
Quantico	●			●	●		8
Remington	●			●			9
Rich Creek	●			●	●		4
Richlands	●		●	●	●	●	2
Ridgeway							12
Rocky Mount	●		●	●	●	●	12
Round Hill	●		●	●	●		8
Rural Retreat	●			●	●		3
Saltville	●			●	●		3
Saxis							22
Scottsburg	●			●	●		13
Scottsville	●		●				10
Shenandoah	●		●	●	●		7
Smithfield	●			●	●		20
South Hill	●		●	●	●	●	13
Stanardsville	●		●				10
Stanley	●		●		●		7
Stephens City	●		●	●	●		7
St. Charles							1
St. Paul	●		●	●	●		1
Stony Creek	●				●		19
Strasburg	●		●	●	●		7
Stuart	●						12
Surry	●				●		19
Tangier	●						22
Tappahannock	●		●	●	●		18
Tazewell	●		●	●	●	●	2
The Plains	●		●	●	●		9
Timberville	●			●	●		6
Toms Brook							7
Troutdale	●				●		3
Troutville	●			●			5
Urbanna	●		●		●		18
Victoria	●		●	●	●		14
Vienna	●	●	●	●	●	●	8
Vinton	●		●	●	●	●	5
Virgilina							13
Wachapreague							22
Wakefield	●						19
Warrenton	●	●	●	●	●	●	9
Warsaw	●		●	●	●		17
Washington				●			9
Waverly	●		●		●		19
Weber City					●		1
West Point	●		●	●	●		18
White Stone	●			●	●		17
Windsor	●			●	●		20
Wise	●			●	●		1
Woodstock	●		●	●	●		7
Wytheville	●		●	●	●	●	3

primary responsibility is planning), and the establishment of a planning commission.

Appendix D

REMOTE SENSING APPLICATIONS AT VARIOUS LEVELS OF PLANNING

Any program aimed at increasing the utilization of remote sensing techniques by planners must include as a major component the justification of remote sensor applications to planning related problems and information needs. The following discussion addresses such applications, beginning as a general overview of the field of remote sensing then progressing to detailed analysis of information categories and case study applications (Appendix E).

THE INVENTORY PROCESS AND REMOTE SENSING

Public concern over the preservation of agricultural land, the haphazard expansion of urban areas, and the misuse of land resources, have begun to generate pressure for land-use plans which accurately portray present and future patterns of use. Meaningful, intelligent planning, policy formulation and decision making require much qualitative and quantitative information. Without a solid information base, the planning process is often reduced to guesswork (Tessar *et al*. 1975).

For the inventory phase of areal analysis, several alternatives are available in the collection of land related information. These are: (1) ground observation; (2) enumeration; (3) airphoto interpretation; (4) remote sensing; and (5) a combination of the above. Increasingly, many inventories and surveys are being carried out by using varying combinations of the basic approaches listed above. Generally, a critical question is posed: What single approach or combination of data collection techniques will yield the most data of the type needed, at the least cost, under the constraints which are present?

The costs of acquiring most types of data are relatively high. Remote sensing techniques can provide demonstrable reductions in the costs of data acquisition for some types of resource information. One of the principal areas where the potential application of remotely sensed data is being developed is in the generation of land-use data.

The NASA Resources Program has greatly benefited information gathering programs. The synoptic, repetitive coverage of high resolution sensors has made the collection, analysis, and dissemination of comprehensive land-use data, practical and cost-effective for the first time. Planners and decision makers can now utilize at least three NASA information sources for data inputs: (1) satellite data in digital and photo formats to provide statewide and/or regional coverage; (2) high-altitude photography for more detailed large area analysis and ground truth; and (3) low-altitude photography for detailed small area analysis in selected and critical areas. NASA and other programs have been developed with the goal of providing detailed, accurate land-use and natural resource information to improve and support governmental decision making, the comprehensive planning process, and state and local land-use planning and policy formulation.

PHOTOGRAMMETRY AND REMOTE SENSING DEFINED

Research indicates that remote sensing is beginning to play a role in the planning-decision making process and will continue to do so, provided high standards of accuracy can be achieved and costs to users can be reduced.

Numerous definitions of photogrammetry and remote sensing can be located in the literature. Part of the reason for the variety of definitions is the advancing "state-of-the-art" of technology found in the field. A recent definition can be found in the August issue of the Journal of Photogrammetric Engineering and Remote Sensing. The Journal states (Amer. Soc. Photogram. 1980):

> Photogrammetry is the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena.

The Journal elaborates further by stating:

> A recent important application of photogrammetry is called remote sensing in which imagery is acquired with a sensor other than (or in addition to) a conventional camera through which a scene is recorded, such as by electronic scanning, using radiations outside the normal visual range of the film and camera ...[5]

The use of aerial remote sensing data offers unique advantages for preparing inventories of importance to planning/management functions.

Remote sensing imagery provides a broad view of an area and depicts conditions existing at a given time. These conditions indicate the interrelationships between climate, geology, cultural, environmental and other factors that are of value in attempting to evaluate problems or the impact of proposed plans. Remote sensing provides a method for delineating changes occurring in an area by comparing sequential aerial coverage. Remote sensing also provides a common base for comparison of analysis prepared by investigators of various disciplines in a coordinated planning effort (Rib 1975).

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[5]Amer. Soc. Photogrammetry. 1980. What photogrammetric engineering and remote sensing is. Photogram. Eng. and Remote Sensing. vol. 46, No. 12. Falls Church, Va., p. 1489.

REMOTELY SENSED DATA TO AID THE DEFINITION OF REGIONS

The major types of jurisdictional inventories utilizing remote sensing data include: (1) inventories of constructional materials; (2) preparation of regional engineering soils maps and terrain evaluations; (3) regional slope-stability evaluations; (4) inventories of drainage networks and watershed areas; (5) land-use and natural resource inventories; and (6) regional urban analyses (Rib 1975).

Data acquisition for the purpose of studying intra- and interrelationships of planning units has been limited to a few conventional sources, all of which have been demanding of time and finances and limited to relatively small planning units. No definite methods exist for identifying, describing or explaining regions of different types. Recently, a few investigators associated the similarities of some steps taken in the scientific method and the process of regionalization (Colwell 1975, and Peplies and Keuper 1975).

The regional concept is characterized by some unique temporal relationships. In general, the regional concept follows interest in environmental-conservation (man-land relationships) concerns. The classic Greek era was a period of topical studies of the nature of earth processes.

The Grecian period was followed by the period of the Roman scientist's concern for regional studies (Mumford 1961). Around 1900, increased environmentally oriented studies by scientists, laymen and politicians were evident. This environmental-conservation activity was then followed by the regional resource movement promoting the formation of organizations such as the Tennessee Valley Authority. These activities lessened during the 1940's, 50's and early 60's, but in the late 1960's environmentalism once again attained a position of importance. This environmentalism was followed by a concern for regional activities, land-use mapping efforts and impact assessment programs.

For many different types of planning problems, remote sensing can provide some data inputs for the purpose of defining and explaining the content, organization, relationships and processes of different areas on earth. Since air photos became available for local, regional and nation-wide areas, they have been utilized as a major source for organizing the nation into relatively homogeneous units. Many geologic, vegetative, soil, climatic, and physiographic regions are of this type.

The regionalist approach to planning interfaces well with current remote sensing techniques. Most of the regional analysis research carried out has used the traditional sensors and large scale formats (e.g., low-altitude black and white photography). Investigators have found, however, that regional analysis can be carried out in an efficient and effective manner through the use of remotely sensed data from high-altitudes. Nunnally (1969), for example, was able to identify regions of similar tone and texture using low-resolution radar data which he was able to relate to areas of similar planning problems. Peplies and Wilson (1970) identified regions using the same method, but with Apollo-9 space photography, and Colwell (1973) successfully analyzed regions using Landsat-1 data of the central California area.

REMOTELY SENSED INFORMATION IN THE PHOTOMORPHIC PROCESS

The types of materials that can be examined from a regional and spatial point of view are many. Remote sensing serves as an effective technique for acquiring information about land and water resources. At least 10 different dimensions of land are recognized as important inventory items for use in regional analysis. These are (1) current use or activity; (2) intensity of use; (3) restrictions on use; (4) ownership; (5) quality of development; (6) public services; (7) natural and physical qualities; (8) financial value; (9) location; and (10) type of structure (Parrish 1975). Some of the latter cannot be analyzed by remote sensors. Others can only be partially analyzed.

The interaction of the spatial, physical and cultural landscape elements produce an identifiable unit called a photomorphic area. This image does not become immediately apparent until all of the elements (e.g., drainage patterns, field size and pattern, population factors) are taken into account and treated as a homogeneous areal unit. When different areas are compared on the basis of their photomorphic images, many isoteric details of each region are revealed. The value of relying upon the interpretation of the composite photomorphic image is that large unmapped areas can be described in detail and reduced to meaningful land system units with distinctive production and land-use attributes (Peplies and Keuper 1975).

