Oblique Airphotos for Mapping, Educating Users, and Enhancing Public Participation in Environmental Planning

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Low-altitude oblique color airphotographs were used in a case study of land use planning in Jefferson County, Colorado. Because these photographs help bridge the gap from the real world to maps, they readily enabled the authors to communicate information traditionally available only in map format to the general public, county planners, and a citizens' open space advisory committee. The photographs helped educate citizens in the county about current land use conditions and trends and the degree and rate of land use changes. They documented the impact of urban sprawl and the demands on the land made by competing activities such as resource extraction and housing development. The photographs were used in studies that included siting of open space, landfills, septic tanks, and housing developments; making excavation easier; extracting resources; selecting corridors; and determining optimum sequential patterns of development. In these studies, the photographs helped explain the meaning of technical terms, illustrated the difference and significance of various classes of land use and land cover, and aided in compiling maps and in teaching users how to interpret the maps and establish criteria and guidelines that define suitable lands for different uses. These photographs provide graphic documentation of environmental conditions at specific times and greatly facilitate the evaluation of the impact of changes due to various land use activities and natural processes.

Low-altitude oblique color airphotographs have proved to be a highly effective communications medium for environmental planning. They provide a familiar but more encompassing view of our environment, similar to views from a mountain ridge or a tall building. This similarity allows most people to readily grasp what is portrayed by these photograph.

Traditionally, maps are relied on heavily in attempts to communicate data to intended users. Most people who use maps in their professions take maps for granted because they readily understand them. Some now realize, though, that important classes of users, including many politicians, other decision makers, and much of the general public, do not understand maps. Yet, recent legislation, such as the National Environmental Policy Act of 1969, requires the public to participate in a decision-making process that should be based in large part on maps. To transfer information from the scientists and engineers to lay public users, one needs to portray conventional map data by alternate means. Vertical airphotographs have been used for this purpose. Our experience indicates that the average person finds the conventional vertical airphotograph to be nearly as difficult to understand as a map. For a product to be used by the decision maker and other users, it must be understood by them. Otherwise, it has no credibility. Therefore, in this study we taught map reading to users by letting oblique color airphotographs serve as an intermediate and familiar link to relate the conditions on the ground to the way these features are shown on a map in generalized or abstract form.

Lay people have difficulty in relating to maps because they lack an understanding of the complex and subtle reasoning used by the mapmaker in grouping certain assemblages of terrain conditions as a single map class. Maps use a uniform color, patterns, or symbol to define what appears to be a heterogeneous terrain unit. The real world does not appear so simple and as neatly subdivided as it is portrayed on maps. By means of oblique airphotographs, we can illustrate the kinds of complex assemblages that are mapped as a unit and explain the rationale of why we drew the boundary locations. We can point to places on a low-altitude oblique color airphotograph to show what the green color on the map represents. The impression that a uniform green color on the map is akin to a well-kept golf green gives way to an understanding that it connotes instead an assemblage of residual soil interrupted by outcrops of bedrock and covered by scattered stands of brush and grass (for example, the dissected hills in the middle ground of Figure 1). The map then begins to change from something abstract into something that has meaning to nontechnical people. Lines and points on it are understood as describing specific conditions as well as location.

In addition to being a useful and effective means of illustrating and clarifying the information contained in maps, the oblique color airphotographs can provide an inexpensive documentation of environmental conditions at specific times. Any good-quality 35-mm camera hand held in a light aircraft can do the job well. Photographs taken several seconds apart, centered on the

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same object, provide excellent stereoscopic views, which add more depth, realism, and information when viewed with a stereoscope (13). Any of these photographs may be used later to evaluate and document the consequences of land use changes. For best results, the photographs should be taken through an open window or door of the airplane rather than through the Plexiglas of the window. In addition, the film speed should be considered as about 1½ times normal. For example, if the film speed listed by the manufacturer is 64, the light meter should be set for a film speed (revised) of about 100 to prevent overexposure.

