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Population Estimation

A sample study of inter-census change applies aerial photos and USGS quads to an area near Atlanta, Georgia.

ABSTRACT: *The 1952 population of an area near Atlanta, Georgia, was estimated by housing counts on 1:24,000 topographic maps. In the built-up area where individual houses were not shown, the population was estimated from 1950 city block data and 1968 aerial photographs. The 1968 population was estimated from the photos. The random error of housing counts was less than 5 percent. In the central business area the 1950 city block data were consulted. The results showed a general increase of population in the study area and a significant loss of population from the central business district and the railway zone.*

INTRODUCTION

THE POPULATION of the United States is estimated by the Census Bureau every ten years. Thus, most census data are by necessity out of date and of limited utility for planning and development purposes. Hence an urgent need exists for the development of appropriate techniques by which inter-census population can be estimated with a high degree of accuracy and low cost.[1] This paper presents a method by which inter-census population estimates can be achieved by the use of USGS topographic maps, air photos, and census data. It also contains a sample study of population change in the Atlanta area from 1952 to 1968. The sample area is covered by two 1:24,000 topographic maps, viz., the Sandy Springs and Bolton Quadrangles, Gerrgia. These two topographic sheets form a corridor into Atlanta, Georgia, covering its rural, suburban, and urban sectors. The 1952 population was estimated mainly from housing counts on the topographic maps, whereas the 1968 population was estimated by counts from air photos.[2]

ESTIMATION OF THE 1952 POPULATION

The first part of this study was an attempt to estimate and map the 1952 population distribution of a portion of the Atlanta area. An areal corridor covered by the Bolton and Sandy Springs Quadrangles and including urban, suburban, and rural land use was selected for analysis. The 1952 population was estimated in the following manner from the two quadrangles that were compiled from 1952 air photos. First, a grid with cell size of one-fourth square mile was used as the base for the construction of choropleth maps of population distribution. The population of each grid cell was then estimated by multiplying the number of houses in the cell by the average number of persons per household listed by census tracts in the 1950 census of population.[3] It has assumed that there was no significant change in the average number of persons per household between 1950 and 1952.

TABLE 1. EXAMPLES OF CORRECTION FACTORS OF POPULATION CHANGE

	Census Tract	*Number of Persons*		*(Correction Factors) Ratio of Change*
		April 1, 1968	*April 1, 1950*	
Cobb	CC-003	10,012	3,574	2.80
	CC-004	11,424	615	18.57
Fulton	F-078	16,046	3,489	4.88
	F-084	7,224	2,200	3.28
	F-088	4,417	5,239	0.85

* Presented at the Annual Convention of the American Society of Photogrammetry in Washington, D. C., March 1970 under the title, "Inter-census population estimation by the use of air photos and USGS topographic maps: A sample study of population change in the Atlanta area".

The population density, expressed as the number of persons per square mile in each cell, was then obtained by multiplying the population size by four. This procedure is easily done in the non-built-up areas where individual households are shown.

The most highly urbanized areas are shown in shaded pink on the topographic sheets. Individual houses and buildings are not shown in these areas. In order to obtain population data, it is necessary to consult the 1950 census data[4] of city blocks in the "pink area" *within* the Atlanta city limits, and to use the 1968 air photos for housing counts in the "pink area" *outside* the city limits where city block data are lacking.

Within the city limits the population size of each city block was processed in terms of the number of houses which could be obtained by the following relation: Number Of Houses = (Population Size)/(Persons Per Household). Her *Population Size* is obtained directly for each block from the census of population, and *Persons Per Household* is calculated for each census tract.[5] This means that the latter may not be the same for all the city blocks. By examining the distribution of houses in city blocks from air photos it is reasonable to assume that houses were evenly distributed over the block. Therefore, the number of houses in each grid cell is obtained by regrouping the distribution of houses according to grid boundaries. The population size of each cell is then estimated by multiplying the number of houses by the average number of persons per household listed in the 1950 census tracts. It should be noted that the population size of each cell can also be estimated directly from the population size in the entire and/or portions of city blocks enclosed by the grid boundaries.

