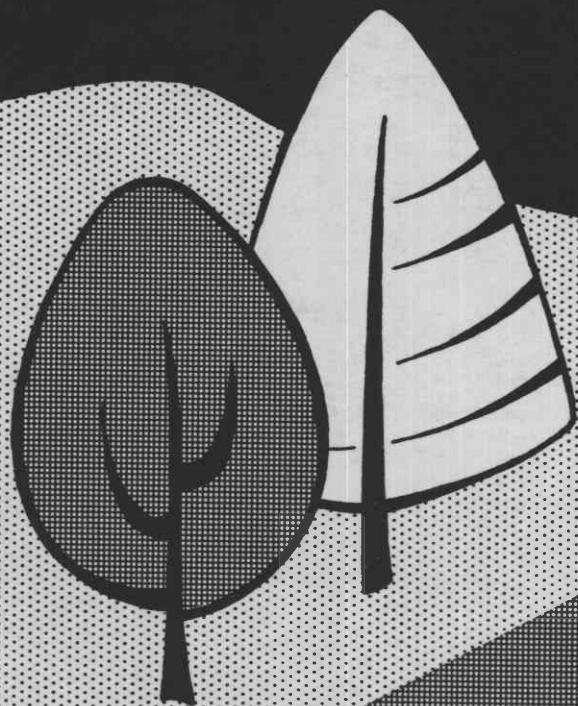


Techniques for Inventorying Manmade Impacts in Roadway Environments

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Abstract

Four techniques for inventorying manmade impacts along roadway corridors were devised and compared. Ground surveillance and ground photography techniques recorded impacts within the corridor visible from the road. Techniques on large- and small-scale aerial photography recorded impacts within a more complete corridor that included areas screened from the road by vegetation. Techniques were compared on the basis of type and quality of data obtained, types of maps produced, area covered, and relative cost and time requirements.

Keywords: Environment, roadside improvement, landscape management, photography.

INTRODUCTION

The public may encounter more environmental blights in driving than in any other pursuit. This is not new. Over 40 years ago a sociologist (Joad 1928) wrote, "One arrives after a motor journey all liver and no legs; one's mind asleep, one's body tired. One is bored, irritable, and listless. Whatever beauties the landscape might offer are hidden behind forbidding lines of advertising billboards." Now, however, we have over 3 million miles of rural roads and highways and nearly 87 million registered automobiles. Passenger vehicles are driven approximately 835 billion miles each year, with perhaps two or more times as many passenger miles (U.S. Bureau of the Census 1970). Thus the indiscriminate blighting of roadway corridors has a major and a growing impact on the visual quality of environmental experiences.

These visual effects have often been overlooked or disregarded for technical or economic reasons (Twiss and Litton 1966), but there is growing public resistance to such neglect (see, for example, DeBell 1970). As per capita space decreases because of increased population, mobility, and demand for conflicting land uses, consideration of the total environment becomes increasingly important. As a first step toward identifying problem areas and perhaps opportunities to reduce conflicts between landscape uses, we developed and tested inventory methods to measure the kind and extent of manmade alterations on the roadside landscape. In emphasizing the development of methodology, we did not limit our attention to blights but included a variety of other man-caused impacts on the landscape.

Our objectives were to compare costs, advantages, and limitations of four techniques for inventorying these impacts along roadways and to illustrate ways of summarizing and displaying the pattern, kind, severity, and possible amelioration of these impacts. The four techniques studied should be viewed only as selected possibilities. They by no means include all the possibilities for inventorying roadway environments.

RELATED STUDIES

A number of other studies have addressed related problems. Philip Lewis (1962, 1964, 1965) incorporated ecological factors into the general planning process along with highways, buildings, vegetation, and interesting views. Soils were also surveyed to determine the forms of recreation suited to specific areas. By superimposing various survey data with overlay maps, Lewis (1964) showed that major resources were concentrated in linear patterns which he called "environmental corridors." Twiss and Litton (1966) developed procedures for evaluating and inventorying specific attributes of the landscape, with emphasis on topographic form, spatial definition, compositional types, and/or perceptual qualities. They suggested that concern is shifting from proper land use to proper landscape use. Litton (1968) illustrated procedures by making landscape inventories. Sargent (1967) developed a scenery classification scheme to rate landscape qualities based on distance, variety, and eyesores. Burke et al. (1968) also developed a scenery classification scheme based on the "characteristic landscape."

