THE USES OF AERIAL PHOTOGRAPHS IN GEOGRAPHIC RESEARCH*

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Geographic Research and Its Problems

MODERN research is the forerunner of all human progress, and today inquires into every phase of man's thoughts and endeavors. One of the very active segments investigates the intricately interwoven physical and cultural phenomena of the earth's surface. This investigation involves the distributional patterns and expressed character of the many physical landscape elements such as landforms, soils, water resources, climate and weather conditions, and natural vegetation, as well as the many superimposed "works of man" which take their form in crops and pasture lands, irrigation systems, transportation nets, urban developments, factories and mines—and, even man himself.

Much inventory and research work involved in the investigation of specific phases of these multiple elements of nature's complex landscape falls within the realm of Modern Geography, which may be thought of as a study of the structure and function of man's physical and cultural environment. The problems of Modern Geographic Research are tremendous, because the entire expanse of the earth's surface must be considered and studied. Of this whole vast areal complex not one small part or specimen feature can be brought into the geographic laboratory for consideration and evaluation, let alone several parts or several specimen features for comparative study. The geographer must carry out his inventorying and research strictly in the "field," *or*, through the employment of tools and techniques which permit him to reproduce a "miniature likeness" of the geographic landscape phenomena which then can be utilized in the laboratory.

Nature of Today's Major Research Tools

The map has long been known and used as a method of reproducing landscape likenesses in the laboratory. Possibly its use dates back into early history, to the dawn of geographic thought in the minds of primitive men. The map has come to be a universal research and record tool, written in a universal sign and symbol language. The map has served the world of research essentially alone and unaided until very recent years, when the aerial photograph came into wide use as a second research and record tool of great utility and flexibility.

The aerial photograph is the first and only available device by which the geographer can capture a nearly complete and definitive full-detail miniature-likeness record of a given landscape complex, at any specified moment or series of times. As such, the aerial photograph is unique and becomes a priceless tool in the hands of the modern geographer. But it must be fully recognized that the photograph is no panacea, and does not spell doom for the maps now in use. Neither photograph nor map is fully complete within itself; they are definitely and conclusively supplementary to each other, and neither is in any way capable of supplanting the other. The geographer who does not today fully utilize their combined potentialities is sacrificing the cause of Modern Geography.

Uses for Aerial Photographs in Regional Geographic Research

It is universally recognized that in regional geographic research, aerial photography provides many vital links in the chain of inventory data and impression development, links which are important to the solution of geographic field problems.

Study-region selection

Probably one of the first and more elementary uses to which aerial photographs and mosaics are put in geographic research

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is that of suggesting field problems and in aiding in the selection of geographic regions for study. When the general study-region has been selected the aerial photographs further serve admirably in determining approximate regional extents, and in establishing the first basic regional concepts. Occasionally the study of an aerial mosaic strongly suggests important variances with established ideas already published in text and map form about a study-region, and thus commands a thorough investigation and restudy. Or, the study of a large-area set of mosaics may suggest the most logical localities within which to carry out a series of type studies to satisfy a regional geographic problem already conceived. Not only have untold numbers of geographic research hours been thus saved through the use of aerial photographs, thereby permitting more profitable expenditure by the geographer in other ways, but the net research results have undoubtedly been much superior.

FIELD RECONNAISSANCE

The success of a geographic field reconnaissance may be largely measured by its completeness. Its completeness is most often determined by the investigator's preknowledge of the general conditions of the region involved and the peculiarities of its geographic problems. With the aid of aerial mosaics and stereo-pairs, a rather precise sketch map or series of maps can be constructed of a region, showing all the directly readable facts as well as many additional interpreted facts. Landform character, surface slope, drainage patterns, and vegetation cover, and the cultural imprints of man can frequently be recognized and partially understood from photographs, even before the first actual entry into the field. The physical accessibility and the best possible routes of entrance may be determined with considerable accuracy, and those portions of the region which give promise of furnishing the most needed and pertinent data can be selected with surprising correctness. Likewise, regional traverses may be plotted which can be later followed in the field, with practically no deviation whatsoever from plan. The geographer can "see," through the medium of the aerial photograph, the entire areal complex as nature has developed it. The field geographer usually in the past has utilized hill tops and other high vantage points for field observation; the geographer can now use the aerial photograph for the same purposes and with much superior results. The aerial photograph has become the geographer's "crystal ball," from which he may learn many things otherwise not possible even in the field. Thus, through the use of aerial photographs, the efficiency of the actual geographic field reconnaissance may be greatly enhanced, its completeness extended, and its cost in time, human effort, and valuable research monies enormously reduced.

