*Using Airphotos to Measure Changes in Land Use Around Highway Interchanges**

ROBERT R. WAGNER,
Washington, D. C.

ABSTRACT: *The task of studying changes in land use of urban, suburban, and rural areas can be extremely expensive, requiring personal interviews with local inhabitants, thorough searching of public records, and preparation of a map showing the past and present types of land use. Further, field methods are often inadequate in determining past land use changes. A method of airphoto comparison analysis may be used to interpret and measure changes in land use. This method was employed in order to measure land use changes in areas around highway interchanges and proved to be fairly efficient, cheap, and accurate.*

INTRODUCTION

VACANT improved and unimproved land is rapidly going into urban development. One type of development which has caused a tremendous impact on land use is the construction of a 41,000 mile National System of Interstate and Defense Highways. The type of land use changes occurring within a mile or two of interchanges on the new limited access system is drawing the attention and study of urban planners, highway engineers, industrial location specialists, and geographers. Since access to the free and toll roads is limited to widely-spaced interchanges, most land use changes are occurring adjacent to the interchange and primarily along the crossroads for easy access to the freeway or toll road. This change in land use has caused highway planners in particular to be concerned. These changes generate a great amount of traffic and may cause an interchange to be congested and prematurely obsolete unless it was designed to handle this traffic effectively.

In order to plan future interchanges in anticipation of land use developments, the highway planner must know how and why these land use changes occur. He must also know their location in relation to the interchange and what type of changes are involved. If a pattern of development is evident this can be applied by the highway planner when planning future facilities.

Information of this type is difficult to obtain. The amount of time, money, and personnel necessary for extensive field study is often prohibitive. A relatively easy method is needed to collect these data.

The requirement to know what kind of land use changes occurred and where they occurred led to the use of airphotos. Using two sets of photos the area around an interchange could be (a) compared to determine the kind of land use change that had taken place and (b) measured to determine the amount of land involved in the change.

The comparison and analysis of airphotos has been used in other land use studies.[1] Their use provides a quick and inexpensive method of identifying and measuring land use changes.[2] In many cases it is the only means by which the land use prior to construction of the interchange can be determined with any amount of ease and accuracy.

With airphotos it is not essential that the researcher go directly into the field for observation. However, a certain amount of field checking might be helpful to the researcher to establish the classes of land use, especially if he is not acquainted with the area of study.

The photography used for this study was obtained from the Performance Division, Commodity Stabilization Service, U. S. De-

[1] Dill, H. W., Jr., "Use of the Comparison Method in Agricultural Airphoto Interpretation," PHOTOGRAMMETRIC ENGINEERING, Vol XXV., No. 1, March 1959, pp. 44–49.

[2] This same method can be adapted to transportation, urban planning, industrial development, recreation, and natural resource studies on a sampling basis or for complete coverage of any area for which airphotos are available.

* This article is based on a study conducted while the author was employed at the Agricultural Research Service, USDA. He is now on the staff of the Bureau of Outdoor Recreation, U. S. Department of the Interior and his home address is 5025 Sherrier Pl., Washington, D. C.

partment of Agriculture. Nine-inch square contact prints were used. The scale of the air-photos was approximately 1:20,000, or 1 inch representing 1,667 feet. Larger scale prints would have permitted more detailed analysis but these would have added greatly to both the cost of the photographs and the time needed for interpretation.

Methodology of Selecting the Interchanges

The study was limited to interchanges on highways designed and constructed with full control of access, i.e. where access is permitted only at widely spaced interchanges. Because of the scarcity of freeways for which appropriate photography was available, and which had been in operation for a sufficiently long period, interchanges were selected on both toll and non-toll roads. Initial criteria included (1) availability of photographs taken not more than 5 years before the opening of the interchange and at least one year after it was opened, and (2) urbanization of not more than 50 per cent of surrounding land, Urbanization was based on a block pattern of streets, and was estimated from index sheets of the "before" photography.

The most restrictive of these criteria was the availability of photographs. The sample of interchanges was dictated largely by the areas of the country that had been "flown" for the Commodity Stabilization Service, for the purpose of estimating crop acreages, and the dates on which these flights took place. The initial criteria was finally expanded and some photos were used that had been taken more than 5 years before the opening of the interchange, and more than 5 years after the opening of the interchange. For many urban areas, no postwar photography at all is available, thus eliminating many interchanges that would have made good case studies.

An additional disadvantage of having to rely on available photography is the difficulty of identifying changes in land use that occurred between the time of the "before" photography and the construction of the road. This would have required interviews, and it would have been almost impossible to separate changes in use of land that came about because of the announced construction of the road. In this study, no attempt was made to isolate and adjust for this change.

Thirty-one non-toll interchanges and thirty-three toll interchanges were studied in eight states. These were California, Connecticut, Indiana, Maryland, New Jersey, Ohio, Oklahoma, and Pennsylvania.