In the built-up area *outside* the city limits, the population distribution for 1950 was estimated directly from the 1968 air photos (by housing counts) in the following manner. If earlier photos had been available, they would

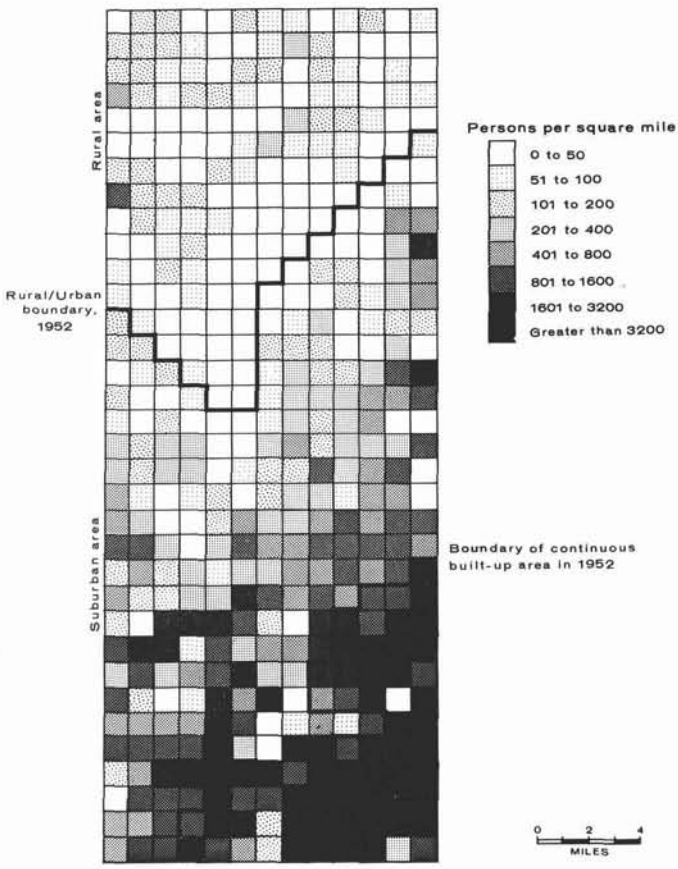


FIG. 1. 1952 Population Density.

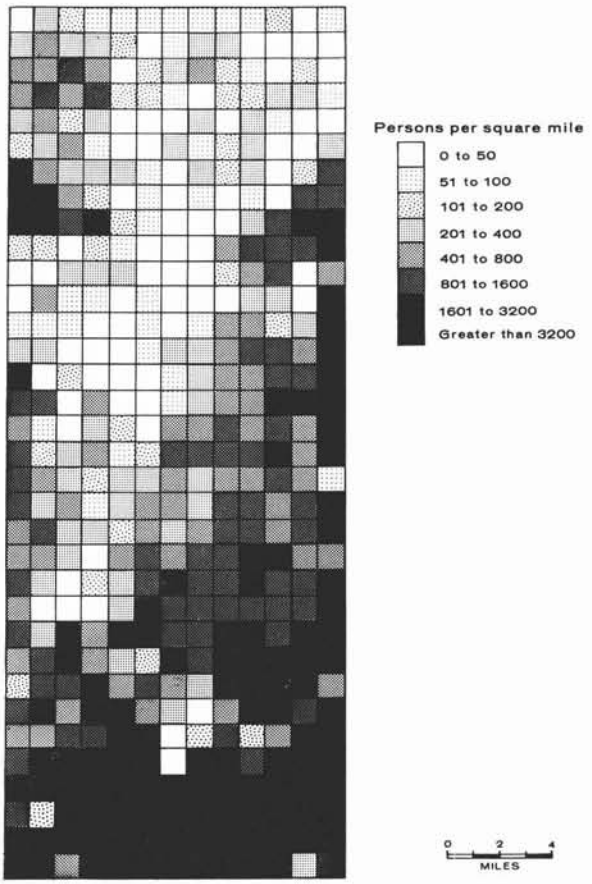


FIG. 2. 1968 Population Density.

have been used for better estimation. A floating grid covering a photo area of one-fourth square mile was constructed to "pick up" housing counts for each corresponding cell of the map grid. By following the same procedure mentioned above, the population size of each grid cell was calculated. To estimate the 1950 population from the 1968 housing counts, it was necessary to calculate a ratio of population decrease or increase as a correction factor for each census tract. It is obtained by direct comparison (by census tract) between the population of 1968 and that of 1950 given by the local census. Examples of the correction factors are shown in Table I.[6]

Then the 1950 population data were obtained by multiplying the 1968 population size of each cell by the corresponding correction factor. A supplementary source for 1952 or 1950 population and/or household counts would have been city directory or public utility records. Finally, the choropleth map showing the 1952 "rural" population and 1950 "urban" population was constructed. It will be referred to as the 1952/1950 population map in later sections (Figure 1).