Our experience over the past 3 years in Jefferson County, Colorado, serves as a case study. During this period, oblique color airphotographs were effectively used in a sequence of tasks that included (a) educating the voters about the need for legislation for open space, (b) educating lay persons on advisory boards and in civic groups about the means of implementing the legislation, (c) compiling maps, (d) explaining the maps to the users, and (e) documenting both objective and subjective features of the terrain. The oblique airphotographs were especially useful in mapping vegetation assemblages because they permitted us to interpret the understory or substratum by allowing us to see beneath the canopy of evergreens in the mountains and uplands.

JEFFERSON COUNTY CASE STUDY

The Need

Initially the need was to educate the voters about the problem of accelerating depletion of open space lands in Jefferson County (11). In 1972, concerned citizens formed an action group called PLAN Jeffco to determine the best way to get an official open space program, with sufficient funds to acquire and maintain land suitable for preserving as open space. This group decided to attempt to have an additional sales tax enacted as the source of funds, even though this traditionally is the most difficult kind of legislation to get voters to agree to. A detailed account of how this citizen group was formed and how it operated and succeeded in getting open space legislation passed for the entire county is given by Ward (14).

A resolution calling for planning for, developing necessary access to, acquiring, maintaining, administering, and preserving open space real property and developing paths and trails thereon was adopted by unanimous vote of the Board of County Commissioners of Jefferson County, Colorado, September 26, 1972. The resolution passed during the election of November 7, 1972.

Many individuals and civic groups rallied behind the PLAN Jeffco campaign to get the open space legislation passed. John C. Reed and Harry W. Smedes were among those who helped design the lecture program that served to alert the county voters about current land use conditions and trends that threatened the vital open space lands. Color slides were an integral part of the lectures; they included oblique airphotographs that provided enlightening views of the terrain. Repeated low-altitude color airphotographs powerfully illustrated changing land use. For example, a present-day oblique airphotograph (Figure 2), which closely duplicates the camera position and angle of an airphoto taken 38 years earlier (Figure 3), demonstrates the degree and rate of land use changes and effectively documents the impact of urban sprawl on the land. Such photographic comparison has sparked much interest by the lay public.

Oblique airphotographs were used to explain the significance of technical terms and to illustrate specific problems such as development in uniquely scenic areas (Figure 4) or in potentially hazardous areas (Figure 5). No maps were used at this stage.

In Figure 4, the following codes are used:

Code	Term	Code	Term
hr	Hogback ridges	mf	Mountain front
hv	Hogback valleys	mu	Mountains and uplands
tl	Tablelands		

Approximately 200 hm^2 (500 acres) of the area shown in Figure 4 were purchased on November 3, 1975, by the Colorado State Parks and Recreation Board to be set aside as the state's sixth park. This purchase provides one more link on the Colorado Trail, which leads from metropolitan Denver into the Pike National Forest. The area shown in Figure 5 is one of rapidly expanding housing development on landslide-prone deposits and slopes.

Implementation of Open Space Act of 1972

The open space legislation passed by a wide margin in the county election of November 1972. Key items included were (a) 0.5 percent increase in sales tax to be used to acquire suitable lands for open space and (b) formation of a citizens' open space advisory committee of 10 persons to advise the 3 county commissioners on what constituted suitable lands. Thus the immediate goal was to educate the advisory committee and, through them, the commissioners, on the rationale needed to objectively define "suitable." The first step in this education was to compile maps, teach the users how to interpret the maps, and assist them in establishing criteria and formulating logical and objective guidelines or strategies that define suitable lands for open space.

Continuing their initiative and involvement, private citizens with a wide variety of backgrounds and technical expertise made several maps that portrayed attributes important for any strategy of selecting land for open space. Because environmental impact studies involve a consideration of the consequences of a change in land use, a map showing current land use was of prime importance. Such a map did not exist for the county but was prepared by two of the authors (Reed and Smedes) from National Aeronautics and Space Administration high-altitude color photographs in about 1 man-week.

Oblique color airphotographs were used in public hearings, symposia, and meetings of smaller groups to illustrate the differences and significance of the various classes of current land use and land cover. Without a comprehension of this single land use map, citizens would not have been able to go on to more complex concepts, such as cartographic overlay of two or more maps and the use of maps portraying rock, soil, vegetation, and the like, to arrive at concepts of land capability, which is quite a different concept than current land use.