The application of the photomorphic process to mapping, land-use analysis, land planning and other fields, are almost limitless. The process offers ecological perceptions rarely available even in detailed field analysis, because the interpreter can view objectively many of the relationships of environmental importance. Planners at urban, county, state, regional or national levels can rely on photomorphic information because the entire character of the landscape is well defined for them. They have a unique tool for handling the range of problems from land-use and its environmental impact, to related problems such as natural hazards. Physical, biological, agricultural, and social systems all contribute to the composition of the photomorphic units. With more efficient definition and evaluation of inherent problems in the landscape, possible solutions may be more easily addressed.

The photomorphic area can become a useful diagnostic tool in several ways. It can be used as a framework for quantitative analysis because the areas are measurable planimetrically. Sample areas, randomly selected, may provide additional information not available from other sources. Also, the photomorphic areas can be used to correlate and analyze a variety of thematic maps in a given region, and to develop a hierarchy of regional units needed in environmental planning and problem solving. An example of the latter might involve relating present land-use characteristics with those of erosion patterns and land capabilities (Peplies and Keuper 1975).

The photomorphic process has proven not only highly reliable and accurate, it is also much faster than extensive, detailed field work, particularly for large areas. It is also a relatively inexpensive process from which to obtain imagery, data, data-interpretation and maps. This process seems most useful as a reconnaissance or regional technique for analyzing homogeneous spatial relationships (Peplies and Keupner 1975).

The basic tool for accomplishing the photomorphic interpretation is the imagery itself. There are many types available through a number of sources in the United States and abroad. Most familiar are the conventional 9 by 9-inch black and white vertical aerial photographs which have been developed for much of the United States. These are available from the U.S. Forest Service, the U.S. Geological Survey (EROS Data Center), and from many regional and metropolitan planning agencies in urbanized areas. Index mosaics (reduced composites of adjacent photos) for most United States imagery are available from the federal government and some sources in the private sector. There are some uncontrolled mosaics available through many private firms and planning agencies. Mosaics are often valuable in photomorphic analysis.

Some less conventional materials exist in the form of orthophoto maps and high-altitude and satellite imagery. The high-altitude, small scale images can usually be obtained from NASA, Sioux Falls, S.D. Satellite imagery from Gemini through Landsat is available from NASA and some private research companies such as IBM and Bendix Corporation. The orthophoto maps in existence have been completed for small areas, usually for experimental purposes, such as the coverage available for the Connecticut River Valley.

RELEVANCY AND TIMELINESS OF REMOTELY SENSED DATA/INFORMATION

The usefulness to the planner or decision-maker of accurate periodic data is evident: wise planning and management of resources requires the execution of the three-phase process -- inventory, analysis and implementation.

In the inventory phase, the amount and quality of each type of resource, in each portion of the area to be planned and managed, is determined. In the analysis phase, management decisions are made to allocate resources. Implementation of each decision made in the analysis phase is then attempted.

Public land-use decisions often are made with too little information about land-use options or without the long-run impact of alternative land-uses on the planning area (National Planning Committee 1976). In too many instances, planners lack basic information on land-use, soils, land productivity, vegetative cover, the suitability of land for special uses, land ownership, and other characteristics of the land-resource base. These factors, and many more, are important determinants of the economic, social, and environmental impacts of changes in land-use.

Modern planners have a great need for more accurate, up-to-date, comprehensive land-use data for several reasons: (1) the nation experienced a conscious revival of environmental concern which mandates wise planning/management of natural resources; (2) this consciousness has spurred legislation such as the Coastal Zone Management Act of 1972, Clean Air Act of 1970, Noise Control Act of 1972, Water Pollution Control Act of 1972 and the National Environmental Policy Act of 1969, which require detailed management strategies; and (3) population growth and land development continues.

Traditional methods of collecting, disseminating and manipulating data are rapidly becoming inadequate (Rado 1975). Consequently, remotely sensed data inventories should be viewed as a necessary input to a wide variety of on-going planning programs, current policy decisions, and land resource issues. The emphasis upon applications requires that the inventory be completed in a flexible geographic format, at a variety of scales, with both detailed and broad categories, and at times, in a machine processing system which permits high-speed, special purpose access to a variety of users (Rado 1975). Remote sensors have been applied widely to problems often faced by planners. Discussion of some of these applications follows.

General Applications

Hydrology

Hydrologic parameters are important in physical planning strategies because of their construction liabilities and because of their importance to fisheries, wildlife and water supply systems. Past is the day when construction and development proceed when wetlands are present.

The variety of wetland habitats offers unique remote sensing problems. Some wetland types (e.g., lakes, ponds and large streams) can be easily identified on all types of imagery. Others (e.g., marshes, wooded wetlands, shrub swamps and shallow inlets) require additional effort (e.g., low-altitude photography, special film/filter combinations, temporal series photography) to obtain acceptable results. The author has been involved in several wetland related studies (Batie and Niedzwiedz 1981, MacConnell and Niedzwiedz 1979, and MacConnell and Niedzwiedz 1973), the results of which indicate that some marshes, swamps and wooded wetlands cannot be accurately delineated without extensive field work.

At present there are at least three broad categories for utilizing remotely sensed data in hydrological-wetlands studies.

In the first category, simple qualitative observations are made. A visual observation that sedimentation is occurring in a stream as a result of a nearby construction site would be an example.

In the second category, geometric form, dimensions, patterns, geographic location and distribution are the types of information sought. Area, shape, length, as well as man-made features such as dams, represent information recorded. The quantitative analysis of a drainage basin and channel network, and the geographic location of fractures, faults, lineaments, etc., would fall into this category. Remotely sensed data often can be used to detect and map such features far better and more quickly than through ground-based methods (Meyer and Welch 1975).

In the third category, correlations are made between point measurements on the ground and some property of the remotely sensed data, such as the density level of some selected spectral band or the difference in the density level between two spectral bands. The distribution of this density level or difference in density levels provides a means of extrapolating the ground data in areal space. As an example, the density difference between several spectral bands on multispectral data may permit water depth to be mapped (Meyer and Welch 1975).

Numerous remote sensing studies have examined reflectance properties of soil-moisture content in the upper layers of the ground. The relationship between soil spectral reflectance and soil-moisture content was investigated by Myers and Heilman (1969), Ulaby (1974). Major results obtained by MacDowell were: (1) the moisture-reflectance relationship was influenced by even small variations in soil texture. With increasing content of fine soil particles, integral reflectance (specular plus diffuse) of the soil increased for all moisture levels, and the minimum reflectance occurred for increasingly higher moisture contents; (2) the integral reflectance of individual soil samples was fairly consistent in response to various moisture levels but there was a considerable variability among samples, even for the same textural class; (3) for every soil sample there were two different moisture contents with the same integral reflectance. Limited measurements of till and lacustrine parent materials suggested character of the moisture-reflectance relationship depends also on the nature of the parent material.

Water, being more heat conductive than soil, when added to soil will generally increase the conductive capacity of the soil. This causes an attendant decrease in the temperature range at the soil-air interface. Unfortunately, surface vegetation often masks the temperature range at the soil-air interface so that attempts to utilize thermal remote-sensor data as a means of observing the areal temperature change or distribution of an area have not been successful (Estes et al. 1977).

Burge et al. (1971) reported that thermal infrared data obtained of an irrigated area near Lake Moses, Washington, allowed them to develop a thermal model from which soil-moisture changes, caused by surface-moisture differences, were large enough to detect. From their work they stated that the largest temperature contrast between soils of different surface-moisture conditions occur in mid-afternoon. Finally, they stated that contouring of the thermal data successfully delineated regions of various moisture contents both quantitatively and qualitatively.

Lakes, Marshes and Swamps

Remote sensing applications to hydrological studies of lakes, marshes and swamps has been varied. For such purposes, elements of interest include shoreline, shape and location of islands, sand spits, bars, shoals and depth. Other factors of interest in the hydrology of wetlands that have been studied via remotely sensed data include surface temperatures, regions of spring inflow, water circulation, sources of pollutant input, and the mixing of polluted waters (_Aerial Applicator_ 1978, Benton _et al_. 1978, Carter 1978, and Chime _et al_. 1978).

An example of such application is the study of the biological setting for a portion of the Everglades and its relation to the hydrology of the area (Meyer and Welch 1975). The study points out that encroachment of man-made development along the edges of swamps and lakes can severely change the life span or cycle of a lake or swamp. The imagery used documented these changes.

Agricultural Land

Agricultural land has received an extensive amount of remote sensing research during the past decade. Researchers have shown that agricultural land can be delineated with varying degrees of success depending on the sensor being used (Badhwar 1980, Garcia 1980, Lathrop and Pennypacker 1980, and Ulaby _et al_. 1980).

Extensive research into crop discrimination via remote sensors in the Imperial Valley, California, and elsewhere, has led to the development of several methods to develop computer-oriented, land-use mapping systems. These methods use both single and multiple images. Research indicates that single image methods are less accurate than multiple image methods. Johnson _et al_. (1969) and Wiegand _et al_.

(1970) both found that plant height, percent ground cover, row direction, and salt-affected fields had effects on accuracy. Further, Johnson _et al_. (1969), Yost _et al_. (1970) and Anuta and MacDonald (1971), stress the need for good field observation.