ESTIMATION OF THE 1968 POPULATION

The second part of this study was an attempt to estimate and map the 1968 population distribution from air photos taken of the Atlanta area in April, 1968. The average photo scale was 1:5,000. The housing units on the photos were transferred onto acetate overlays by the dot method. As mentioned before, a floating grid covering a photo area of one-fourth square mile was constructed as the base for obtaining housing counts comparable to those in map grid cells. This grid was then moved so as to register on the photo the cell area given by the map grid. Housing counts in the floating grid were then read and recorded on the corresponding map grid cell. This procedure was repeated until all of the map cells were analyzed. The population

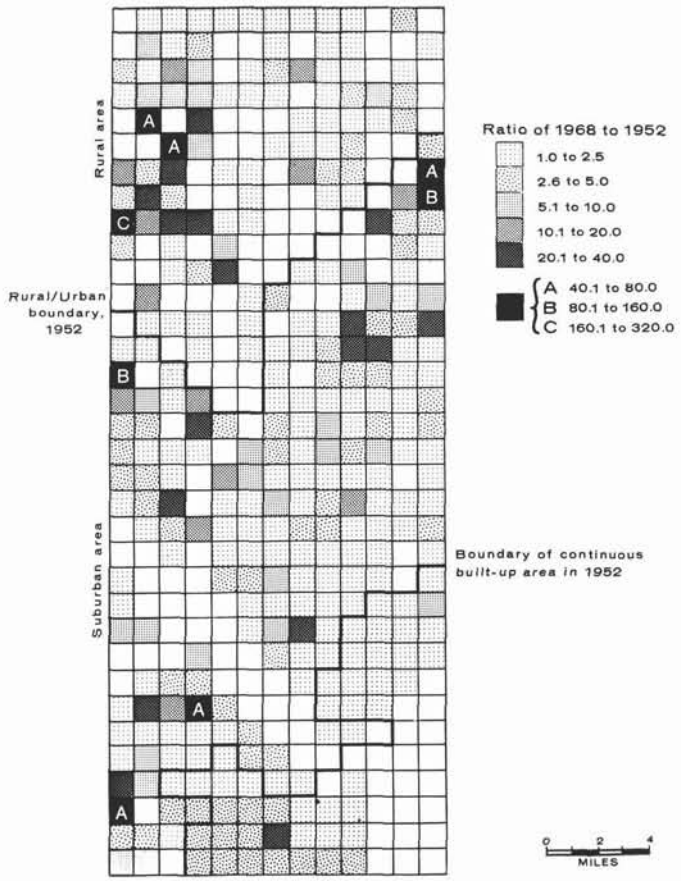


FIG. 3. Population Increase 1952 To 1968.

density of each cell was then calculated from the following relation:

$$\text{Population Density} = (\text{Persons Per Household}) \times (\text{Housing Counts})/4.$$

The persons per household ratio was obtained from local planning agency's census statistics.[7] The housing counts were obtained by reading the dots on acetate overlays. Accuracy depends on the skill and experience of the photo interpreter in the identification of houses. A field check proved that only where evergreen vegetation and dark-colored roofs and driveways occurred together were any houses missed in the count. In most residential areas, the random error was less than three percent. High-rise apartment buildings are impossible to be distinguished from multistory office buildings. An alternative technique was to consult the 1950 city block data from census material, and employ the correction factors mentioned previously. The housing counts within apartment buildings were estimated by the size of the apartment complex. The interpretation keys for this purpose were developed from field experience. Finally, a choropleth map of the 1968 population distribution was constructed (Figure 2).