Computers are now increasingly popular for assistance in evaluating landscapes. Amidon and Elsner (1968) developed a program for plotting areas visible from a selected location, with vegetation disregarded. However, vegetation can be considered in computer-drawn perspective views of landscape and vegetation patterns as they would appear from any selected point.^{1/} These drawings not only show how vegetation may shield an undesirable impact but also indicate the visual effects of such proposed impacts as clearcut logging--given various sizes, shapes, and positions.

Because studies for improving roadway corridors have generally focused on natural scenery or road alignment and design, we have emphasized procedures for inventorying manmade impacts that often affect the visual quality of existing roadway corridors. We therefore included some impacts that often are a pleasing complement to the natural landscape--farming, for example. We did not judge the desirability of manmade alterations nor did we attempt to determine their effects on potential viewers.

TECHNIQUES

Initially, 25 miles of Washington State Highway 530 were inventoried (1) to determine the usefulness of aerial photographs for field recording, (2) to identify problems with inventorying, and (3) to explore alternative means for inventorying. This showed aerial photographs of 1:20,000 scale to have more detail than needed and, because of the large number of photos necessary, to be awkward to handle in recording data under field conditions.

Based upon this preliminary work, four inventory techniques were devised and tested on a 12-mile section of U. S. Route 2 in Washington. These were ground surveillance, ground photography, and large- and small-scale aerial photography.

The two "ground" techniques were applied within a *visual corridor* defined such that only impacts visible from the roadway were recorded. If an impact was hidden by vegetation or terrain, it was not tallied.

The two aerial photography techniques, on the other hand, were applied within a *topographic corridor*. This is the corridor that would be visible from a highway if only topographic relief restricted site distance. Impacts within the topographic corridor were therefore tallied even if obscured from the roadway by vegetation.

Ground Surveillance Inventory

In the ground surveillance inventory, impact data were gathered by a two-man crew traveling along the highway. One person recorded impact data on topographic maps (15-minute quadrangle sheets) while the other drove.

^{1/} An excellent example was developed by Michimasa Kojima. Unpublished paper available at the Univ. Wash. Coll. Forest Resour., Seattle.

Impacts were recorded by type and frequency. *Type* included farming, logging, utility lines, advertisements, railroads, roads, mining, dumps, buildings, air or stream pollution, and towns. *Frequency* indicated whether the impact was seen constantly or intermittently for a given section of road. Possible amelioration such as screening, zoning, educating the public, and relocation also was recorded for each impact. The road mileage (to the nearest tenth) was recorded each time an impact came into view or dropped from view, defining one or more sections of road as affected by each impact.

A computer program was developed to summarize data. This provided a record of the miles of roadway from which each impact type was visible. It also summarized amelioration possibilities, computed a net and gross mileage of roadway from which impacts could be seen, and gave the percentage of the total road involved.^{2/} Such calculations aid in comparing one road with others, as in selecting the best of several highways for a scenic route or entrance corridor for a park.

Ground Photography Inventory

The ground photography technique was similar to ground surveillance procedures in that data were collected for a visual corridor by on-the-ground procedures. However, data were recorded primarily on film. This created a permanent record of the landscape for future comparisons.

Inventorying consisted of taking four wide-angle 35-millimeter photographs every two-tenths of a mile along the highway--one straight ahead, one 90° to the right, one straight back, and one 90° to the left of the photo point. If vision were unobstructed, this would provide a nearly complete record of the visible landscape (see fig. 1). The only field note-keeping necessary was to record the road sector location, film frame number, and direction of picture. This facilitated identification and location of each photo point when photos were analyzed. Our data showed that several impacts were overlooked on the photos, but this appeared due to interpretation rather than "blind" areas between photo points.