Some of the problems inherent in single image techniques can be overcome through the use of temporal imagery. When coordinated with crop cycles, temporal imagery can provide greater identification accuracy and crop survey capabilities than can single season imagery. Multi-spectral (MSS) scanning devices have also enhanced remote crop identification. The MSS imagery assigns several wavelengths to each crop, thereby increasing the probability of correct identification.

Several choices of platform altitudes are available to the researcher, manager and decision maker, for all types of remote sensing work. These choices are: (1) ground level reconnaissance; (2) low-altitude aircraft (15-20,000 feet); (3) high-altitude aircraft (40-65,000 feet); and (4) satellite imagery.

From ground level, all of the surrogates of crops, except field size and shape, are detectable. Tone, crop pattern, plant size and shape, texture, and farming practices can be seen. "Windshield" surveys can be the most accurate identification method (Myers 1975).

The benefit of low-altitude imagery is the added dimension of field size and shape, as well as the relationship to other fields in the immediate area. At low-altitude, and with consequent high resolution, the distance between rows can be detected, a significant clue to the identification of many crops.

Low-altitude imagery is probably the best all-around imagery for crop identification from a single image. However, low-altitude imagery can become an "overkill" system that provides much more information than is needed for accurate interpretation. In such cases, the cost-benefit ratio soon becomes a limiting factor when compared to other available imagery (Meyer and Welch 1975).

Techniques for using aerial photographs to inventory livestock have been developed by Huddleston and Roberts (1968). Utilizing factors of film-filter combinations, photo-scale, season-of-year and time-of-day, animal inventories can be made.

Forest Vegetation

Foresters continue to be the largest single group of users of remotely sensed data. Foresters utilize various formats of photographs and imagery for many forestry related decisions. Historically, black and white panchromatic photography has been the forester's mainstay. However, the quality of color and color infrared (CIR) films has improved substantially over the past few years. The use of color photography for the purpose of forest land classificton is rapidly expanding. Becking (1959) determined that aerial color photography offered greater possibilities for mapping forest vegetation and soil types, and discriminating between tree species than conventional black and white photography. In addition, Becking found that accuracy increased with increases in large-scale on both types of film.

The concept of multiband photography, exploiting differences in tonal signatures of terrain objects as photographed in various portions of the electromagnetic spectrum, is not a new concept to managers responsible for classifying forest lands. Several recent studies have shown that, for vegetative-terrain type classification and tree species identification, interpretive results can often be improved using color multiband photography rather than standard black and white or color film formats (Colwell 1975).

Despite the fact that remote sensing from space is still in the experimental phase, it is possible to discuss the feasibility of classifying forest land using imagery obtained from earth-obital platforms. Avery (1976) has stated that one advantage of space imagery is the synoptic view provided, enabling any particular forest type to be seen relative to its surroundings. Possibly the most useful characteristic of the earth satellites is their ability to acquire multispectral imagery for the same place on Earth every nine days.

Although automated classification methods are applicable to satellite imagery, the present techniques can do no better than delineate hardwoods, softwoods and mixed forest categories (Bryant et al. 1980 and Thorley 1975). Consequently, if accurate data are needed, manual interpretive methods must be used. With manual methods and appropriate photo-image scales, forest areas can be delineated into forest stands grouped by species, height, and crown densities (MacConnell and Niedzwiedz 1973).

Physiographic Features

Topographic characteristics of land can be of prime importance in any site location problem. In many respects, remote sensing of ground relief is still in its infancy. Most literature on the subject is dated by 30 years. However, current interest has been shown in the use of digital terrain matrices, which digitally store elevation as a function of horizontal position. The topography of the entire United States has been digitized by the Defense Mapping Agency (DMA) from 1:250,000 scale topographic maps. Approximately two billion elevations at a spacing of 203 feet have been recorded on magnetic tape.

Users of DMA data have found that some of the data is not accurate. Unfortunately, one cannot judge the accuracy of the data unless it has been tested previously.

Slope, like topography, is lacking an effective, efficient automated technique of measurement. Most literature relating to slope is dated by 30 years and extremely basic in content (Moore 1947, and Hackman 1956). Presently there are a number of devices to measure slope of up to 30 degrees on conventional photography and some radar imagery. These devices are, however, manual.

Geology

Limited success has been achieved in interpreting bedrock materials with remotely sensed data. Radar has been used to delineate bedrock formations with some success. The low to medium-altitude sensors are of limited use for bedrock studies.

Wobber (1968) reported that rectified Gemini photographs, used as small-scale photomaps, facilitated tectonic studies. From the Gemini photos, an analytical sequence for reconnaissance can be developed for mineral exploration. Gemini photos did not prove effective tools for differentiating metamorphic and igneous rocks by type, but did prove that lithologic discrimination based on interpretation of small scale photography is difficult despite intensive analysis of density uniformity, orientation, and spatial distribution of fracture and drainage patterns. Wobber further suggested that even marginal success in lithological differentiation required increased levels of image detail.

Following analysis of small-scale Apollo-9 multiband imagery of southern Arizona, Wobber (1971) concluded that lithographic variations were most easily detected when they were expressed by variations in relief. Based on an analysis of comparative color versus multiband orbital imagery, small-scale multiband photographs were judged somewhat better than broad-band color imagery when viewed monoscopically. Wobber's studies further suggest that when the interpreter must depend on textural variations for lithological discrimination, multiband imagery is superior to color.

The extent to which radar can be applied successfully to geologic investigations varies considerably, depending on the geological and geomorphological character, climate, and especially vegetative cover in the study area (Reeves et al. 1975). Radar systems available on a commercial basis do not penetrate vegetation to any significant degree.

Outcrop patterns, drainage, vegetation, and landform structural configuraton are displayed on radar imagery as recognition elements which can include tone, texture, shape and pattern. It is largely the analysis of these four recognition elements on the radar imagery which contribute to interpretation of geologic data (Reeves et al. 1975).

The large area covered by one frame of satellite imagery, with near uniform lighting conditions, provides a synoptic view that aids in the identification and location of extensive structural and geomorphic features. This synoptic view also allows the interpreter to see the relationships between major terrain features, aiding in regional interpretation. Reeves et al. (1975) stated that large areal coverage cannot be obtained by the remote systems presently in use without a decrease in resolution. Space photography and imagery from the Landsat and Apollo-Gemini programs are poorly suited for small-area studies.

Soils

Black and white photographic interpretation has been the basic remote sensing method for various regional engineering soils investigations in the past. Because of the value of soils maps, extensive investigations have been conducted with a variety of remote sensing systems in an effort to increase the accuracy of interpretation of soil and terrain conditions and decrease the amount of field verification required.

The reflectance properties of minerals are determined largely by surface roughness, particle size, water film, contaminants, dust, dew, and physical discontinuities occurring on the surface of the objects of interest. Using these features, Hovis (1966), established that infrared reflectance spectra of minerals of the carbonate, sulphate, nitrate, and silicate families exhibit spectral absorption band patterns that can be detected by remote sensors. Studies of reflectance of minerals have been performed by Lyon (1965) who developed infrared techniques for analyzing the composition of soils. In Lyon's work, samples were analyzed by traditional mineralogical means and then spectral signatures were established for rocks and soils in the 8um to 13um (micrometers) wavelength region. By matching the incoming spectrum with standard curves in the memory of a computer, the bulk composition of the rock surfaces can be established.

Johannsen and Baumgardner (1968) suggested that soil texture or the amount of different soil particles present appear to have an influence on spectral response. Al-Abbas et al. (1972) have also shown a relationship between multispectral response and clay content of surface soils. Research results indicate that multispectral analysis and pattern recognition techniques may be used to delineate and map gross textural differences in surface soil.

Organic matter and iron compounds in soils have a significant influence on soil color. Kristof and Zachary (1971), and Baumgardner et al. (1970), used multispectral data and computer implemented analysis to delineate and map five different ranges of organic matter content for mineral soils. Prairie, forest, and transitional soils were included in their study.

Urban Land Use

Besides the overriding importance of aerial photography as the principal information backdrop for physically planning a city or town, there are many particular studies, conclusions and decisions which are greatly facilitated or extended by aerial photographs.

Many urban problems have been and are being solved with the aid of remotely sensed data (MacConnell and Niedzwiedz 1973, and Gray et al. 1973). Most of these applications involve conventional sensors. Not a great deal of research has been completed using the more recent remote sensing techniques to assess urban land-use problems.

Uncontrolled urban growth can seriously damage the quality of both the physical and human environment of a region. Monitoring urban growth is a requirement of sound management technique.

An important avenue of remote sensing research is the continuing investigation of industrial air and water pollution. It becomes critical to monitor the micro-effects of sources of air pollution (thermal and particulate) in the local heat budget as a result of industrial concentration. Chisnell and Cole (1958) showed that each industry has a specific signature which results from its spatial arrangement of raw materials, buildings, equipment, end-products and waste products.

Industries can be grouped into three major categories; (1) extractive, (2) processing, and (3) fabrication. Certain types of industries are thought of as "clean." However, Barringer et al. (1968) proved that even so-called "clean" industries can be a serious threat to the environment. Using a correlation spectrometer, a variety of pollutants were measured from airborne and orbital altitudes. The tests clearly demonstrated the ability of various sensors to detect sulphur dioxide and nitrogen dioxide using solar energy reflected from the earth's surface. These gases are in the invisible portion of the electromagnetic spectrum.

