*Aerial Photographic Interpretation and the Human Ecology of the City**†‡

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ABSTRACT: *This paper describes photographic interpretation research in the analysis of residential areas in several cities in the United States. Photographic interpretation techniques were used to provide accurate data on such items as residential housing types, numbers and densities, ecological location and distance, and land use characteristics. From analysis of these data, further conclusions were drawn as to urban social structure.*

(Die Mitteilung schildert Luftbild Interpretation Nachforschung in der Zergliederung der wohnsitzlichen Gebiete in verschiedenen Staedten der Vereinigten Staaten. Luftbild Interpretation Techniken wurden betrieben, um genaue Daten auszuliefern an Einzelheiten wie Gepraege der Wohnsitz Gebiete, Zahl und Dichtheit derselben, ekologische Unterbringung und Entfernung und Landanwendung Kennzeichen. Von der Zergliederung dieser Daten wurden weitere Entschluesse gezogen, die staedtische, gesellschaftliche Gefuege betreffen.)

TRADITIONALLY, urban ecologists and others concerned with intra-city population distributions have depended on census data and certain municipal records to obtain reliable information for their investigations. These sources have been quite adequate where data are available by census tracts, blocks or similar subareas. In many cases, however, information required for urban social analysis is not reported by small spatial units. Also, since it is often found that such data lack comparability from area to area, systematic analyses become very difficult, if not impossible. The purpose of this paper is to summarize a series of studies wherein methods were developed for using aerial photography as a supplementary source for fulfilling this data requirement in urban ecological analyses.

As indicated, in the over-all project, the field of urban ecology provided the basic framework within which aerial photography was used for relating the physical-spatial structure to the social structure of the city. However, the social data derived by the photo interpretation method are also quite relevant to many aspects of the fields of urban sociology, city planning, human geography and demography, among others. In this respect, these studies represent the first systematic attempt to adapt photo interpretation as a research tool in the social sciences.

Indeed, there are good reasons why aerial photography should make useful contributions in urban social analysis as it already has done in applications to geology, forestry, military science and engineering, for example. In addition to the vast amount of detail in the air view and in contrast to conventional data sources, aerial photographic study reveals the urban area as a total configuration in all its complexity. Spatial units of the city are seen in their true relationships to each other and to the natural environment. Consequently, urban subareas studied within the context of surrounding influences and neighboring districts assume a realism which can hardly be interpreted through analyses of statistical tabulations alone.

The authors' findings confirm these notions and especially the basic idea that photo interpretation may be used to fill a gap in the availability of certain categories of spatial data related to the social structure of the city.

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† For another report by Working Groups see PHOTOGRAMMETRIC ENGINEERING, Vol. XXV, 1, p. 128.

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As described in the following paragraphs and in the listed references, the photographic method appears to be particularly useful for urban studies concerned with population size and density distributions, and with the patterning of intra-urban socio-economic areas. The results obtained are contrary to the prevalent belief that photographic interpretation information in urban area analysis is limited to physical or material factors.

The research activities summarized herein had two principal objectives: (1) to test the accuracy or validity of photo interpretation data on certain physical-spatial categories by correlation with observations from ground surveys, and (2) to develop methods and techniques for identifying and defining systematic relationships between the physical-spatial categories and certain demographic and social structural characteristics of the city. Underlying these objectives as a theoretical consideration of the urban agglomeration as a complex socio-physical system.

The first task, undertaken in 1952, was the development and testing of "keys" or criteria for the identification and classification of residential structures by aerial photographic interpretation. The rationale for concentrating on residences as one of the more imporhat items of urban physical structure was based on commonly accepted social values and sentiment associated with housing and various types of residential neighborhoods. One of the key concepts is that a person's "address" usually indicates a lot more about him than just where he lives. Residence location has meaning not only in terms of real estate cost or rental, but also frequently in terms of occupation, educational level, income class, nationality group, cultural attributes and even religious preference.

As developed and evaluated in the 1952 pilot study of subareas in Birmingham, Alabama, the photo keys proved to be workable and sufficiently comprehensive, at least in this first test. The margin of error in identification of total numbers of residential structures was of little or no practical significance. Some refinement was indicated to improve the adequacy of the keys for classification of residences according to family units contained. Also, questions were raised regarding the application of the method to different culture areas and geographical regions having varying architectural features and physical conditions, all of which would affect its general utility. For these reasons, it was appropriate to investigate the adaptability of the approach used in the Birmingham study to another urban complex.

Rochester, New York, was selected for this more intensive follow-up study. This city contrasts sharply with Birmingham in many respects. As a result of climatic and sub-cultural variations alone, there are marked differences between the two cities in residential housing. For example, slums in Birmingham are generally characterized by small, wooden shanty-like homes crowded together in transitional or interstitial subareas. In Rochester, on the other hand, most all lower class lodgings are concentrated in large, old converted structures, outdated apartments, and dilapidated "triple-decker" tenements. Also, of course, there are distinct differences in both the physical settings and economic bases of the two cities. The combination of all these contrasts provided the desired conditions for extending and retesting the methodological development: (1) an increased variety of residential structure types, and (2) an increased variety of social, economic, geographical and cultural characteristics.

The over-all results of the Rochester study showed a distinct improvement over the findings of the Birmingham pilot study in two ways. First, for all subareas investigated, there was an average photo error of only two per cent in the identification of nearly four thousand residential structures. Secondly, the Rochester study was more successful in classifying these structures according to units contained, such as single-unit, "duplex," multiple-unit, 3 to 5, 6 to 8, etc. Thus, the follow-up investigation provided substantial evidence of the adaptability and validity of the photo keys, the primary focus of interest in the Rochester undertaking.