If a large region were inventoried, a four-camera system mounted on top of a vehicle would speed the fieldwork, and the technique used in this study was designed to simulate such a four-camera system. However, 86 percent of total cost was for film and processing which contributed to a poor comparative cost position for the ground photography technique.

The "office" portion of this inventory technique was very similar to the "field" procedure of the ground surveillance technique. The film negatives were printed--24 frames on an 8- by 10-inch sheet of photographic paper. The interpreter then examined photos under a magnifying glass as if he were actually traveling the highway (fig. 2). Data were coded and summarized by computer as in the ground surveillance inventory.

^{2/} Net mileage equals the miles of roadway from which any impact can be seen. The road mileage affected by each impact was included in gross mileage. Therefore, gross mileage could exceed the total road mileage in the inventory.

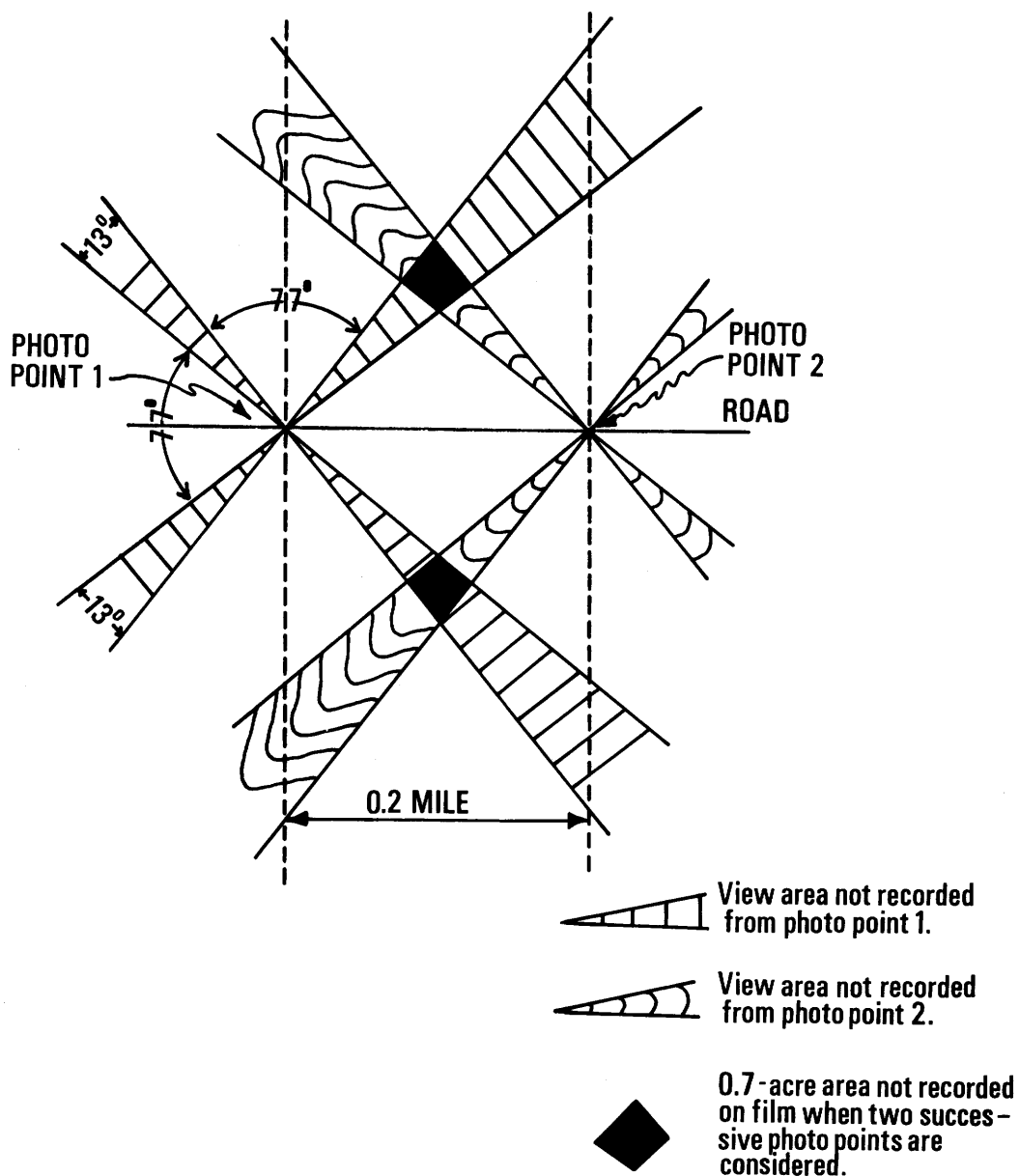


Figure 1.—Diagram showing theoretical area covered by two photo points. The 77° is one of four camera view areas that is recorded at one photo point. The 13° indicates one of four landscape areas that is not recorded on film as a result of using a 28 millimeter, wide-angle lens. When two photo points are considered, much of the "lost" area from one point is subsequently recorded from the other point. Calculations show the actual area "lost" between any two points two-tenths of a mile apart is 1.4 acres.