In the field, the geographer finds the aerial mosaic or photograph of inestimable value. By carefully checking his field movements, the geographer may determine his exact position on the photograph at any moment, and thus read from the photograph the complete physical situation and character of the landscape on all sides—conditions which may be actually cut off from his direct on-the-spot view. The photograph allows him to "see" beyond the ridges or through a dense vegetation mantle, which his own vision can not possibly penetrate.

No other device can serve as efficiently and precisely as a base for field annotations as an aerial photograph. The physical and cultural features involved are already shown in their true form and in the exact areal location; this cannot always be said of a map. The explanatory notes need only refer to feature character—hill, stream, field, road, or house. These annotations can be inscribed in lines, symbols, or words, directly on the face of the photograph or preferably on an overlay of translucent frosted acetate.

REGIONAL APPRECIATION

Regional understanding and appreciation can be acquired through the study of aerial mosaics and photographs to a degree far outreaching the possibilities through ground reconnaissance or map study alone. The only reconnaissance technique superior to aerial mosaics for gaining direct first-hand understanding of a region, is actual flying over the area in a slow low-flying airplane; this superior technique is further enhanced if the aerial mosaics are taken aloft for comparison study reference and for extensive annotations.

Regional geographic boundaries clarify themselves quite readily on aerial photographs; they may be actually seen and

studied in true relationship and form, and not simply as abstract lines and symbols on sketches and maps. In similar fashion, regional "core areas" define themselves much more readily and accurately within the geographer's regional consciousness, if studied in true perspective from aerial photographs.

PATTERNS AND RELATIONSHIPS

The broad regional patterns of landforms, drainage systems, or natural vegetation are frequently difficult to comprehend and to associate from field observations alone; and the patterns of the "works of man" are even more difficult to visualize and collate, because only relatively tiny pieces of the whole complex are "seen" at one time. But within the aerial photograph the landform likeness pattern, or any other specific landscape pattern, is displayed in total—spread out in a wealth of detail in panoramic perspective not obtainable through any other means or technique. Hills and valleys are displayed in true size, shape, character, and location, while the whole landform association is displayed in its true regional complex and its precisely correct space pattern.

In general, most pattern relationships are difficult to make on the ground, because on-the-ground observers become "lost" in the valleys or among the trees, and cannot properly and fully see their subject; the observer must rely almost exclusively on memory and on the art of image composition in the mind. Even the map cannot give the geographer the same completeness of pattern relationship that the aerial photograph is capable of because no single map, however large in scale and completeness, can carry *all* the detail of *all* the patterns in a region. At best there must be several maps in order to include all features, and comparisons must be made from one to another, a procedure definitely not ideal. Only through the medium of an aerial photograph, or through actual observation from an airplane above the region itself, can a full regional pattern-relationship complex be fully recognized, appreciated, and understood.

Uses for Aerial Photographs in General Geographic Research

The aerial photograph is a great boon to such research. This new versatile tool and technique makes possible for the first time a precise geographic study of "changes through time" of specifically selected phenomena of the geographic landscape, by means of a sequence of photographs taken at selected and controlled time intervals.

