

phy as an important geographic research tool. Now, with good photo likenesses of a region it is possible to simplify and to greatly improve on the old field-investigation methods. It is possible, with a minimum of ground inventory control work, to efficiently and accurately prepare regional reconnaissance and even final pattern distribution maps, in requisite detail for most regional geographic survey studies. It is possible now to dispense partly with the

laborious and costly "ground-walk" over an area, in conducting a geographic field research investigation.

And with the tools now proven and available to make his own "personal" aerial photographs cheaply and quickly, the geographer should find still more profitable ways of utilizing the great versatility of aerial photographs in the geographic field research of the future.

## USE OF AIR PHOTOGRAPHS BY GEOGRAPHERS\*

*John E. Kesseli, University of California, Berkeley, California*

**I**N THE opinion of most people, a geographer is a person who can tell where places and countries are. A geographer of this definition would have little use for air photographs because they carry no names. Any voluminous atlas with an extensive index of place names would serve as a much better source of information.

Luckily, geographers have a considerably better opinion of themselves and claim interest in a much greater variety of features of the earth's surface. They study land forms, climate, vegetation and, above all, people, and the marks they have left and are leaving on the landscape. Geographers want to know how many people, where they live, and why they live there. They pay attention to the different forms of settlement,—single farms, small towns, large urban agglomerations—and study their distribution, site, size, functions and morphology. Their interest in the economic pursuits of mankind leads to their studying agriculture, animal husbandry, mining, and manufacturing, all of which leave distinctive marks on the land. They want to know in what areas one or another form of making a living dominates and why this specialization has taken place. This leads to investigating the physical basis of such areas; they are forced to pay due attention to topography, climate, natural vegetation, drainage and soils.

Some geographers have proclaimed that the chief object of their science is the study of the distribution of phenomena over the earth surface. Others have postulated that the geographer's main job consists in dis-

cerning a pattern in the apparently haphazard distribution of phenomena, that is, that he find areas of similar physical or cultural aspect, the so-called physiographic, geographic, cultural, or natural regions. Still another group believes that geography is the science which demonstrates the control which landforms and climate have exerted or are still exerting upon the mode of life and the fortunes of a people.

The great variety of features of the earth surface which claim the interest of the geographers clearly indicates that they could use aerial photographs to great advantage in their investigations. Air photographs are obviously only a new tool added to many others already in use for some length of time. In geographic research, extensive use has always been made of maps of all kinds, such as topographic, geologic, climatic, soils and vegetation maps. In economic and climatic research, the varied statistics, laboriously collected by government and private agencies, provide an immense amount of information which the geographers can use. Another and possibly even greater amount of information useful to geographic inquiry is embodied in the thousands of articles spread through hundreds of scientific journals, yearbooks, bulletins, and kindred publications, in which material closely or remotely related to geography is preserved for posterity. Any historic-geographic inquiry into the spread of population, or the changes of land use, or the growth and decay of settlements, must rely heavily upon the written record. There is, furthermore, the possibility of

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collecting information personally and at first-hand by means of field work.

The great variety of ways by which basic evidence for geographic ends can be gathered explains the attitude of established geographers, as well as students, towards air photography. A great number, probably the majority, regard it as an unnecessary tool and believe that the time involved in studying air photographs, or in acquiring a basic training in their use, can be spent more profitably in another form of research or of professional preparation. There is, therefore, no great haste among geography departments to introduce courses in air photograph interpretation or, where such courses are offered, there is no general rush of students into such courses. Departments predominantly interested in economic geography, regional geography, or climatology, generally find the old forms of source material entirely satisfactory, although they use an occasional low-oblique air photograph taken at low altitude for illustrative purposes. Such departments form the majority of the geography departments of the country. Only in departments sufficiently staffed to consider all parts of the geographic field can it be expected that air photography has found, or may find, its due consideration as a research tool.

But in well-staffed departments, the number of courses offered has become so great that no undergraduate majoring in geography, or even a graduate student, is able to take all the course offered in the department, in addition to a reasonable number of courses in related fields. The student has to make a choice according to his special interests. His eagerness for information often leads him to give preference to lecture courses in which he can acquire a voluminous collection of facts and ideas which he deems of primary importance to his future development. Conversely he is inclined to neglect field and laboratory courses which provide a training in the gathering and interpretation of information, hoping that this problem will take care of itself when the time for independent research arrives. Often the greater number of hours of attendance connected with laboratory courses causes students to avoid them in order to save precious time.

Against this background of general considerations, I will describe the position which the study of air photography has attained among graduate students in the De-

partment of Geography at Berkeley.

