

L. ALAN EYRE*
BLOSSOM ADOLPHUS
MONICA AMIEL
Florida Atlantic University
Boca Raton, Florida 33432

Census Analysis and Population Studies

Population and agricultural data acquisition was both facilitated and improved by using aerial photographs.

INTRODUCTION

THE COLLECTION OF census data and analysis of the resulting statistical material are traditionally undertaken by specialists and agencies with very little experience or interest in photogrammetry. This situation is exacerbated in many developing countries where indigenous specialists, trained only in statistics and population theory, may have only peripheral interest in any form of spatial

social scientist that he did not believe that there was any information put on maps which would not be more meaningfully represented in some form of table. Another reason for lack of interest in photogrammetry as a tool in population studies derives from the very real problems associated with its use. Some of the more significant of these problems are considered below, and certainly great care must be exercised in calling photogrammetry to

ABSTRACT: Aerial photography has been little used to date in demographic studies, specifically in the analysis of census data. This review of the utilization of both time-sequence vertical photography and census material in an analysis of certain features of the population of Jamaica demonstrates that each can be used to enhance the utility of the other. Examples are given where aerial photography increased the validity of the census and detected inadequacies. Problems associated with use of aerial photography in census work are discussed. It is concluded that with proper safeguards, particularly careful sampling techniques, such photography can be a valuable tool in extrapolating demographic data beyond areas of detailed census coverage and in other types of detailed population analysis.

or cartographic representation of the data which they collect. This may originate partly from the conviction, having some justification in many such countries, that maps and other spatially-oriented media lack the accuracy and veracity which they (often quite mistakenly) perceive in their massive volumes of statistical tables.

Typical of such attitudes was the comment of an internationally recognized West Indian

the aid of the demographer and population geographer. This paper suggests strongly, however, that on the basis of the authors' work such aid is very real particularly in the finer details of accuracy evaluation and distributional analysis. One of the most serious problems in the spatial analysis of population is that so frequently the available data are on far too gross a scale to be meaningful.

Between 1965 and 1969 the authors, all Jamaican geographers with a basic interest in population, made various analyses of the basic data in the 1943 and 1960 censuses of Jamaica utilizing the two complete photogrammetric coverages then available: 1941-42

* Senior author; the junior authors worked with the Town Planning Department of the Jamaica Government. Submitted under the title "The Utilization of Aerial Photography in Census Analysis and Population Studies."

and 1961.† The relative contemporaneity of censuses and aerial photography was quite fortuitous, but greatly enhanced the utility of both. A few of the significant points which emerged are summarized here and also a number of pitfalls which beset the use of photogrammetry in population studies.

ELUCIDATING INADEQUACIES IN THE CENSUS

The ultimate purpose of the analysis was to explain intercensal changes in population distribution, fertility and other parameters. As a basis for this the two censuses were subjected to close scrutiny, compared with the photographic imagery, and distribution maps were made (Figure 1). The comparison confirmed generally the demographers' conviction that population censuses in Jamaica possess a high order of reliability considering the non-industrial character of the country. Nevertheless, inadequacies in the census were revealed and elucidated and a distinct improvement in its validity was made possible. Three types of inadequacy met with will now be considered.

POPULATION EXISTING BUT OMITTED IN THE CENSUS

It would be a remarkable census which had no problems of underenumeration of this kind, particularly in a developing country. Schedules may be mislaid, lost in transit or misfiled. Enumerators may misread directions as to boundaries, may fail to locate homes far into the bush or consider the walk not worth the financial return. Figure 2 shows an area in the St. Elizabeth plains of southern Jamaica for which all data was lost and consequently omitted from the census. The parish and regional totals were consequently affected, requiring subsequent adjustment upward of the published figures. To ascertain an acceptable estimate of the population composition and distribution in the officially *empty* area a house count was made by use of stereo pairs, bearing in mind certain complicating factors noted below. The probable range within which the number of persons per household would fall was calculated by comparison with twelve surrounding enumeration districts. Various other parameters of population composition such as fertility and sex ratios were derived in similar fashion.

† Eyre conducted this study while associated with the University of the West Indies, the University of Maryland and Florida Atlantic University; Adolphus and Amiel worked with the Town Planning Dept. of the Jamaica Govt.