Categorizing the Classes of Land Use

Choice of the number and content of classes of land use was dictated by two considerations. Detail and specificity in the classification were desired to make the information on "after" uses of maximum value. Rigidly limiting the breakdown, however, were the small scale and uneven quality of the photographs. While on the best photographs it would be possible to distinguish commercial from industrial uses, and semidetached dwellings from single family houses, this could not be done for all interchanges. Therefore, if comparisons were to be made, it was necessary that the classification scheme have a "least common denominator" set of use classes. The classes of land use on the following page could definitely be determined and identified on all the photos and were used in this study.

Delineating the Areas

The selection of the shape and dimensions of the study area for each interchange was necessarily somewhat arbitrary. The area chosen for this study was a circle three miles in diameter centered on the point of intersection of the freeway with the crossroad. A circle was so chosen that the perimeter of the study area would be the same distance from the point of intersection. The three mile diameter was chosen because more than one interchange was studied on the same road, and a circle with a diameter greater than three miles would have overlapped with the outside circle of other interchanges. For greater precision in comparison, concentric circles of one- and two-mile diameters were drawn inside the outer circle. Measurements were then made separately for the inside circle designated Ring *A*, for the area between this circle and the two-mile circle (Ring *B*), and for the outside circle (Ring *C*).

The circles were first drawn on the "after" photos (Figure 1), the center points transferred to the "before" photos (Figure 2), and the circles recorded on the latter. The uses of land on corresponding areas of the two sets of photos were then compared. Areas of change were outlined on the "after" photos, and a letter designation was applied to each area, indicating both the "before" and "after" uses.[3] For purposes of clarity in presentation

[3] As an example, an orchard that had been developed as a subdivision would be given the designation Rs(*A*). It is now in residential use, but was formerly in agricultural use.

Symbol	*Description*
A	Agricultural land (crop, orchard, pasture) including farmsteads.
Id	Idle.
F	Forest.
W	Water (ponds, lakes, rivers, reservoirs).
Rd	Roads.
C	Land in process of conversion to a new use. At the time it was photographed, clearing or grading was in evidence.
I	Interchange—This includes the entire immediate area of the interchange, bounded generally by the approach ramps. Portions of the freeway and the intersecting road lying within this area are included.
B	Borrow pits.
Rs	Residential (except farmsteads).
IC	Industrial, commercial, institutional (factories, stores, schools, churches, cemeteries, gravel pits, quarries, gas stations, motels, drive-in-theatres, etc.).
R	Recreation (open space such as parks, playgrounds, golf courses, ball fields, etc.).
U	Urban—This was used only with the "before" photos. It is a catch-all category for residential, industrial, commercial, institutional, and recreational, and was used when an interchange was located in a developed area. The urban category was adopted because, for purposes of this study, little was to be gained by using a finer classification for the "before" uses in developed areas. The category was usually associated with a block pattern of streets.

the areas of change are not outlined on the "after" photos, but rather a separate drawing has been prepared. (See Figure 3.) After the areas of change were identified, outlined, and labelled, they were measured with the help of a transparent acetate grid overlay containing 40 dots to the square inch. Areas showing no change in use were identified and measured in the same way. A data form was prepared so all land uses whether they changed or not, could be recorded. (See Table 1.)

The number of dots were counted, recorded on the data form and later expressed in percentages, both for ease of interpretation and because small variations in the scale of photography make acreage estimates hazardous.

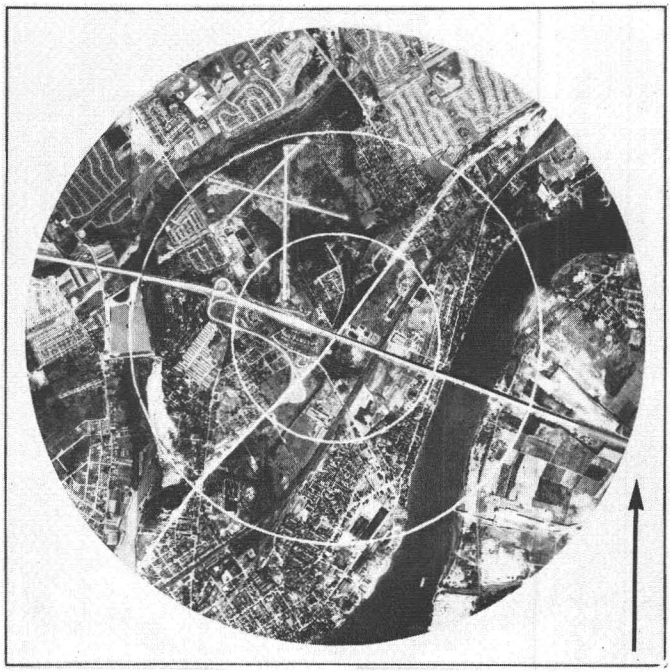

FIG. 1. This photo was taken four years after construction of interchange No. 29 on the Pennsylvania Turnpike. This interchange links the Turnpike with U. S. Route 13 which runs along the southeast edge of Levittown and connects Levittown with Philadelphia. Most of the change has occurred in Ring *C* and was primariy caused by the expansion of Levittown. (Commodity Stabilization Service, USDA.)