A study sponsored by the U.S. Environmental Protection Agency produced a technique for systematically assessing the potential for spills of oil and other hazardous materials in industrialized areas (Welch et al. 1972). The technique uses small-scale color IR photography for regional surveys followed by large-scale color photography of selected areas identified on small-scale coverage as warranting further study because of proximity of industrial areas to waterways.

Remote sensing is not a method for solving the problems of housing, commercial development or residential quality, but does have considerable potential for being a continuing aid to inquiries of these problems. CIR transparencies have proven superior to any other sensor imagery (multispectral, color, side-looking airborne radar, or thermal infrared) for the above types of studies (Mullens 1969). However, for urban evaluations on a practical basis, conventional panchromatic (B and W) photography remains the cheapest and most widely used (Mullens 1969).

The use of high-altitude photography is an excellent, and perhaps optimum, method for detecting urban land change. Not only can the method produce possible savings in time and money over alternative low-altitude aircraft and ground based methods, but it can do so while simultaneously providing high-quality data. Bowden (1975) stated however, that the resolution needed for delineation in heavily urbanized areas cannot be obtained with high-altitude photography. Bowden also stated that a one-hectare-or-less minimum parcel size is required, which is not obtainable with high-altitude imagery.

A further recommendation by Bowden is the use of CIR photography for urban land-use change detection because it reveals ground scarring more readily than other films.

Transportation

Low to medium-altitude photography is highly suitable for transportation planning needs including railroads, airports, streets, highways and parking areas. The author personally used black and white film at the scale of 1:20,000 in a Massachusetts land-use study and experienced little difficulty delineating the above types (MacConnell and Niedzwiedz 1973).

The transportation system is completely displayed, except for a few places where it is underneath overhead structure or landform: primary network of vehicular and other circulation, local street system, alleys and driveways providing access to private properties, often even informal pedestrian movement across vacant lots and other open ground. Particular parking provisions and spaces for the individual dwelling unit, workspace, shopping center, strip commercial areas, and recreation sites are shown to the point of accurate measurement within several percent.

Traffic movement is often shown by oil-spotting of the street surface. Other transportation facilities such as railroads with their terminals and marshalling yards, airports, and harbor works, are also shown clearly as urban subsystems, and in considerable detail.

Studies of gasoline stations (Rib 1975) are made quickly with aerial photographs which show their exact location and number, their relation to traffic-ways and their locational determinants, and the changes in adjoining and nearby land-use which such dwellings so often trigger or aggrevate.

Simonett <u>et al</u>. (1969) used Apollo-6 photographs to study the transportation network in the Dallas-Fort Worth area. The system was aimed at systematically documenting the potential of space photography in detecting and identifying the road network which is used to organize the geographic area. As a further objective, the study aimed at discovering how road width, surface type, topography, land-use and linearity affect road visibility. The study indicated that space photography with a resolution of 300 feet, would be difficult to use for accurate road delineation.

Summary

Materials presented within this appendix portray the utility of currently available remote sensing techniques. Discussion indicates that the breadth of application has been wide, often encompassing problems encountered by planners.

Appendix E

AN ANALYSIS OF REMOTE SENSING APPLICATIONS PROJECTS

Discussion in Appendix D presents problem areas of a broad and general nature. The reader should be able to conclude that remote sensing techniques have a wide range of application, both actual and potential. As stated earlier, some planners and planning agencies have developed and applied coordinated data/information gathering projects that were partially or wholly dependent upon remote sensing techniques. A discussion of some of these applications follows.

LOCAL APPLICATION

Elgin, Illinois is located approximately 40 miles west of Chicago. Elgin is a rapidly developing city of 63,600 people. The city serves as a "bedroom" community to Chicago; occupies 18.66 sq. mi. (48.3 sq. km) of land area; and is partially located in the floodplain of the Fox River and its tributaries (Civil Engineering 1976).

Elgin has been experiencing problems similar to those experienced by countless other American cities and towns: jurisdictional boundaries are changing constantly as a result of annexation; population continues to expand;

demands on land resources, facilities and services continue to rise; and, higher costs coupled with ever shrinking budgets make the mission of government and planning agencies alike, more difficult.

Photomap/USGS and Field Survey Maps: A Comparison

Longstanding Elgin city regulations mandate the submission of topographic maps for every major construction project. Also required of course, are the plans and cost estimates for each project. Prior to city ownership of topographic maps (the theme of this case study report), responsibility for map production fell upon the contractors and/or consultants. Often, a variety of maps accompanied project plans, e.g., USGS maps, or individually produced maps via contract. Though USGS maps do provide particular advantages, they do have 10 ft. (3 m) contours, and as stated in the study report, "do not provide the precise contour data required for most municipal projects."

An alternative to USGS quandrangles are field survey maps. These are however, very costly to the city because higher consultant fees are passed on, and, there is a considerable loss of time. Because of the high cost of such surveys, the surveys are limited to the definitive boundaries of the project at hand. Outlying areas are not analyzed, therefore, an opportunity to guage future potential problems is lost. As outlined in the project report, an example of this drawback would be the design and construction of a sewer depth for a housing development to be annexed to the city. At a future date, a second development on the outer edge of the first, but at a lower elevation, might require the city to construct a costly lift station to tie into the existing sewer lines.

Recognizing that a comprehensive topographic map would eliminate many of these problems, the Elgin Community Development and Public Works departments recommended that the City purchase a unique mapping system. Labeled Topo-Plan, the system consists of an aerial photo base map of the city and surrounding environs, and a transparent contour overlay. The contour overlay was designed specifically for urban usage. The overlay does not delineate the positioning nor dimensions of existing buildings but does delineate two foot (.61 m) contours, elevations and limited planimetric detail. Incremental base map updating of major areas (e.g., industrial or residential development) is accomplished via new aerial photo base maps.

Benefits -- Time and Cost Savings

Topo-Plan has proven to be a substantial aid to city planners, consultants and developers. To increase coordination of data bases, consultants affiliated with city projects are given a set of appropriate maps for each project. Further, independent developers are permitted to purchase appropriate maps from the city at considerable savings over their previous costs for field survey maps. Other benefits derived from Topo-Plan include:

- Substantial savings in time for the city, consultants, and developers because it is no longer necessary to wait for field surveys for each project;
- Each project results in a savings in cost since the need for expensive field surveys has been greatly reduced. In projects designated to consultants, these savings are passed on to the city in the form of lower consultant fees;
- Increased resolution of the two foot contour interval maps has helped the city and their consultants avoid costly errors that might have resulted had the 10 ft. contour interval maps (USGS) been used;

- The Topo-Plan maps provide a comprehensive "overview" of the city and surrounding areas which may be annexed to the city in the future. This permits the study of the effect current projects will have on other areas and future projects, an advantage not possible with field surveys of small areas for individual projects;

- Developers have gained the advantage of the Topo-Plan map usage for site improvement, drainage and water line routing. Better data should result in more effective site procedures;

- All plans submitted by developers are consistent with other city records because they are based on a common mapping system;

- The Topo-Plan maps are made to the same scale as the city's property line maps. This allows the property line maps to be overlaid on the aerial photo base map. The above allows for an efficient assessment of new improvements or changes on property. Further, streets, alleys and other rights-of-way are always evident on property line maps. The construction status of these rights-of-way therefore, can be efficiently checked. Previously, such checks had to be made by field visits of city employees. This costly and time-consuming task has been replaced by an efficient office system;

- The maps are used at city council meetings as a visual aid in discussing plans and projects located within the city. Aerial photography is more easily understood by people unfamiliar with engineering mapping.[6] The increased cognizance facilitates presentations to both city officials and the general public; and,

- The new Topo-Plan has represented a significant dollar savings for taxpayers.

Applications

The Topo-Plan system has become an integral component of the city's information storage and retrieval system. The system has been implemented successfully in a wide variety of applications by city officials, their

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[6]The author would like to note that in an application of aerial photography to tax assessment of property in Petersham, Massachusetts, many citizens who were quite familiar with maps, having grown up with them, were often confused when observing enlarged aerial photographs. The increased detail of aerial photos, a boon to skilled interpreters, often confused the lay-person.

consultants, by private contractors and developers. The following represent a partial listing of Topo-Plan applications.

- City Master Plans: Topo-Plan maps are used by the Elgin Planning Commission as a component of the city's master plan.

- Zoning and Land Use: Topo-Plan maps are used by the city's Zoning Administrator and planning staff to review zoning and subdivision proposals.

- Storm Sewer and Street Improvement Projects: Consultants used the maps for all preliminary design work for these projects.

- Landfill Projects: The Urban Development Department used the maps to determine the potential location of a sanitary landfill project.

- Sanitary Sewer Expansion Projects: City personnel used the maps for preliminary planning of additional sanitary sewers.

- Highway Improvement Projects: The Illinois DOT used Topo-Plan maps in conjunction with their own maps for the improvement of State Highway 19 within the city limits of Elgin.