Among our graduate students during the past few years, who have been working towards a master's or doctor's degree, seven have relied, or are relying, to a considerable extent on air photographs, in their research. This number is about a third of the students working toward an advanced degree. Five of the seven were led to using air photography because they could find no published maps at a scale large enough for use during their field work, or sufficiently precise and informative for the orderly arrangement of evidence gathered in the field. The best maps which these students, working south of the border, could find were aeronautical charts at a scale of 1:500,000 and smaller. Although they had had no previous training in using air photographs, they realized that air photography was next best to the detailed topographic maps previously planned for use in their research. With only occasional advice and encouragement by the instructor they had to develop skill in using the photos. They began to regret neglected opportunities; but in the end, all were able to use the air photographs effectively.

Two students found it necessary to compile their own base maps. Using an acceptable plan and several spot elevations obtained from published maps, one student established the elevation of additional points by altimeter, and used vertical and oblique trimetrogon photography to estimate the location of contours. By careful work, a good familiarity with the terrain acquired by ground work and the laborious process of trial and error, he produced a good, reconnaissance type, topographic map of an area of 250 square miles at a scale of 1:300,000 with a form-line interval of 1,000 feet. This map may not satisfy the rigorous requirements of the topographic and photogrammetric engineer, but at present it appears to be the best available physical map of the Cape Region of Lower California.

Another student, needing a good base map for the presentation of his work, made an accurate ground survey with plane-table and alidade, of a flat basin forming the prime object of his investigation. Later, vertical and oblique trimetrogon photography permitted a satisfactory extension beyond the basin into more rugged terrain, by using overlays of appropriately

spaced squares on the verticals and of perspective grids of squares on the obliques. Insufficient points of known elevation within the map area precluded drawing of contours or form lines; hachuring was found too laborious and inaccurate in the absence of contours. The morphographic method of terrain representation was then chosen—physiographic diagrams and land-form maps on which the terrain is shown in a simulated oblique bird's-eye view. Although the map lacks absolute accuracy in its horizontal control outside the surveyed center, since no radial triangulation was carried out, the limited distance the plan was extended by crude means excludes the possibility of gross mistakes. The map well fulfills the purpose for which drawn; it provides a good idea of the topographic configuration of the area, and correctly shows the location of pertinent details established by ground survey.

In preparing seven theses airphotography was used extensively. Five deal exclusively with land forms and two are historical studies investigating successive stages of human occupation and land-use. In all studies, the use of air photographs was supplementary to field work. In most cases, the photography was not available until after the students left their area of investigation. In all cases, the air photographs permitted a clearer grasp of the terrain relations than could be attained in the field, either because the country was too flat and too densely tree-covered,—the case on a Caribbean coral island—or because the country was too rugged, too difficult of access, or too extensive, as in parts of Lower California, the Mexican Plateau, and the coast of California.

Familiarity with terrain features acquired on the ground made subsequent interpretation of the air photographs under the stereoscope relatively easy and trustworthy, while the necessity of using the air photographs to the fullest extent forced the students to acquire the patience, concentrated attention, and perseverance necessary for their interpretation.

One student carried out an intensive study of land forms on the ground and on vertical and oblique trimetrogon photography. This resulted in a detailed and precise map of landform regions from which the geomorphic history of the territory and the varied processes responsible for its transformation could be elucidated.

Another student, investigating sequent land-use of a coral island, could use the differences in natural vegetation and, where the land was cleared, the differences in soil drainage,—both stand out clearly on air photographs by their difference in color and/or texture,—to map the areas suitable and unsuitable for cultivation, after he had recognized these relations on the ground through field work. With this accurate background and additional information on the photographs, such as evidence of shifting land-use revealed by varied stages of second growth, the interpretation of the historical record will be greatly facilitated, and contradictions or inaccuracies in that record can be corrected.

The successful use of air photographs in connection with field work, which these cases indicate, reveals that air photograph interpretation can be learned without the benefit of formal course work in the subject. It seems to assure a spread of use of air photographs by geographers, even if the multitude of geography departments neglect instruction in the subject.

Only one of the seven students had taken the photo-interpretation course given in our department prior to starting his thesis work. Realizing the value of air photographs and large-scale topographic maps, he carefully chose an area along the California coast for his terrace study. From a stereoscopic study of the vertical air photographs, he determined the localities he had to visit in order to find needed evidence and the areas he could avoid for obvious lack of evidence. He also used the photographs for mapping in the field, being well aware that fence corners, field margins, forest groves, and single trees, faithfully reproduced on air photographs, are better reference points than the contours of a topographic map which are invisible in the field. To transfer the mapped area from the vertical air photographs to the topographic map of slightly smaller scale, the student used a vertical sketchmaster, applying the necessary corrections for height displacements based upon the measured elevation of numerous points determined for other purposes by a precision altimeter. Although the topographic map had been made by photogrammetry utilizing conceivably the same air photographs he was using, he found that the U.S.G.S. contours and his altimeter measurements, corrected for variations in temperature and air

pressure, did not always agree. The student had sufficient confidence in his own work to modify the contours.