POPULATION CHANGE

The final part of this study was to analyze the population change in the sample area by a comparison of the 1952/1950 population density map with the 1968 map. The results are as follows. The mean population density of the "rural areas" increased from 67 persons per square mile in 1952 to 271 persons per square mile in 1968—an increase of 304 percent. The increase in suburban section is from 552 to 1,098 persons per square mile (98.9 percent). The increase in urban areas is from 3,856 to 4,556 persons per square mile (18 percent). Maps of population change (increase and decrease) were then constructed, using 1952/1950 population data as the basis for comparison (Figures 3 and 4). The Z-value

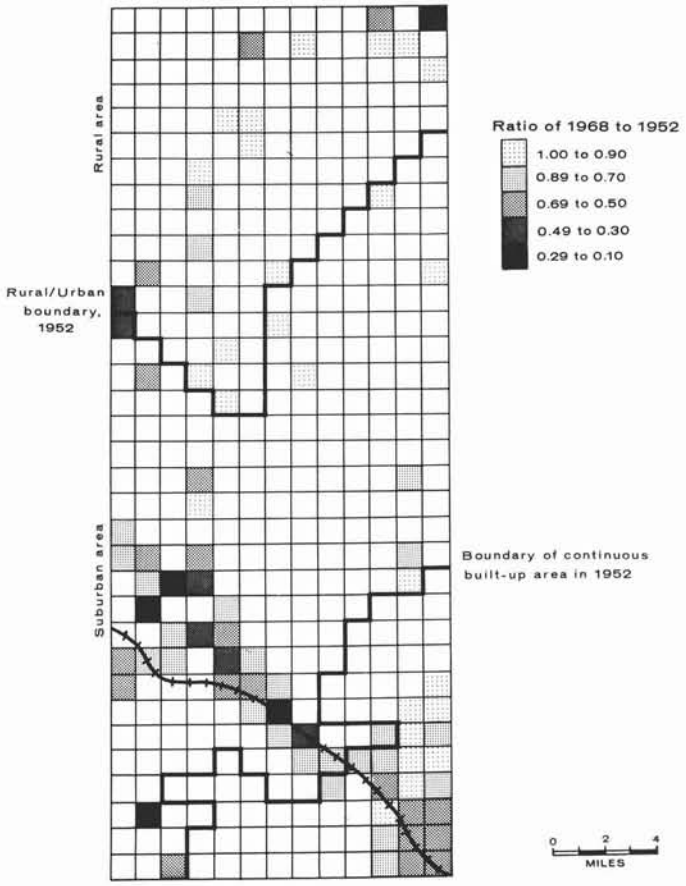


FIG. 4. Population Decrease 1952 To 1968.

categories of the choropleth maps indicate the 1968 population as a percentage of the 1952/1950 population.

Four major points should be noted in Figure 3. First, there is a general population increase in the study area, except within the central business district (CBD) and within a narrow corridor extending northwest from the CBD. Second, the rate of increase within suburban and "rural areas" is much greater than that within the urban sector. Third, the trend of population increase is oriented towards the northwest portion of the sample area. Finally, the 1952 boundaries showing the separation of the rural sector from the suburban sector and showing the limit of the built-up area are not valid in 1968. In other words, the rural area of 1952 has become the suburban sector of 1968, and the 1952 built-up area has been expanding into the original suburban sector.

Population decreased in certain areas between 1950 and 1968 (Figure 4). A loss of more than 50 percent of the 1950 population occurred within the CBD and the suburban sector along the railway zone despite the fact that the urban area experienced a *total* increase of 18 percent and the suburban sector had a *total* increase of 99 percent. In other areas, the magnitude of loss was less, and the pattern of loss is more random.

CONCLUSION

This study was an attempt to conduct an inter-census population estimate by utilizing topographic maps, air photos, and local and state census of population and housing. Topographic maps are used as the basic source for the estimation of the 1952 population and air photos for the estimation of the 1968 population. However, the city block data of 1950, and the census tract data of 1950 and 1968 are indispensable to the estimation of population in the core of the city.

Maps of the 1952 and 1968 population distributions were constructed from the derived

data. The magnitude of population change was also mapped. Such maps may be used as guidelines for regional and urban planning and development within the study area.