- Water Source Location Project: Consultants used the maps to locate additional sources of surface and deep well water for the city. In conjunction with this project, the maps were also used to plan the expansion of the city's water treatment plant.

- Subdivision Sanitary Sewer Project: Consultants used the maps to determine sewer routing and depth-of-cut required in a subdivision project.

- Flood Plain Identification Project: Topo-Plan products were used to identify floodplain areas and for zoning within these areas. They were also used for application to the HUD Flood-Insurance Program and for verification of requested changes in the less accurate HUD maps.

- Watershed Analysis: In connection with a consultant authored storm water run-off study, Topo-Plan maps were used early in the planning process to determine and rank potential reservoir sites.

Collection and Analysis of Housing and Urban Environmental Data

Los Angeles, like most cities, faces the substantial task of developing and maintaining information files describing urban conditions. One of the key problems restricting efficient and ordered growth management of cities is the inability of planners/managers to obtain adequate, relevant and timely information concerning the condition of their cities. For Los Angeles in particular, members of the Community Analysis Bureau (CAB) have determined that additional detailed information about urban blight and obsolescence, urban growth and decay patterns, and urban land usage is necessary to upgrade the planning/decisionmaking effort at various levels of government (Joyce 1974). The bureau has surmised that with such information, planning agencies could develop and implement plans that would "best stimulate desirable urban growth patterns." Further, the bureau notes that the development of urban blight conditions could be identified, and suitable actions could be employed to control the conditions.

Developing an urban data base that meets the requirements of city planning is a difficult process. Conventional data gathering methods are both time and financially consuming. Conventional techniques often require ground observation strategies to identify and catalog every parcel of land within an urban jurisdictional area. Obviously, costs vary according to size and scope of the project. However, with cities of the size of Los Angeles, approximately one million land use parcels, comprehensive field surveys are prohibitively expensive.

Approach to the Los Angeles Problem

The development of a comprehensive data base and subsequent analysis, program recommendation and evaluation are critical components of the Los Angeles CAB approach. Because of the dynamic nature of urban areas, any urban data base must address the requisites associated with such dynamic processes: namely, the data base must include accurate and appropriate data; these data must be easily accessible; and, these data must be easily updated. Such criteria accentuate the importance of developing data gathering procedures that are economical.

Exposed to past and continuing remote sensing research and applications to urban planning problems (including National Aeronautics and Space Administration -- NASA research), the Los Angeles CAB began its evaluation of remote sensing techniques to meet the city's data collection/analysis problems. The CAB quickly identified the potential of existing remote sensing techniques to be high, and an "attractive alternative to present urban data gathering techniques." The CAB identified a photographic system using color infrared film (CIR) as the sensor best suited to meed the requirements of their city. The CAB based this decision on the fact(s) that CIR:

- is being increasingly utilized in urban land use studies;
- has been used to identify general land use information;
- has been used to produce detailed urban information, e.g., estimation of existing square footage of building space, estimation of urban blight conditions; and,
- appears to be cost-effective.

Further, the CAB found that:

- using proven methods of interpretation, CIR photography is able to provide more detailed and accurate urban land use data than can any other available system;
- the number of man-hours required to produce land use data from CIR photography is substantially less than for existing field survey methods;

- CIR photography appears to offer significant advantages when factors of timeliness, flexibility and reliability of information are considered in relation to the cost of acquiring the data; and,
- the photographic format obtained at some vertical distance from the area(s) to be studied provides a comprehensive perspective not available via other existing methods.

CAB Program Elements

The initial step of the Community Analysis program was to obtain CIR photography of the Los Angeles area. Total city coverage at a photographic scale of 1:10,000 was contracted in 1971 for less than $15,000. This figure represents a small fraction of the estimated one million dollar cost[7] assigned to field survey methods for extracting the same type of data. Costs approaching that figure would, of course, be prohibitive. Although parameters of staff (individuals assigned, education, interpretive skills) could not be determined from the report, it was reported that interpretation of the aerial photographs was conducted primarily by members of the CAB staff in order to enhance

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[7]CAB staff estimated that a "per parcel" cost for field survey methods would be slightly over $1.00.

the production of a workable data base for the city.

Results of the project indicate that the 1971 CIR aerial photography has provided an accurate, up-to-date source of urban information. Comparison of data developed via the CAB project with 1970 Census Bureau information suggests that CAB project data are superior. Problems associated with this approach to the generation of urban data, however, include the integration of photo produced data with existing urban data files. CAB officials suggest that only when data captured on the aerial photographs are machine readable and transferrable to existing data files, can these data be used most effectively in the development, design and implementation of programs aimed at problems of the city.

Joyce states that individual components of the city government have met their data requirements with the CIR developed data base. Joyce notes as examples, that the Community Analysis Bureau has produced "vital" information on housing and other environmental conditions within communities of the city; that other units have developed essential data to meet their input requirements; and, that the Southern California Regional Information Study (SCRIS) and the Los Angeles City Planning Department have used the CIR photography to satisfy their data requirements. Though no figures accompanied Joyce's discussion, it can be assumed that cost-effectiveness parameters were positive in all reported cases.

<u>Data Elements Delineated</u>

The Los Angeles Community Analysis Bureau has reported the following elements as identifiable with CIR photography and the interpretive techniques administered by the CAB staff.

Land Use

Very accurate down to the second digit of the Southern California Association of Governments' (SCAG) classification system.

Some information down to the fourth digit of the SCAG's classification system.

Transportation Network

Pavement type
Pavement width
Pavement condition
Street pattern
Street traffic
Alley width
Alley condition

Open Space

Type (park, golf course, cemetary, vacant, right-of-way, etc.)
Areal description of land
Condition of vegetation (if present)
Degree of landscaping

Housing Inventory

Trailer parks
Type of dwelling unit (multiple or single family)
Number of dwelling units (approximate)
Age of housing (by surrogate analysis)
Dwelling size
Housing condition/quality (by surrogate analysis)

Parcel Inventory

Parcel area
Percent coverage by structures
Percent lot landscaped
Presence of front, back and side yards
Presence of convenience structures (swimming pools, patios, courtyards, etc.)
Presence of parkway, sidewalk, curb, walkways

Community Facilities

Presence of overhead utilities (street lights, telephone poles, powerlines, etc.)
Schools and colleges
Churches
Hospitals
Storm drainage channels
Sewage treatment plants
Power stations
Public buildings (city hall, libraries, administrative buildings)
Reservoirs

Interpretation of CIR Photo Base

The degree of difficulty experienced in the interpretation of aerial photographs follows a continuum. Basically, the degree of difficulty is often defined by the type(s) of land uses captured on the aerial film. Natural land uses (wetlands, forest, etc.) because of their irregular and, at times, poorly defined boundaries, provide the interpreter(s) his/her most difficult challenge. Man-made land uses are normally the most easily interpreted units because they are captured on aerial film as regular, distinct units, often arranged in a linear or curvilinear pattern.

Joyce reported that learning to interpret and evaluate the above classification scheme was "relatively straightforward." A minor problem was noted in reference to the "false color" of CIR film. The visual techniques used required only basic equipment, such as light tables, magnifying tubes and stereoscopes.

Color infrared aerial photography is particularly suited to urban information problems because the film can capture distinct spectral responses or signature.[8] Urban environmental research using CIR film has yielded bands of the electromagnetic spectrum (EMS) that are characteristic

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[8]Any character or set of characteristics that can be used to identify an object or area.

to particular urban forms. Because each urban land use is captured on a distinct portion of the EMS, interpretation of definitive boundaries can proceed accurately.

Studies have shown that data acquired via aerial photography (of any format) will rarely satisfy all of the information requirements of a particular research effort (Stewart et al. 1980, Morgan et al. 1980 and Carter et al. 1979). The Community Analysis Bureau study exemplifies these findings. Data collected with CIR photography by the Community Analysis Bureau was used in conjunction with existing data bases at the CAB. Joyce reports that the combination of information files provided the optimum means for utilizing the data obtained from the CIR photography. He notes further that the urban data base provided the requisite information for the analysis of urban problems, but that the aerial survey has provided valuable supplementary conbributions.

Applications of CIR Aerial Photography

The Community Analysis Bureau identified five elements as being minimum expectations of the CIR program. Enumerated, these are:

1. A set of blight analysis studies of specific areas in the city of Los Angeles;

2. A delimitation of the optimum methodology for the acquisition and maintenance of an airphoto input to the urban data base;

3. A manual of interpretation of color infrared imagery[9] describing the procedures used to extract planning type data essential to the urban data base;

4. Specification of the information requirements of other departments of city government which can be derived from the CIR photography; and,

5. An examination of the potential utility of color infrared for the detection of various levels of urban blight with the description of how these potentials can be implemented.

Components of Los Angeles city government have utilized the CIR photography in various ways. The thrust of the program, however, appears to be toward the quantification of the relationship between environmental factors and

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[9] The term "imagery" is incorrectly used here. Images are produced via electronic processing at at least one stage of data transformation and presentation. The final product may be photographic, the correct choice for the above statement, however, it was not a <u>direct</u> recording of data from "scene-to-film," which is the definition of photography. The CAB color infrared project is photographic.

the incidence of poor housing conditions. Empirical study indicates that the relationship exists and that correlations are highest at the block or census tract level of definition. Information produced as a result of the CIR project has served as input for the City Demonstration Agency, the Advance Planning Division of the City Planning Department, and the Building and Safety Department. Specifically, project data were used to select possible sites for a federally assisted code enforcement program (FACE). Additionally, the CAB has used the CIR derived data to develop a housing model for Los Angeles that was used to assist decision-makers in their determination of the most appropriate housing programs for each section of the city.