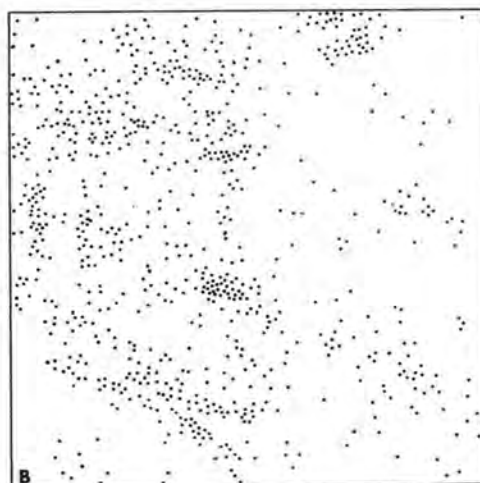


FIG. 1. Two examples of population distributional patterns in Jamaica plotted from census data and aerial photography. *A*. An area in the sugar belt. *B*. An area of shifting cultivation. One dot represents ten persons. Each square covers 25 square miles.

POPULATION NON-EXISTENT BUT "ENUMERATED" IN THE CENSUS

Where enumerators are paid by the number of schedules completed, some overenumeration is possible. Political considerations also have a bearing on inflation of population counts. The enumeration district delineated in Figure 3 had no population at the time of the 1960 census and in fact had never had any within living memory, despite the published tabulations which listed more than 200 persons of various ages. The photography showed the only structures to be cattle byres. Careful comparison with all surrounding dis-



FIG. 2. Estimates of unenumerated population totalling several hundred and various demographic characteristics in the district shown were made by air photo interpretation. Care was needed to distinguish in this semi-arid area small homes from large water cisterns and catchments (small square shows one of each).

tracts revealed none into which the tabulated population could be fitted satisfactorily, and in any event there was no doubt of the division boundary, because here both cartographic and verbal definitions were available. Comparison with surrounding areas was made to seek evidence of gross imbalance in any parameter which might prove fictional origin of the enumerated population, but if the persons were indeed imaginary, it was not clearly evident.

PROBLEMS ASSOCIATED WITH URBAN POPULATIONS

Detailed examination of small town populations proved to be the most intractable problem of interpretation. G. W. Roberts, using boundary definitions adopted in the 1943 and 1960 censuses, published in 1967-68 an analysis of intercensal growth of small towns in Jamaica. But photogrammetric study showed these definitions to be illogical to the point of absurdity. Thus in the 1960 census the town of Mandeville includes an isolated enclave in the center of the unconnected township of Williamsfield six miles distant. In the case of Lionel Town, one side of the main commercial street, the hospital, government buildings, post office and a substantial built-up area has been arbitrarily excluded from the town as defined and enumerated in the census. The definitions for 1943

proved equally frustrating, omitting significant sections and in most cases being considerably smaller than the effective urban area.

Thus, on the basis of the above definitions, Spanish Town, key nodal center in the sugar belt of St. Catherine parish, seems to have exhibited only a modest intercensal increase of 23 percent to a 1960 *official* population of 14,706, a figure with a deceptive aura of exactitude. In fact, however, this refers to the restricted core area only; delimitation by the photography of the extension of urbanization which included in 1960 the growth suburbs of Homestead, Highfield, Hampton Green, Friendship and Thompson Pen, indicated a population of about 28,500 within a radius of two miles from the market and an intercensal growth within the range of 45 to 55 percent. The demographic stagnation attributed to Spanish Town proved to be more apparent than real and is largely an artifact of the Department of Statistics (Figure 4).

The well known resort city of Montego Bay provides another illustration. There the combined influence of tourist development and an entrenched plantocracy has resulted in squeezing lower-class peripheral expansion into inconspicuous satellite communities tucked away in valleys several miles from the city center. The total population of these communities in 1960 was in excess of 5,000. Geographically they represent urban over-