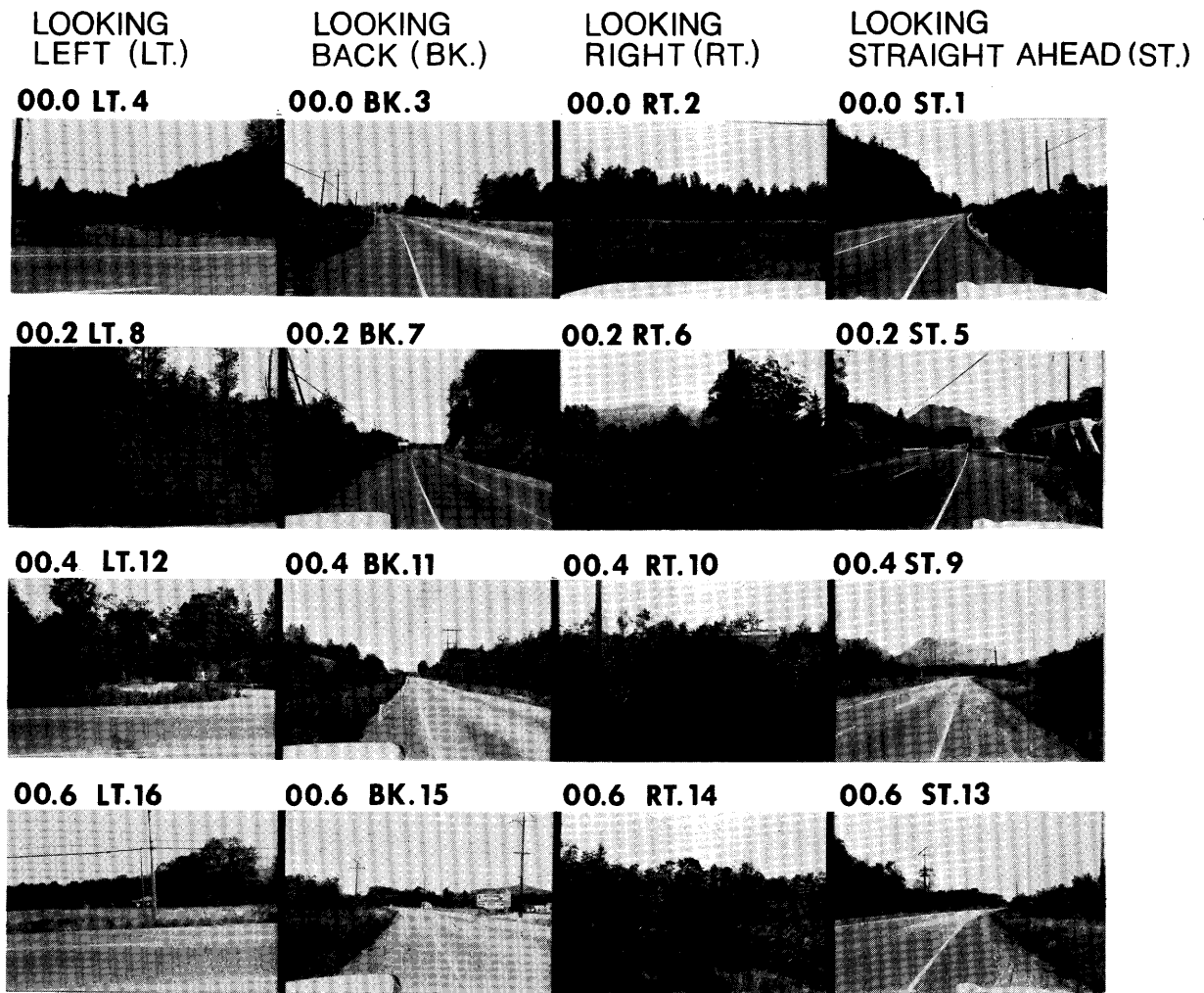


Figure 2.—A portion of a 35-millimeter “proof sheet” used to measure manmade alterations within the visual corridor along U.S. Route 2. Photographs should be read from right to left. Each group of four represents a photo point two-tenths of a mile from the last photo point. The notations above each frame give the photo point relative to the start of the inventory, the view direction, and the photo frame number.

Large-scale Aerial Photography

Initially, large-scale photographs (1:24,000) were tested to determine if impacts could be inventoried from them. To determine whether or not impacts could be seen from the roadway, a "floating line" technique (same principal as the "floating dot" technique described in most elementary aerial photogrammetry texts) was tried on stereo-paired photographs during a preliminary inventory. This was found too time-consuming if every impact on a large-scale inventory were checked, especially when the "floating line" crossed more than one stereo pair. It is applicable, however, for checking individual points.

Because of the difficulty in establishing lines of sight from aerial photos, the question of whether or not impacts could be seen from the road was ignored in an attempt to develop a more workable aerial photo technique.

Based on initial work with standard aerial photos, an inventory technique was devised using "blueline" photo enlargements (scale 1:24,000). Each of these measures approximately 18 by 18 inches and each covers a township. These give adequate detail, and their large size, scale, and the identification of many features compensate for their lack of stereo viewing. Section lines and numbers are indicated, and many towns, roads, streams, and lakes are labeled.

Photo enlargements with these characteristics may not be readily available outside the State of Washington, in which case photo mosaics or other large-scale photos comparable to the blueline enlargements would have to be substituted.