Other applications of the CIR photography include:

- A complete preliminary analysis of the entire city of Los Angeles was conducted. Each census tract was delineated and rated on a scale (1-10) based upon the appearance of all observable environmental conditions. More detailed aerial analysis is produced for various sections of the city as required;

- The environmental quality index (above) was used as documentary evidence in the 1972 Los Angeles "State of the City" reports. The index was a component in the scientific urban matrix as a performance measure indicating the degree to which the neighborhood provides an adequate environment. The CIR produced data were believed to provide a relative measure of the quality and pattern of numerous environmental features, as well as evaluation of overall housing quality based on the relationship between the above mentioned characteristics, other surrogates and housing maintenance.

* The Community Analysis Bureau produced (at publishing time the CAB was in the process) an accurate method of estimating housing quality in the city of Los Angeles. Particular emphasis was placed on the delineation of substandard housing and housing with potential for rehabilitation. The information was deemed essential for the determination of appropriate housing programs within each section of the city. The CIR data were particularly useful since Census information on substandard housing was determined to be highly unreliable.

Information provided by the CIR project was described as having the following advantages over previously utilized methods for obtaining the same information; the data were comprehensive, city-wide coverage was provided, the data obtained were available in the same form for the entire city, and the data possessed the reliability that was absent from other data sources.

Project Conclusion

The Community Analysis Bureau, because of its success with the CIR project, had developed plans to acquire additional aerial photography at the scale of 1:5,000. The new photography was to serve as a means for delineating more detailed information about the city environs and as a means to update existing files. Extimated cost of the additional photography is $50,000, a figure CAB personnel believe is most cost-effective particularly in light of the $1,000,000 figure estimated as the cost to conduct a sidewalk survey.

An unsolved problem concerning photographic inputs to the Los Angeles planning process is the lack of automated storage of photographically derived data.

COUNTY AND REGIONAL APPLICATIONS

Development of data for large areas, e.g., counties or regions, appears particularly applicable to remote sensing techniques. Medium to high-altitude aerial photography and satellite imagery provide large area coverage at appropriate scales at a reasonable cost. Such techniques provide detail of information, comprehensiveness and perspectives not attainable with other methods of data collection.

Laramie County, Wyoming is the state's most populous county, as well as a county containing very large private land holdings. Until recently, county planners had no current, comprehensive land use data of the county. County officials had prepared and submitted specifications for production of such maps, however, the estimated cost was high (Tibbits 1977). Photogrammetric contractors, in conjunction with county officials, developed a program that consolidated the data needs and requirements of various county agencies. Multiple involvement by county agencies minimized data duplication and enhanced cost-effectiveness of the photogrammetric project.

Hogan/Olhausen, a civil engineering firm, was contracted to obtain aerial photography of 2,500 square miles of land area. As contracted, the firm may be required to produce large-scale halftone maps of the county's eight major growth areas and transparencies for overhead projection of slow-growth areas within the county. Project cost to Laramie County was $24,000.

Maps produced from the aerial photographs satisfied the needs of four county agencies. Maps of the county's urban areas were produced at a scale of 1:400; maps of rural and wilderness areas were produced at a scale of 1:1,000. All maps prepared for the county were made to accomodate the diazo printing process. Diazo printing allowed for inexpensive mass-production of any map (e.g., a given high-quality print of 36 x 36-inch dimensions could be produced for approximately $1,50).

Applications

The Laramie County planning department, along with the county engineer's office, has utilized aerial photography to study growth dynamics of the county and to coordinate county plans for future development. The county sheriff's department which is responsible for county fire-fighting tasks, utilized the aerial photography to develop accurate road and overall vehicle trail maps. These maps allow for more effective fire control strategies. Previous to the creation of the road maps, fire control personnel were required to rely upon the identification, however dubious, of wilderness roads and trails via the memories of county residents.

Further utilization of Laramie County aerial photography includes development of a land ownership parcel map to identify current data on property parameters for tax assessment; to develop strategies of future land use development, access, and patterns of access; and, to delineate floodplain parameters.

Conclusion

In every case of aerial photographic application to a Laramie County problem, municipal officials found that aerial photography was easily affordable if it could be tailored to meet the needs of several agencies.

Landsat: A Technique for Regional Analysis

All above remote sensing applications have utilized what are considered "conventional" techniques to help meet planning data requirements. The following discussion presents a case analysis of a project considered to be "the most significant test of the use of Landsat data in terms of geographic size and discipline diversity" (Hedrick *et al*. 1976).

The Pacific Northwest Regional Commission (PNRC) in the fall of 1974, identified the need for accurate and current natural resource and land use information beyond that already available to the commission. The data were to be used for planning functions and management decisions, and were to be both reliable and continuous. A task force representing various governmental agencies of the states of Idaho, Oregon and Washington was formed to analyze the alternatives available to solve the problem. Initial efforts of the task force included consultation with the National Aeronautics and Space Administration (NASA) and the U.S. Geological Survey (USGS). With these federal agencies, the task force identified a five phase program that would be implemented over a three-year period.

Unlike previously discussed projects included in this document, initial PNRC project findings suggested that considerable quantities of technical expertise, software and hardware would be required to implement a satellite based land use information extraction program.

Phase I

The initial project goal was to develop early a "cooperative effort among the local and state agencies and the universities of the region." Phase I products were a series of base maps and overlays developed directly through the use of Landsat imagery. Scale parameters of these base maps are 1:250,000, 1:500,000 and 1:1,000,000. All of the Pacific Northwest region was covered. In concert with the above maps, five overlays were produced. These include:

- Soil information at a resolution consistent with level one of the USGS Land Use and Land Cover Classification System for Use with Remote Sensor Data;

- Land ownership delineation at the federal, state and private levels;

- Drainage basin location and extent;

- Energy related features such as coal fields, power line corridors and geothermal areas; and

- Visually interpreted land use.

The authors anticipated at the time of publication that these products would be used by cities, counties and regional councils, Indian tribes, state and federal agencies, universities and interest groups and organizations which utilize natural resource information in the Pacific Northwest.

Phase II

This phase of the project was concerned with preliminary digital analysis of range management, agriculture management and forestry resources. It was also a goal of phase II "to familiarize state agency personnel with Landsat products and its capabilities."

Phase III

Phase III was designed to train participating agency personnel in the extraction and use of information from Landsat imagery. This phase constituted the major effort of the project. Phase III goals included the transfer of remote sensing technology from NASA and USGS to the states in the Pacific Northwest.

Phase IV

Establishment of a viable and operational regional information system defined the goals of Phase IV. The effort included an analysis of various current systems and of systems under development.

Phase V

The final phase of the project was devoted to project cost documentation. Comparisons between the actual cost of acquired information derived via project approaches versus conventional methods utilized in the three states were made.

The Pacific Northwest project exemplifies a major and unique undertaking: major in that numerous federal, state and local agencies required project coordination; unique in the fact these same agencies shared technology, ideas and concepts in concert to improve resource planning and management in three states. According to Hedrick, the project is completely user driven and designed to meet the specific needs of the agencies in the three states. Participants included 80 state and local agency individuals actively involved in the project, representing 35 state agencies, regional councils and local units of government. The project allowed agency personnel to "take a realistic look at a new technology that promises a better, more efficient method of obtaining land resource information" (Hedrick et al. 1976).

Noting the diversity of individual planning information requirements, Hedrick et al. addressed the problem(s) of information needs at various levels of planning. Attempts were made to judge the impact of the project on the average city, county, regional council or state agency which is endlessly in search of information upon which to base planning and management decisions. Three areas of informational needs were identified; landform data, land tax data; and, land cover data. Project administrators noted further, that the major input to information management involves data acquisition and updating. It is here that the role of remote sensing technology appears to be potentially the greatest in terms of both time and cost savings.

The above statement served as the main driving force behind the Pacific Northwest project. An important objective of the project was to prove, or disprove, the theory that remotely sensed data collection saves time and money over previously used data collection methods. Testing of this theory required an unbiased project design and implementation. Noting this requirement, participating agencies selected test sites in areas that harbored "significant problems" and which posed "not simply textbook problems." Hedrick <u>et</u> <u>al</u>. state "from that standpoint, the project is the truest test of the remote sensing technology, and the results should demonstrate whether it is, in fact, a better data acquisitions method."

Project Applications: Idaho

Eleven state and local agencies were involved in the Land Resource Inventory Demonstration Project (LRIDP). Project involvement was defined at various levels representative of three functional areas associated with Idaho agencies. These functional areas include agricultural resource, urban resource and rangeland resource management and planning.