LANDFORMS AND VEGETATION

Whether it be in exceedingly torturous terrain, or in a broad flat plains area, the study of landforms is a relatively difficult task for the geographic field investigator. Even the very best maps fail to indicate the fine detail of surface configuration which falls within the tolerance of the contour interval; they do not show all the rock outcrops and the soil mantled areas, the faults and the scarps, the detail of broad rivers and the tiny rivulets, or even man's activities in the area and the scars he has inflicted on it. By on-the-ground field investigation alone, it is difficult, if not frequently impossible, to view as a "total area composite" either areas of great or small relief, where hills and ridges blot out the view, or where extreme flatness confines the horizontal view to short ground distances. But, through employment of aerial photographs, the geographer is able largely to overcome the difficulties associated with on-the-ground observation; the landform features are revealed in precise panoramic arrangement, without view limitations or space relationship confusions.

Vegetation-type patterns may be plotted very efficiently and correctly from aerial photographs, either directly on transparent acetate overlays or transfer-plotted onto prepared base maps. Zones of vegetation transition are readily observable in aerial photographs and the arbitrary boundary lines, so necessary in inventorying and mapping, can be adjusted with fine calculation by tree-crown counts and studying slight variations in tone and shadow. Aerial photographs are especially valuable to the geographer in areas of heavy vegetation, such as tropical forests and jungles.

LAND USE AND CLASSIFICATION

The geographer is frequently interested in the system of land utilization employed within a given area or political unit, or in the sequence of occupance through a period of time. In land utilization studies, the employment of aerial photography adds tremendously to the investigators effi-

ciency, and probably even much to his research accuracy. Generally, a land use map can be made with great precision directly from an aerial mosaic, or such a map may be compiled from data gleaned from stereopairs or even from aerial obliques. Land areas may be measured with the planimeter, and precise data relative to acreages for each type of utilization can be very accurately determined. Also the aerial photograph bears witness to those areas of relatively good and poor crop production, even more effectively than an on-the-ground observer can ordinarily determine. The planning of agricultural policy, on both large-area scale and individual farm or field scale, can be most effective when based upon the study and evaluation of the geographic factors gleaned from aerial photographs—relief, slope, drainage, erosion, good or poor crop showings, and even evidences of mono- or multi-cropping.

In land classification, the geographer may consider a host of determining factors with relative ease from aerial photographs, to best establish a sound and utilitarian classification. Here the factors of relief, slope, drainage, vegetation cover, general soil types, house types, crop types, cultivation intensity, irrigation developments, and many others can all be studied in the complex form in which nature has developed and now exhibits them and not simply as piecemeal studies in unrelated fragment patterns.

RECLAMATION, FLOOD AND EROSION CONTROL

Thorough study of the geographical bases in land reclamation programs is essential the world over. Planning reclamation projects on any scale, and especially on a sub-continental or a national scale, requires a thorough knowledge of such fundamental geographic facts as the occurrence, distribution patterns, and areal associations of landform types, vegetation cover, soil types, climate and weather, developed agriculture and agricultural potential, as well as man himself. Most of these basic geographical facts can be partly obtained through the skillful use of aerial photographs, Research accuracy, speed, and economy are increased appreciably through their use, as compared with old on-the-ground survey and sketch methods.

Flood and erosion damage and control can be most effectively studied from aerial photographs. Floods appear and disappear so rapidly that it is only through the medium of the aerial photograph that they can be accurately recorded; mapping is too slow. Also, in erosion study and control, the aerial photograph makes possible inexpensive and absolutely authentic periodic records, which show accurately the stages and rate of erosion advancement or decline. Even large-scale maps, with very small contour intervals, could not as conclusively demonstrate to the geographer the actual stage conditions of erosion in the same complete and definitive way of which photographs are capable.

SETTLEMENT AND TRANSPORT PATTERNS

Man's distribution and the settlement patterns he develops over the face of the earth are probably among the most basic and fundamental factors in Modern Geography, and at the same time probably among the most difficult to determine with any relative ease and precision. In sparsely populated areas the scattered nature of man's pinpoint dwellings make inventory and location difficult. But whether it be in tortuous mountain terrain where man's cabins and villages are nearly hidden from view among heavy vegetation, or in the broad expanses of the Great Plains where a few ranch-houses may be almost lost in tremendous flat distances, or in the towns and cities of the world, the study of man's location and geographical pattern, as well as the character of his settlements, can be greatly facilitated through the use of aerial photographs. Areas can be easily planimetered and man's dwellings accurately counted; per square-mile population-density results can be quite accurately computed.