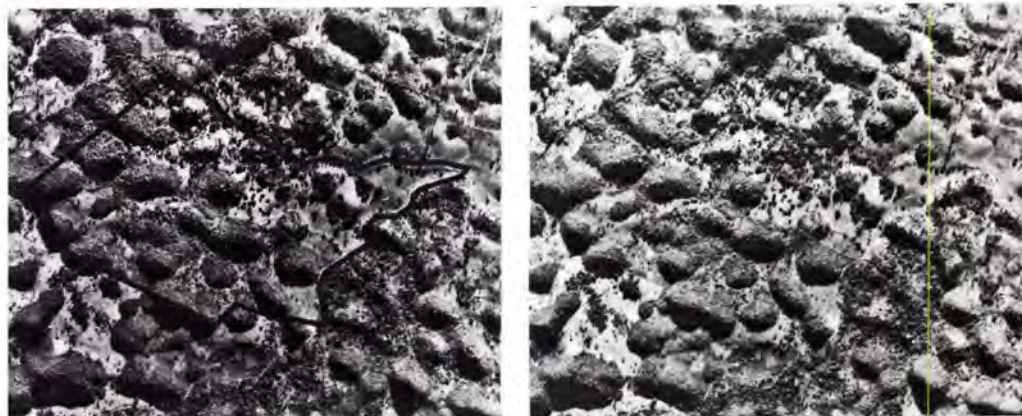


FIG. 3. In this district population was enumerated in the census but proved to be non-existent on the ground.

spill and depend economically upon Montego Bay. Any consideration of rate of growth must take such communities into account.

In some areas of the world, the converse may be noted. Official populations of urban places in Latin American countries, for instance, frequently include dispersed rural population within the *municipio* and figures for the actual urbanized centers are only obtainable by examination of aerial photography. In some instances places listed as urban with populations in the thousands prove under closer scrutiny to have only a minuscule nucleus of truly urban character.

PROBLEMS IN THE UTILIZATION OF AERIAL PHOTOGRAPHY IN POPULATION STUDIES

During the course of the work conducted by the authors, various cautionary factors were noted and some of these will now be discussed briefly as they are of general interest. In the hands of the inexperienced quite invalid deductions are possible from any form of remotely sensed imagery.

TEMPORARY DWELLINGS

In mountain areas especially a bogus distribution can be derived through failure to recognize a pattern of transhumance, and mistakenly identifying temporary or seasonal cabins, shelters and huts as permanently occupied dwellings. Even thatched rain shelters in humid hill country can look deceptively like homes. In the Blue Mountains of Jamaica are hundreds of such structures dotting the upper slopes of the ridges, and other supporting signs of permanent occupancy must be sought. Often a regional pattern can quickly

be observed (e.g., certain forms of garden plot, orientation along tracks, etc.).

DETAIL OBLSCURED BY VEGETATION

In humid tropical areas shade is eagerly sought and homes are erected beneath the shadow of large trees, thus making identification on vertical stereo photography difficult. In areas with annual precipitation in excess of 1,500 mm. per annum, this problem resulted in serious loss of accuracy. However, certain types of trees are characteristic of *house spots* and increasing familiarity with the regional land and occupancy characteristics led to results of greater validity.

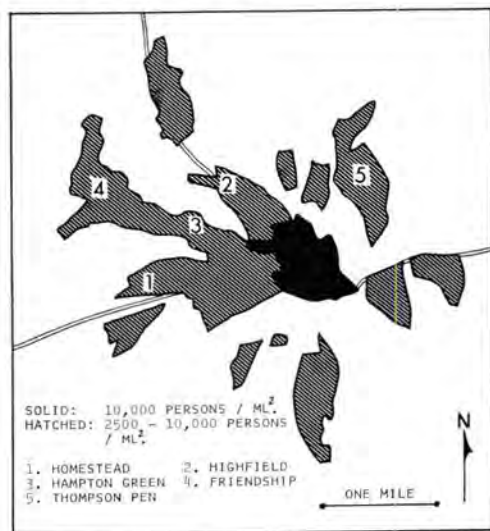


FIG. 4. Spanish Town, Jamaica. Hatched areas of growth identified from aerial imagery indicate a larger urban population than is listed in the census.