In the inventory, the topographic corridor was drawn on the blueline photographs after its location was estimated from inspection of contour lines on a topographic map. In some instances, contour profiles were constructed to find the most distant point that was potentially visible from the roadway. Impacts within the corridor were then located and identified on the photographs. The area was calculated in acres for these impacts, except for roads and railroad rights-of-way, which were measured in miles.

Small-scale Aerial Photography

Because large-scale aerial photographs can be cumbersome to handle and often have unnecessary detail for interpreting impacts, we also tested small-scale photos. Fortunately, earth satellite simulation photos were available, through the Washington State Department of Natural Resources. These photos had been taken for appraising effectiveness of U.S. Geological Survey Earth Resources Observation Satellite (EROS) for natural resource surveys.

The photos were taken in mid-May of 1969 from an altitude of approximately 36,500 feet, using an extreme wide-angle lens. This provided coverage of 250 to 300 square miles on each 5- by 5-inch photograph, giving a photo scale of approximately 1:250,000. Stereo coverage was taken using "false" color film (Ektachrome Infrared Aero).^{3/}

^{3/} Mention of product by name is for identification only and does not imply endorsement by the U.S. Department of Agriculture.

For the inventory, the analyst began by sketching the topographic corridor on the photos. This was sketched under stereo-viewing and guided primarily by direct observation but with frequent use of the "floating line" technique mentioned earlier. Impacts within the corridor were then located, identified, marked, and labeled on the photos.

COMPARISON OF THE TECHNIQUES

The four inventory techniques investigated were compared on the basis of the type and quality of data obtained, the types of maps that resulted, area covered, and costs and time required.

The number of discernible impact types varied from seven for the small-scale aerial photography technique to 12 for the ground surveillance and ground photo techniques. But in the actual inventories, only four to eight impact types were observed. For the ground surveillance and ground photography techniques, each of the original 12 impact types could have been identified had they been present.