At public meetings we presented our ideas concerning the data that would be useful and that also existed or could be compiled readily on the basis of objective criteria. We also suggested and demonstrated—through manual techniques at first and later by computer—a rationale for putting together strategies for selection of optimum land for open space. Throughout all this, effective use was made of oblique color airphotographs as an aid in assisting lay persons to bridge the gap from real-world conditions to maps. The advisory committee responded enthusiastically to these ideas and began to assume leadership in making decisions about data and strategies or guidelines.

User Groups

Clearly, the immediate user was the advisory committee, a group of 10 citizens representing a cross section of the public. The county commissioners to whom the advisory committee made recommendations composed a second user group, and the citizens of the county formed a third. Through a series of regional meetings, the advisory committee, the director of the open space program, and the Jefferson County Planning Department presented the program to the citizens of the county. These regional meetings served to educate the citizens about the open space program and to encourage citizens to give their views on open space priorities. Oblique color airphotographs again played an important role as an alternate for or supplement to maps in the transfer of technical information to the general public. As a result of the citizens' comments and recommendations, the criteria to be used for selecting open space were modified and expanded.

Because open space planning fits into and should be in harmony rather than in conflict with master planning, the Jefferson County Planning Department became a user group. Subsequently, the Jefferson County Planning Department adopted our approach for use in long-range planning and master planning (6).

Approach

There is an urgent need to devise a system of combining and manipulating new and existing data, to reformat the data into products that are understandable, and to educate the public and decision makers by aids such as oblique airphotographs.

There are many competitive demands on the land. Our approach is that no one demand should be considered out of the context of all the others (7). Land use planning (including open space selection), land management, and evaluations of the environmental impact of specific changes in land use require a consideration of the total environment. Wise management will ensure proper balance of these competitive demands and will reduce the likelihood of thoughtless foreclosures of fundamental options. This requires map, point, and tabular data of such varied attributes as types of land cover and terrain; surface and subsurface natural physical features such as slope, landform, type of rock, thickness and nature of surficial deposits, surface and subsurface hydrology, vegetation, soils, wildlife habitat, and rangeland quality; ecology; socioeconomic features such as income, ethnic concentrations, and available labor skills; and locations of key facilities.

It is true that we need to accelerate the acquisition of pertinent data. However, many of the data that already exist are not being used because they are peer-oriented rather than user-oriented. In this study a means was developed for combining and analyzing the diverse types of environmental data in a common format by way of a cellular composite computer mapping system. The approach was to select those data that already existed or that were inexpensive and easy to acquire, and that would eliminate the maximum amount of county land that really was not suitable for open space. This meant that the places selected had a high statistical likelihood of meeting all the criteria. After having reached a level of understanding of individual maps, the users were then shown how two or three maps could be cartographically overlaid to portray those places where optimum features on the several maps coincided. These places were of higher rating than others. The oblique airphotographs served as an aid in this step also. At this time, it became clear to us, and to the users, that cartographic overlays were largely subjective and that, if more than four or five maps were overlaid, the result was a hopeless scramble of lines and colors. Objective, manually prepared overlays were time consuming and costly. This awareness prepared the way for objective weighting and overlaying by computer, as described by Smedes and others (7).

The next step in selecting optimum sites was to use data that were more difficult and expensive to acquire. Although those were more costly per hectometer^2, far less area was being considered. Hence this was a cost-effective approach to problem solving. The lay person group now had a good understanding of maps, composites of maps, and formulation of rational objective criteria or strategies for selection of open space tracts.

The next stage was to demonstrate how the computer could accomplish the same steps faster and more accurately. Without having systematically built up to this level of understanding through numerous short briefings supported by color oblique airphotographs, the group could not have envisaged how the computer could accomplish the job of weighting and overlaying numerous maps according to specified strategies and alternatives.

After computer-selected sites were printed, the oblique color airphotographs were helpful documentations of what the preliminary selected sites really looked like. Some attributes that were not covered by any of the basic maps could be detected and were portrayed by these photographs. In addition, subjective features such as scenic beauty could be evaluated and used in further eliminations to finally zero in on the most desirable, available tracts. For example, a unique combination of features produced the striking landscape shown in Figure 4. This can be readily compared with other areas such as the undeveloped area of Figure 1 and part of Figure 5.