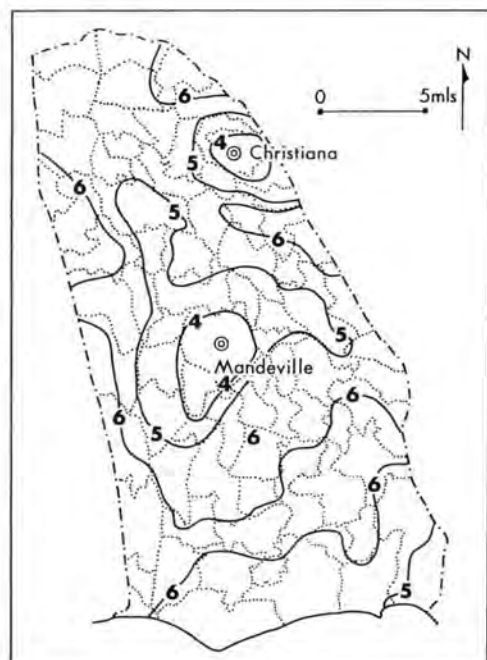


FIG. 5. Variations in the average size of family of procreation in the Jamaican parish of Manchester was one factor used to weight house counts made from aerial photography. The example shown indicates 1943 census divisions; data is for 1965, based upon approximately 1000 sample households.

MULTISTORY DWELLINGS

With stereo pairs height can be estimated and account has to be taken of multi-story dwelling units, particularly in urban centers. In the absence of field checks the degree of

use of lower stories for business premises is largely a matter of educated conjecture.

SIZE AND COMPOSITION OF HOUSEHOLD UNITS

This varies very widely, of course, and the only way to obtain valid data is to establish regional statistical surfaces by the use of tabulated census data or, where this is not available, by sampling. The child-woman ratio (number of infants 0 to 4 years per number of women of reproductive age, known also as the fertility ratio) varies in Jamaica from 35 per thousand in parts of the sugar belt to 120 per thousand in parts of the Blue Mountains. Variations in sex ratios, quinquennial age groups, percentage in the labor force and other characteristics may also have to be taken into account. If considerable extrapolation is being made beyond tabulated data by the use of air photos, it is very necessary to establish by sampling techniques the basic types of household organization in the region, *viz*: single family dwellings, compounds, tenements, plantation barracks, etc., because each has a characteristic population size and composition as well as a recognizable signature on the photographic imagery. To ignore such variables is to grossly distort the overall pattern of numbers and their distribution (Figure 5).

In an area where the population is not homogeneous economically, considerable variation in density per unit surficial area of physical structure is likely. For example, in Jamaica, homes of upper-income families, both rural and urban, are often large spatially, but

TABLE 1

	<i>Clandon</i>	<i>Hope</i>	<i>Dump</i>	<i>Victoria Town</i>
Total households	63	63	63	63
Adults: males	72	71	64	57
females	82	86	83	68
Total adults	154	157	147	125
Total persons	325	344	364	247
Adult-child ratio	100:111	100:119	100:148	100:99
Total rooms	255	347	180	138
Persons per room	1.3	1.0	2.0	1.9
Number of households with more than 5 children living in the home	9	5	17	4
Percentage of households with more than 5 children living in the home	14%	8%	27%	6%
No. of rooms per household	4.0	5.5	2.9	2.2
Households with 1 or 2 persons	18	11	9	22
Households with persons in employment other than agriculture, casual labour, or domestic service	30	49	12	8

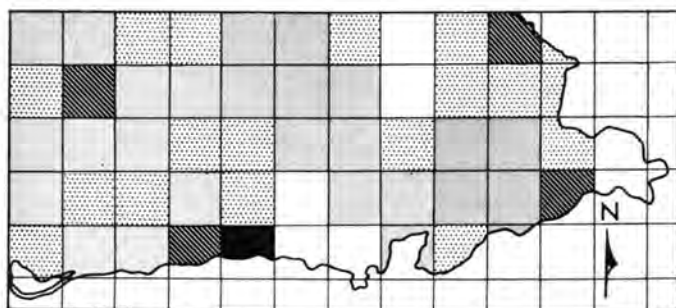


FIG. 6. Index of degree of nucleation and dispersal of population in a portion of eastern Jamaica. Solid: urban. Hatching: highly nucleated (1.0-2.4). Heavy stipple: moderately nucleated (2.5-4.9). Light stipple: moderately dispersed (5.0-7.4). White: highly dispersed (7.5-10.0).

normally they represent a smaller average number of resident persons than very small thatch huts inhabited by large, poor families. Table 1 presents summarized data from four sample districts (actual names) investigated by the senior author in 1965. Twice as many persons per room were in Dump where homes are diminutive huts than in Hope where most of the population resides in comparative affluence in five- or six-room homes built by a mining company. Inflation of the population of Victoria Town would have been easy in the absence of the sample had not the very high percentage of small households been noted, mainly aged couples or persons living alone.