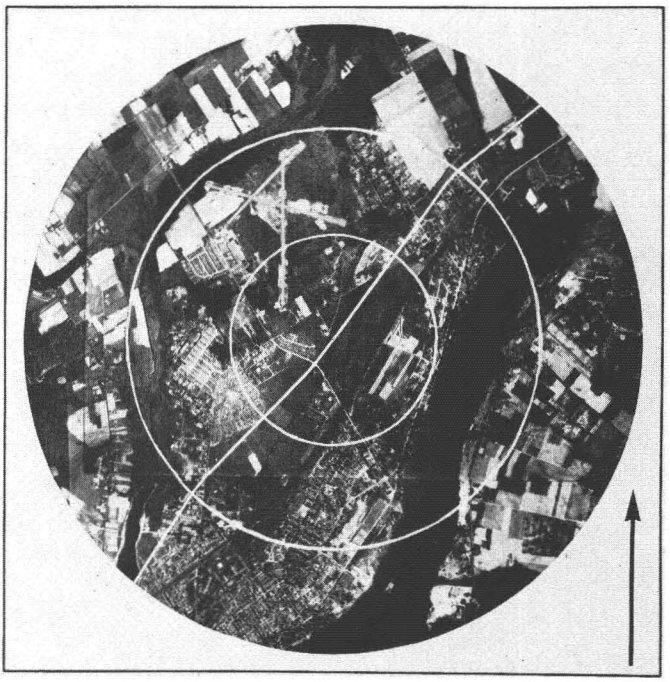

FIG. 2. This photo was taken four years before construction of the interchange and shows Route 13 paralleling the river. The photo also shows a considerable amount of land in agricultural use in Ring *C*. Rings *A* and *B* were largely developed at this time. (CSS-USDA.)

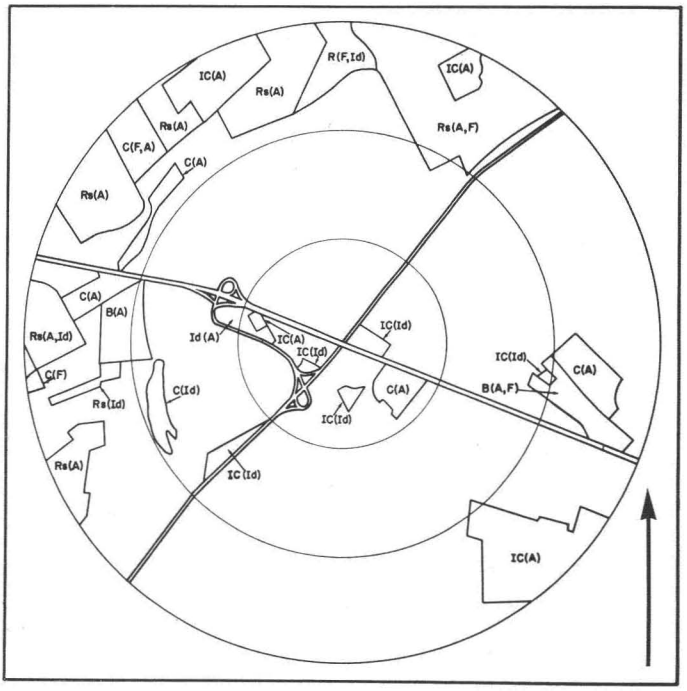

FIG. 3. For clarity in presentation this tracing was prepared to outline and identify some specific areas of change. Very little change has occurred along U. S. Route 13.

TABLE 1

DOT COUNT OF LAND USE AT PENNSYLVANIA TURNPIKE INTERCHANGE NO. 29

Un-change	To / From	U	Rs	IC	Id	I	Rd	B	C	R	F	A	W		Total
	A			2	3		2		15						22
	F														
88	Id			10		8	10								28
5	U														
57	Rs														
108	IC														
	R														
	C														
8	Rd														
															50
Total 266				12	3	8	12		15						50

Ring A—Total 316

An approximate measure of the acreages involved, however, can be derived from the estimated acreage of each measurement ring: Ring *A*, 499 acres; Ring *B*, 1,504 acres; Ring *C*, 2,515 acres; and the three combined, 4,518 acres. Each dot on the overlay represents approximately 1.6 acres.

MAKING FIELD CHECKS

The use of airphotos eliminates to a large degree the need for field study of changes in the use of land. It was considered desirable, however, to check in the field the accuracy of the identifications made from the photographs. Interchanges on the Baltimore-Washington Parkway and along U. S. 240 in Maryland were chosen for field checking. Visits to the interchange areas corroborated the identification of both unchanged and "after" uses made from the photographs.

SUMMARY

This method of airphoto comparison may be the only means to determine "before" and "after" uses of land, or change in land use. There are limitations in using photos that are taken for other purposes. The dates that the photos were taken and the scale of the photos influence the identification of land uses and the classification system that will be developed. Although there are limitations to the use of airphotos for determining land use changes occurring around highway interchanges, it is a method by which reasonably accurate estimates of land use change can be obtained when adequate funds and time are not available.