Although other computer mapping experiments have been made (1, 2, 3, 4, 5, 10, 12), some considered only physical features and others considered only social or economic conditions. This Jefferson County study is the only one that we know of in which (a) both the natural and socioeconomic conditions (the total environment) were considered, (b) users were actively involved in the design and conduct of the study, (c) users were taught how maps are made and interpreted and how planning strategies can be objectively formulated, (d) users made the decisions involving attributes (maps) and weights (priorities), and (e) users adopted the complete system and concept as an ongoing operational procedure, including periodic taking of oblique color photographs from aircraft.

Although we started by addressing only the open space problem, we were able at the last moment to expand the study to include commonly occurring land use problems such as selecting optimum sites for sanitary landfill, septic tanks, and housing developments; making excavation easier; selecting corridors; and determining optimum sequential patterns of development of the land. Starting with 20 maps of basic data (8, 9), we created an additional 23 derivative maps from them.

For a test of corridor selection, the county planners requested a map showing places suitable for hiking trails according to priorities they selected (9). Oblique airphotographs will aid in the final selection among the alternatives.

There are two other corridor applications. First, a proposed Interstate highway (I-470) will pass near the lakes shown in Figure 6. This photograph provides useful information on natural features (the lakes and associated ecosystems) and aesthetically pleasing areas that should be preserved or on which there should be

Figure 1. Northeastward look of Lakewood, Colorado, showing complexity of natural terrain surface features, 1974.

Figure 2. West-southwestward look at part of Lakewood, Colorado, 1972.

Figure 3. West-southwestward look at part of Lakewood, Colorado, 1934.

Figure 4. Southward look of Roxborough Park, 1972.

Figure 5. Westward look of Green Mountain, 1972.

Figure 6. Westward look of Soda Lakes, 1972.

Figure 7. Westward look toward the Front Range of the valley of Bear Creek, 1972.

minimum impact. In addition, the ridge immediately beyond the lakes forms a wind barrier that may be of consequence in subduing dispersal of air polluted by exhaust fumes. Second, a dam is currently being built across Bear Creek valley, shown in Figure 7, which is subject to flooding. Patterns of relocation can be visualized readily by maps accompanied by oblique airphotographs. Sand and gravel quarrying on top of the butte in the foreground (Mt. Carbon) is largely concealed from view at present. In planning the location of new roads required because of the dam and future reservoir, an attempt should be made to maintain this visual concealment at least until the deposit has been mined out and the hilltop reclaimed.

This expansion of the original open space study demonstrates how a bank of basic data can be weighted and combined in different ways to solve a wide variety of land use problems.

Cost

The cost of acquiring about 100 low-altitude oblique color airphotographs was $59. This included $35 for charter of airplane and pilot plus $24 for the purchase and processing of 3 rolls of 35-mm color slide film.

CONCLUSIONS

As far as we know, the Jefferson County study is the only one in which the users actively participated and made the decisions on appropriate attributes and weights. Furthermore, the users were a group of citizens with no training in planning, map reading, or formulating of decision strategies. An important aspect of this study—perhaps the most important—was to instill in these users an understanding of the complex techniques and concepts employed in the study. To judge from the results, this was successful. Use of oblique color airphotographs played a key role in this endeavor. The following summarizes the planning steps for which the oblique airphotographs were used:

1. Environmental planning, which involved mapping, educating, and public participation in the problem (areas in which oblique airphotographs were helpful);
2. Recognizing what is needed;
3. Campaigning for open space legistation to let voters know what was happening to their county so that they would want to vote for additional tax;
4. Implementing legislation by aiding the advisory board in (a) defining and selecting suitable land, (b) understanding maps and overlays, (c) adopting guidelines or strategies, (d) selecting lands by visualizing results of weighting and overlaying many basic maps, first manually and then by computer, and (e) showing photographs of what selected sites look like and making final selection on a visual basis of scenic beauty and the like; and
5. Documenting display areas selected for environmental conditions at specific times and evaluating impact of changes due to various land use activities and natural processes.

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