On the photographs used for the large-scale aerial photography technique, some of the impacts easily recorded from the ground were not discernible. For example, utility poles and powerlines were distinguishable only on cleared rights-of-way. Roadside advertisement was also difficult or impossible to interpret from aerial photos. As it was very difficult to distinguish between commercial or noncommercial buildings, no distinction was made.

Of the original 12 impacts, 10 could have been inventoried by the large-scale photographs. These were farming, logging, powerline rights-of-way, roads, mining, dumps, railroads and airports, buildings, some types of air and water pollution, and towns.

In the small-scale aerial photography technique only seven of the 12 original impacts could have been adequately identified--farming, logging, powerline rights-of-way, mining, dumps, water pollution, and towns. Utility poles and lines along highways could not be seen on the photos, but the cleared rights-of-way for power transmission lines were visible. No mining or dumps were recorded in this inventory, but they would be visible provided they covered an area 100 to 200 feet across.^{4/} An open pit mine or large area of tailings would be necessary for mining to show.

Map Presentation

The type of map used for recording impacts is arbitrary, but the most direct graphic procedures for each technique will yield very different pictures.

For the ground surveillance and the ground photography techniques, impacts were most easily presented on a topographic quadrangle map. For the large-scale aerial photo technique, it was easiest to map impacts directly on the blueline aerial photo enlargements. For the small-scale aerial photo technique, it was most convenient to sketch directly on the photographs (for example, see fig. 3).

^{4/} Unpublished paper by H. Gyde Lund, "Determining the usefulness of space photography for forest fire science," 10 p., Coll. Forest Resour., Univ. Wash., 1969.

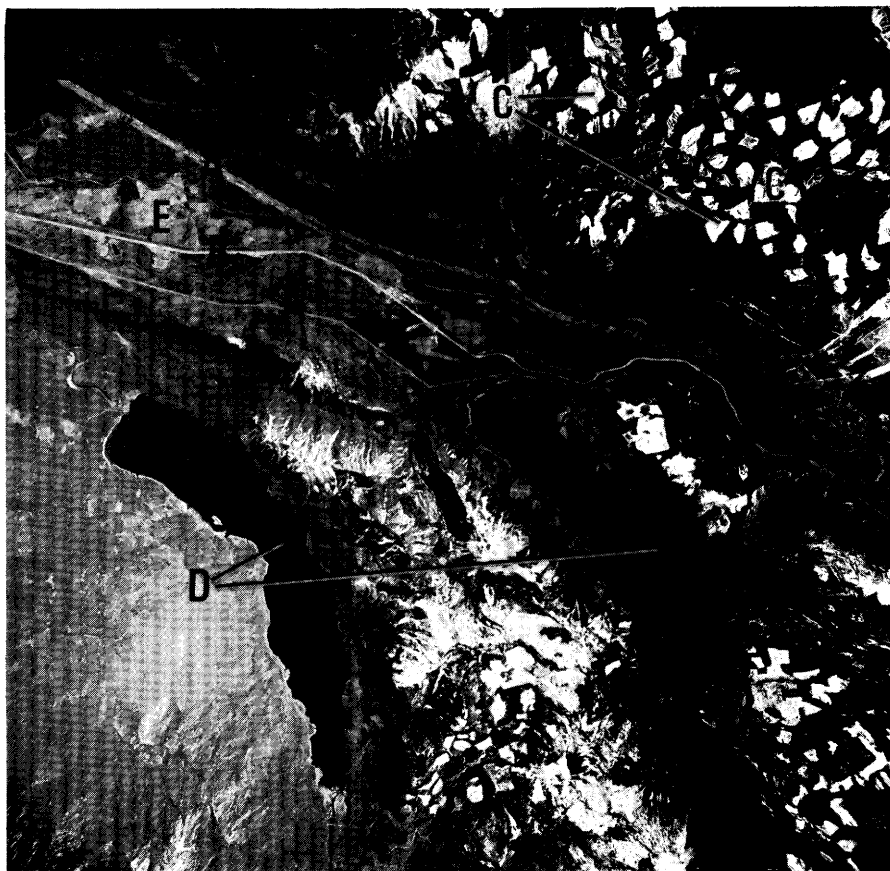


Figure 3.—Actual size of the satellite-simulated “false color” photograph printed in black and white. View is similar to the inventory area. Powerline rights-of-way (A), roads (B), logging areas (C), lakes (D), and agricultural lands (E) are easily seen without magnification. (Photo courtesy of State of Washington Department of Natural Resources.)