The short semester course in the use of air photographs which this student had attended enabled him to make more intelligent and efficient use of the photography, including good planning of his field work.

Thesis work carried out thus far in our department has clearly established the great value of aerial photography as a basis for the compilation of required base maps and as a source for an intensive study of land forms, either for their own sake, or as background for an interpretation of human geography.

Thus far, air photography has not been used for two purposes for which it seems especially well suited—studies of crop distribution and of settlement forms and sites. However, in California, the most readily available photography of its cultivated and densely populated areas largely dates back to the former Agricultural Adjustment Administration and is already considerably out of date; California farmers change their crops at the drop of a market quotation or support price; California settlements, big and small, have all mushroomed during the recent influx of population. The hesitancy of graduate students to study this problem at present with the help of these photographs is thus understandable. But relatively soon, this same photography will provide an excellent historical record permitting the study of this change, a record which will be free of guesswork or hearsay or the blurred memory of old-timers. We hope that this valuable record will be carefully preserved for future use.

As a tool in geographic research, one of its major shortcomings is its great cost. Since the geographer's research work, on the graduate level and afterwards, is not directly remunerative, he does not give consideration to the cost of flying and of taking the photographs, as this expense is definitely out of reach of his purse. He must rely on photography already taken and paid for. But the cost of the prints still remains high in comparison with the cost of other source material. Books, journals, and published government statistics are free; that is, they can be borrowed from the hundreds of libraries scattered over the land. Maps of all kind are either free, when inserted in books, or are avail-

able at small expense. But air photographs cost at least 50 cents a print, and if dozens or hundreds are needed for efficient coverage of an area, the necessary investment looms large. As graduate students generally are not well fixed financially and since all faculty members do not have ready access to research funds and grants, the high cost of air photographic prints discourages their use even when their high intrinsic value is clearly realized. Of the seven students referred to, two were able to acquire the photography on their G. I. allotment; the department was able to acquire the air photographs for two. Three students had to foot the expense themselves; only the certainty that the photography would save them a summer's field work and thus probably advance completion of their thesis by a full year induced them into this expenditure.

Unfortunately air photography is so new and air surveys have been taken at such a rapid pace that adequate and easily accessible collections, comparable in function to the collections of books available in our libraries, have not yet been established. Attempts at creating such collections on a small scale are underway at different university departments and libraries. But here again, the high cost of air photography interferes. If the number of scientific books and journals, or the stack of topographic and other maps which one hundred dollars will buy, is compared with the small package of air photographs which can be obtained for the same outlay, the enthusiasm for collecting the latter is dampened. If one computes the great number of prints necessary to produce a worth-while reference collection, such as coverage of our State or if a reasonable part, the effort of acquiring it in small installments appears directly futile. During periods of rising costs and/or budget cutting, collecting air photographs becomes an expensive luxury and is most likely to suffer or be dropped entirely.

Needed for a more general use of air photography in geographic and related research are numerous and easily accessible collections at which photography can be inspected or from which it can be borrowed. I wish that the varied government agencies which own a large volume of air photographs would follow the example of the Army Map Service which has established map depositories at all major uni-

versities and colleges whereby large map collections have now become easily accessible to students and faculty. Similar collections of air photographs would do wonders in encouraging their use. Such depositories could easily be started if air photographs, no longer needed in office work and destined for the waste paper basket or the incinerator, were sent to university departments with the desired restrictions placed on their use. Government agencies as well as private concerns could cooperate in this worth-while endeavor.

To summarize during the last few years, a number of graduate students in our geography department, representing part of the future generation of college instructors, have become acutely aware of the usefulness of air photographs in geographic research. These photographs have proven valuable in poorly-mapped as well as well-mapped areas, used either in place of, or together with, adequate contour maps. They were especially helpful in the study and interpretation of the terrain; that is, in the investigation of topography, land forms, natural vegetation, and drain-

age. The air photography reduced the time that had to be devoted to field work, but did not eliminate it. It permitted recognition of spatial and other relations which could not be seen on the ground, or were only imperfectly realized in the field. By now, these users of air photography have become devotees and can be expected to popularize their use among future generations of geography students through example, advice, or formal courses.

A more general use of air photographs by geographers and kindred scientists has to await the creation of more and larger public collections of air photographs from which these men can borrow such photography, just as they now are able to borrow books and maps needed in their investigations from libraries and map collections.

The need for such collections appears to be more pressing than instruction in the use of aerial photographs. By interesting itself in the creation and the development of such collections, the American Society of Photogrammetry can perform a commendable public service.

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