The spatial characteristics of any population are just as important as other demographic aspects. One small example, an output which it was only possible to obtain by use of aerial photography, is illustrated in Figure 6. This represents a small portion of a map showing degree of nucleation and dispersion of the population in Jamaica. The grid used is the 10,000-ft. Jamaica national survey grid. The range of the index is from highly nucleated, where all the population within a grid square occurs within one tenth of its area, to total dispersion, where only one tenth covers the same fractional area. Variations in this parameter are significant in

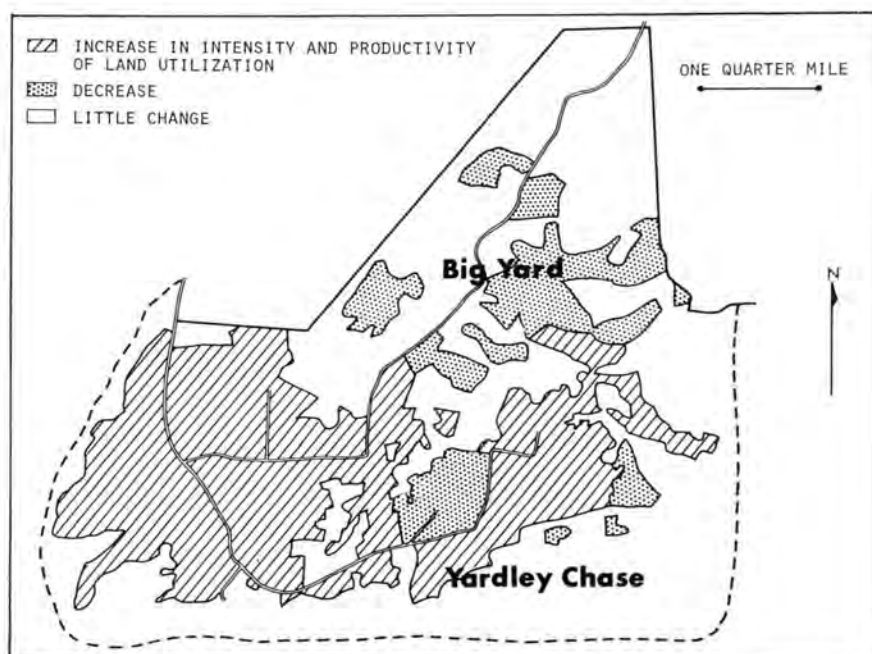


FIG. 7. Districts of Yardley Chase and Big Yard, Jamaica. Changes in land productivity 1942-61 interpreted from time series aerial photography.

terms of social services and amenities, and also correlate with migration differentials. A positive correlation exists between out-migration and degree of dispersion.

AGRICULTURAL CENSUS DATA

An attempt was made to use the same air photo coverage to increase the utility of the Jamaican Agriculture Census of 1961-62, for which no spatial breakdown of data has been published. This clearly represents a much more complex problem than the preceding. Nevertheless, significant output was obtained for several sample areas. The most ambitious part of the study was to identify discontinuities and differentials in agricultural productivity per acre over space and time; the largest unit so examined was the Vere plains, totalling more than 82,500 acres. By this means gross changes and trends have been documented and these were significantly correlated by computer to demographic data and used to explain population change. One case is shown in Figure 7. In another instance, evidence in the agricultural census of the seriously declining productivity of the pocket-sized family holding characteristic of much of Jamaica's hill country was clearly paralleled by evidence of massive out-migration from

such areas. Regions where productivity had sharply risen corresponded just as demonstrably with absolute in-migration. A considerable degree of mutual predictability was indicated.

With these cautionary notes, there is little doubt that photogrammetry can be a valuable aid to population analysis and can greatly increase both the reliability and utility of census data. With proper safeguards its use offers a method of extrapolating from accurate sample data to wider unenumerated areas and in many instances can be expected to provide results more valid than badly organized census-taking. Its most useful role may be envisaged in countries in those climatic belts where obscuring vegetation is minimal.

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