Investigation and application in the field of agriculture involved the Department of Water Resources (IDWR), the

National Aeronautics and Space Administration (NASA) at Ames, the U.S. Geological Survey (USGS), in conjunction with EROS, and the University of Idaho. Agriculture represents the state's largest industry, with a high percentage of all cropland (four million acres) being irrigated land located adjacent to the Snake River. Idaho agricultural resource managers/planners were, and are, concerned with rapid decreases of agricultural land cause by urban expansion and changing methods of agricultural practices (particularly increased land irrigation). In light of such concerns, agricultural administrators expressed the opinion that "a pressing need existed to develop a cost-effective method to monitor yearly increases in irrigated acreages" (NASA 1979). Specific objectives identified by the IDWR include: identifying crop types, mapping and measuring irrigated acres, monitoring annual change in irrigated acres, and identifying methods of water distribution on cropland. It was reported that these objectives were accomplished with varying degrees of success. NASA did state however, that the project was "highly successful" in terms of Landsat technology transfer and integration into ongoing planning and management activities at IDWR.

The Ada Planning Association (APA), USGS/EROS and NASA/Ames participated in an urban application of the remote sensing project. Boise, Idaho, served as the urban test site area. Boise is a rapidly growing city, the growth areas, as is the case in most urban zones, are being developed at the expense of high-quality agricultural land. Conversely, unused vacant land within the confines of Boise is not being considered for development. According to the NASA report, the above problems plus the requisite for a timely, accurate cost-effective method of mapping and generating statistical summaries of land use, promoted APA's involvement in the project. Objectives of the urban application project were: map vacant land within the urbanized area; identify current use of vacant land; delineate old and new residential areas; identify commercial and industrial areas; and, map the agricultrual and wild lands within the county. Project results suggest that information provided served successfully as input in public meetings and as an aid to urban development studies.

A third level of activity is represented by the participation and cooperation of the Idaho Departments of Fish and Game, and of Lands, and the two federal agencies named above. Rangeland studies provided the focus for developing data relevant to the type, location and condition of vegetative cover types indigenous to rangeland areas of Southeast Idaho.

Project results have been utilized as inputs to model and predict the rangeland carrying capacities for livestock and big game animals, and for more effective planning and management of these resources.

Project Applications: Oregon

Several agencies (Pacific Northwest Regional Commission (PNRC), Oregon State University, NASA/Ames and USGS/EROS and Geography) participated in a diverse range of projects within the state of Oregon. Included were projects designed to delineate irrigated lands, urban land use types, and the noxious weed tansy ragwort.

By formal agreement, the Oregon Water Resources Department (OWRD) is responsible for monitoring the degree of irrigated agricultural land in the Klamath River Basin. To aid the task of monitoring, project agencies utilized Landsat imagery and high-altitude aerial photography. These sensor applications proved to be efficient and cost-effective. Results of the project were so positive that OWRD planned further implementation in remaining Oregon river basins.

Tansy ragwort is a noxious weed that infests areas of diverse site characteristics, e.g., recent clearcuts, irrigated pasture, dryland pasture and older clearcuts. Tansy ragwort costs Oregon and Washington three to eight million dollars per year in direct livestock destruction and in elimination of large areas of rangeland from production. The Oregon Department of Agriculture developed programs to control the weed. Success of these programs is partially associated with the ability of program personnel to locate tansy ragwort and classify its community, and to evaluate accurately the success of eradication programs. The Department of Agriculture, in concert with Oregon State University and NASA/Ames, developed a remote sensing project to meet the above needs. Low-altitude aerial photography was capable of capturing individual tansy ragwort plants, though such an approach would be too costly to implement in a large area. Utilizing this capability, the project team designed a statistical sampling scheme to allocate photo flight lines and ground data collection. The photographs were also used to identify potential growth sites for tansy ragwort, these sites later served as Landsat field-verification data.

Project Applications: Washington

In the State of Washington, 17 resource management and planning agencies participated in demonstration projects. Over 30 representatives of these agencies received training in the computer techniques used to analyze Landsat data and the skills in other remote sensing techniques necessary to covert Landsat results into a form most applicable to each agency.

The Department of Natural Resources administered one of the major projects within the state. Located in Western Washington, the project involved analyzing Landsat imagery covering 20,000,000 acres of area. The project employed low- and high-altitude multispectral aerial photography as a complement to the Landsat imagery. Project outputs include timber volume estimates that served as inputs in the Washington Forestry Productivity Study. Further, the DNR has expanded the forest inventory program to other portions of the state.

Urban planners organized a multi-agency project in the Central Puget Sound region to examine the applicability of Landsat data to their needs. Landsat imagery covering approximately 8,000 square miles of area was used to identify and map urban land use, to enhance effective transportation planning and to conduct studies relating to water and air quality standards. Land-use and cover type information developed via Landsat has been incorporated by the city of Tacoma into their computerized management information data base. This system serves every agency within the city. All Tacoma agencies now have the capability to compare and manipulate specific information files defined by their needs, while using a common information base. Periodic analysis of Landsat data represents an efficient and effective means of identifying change and updating the land use/cover type data base.

Four features of the Pacific Northwest Regional Commission Project distinguish it from previous evaluations of Landsat-based resource analysis systems:

1. Most agencies interviewed were well informed about Landsat data products because they had participated in the PNRC's Land Resources Inventory Demonstration Project (LRIDP);

2. Agencies expressed their demands for Landsat products very carefully and realistically because they would have to pay for the products entirely from their own budgets.

3. Costs and benefits of Landsat-based products were compared to the costs and benefits of the alternative products most likely to be selected by agencies. Alternatives which provide information comparable to that provided by Landsat but which would never be selected by the agency were not considered; and

4. Total benefits were defined as the area under the aggregate agency demand curve for Landsat-based products, or the total willingness of agencies to pay an operational facility for Landsat-based products (Farness _et al_. 1978).

Based upon benefit-cost ratios developed by the study, the following findings were made:

1. The high and low benefit-cost ratios for each system at all levels of operation are low, with none exceeding the value of 0.29 for a centralized Landsat automated system. This quantitative evidence, together with qualitative evidence gathered from the agencies, suggests that an unsubsidized regional Landsat-based resource analysis system commencing operations in 1978 was not economically justifiable;

2. The benefit-cost ratios for a centralized system equal or exceed the benefit-cost ratios of decentralized systems at the same level of operations. The increase in total costs to decentralize greatly exceeds the increase in total benefits as measured in the study (Farness _et al_. 1978).

The authors note that much care should be exercised when interpreting these findings. Farness *et al*. point to the following conditions as possibly confounding the results: agencies often confront uncertainties when utilizing Landsat products because of the current development of Landsat products and in agency experience (or lack of) with Landsat products; agencies are not certain of Landsat product characteristics, the adaptability of their planning and decision processes to new data, and the acceptability of Landsat products to the groups they serve; and, agencies are not cognizant of the economic feasibility of Landsat products and whether legislatures would provide the necessary funding. The authors note also, that the benefit-cost analysis was structured to determine if an unsubsidized regional system beginning operations in 1978 would be economically feasible. No answer is offered the question: will a subsidized or unsubsidized operational system become economically feasible at some future time? Grounds for this omission are based in the theories of the process of technological innovation and the timing of investments. The authors suggest that in concert, these theories predict that the dynamics of technical and operational change greatly influence the timing for successful adoption of a new technology.

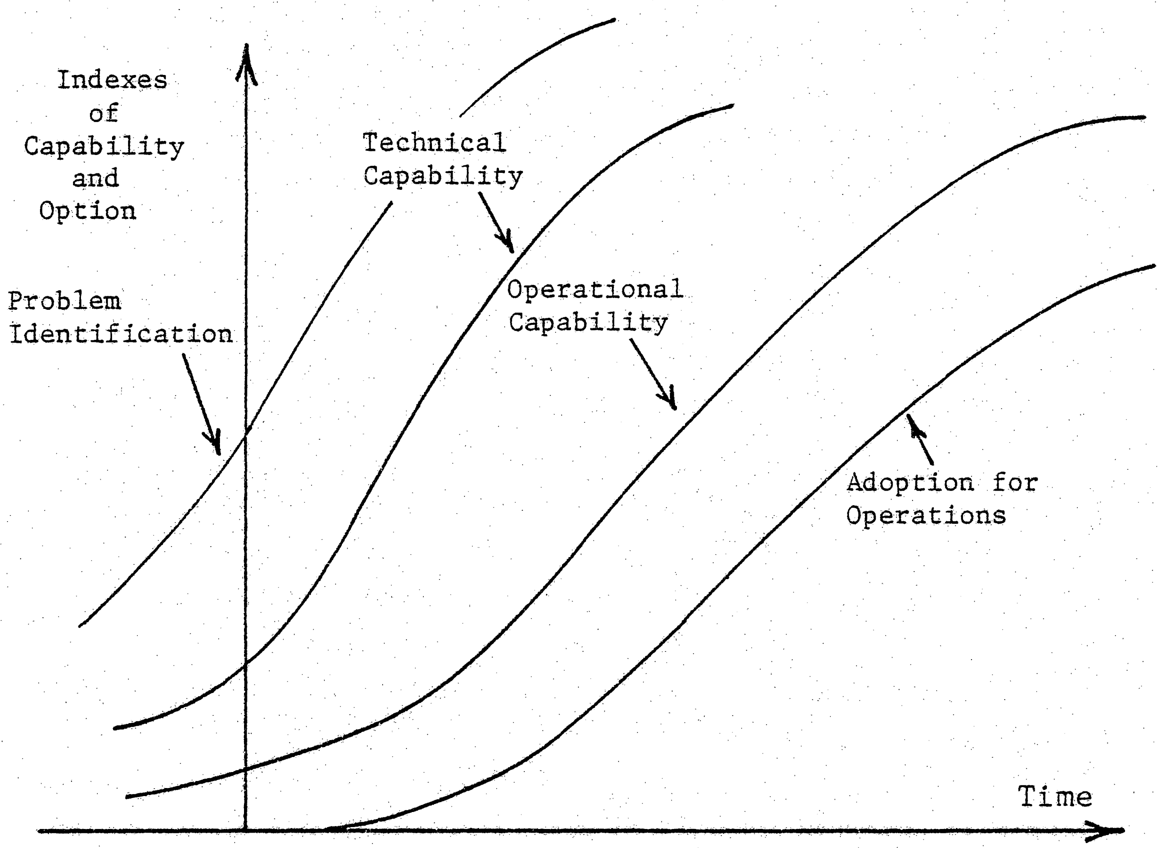

Figure E-1. The Process of Technological Innovation
(Modified from Farness et al. 1978)