Inventory acreages differed substantially depending on inventory method. The topographic corridor, used for the aerial photo techniques, covered approximately 3-1/2 times as much area as the visual corridor, used for the on-the-ground techniques. On the large-scale photos, the topographic corridor acreage measured was 17 percent greater than on the small-scale photos, and the visual corridor acreage for the ground surveillance was 14 percent greater than for the ground photography.

Impact Data

For the two ground techniques, impacts were summarized by the computer, by gross mileage, net mileage, and amelioration possibilities.

To indicate the biases involved in the ground surveillance and ground photography techniques, differences in the gross mileage for eight impact types were compared. Ground photo mileages were subtracted from ground surveillance mileages. For the 10.3

miles of highway examined, the ground photography technique gave slightly more mileage than the ground surveillance technique:

<u>Impact</u>	<u>Ground surveillance minus ground photo</u> (Miles)
Logging	5.3
Utility poles, lines	1.2
Advertisements	.8
Mining	-.1 ^{5/}
Railroads	.7
Buildings (commercial)	-.2
Buildings (noncommercial)	.1
Towns	-.2

This is consistent with the more intense and continuous data collection of the ground surveillance technique. The greatest difference was in logging and resulted primarily from misinterpretation of the older logging areas, which, on photos, do not differ markedly in contrast from surrounding area.

Data interpreted from the large-scale and small-scale aerial photography techniques are summarized below. Because only farming, logging, towns, and powerline rights-of-way were identified on the small-scale photos, techniques can be compared for only these four impact types. For farming impacts, measurements obtained from small-scale aerial photography were 9 percent less than measurements obtained from large-scale aerial photography. For logging, the acreage measured on small-scale aerial photos was about 5 percent less.

<u>Impact</u>	<u>Large-scale (1:24,000)</u>	<u>Small-scale (1:250,000)</u>
-----Acres-----		
Farming	813	740
Logging	1,405	1,331
Towns	179	228
Buildings	13	--
Powerlines	563	--
Unknown	140	--
-----Miles-----		
Railroads	15.3	--
Roads	79.8	--
Powerline rights-of-way	16.0	20.8

^{5/} The minus sign results from the algebraic sum of ground surveillance minus ground photo. For example, there was more "mining" recorded by ground photo than by ground surveillance.

Because logging areas are often along ridges, they are subject to measurement error resulting from misplaced corridor boundaries. This is especially true on small-scale aerial photography where a small error in boundary placement may account for large acreages.

Towns showed the greatest difference between acreages for the two aerial photo inventory techniques. Twenty-one percent more acreage was measured by the small-scale aerial photography technique than by the large-scale. This large measurement difference resulted from misinterpretation of the small-scale, "false" color photographs. More knowledge of town boundaries and greater experience in photo interpretation should help reduce this error.

For powerlines, 23 percent more miles was recorded from the small-scale than from the large-scale photos. This resulted primarily because part of a powerline was located on the same ridge as the topographic corridor. On the small-scale photos, 5 miles of powerline were interpreted as within the topographic corridor; but on the large-scale photos, the line was judged as outside the corridor.