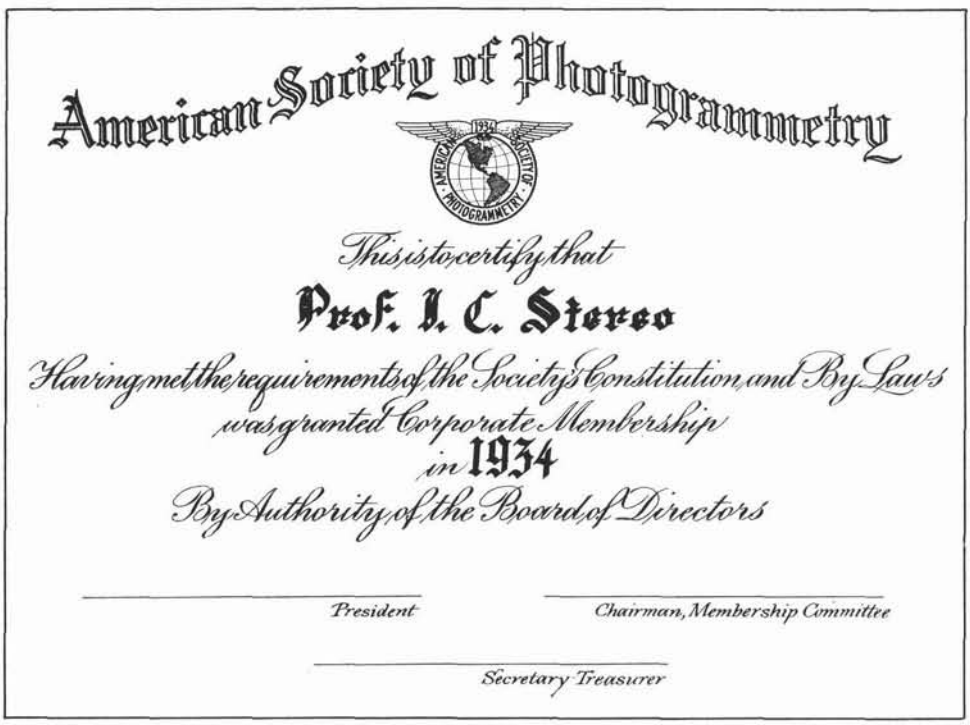
References

1. An example of such effort for Jamaica was in Eyre, L. A.; Adolphus, B.; and M. Amiel, "Census Analysis and Population Studies", *Photogrammetric Engineering*, Vol. 36, No. 5, (May, 1970), pp. 460–466. Earlier references to the applicability of air photos in sociometrics can be found in M. M. Witenstein's papers: "Photo Sociometrics—The Application Of Aerial Photography To Urban Administration And Planning Problems", *Photogrammetric Engineering*, Vol. 20, No. 3, (June, 1954), pp 419–427; "Use And Limitations of Aerial Photography In Urban Analysis And Planning", "*Photogrammetric Engineering*," Vol. 21, No. 4, (Sept., 1955) pp. 566–572; and in Roscoe, J. H., "Photo Interpretation In Geography" in *Manual Of Photographic Interpretation* (American Society Of Photogrammetry) Washington, D.C. p. 764–765.
2. Regional Photo-Maps, Atlanta, Georgia, 1968, Vols. I, II, and III (Atlanta, Georgia: Thomas M. Lowe, Jr. & Assoc. Inc., Consulting Engineer, 1969).
3. *United States Census of Population: 1950*, Vol. III, Chapter 2 (Atlanta, Georgia) (U.S. Dept. of Commerce, Bureau of the Census, 1952).
4. *United States Census of Housing: 1950*, Vol. V, Part 9 (Atlanta, Georgia) (U.S. Dept. of Commerce, Bureau of the Census, 1952).
5. *Atlanta Standard Metropolitan Statistical Area Population: Housing As of April 1, 1968* (Atlanta, Georgia: Atlanta Region Metropolitan Planning Commission, 1968). Tables 6 and 9.
6. *Ibid.* Table 6.
7. *Ibid.* Tables 6 and 9.

(*Continued from page 447*)

grammetric stereomodels from *pairs* of overlapping photographs. The new technique has been applied to photographs of small objects as well as to regular aerial photographs such as the pair shown in Figure 2.

The resulting holographic image (Figure 3) captures the relative orientation and allows one to discard the photographs. An important characteristic to point out is that each small area of the holographic plate contains information about the *entire* stereomodel. Current efforts include the use of developed techniques for mapping the newly formed holographic models of terrain.



Illustrated above is the certificate that is available to members of the American Society of Photogrammetry. The original, suitable for framing, is 8½ by 11 inches with the name of the member attractively hand engrossed. The price is $2. Orders should be sent to ASP, 105 N. Virginia Ave., Falls Church, Va. 22046.