In another part of this same study, the investigators computed several ratios and percentages representing various combinations of structural types existing in the different subareas of the city. This was in accordance with the basic objective of developing and interpreting social data from the photographic information. Subsequently, these structure ratios were used as predictors in establishing socio-economic status classifications and rankings of the urban subareas. In addition, the photo data on dwelling-unit density were employed in analyses of population density patterns within the city of Rochester.

As indicated, these latter aspects of the Rochester study were directly related to the second major phase of the research program, an empirical investigation of statistical rela-

tionships between physical and social characteristics of the city. By this means, certain physical-structural-spatial data categories could be developed as objective criteria for photographic interpretation of urban demographic and social data. The ratios and percentages of structural type combinations referred to above constituted the first exploration of this concept. The Rochester findings offered preliminary evidence of the practical utility of aerial photography in this new role.

The technique involved classification of the Rochester subareas on a nine-point socio-economic status scale derived from U. S. Census data. Photographic data on combinations of building types were correlated with the constructed scale criteria. Clear gradient patterns of increasing and decreasing percentages of structure types were found to match the gradations of socio-economic status areas. Predominant at the lower end of the scale were heavy proportions of all structural types except one- and two-family homes, while at the upper end, the one outstanding feature was the single-family structure. Further investigations of this nature included additional photo data categories and more precise techniques for specifying the complex socio-physical inter-correlations.

These continuing studies produced detailed ecological analyses of several cities in the United States and also elaborated the theoretical framework and design for the ongoing research. In addition, a method was developed for the mathematical expression of multiple inter-relationships characterizing urban physical and social structure, the center of interest in this second phase of the project.

One of the key studies in this series was a statistical analysis of ecological data for Birmingham, Alabama. In this work, the Guttman scalogram model was adapted to the construction of a scale of residential desirability based on housing types, density patterns, land use characteristics and ecological location. This physical structural scale was then correlated with a similar Guttman scale comprised only of social structural data categories. A high positive relationship was found between the two scales, to the extent that the physical-structural-spatial data comprising the residential desirability scale, accounted for seventy-eight per cent of the variation of Birmingham's subareas on the socio-economic status scale. In terms of methodology, this study demonstrated that the Guttman scale analysis technique, conventionally applied to attitude data in social psychology, is also an excellent model for defining complex relationships in the spatial patterning of intra-urban social and physical characteristics.

In addition to this statistical analysis and scaling of Birmingham data, there were similar investigations using census tract data for six other U. S. cities. This work centered on four items of physical-structural-spatial information which could be obtained by photographic interpretation: (1) the location of the tract relative to three concentric circular zones having a midpoint in the central business district; (2) the description of the tract in terms of land use characteristics; (3) the prevalence of single-family homes in the tract; and (4) the density of housing in average number of dwelling-units per block in the tract. Statistical analyses of data for all these cities revealed many consistent and significant relationships between categories derived from the four items and a variety of social structural categories. These empirical findings thus provided further evidence of the predictive value of the photo interpretation information.

The next step in the project was a continuation of the above-mentioned scale analysis methodology. In this case, the technique was applied to data for the same sample of six United States cities. Similar to the Birmingham results, the four physical structural items, comprising a total of twelve data categories, were found to constitute a scale which defined mathematically their joint relationships with several aspects of the social topography of these cities. The scalogram for Chattanooga reflected the spatial pattern of racial segregation in that city. In the case of Spokane, Washington, the scale types helped to portray intra-urban social areas by indicating housing rental value distributions. In Austin, Texas, and Bridgeport, Connecticut, the physical structural scale correlated on the order of .85 with the ecological patterning of income class groupings. Generally speaking, these results showed that the so-called residential desirability scale variable, combining all the photo data categories, was a considerably efficient predictor of the socio-economic status ranks of urban subareas.

Among other related studies, special attention was given to technical problems regarding the accuracy of the photographically collected data. In this part of the work, it was discovered that discrepancies in the photographic observations were distributed non-randomly. This situation provides a basis for constructing systematic correction factors through knowledge of the nature, amount and direction of the photo data errors.

In summary, the results of this research to date permit the following conclusions with reference to U. S. cities: (1) photo interpretation of urban areas provides accurate data on physical-structural-spatial items such as residential housing types, numbers and densities, ecological location and distance, and land use characteristics; (2) these physical structural items are systematically related to many features of the social and demographic structure of the city; (3) the Guttman scale analysis technique is an excellent method for gaining maximum predictive power from the photo data categories in multiple correlation with the social data categories; and (4) by this method, the photo interpretation data may be translated into information pertaining to urban social structure, including rankings of subareas on population size and density and on socio-economic status.

All in all, the research program has developed quite convincing evidence that photographic interpretation is a profitable approach to problems in urban social analysis. In some situations it may be the only source for certain classes of data. It would seem desirable, in extending this work, to test the development on a larger sample of cities, and particularly to investigate its transferability to regions outside the United States. In so doing, emphasis should be placed on the adaptability of the techniques and procedures and not on any notion that specific findings obtained for U. S. cities will necessarily hold for other areas. The underlying assumption is, however, that socio-physical relationships such as those revealed in the present work exist in varying forms in urban complexes cross-culturally. For this reason, aerial photography may be used to derive social or non-material information from the physical form and material structure of the city.

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*Microforms and Features**†

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(*abstract is on next page*)

AS NATURAL occurrences, geologic micro-features, like bacteria, have always been with us. And, as with bacteria, it has taken an increase in scale and perspective to bring them to light. Without aerial photography, these features would have remained unknown or irrelevant. Even with today's photography they pass relatively unnoticed with the casual appraisal it receives.

The term "micro-features" applies to minor

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† For another report by Working Group 3 see PHOTOGRAMMETRIC ENGINEERING, Vol. XXV, (1), p. 121 (March 1959).