Cost and Time Expenditures

Cost data for the four inventory techniques are not directly comparable. The amount and nature of the information obtained varies considerably from one technique to another. Therefore, inventory objectives as well as inventory costs may dictate procedures. Costs can be divided into labor costs and equipment or special services costs:

<u>Technique</u>	<u>Materials and equipment^{6/}</u>	<u>Man-minutes^{7/}</u>	<u>Total cost^{8/}</u>
	-----Amount per mile-----		
Ground surveillance	\$0.42	29.0	\$1.87
Ground photography	3.35 ^{9/} 3.03 ^{10/}	32.0	4.95 ^{9/} 4.63 ^{10/}
Large-scale aerial photo	.49	17.0	1.35
Small-scale aerial photo	1.74 ^{9/} 1.14 ^{10/}	9.5	2.22 ^{9/} 1.62 ^{10/}

Labor costs for the two ground techniques were about equal, but materials and equipment costs for ground photography greatly exceeded those for ground surveillance. Labor, materials, and equipment costs for small-scale and large-scale aerial photography may fluctuate greatly.

^{6/} Includes cost of transportation, film and processing, computer time, air photos, and miscellaneous.

^{7/} Includes field and office labor and keypunching.

^{8/} All labor figured at \$3 per hour, excluding overhead and administration.

^{9/} Camera-stereoscope costs were amortized over a 500-mile inventory.

^{10/} Camera-stereoscope costs not included, assuming cost absorbed elsewhere.

Cost depends on several factors. As the size of the inventory increases, costs per mile may drop, especially if equipment can be amortized over a greater number of miles. Equipment and photo-processing costs could vary greatly depending on their availability and ownership.

DISCUSSION AND CONCLUSION

For inventory of visual impacts along roadways, the choice of method will generally depend on cost, detail needed, and availability of photos, maps, and equipment. The ground surveillance technique and the two aerial photo techniques are each suited to operational use for inventories of visual impacts in roadway corridors. Ground photography tends to undermeasure the total impacted area and is more costly than ground surveillance procedures. However, it provides a permanent record of the landscape, permitting examination of landscape changes over time.

Inventory techniques can be selected or modified to suit specific needs. Thus, if the view from the road is important to inventory objectives, some version of the ground surveillance technique would be appropriate. For example, to take advantage of Federal matching funds under the Highway Beautification Act, a State highway commission might need information on all impacts visible from the road. On the other hand, in determining where to put additional powerlines, a governmental unit might decide that powerlines should be concentrated wherever possible to leave other areas unblemished. Then an aerial photo inventory technique would be adequate for determining where existing powerlines and other manmade developments were currently concentrated.

Ground surveillance data can be recorded and presented on maps, aerial photos, or photo mosaics. The recency of maps and photos may dictate the choice. Aerial photos are generally more up-to-date than available maps, especially U.S. Geological Survey topographic maps which may not be updated for decades. During this time, many cultural features will change. As an example, the most recent topographic maps available for the study reported here were dated 1957, whereas the most recent "blue-line" and small-scale photos were dated 1966 and 1969, respectively.

For some purposes, the detail on photo mosaic index sheets may be sufficient for an inventory conducted primarily in the office, with fieldwork only to calibrate and improve office interpretations of impacts. Each photo mosaic index sheet is a photo reduction of approximately 200 9- by 9-inch aerial photographs assembled in mosaic form. Such sheets measure 20 by 20 inches, have a scale of approximately 1:63,000, cover about 300 square miles, and can be purchased for \$2.50 to \$3 each.

Color photography, in either true or "false" color, costs about 1-1/2 times as much as standard black and white aerial photos. The major advantage of color, especially "false" color, is the increased differentiation it provides among small variations in ground objects. However, the added expense is not likely to be justified unless the photographs are already available.

Whatever the combination of procedures and techniques, inventory of visual impacts is important. We now have a steady and indiscriminate encroachment of unfortunate visual impacts along roadway corridors. If this continues, most of these corridors will be reduced to scenic monotony and mediocrity.

Ideally, unavoidable scenic blemishes would be concentrated in the fewest possible "visual sewers," thereby protecting the scenic quality of all other roadway corridors. Thus truck routes, powerlines, pipelines, etc. might be assigned to the least scenic routes. This ideal will probably never be reached. However, public sentiment seems to be growing for more careful land use and zoning that can at least prevent the worst of all possible worlds. The techniques reported here can help to define both scenic problems and opportunities and can provide data for those who must determine what patterns of use--among those still possible--would be most desirable.

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