The aerial photograph also serves the geographer excellently in the general understanding of regional transportation systems, especially their areal pattern forms and their relationships to the landform, drainage and settlement patterns of the landscape complex.

Some Limitations of Commercial Photography

It has been stated, "It is universally recognized that in regional geographic research aerial photography provides many vital links in the chain of inventory data and 'impression development,' links which are important to the solution of geographic

field problems." But, the geographer must recognize that unfortunately he is not generally in control of the tools for producing this extremely valuable aerial photography. Making these aerial photographs always has been and still is almost exclusively in the hands of commercial or governmental agencies; there is a very good reason, namely, the great cost of their production.

New Horizons in Aerial Photography for the Geographer

The geographer is now in a position whereby he can readily and cheaply provide himself with "personalized" aerial photographs, photographs of his own making which may well serve in most cases as completely workable substitutes, and in all cases as highly prized supplements to the already proven commercial aerial photographs.

In the light of the widespread and fundamental needs of the geographer for more and specialized aerial photographs, the author, during the last several years, has experimented with the combination light reconnaissance airplane and the ordinary and inexpensive 35 mm. camera in geographic field study and general areal inventory. Such general utilization of these two field tools is by no means new; it is only the specific form of utilization in geographic field investigations that is new. Nothing is needed to be developed, except a simple technique, or "know-how," of using these tools effectively.

The first experiments were largely in the nature of a hobby which had its beginning at World War II's end, but results were so promising that it was inevitable that these hobby tools would eventually be put to more serious uses. During the summer of 1947, a full-scale land use survey was made of the Santa Maria Valley in Southern Coastal California, using the 35 mm. camera from the light airplane at low altitudes. These two tools served as extremely versatile and dependable geographic field inventory aids.[1]

Further experimentation continued within the Southern California region with increasingly satisfactory results. Numerous refinements in utilization were gradually developed, and color film soon replaced the customary black and white. In tropical Ceylon, during 1950–51, these same two field tools further demonstrated their great utility in geographic reconnaissance and inventory work, especially within those areas which were exceedingly difficult of access, due to heavy tropical vegetation and an almost complete lack of roads and trails.

With these two well-proven field tools, —the ordinary and inexpensive 35 mm. camera and the light airplane—the geographer may now make his own aerial photographs; he can make precisely the photographs he wants, when, how, and at extremely low cost in time, effort, and money. By this new procedure the geographer can greatly enhance his field source materials, and materially extend the horizons of his geographic field research.

One of the many major advantages this development offers to the geographer is that he may now avail himself always of up-to-the-minute aerial photographic materials—photographs which can be put to use in the laboratory the same day they are shot. Also, such photography has the great advantage of complete adaptability to the research needs at hand. The geographer-photographer has complete control over such elements as subject matter, composition, scale, detail, and the all important angle of view. High obliques, low obliques, and vertical photographs can all be obtained of the same landscape feature, from roof-top levels or mile-high heights, completely at the discretion of the geographer himself and, too, all in the short time space of an hour or so of flight.

But possibly the greatest advantage to the geographer lies in the fact that these personally made aerial photographs can be made in full natural color, as well as ordinary black and white. It must be remembered that up to the present no color aerial photographs have been available through normal commercial channels, and probably will not be for some time to come.

Conclusion

The methods of geographic research have been greatly advanced within recent years, by the adoption of aerial photogra-

[1] For details see, "Some Preliminary Notes on the use of the Light Airplane and 35 mm. Camera in Geographic Field Research," C. H. MacFadden, *Annals of the Association of American Geographers*, vol. XXXIX, Sept. 1949, No. 3, pp. 188–200.

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*

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IN 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 discerning 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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