Any successful technological innovation process may be delineated into four overlapping processes: problem identification; technological innovation; operational innovation; and, adoption for operations (Fig. E-1, modified from Farness et al. 1978). Capabilities evolving from each process develop slowly at inception, increasing dramatically over time until a steady-state region is reached. An "s" curve represents such an evolutionary trend.

Upon application of technological innovation theory to the case of Landsat technology, Farness et al. offer the following analysis. It should be noted here that Farness et al. identify technological innovation as a three-stage process; technological innovation, operational innovation and adoption for operations. This author is of the opinion that successful innovation of any type must first begin with a defined problem or application area. The above three-stage process unfortunately, parallels methodology utilized during the early days of the Earth Resources Technology Satellite Program (ERTS). That program, now dubbed Landsat, produced orbiting satellites which produce data, but for no specific use. Project personnel could almost be heard bellowing, "Here is the output, to what can it be applied?" Technological capability, the first process of the Farness methodology, has evolved through early conceptual stages and has achieved rapid development of hardware and software. Operational capability follows development of technical capability and its effectiveness often depends upon the development of resource planning and management models, as well as institutional adjustments to newly demonstrated technical capabilities. With technical and operational ability of a Landsat data system in place, agency adoption may transpire. It has been shown, however, that the lag-time separating operational feasibility of a system and agency adoption may be quite long.

The PNRC's study demonstrates further that the technical capability of Landsat-based systems are well-advanced, with continuing improvements being made, e.g., Landsat IV, that operational capability of the systems are definitively less advanced which directly affects the rate of adoption, which is poor. Identification of the level of adoption by Virginia planning represents one of the objectives of this study.

Summary

The preceding discussion establishes quite definitively the utility of remote sensing techniques. Conventional sensors, e.g., aerial photographs of the formats black and white, color, infrared and modified color can be applied successfully to a wide range of problems, many of which are addressed by planning agencies, e.g., land use classification, site analysis, pollution source location, transportation studies, resource base analysis. Unconventional sensors carried by aircraft, e.g. radar, microwave scanners, laser systems, offer additional flexibility to those requiring data about certain objects or areas. However, this group of sensors (usually electronic versus photographic) have limited utility, are often more expensive than conventional sensors[10] and should be utilized only when the information needed is paramount and not obtainable with conventional sensors.

Satellites represent still another type of unconventional sensor. Satellite coverage of any portion of the world is provided every nine days, barring "noise" from cloud cover. Data registered in 1.1 acre pixel elements on magnetic computer compatible tape (CCT) may be purchased directly from NASA-Sioux Falls at approximately $200 per tape. Each tape covers an area of the approximate dimensions 90x90 square miles. Automated land-use classification using satellite CCT input can be highly efficient and effective for large-area analysis. Satellite systems are

[10]Coverage area and requisite scale are important determinants. Study areas of large dimensions and low resolution requirements might swing the benefit-cost ratio to one or more of the electronic sensors.

repetitive, synoptic and timely, advantages of which can be used to develop a highly coordinated resource management/resource change detection program. As pointed out by Farness *et al.*, however, because of the cost constraints resulting from high technology hardware, complicated software requirements and associated high education/skill levels required for those who apply satellite technologies to resource planning problems, satellite based information systems are often not yet cost-effective.

Appendix F

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION TECHNOLOGY TRANSFER PROGRAM

The National Aeronautics and Space Administration (NASA) has conducted one of the largest technology transfer programs to date. The program is directed at horizontal transfer, i.e., a process whereby technology developed in one institutional setting is adopted for use in another. This NASA program has addressed both private and public users, although private users represent a much higher proportion of program activities.

According to Doctors (1971), any transfer of technology requires certain elements:

1. An invention or some new area of technology;

2. Incorporation of the invention or new technology in an innovation;

3. A difference between the context of the invention and the context in which it is incorporated in an innovation; and

4. A communication or linking process which brings the incorporation about.[11]

As might be expected, these elements may evolve only after a considerably long period of time. Factors affecting the temporal length of the transfer process include: (1) dynamics of a potential "host" problem, (2) the relative "urgency" to find a solution to a problem, (3) the effort made by the developers to transfer a particular technology, and (4) the effort made by potential adopters to identify technology used in other fields that may aid them in their own.

A major theme of the NASA transfer program is the publication and dissemination of a variety of technical reports, manuals, journal articles, translations, invention reports and other assorted aerospace-related materials. Other transfer mechanisms identified by Doctors are technologist, mobility and internal technical entrepreneurship. Doctors defines technical mobility as the movement of a technologist from one job to another which results in the development of a new "product." The technologist may bring a specific item(s) or a specialized expertise which is directly applied to new product development. In this case, it is an easy mental exercise to "see" the transfer and application of remote sensing technologies to a wide range

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[11] Doctors, S.I. 1971. The NASA Technology Transfer Program — An Evaluation of the Dissemination System. Praeger Publishers, New York. p. 57.

of planning problems. Barring movement of the specialized technologist, however, new product development would likely not occur.

It would be folly to suggest that a "cure" for the lack of remote sensing technology utilization within Virginia planning agencies would be for the agencies to recruit technical experts in remote sensing. Few planning agencies could compete with the salaries available in private firms. An alternative approach, however, would be to elevate the educational and skill backgrounds of practicing planners. Such an approach should offer short-term, but continuing, remote sensing education, e.g., extension courses, conferences, and long-term education by building strong remote sensing components into college planning curricula.

Doctors' defines technical entrepreneurship as "the transfer of a new technology by means of the initiative of an individual acting as a 'champion' within an existing organization ..."[12] Such a definition could profile the planning student who has followed a regimented sequence of remote sensing courses.

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[12]Doctors, _op_. _cit_., p. 138.

Results of Doctors' evaluation of NASA's technology transfer program reveal that NASA's main approach to technology transfer -- literature dissemination -- has not been very successful, especially in the arena of short-term transfer. Doctors notes, however, that literature dissemination may have a cumulative educational impact, thereby stimulating long-term "receptivity" of sophisticated technology.[13] Depending upon one's definition of "long-term," and relying upon results of this study, one might judge as unsuccessful NASA's attempt(s) at transfer of remote sensor technologies to state, regional and local agencies. NASA has been implementing a major (in terms of dollars) broad technology transfer program since 1964.

Doctors results also indicate that horizontal transfer requires that technical information be tranferred from person to person. Further, it appears that such interpersonal contact must be made on a continuing basis if successful motivation to adopt a new technology is to be achieved. Most importantly, Doctors suggests that general area transfer (the type associated between planners and remote sensing technologies) might be possible with less intensive interpersonal contact. Dissemination of literature, conferences and seminars could play a major role in general

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[13]Ibid., p. 161.

area transfer of remote sensing techniques to the planning profession.

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An Assessment of Remote Sensing
Technology in Virginia Planning Agencies

by

William Robert Niedzwiedz

(ABSTRACT)

Remote sensing techniques have proven utility to a wide range of planning problems. This research explores the adoption and application of remote sensing techniques by Virginia planning agencies. All planning agencies within the Commonwealth were sent a Remote Sensing Utilization Questionnaire. Survey results indicate that adoption of remote sensing products is low at all levels of planning; that most agency characteristics, e.g. staff size, budget, are not correlated with utilization; and, the lack of remote sensor adoption and use appears to be a result of the lack of remote sensor education among Virginia planners.

Research results suggest also that the demand for information concerning remote sensor applications to planning problems is high among Virginia planners at all levels of planning. A high proportion of respondents at all planning levels stated that they would like additional remote sensing/planning applications information; would like more remote sensing/planning applications articles in professional planning journals; and, would send a representative

to a remote sensing/planning applications conference if the conference were held within the state.

Research results define major programmatic roles for federal and state agencies involved with remote sensor technologies and Virginia colleges and universities with remote sensing capabilities.