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Flood Plain Delineation with Pan and Color

Airphoto Interpretation can be useful where the lack of hydrologic data, time, and funds prohibit plotting the boundary by traditional engineering methods.

Introduction

The purpose of this study was to evaluate the placement of rare flood boundaries derived by interpretation of panchromatic, and color aerial photographs of a glaciated area. The accuracy of these boundaries was determined by comparing them with the boundaries of an Intermediate Regional Flood (approximately 100 years return frequency) plotted by the U. S. Army Corps of Engineers (1967).

Abstract: *Boundaries of rare floods, such as a 100-year recurrence interval flood which is widely used for planning and regulatory purposes, are ordinarily plotted by engineering procedures. In this study flood plain boundaries were interpreted on panchromatic, and color aerial photographs along a stream in a glaciated area of southern Wisconsin. The accuracy of these boundaries was determined by comparison at 29 cross sections with those of an Intermediate Regional Flood plotted by the U.S. Army Corps of Engineers. Boundaries on both types of photography agreed with the engineering boundary at 28 percent of the cross sections, were within 100 feet at 67 percent of the cross sections, and within 300 feet at 95 percent of the cross sections. Flood plain boundaries were most accurately delineated where physiographic landforms were well defined. The results indicate that airphoto interpretation can be a useful tool to delineate flood plain boundaries where the lack of hydrologic data, time, and funds prohibit plotting boundaries by traditional engineering methods.*

Land forms such as a physiographic flood plain can be identified by study of airphotos (Kiefer, 1967) or of detailed soil maps (Cain and Beatty, 1968). Little is known, however, about the usefulness of airphoto interpretation for determining the boundaries of a rare flood, such as the 100-year recurrence interval flood, which is widely used for planning and regulatory purposes. The boundaries of such floods are ordinarily plotted on the basis of engineering studies which are time consuming and expensive. Thus it becomes important to know how accurately rare flood boundaries can be determined by more rapid and less expensive methods. The present study is an attempt to determine the usefulness of airphoto interpretation for this purpose.

Review of Literature

Several alternative methods have been proposed for mapping the boundaries of flood plains in recent years. One of these is by interpretation of aerial photographs. According

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to Kiefer (1966) airphoto interpretation consists of observing and analysing the topography, drainage, erosion, photo tone pattern and land use areas shown on airphotos, usually with the aid of a stereoscope. Soil surveyors have long used airphoto interpretation as an aid in locating soil boundaries. Kiefer (1967) studied flood plains by airphoto interpretation and showed that panchromatic airphotos clearly reveal many diagnostic features and provide an excellent overall perspective of an area.

Burgess (1967) also advocated the use of airphoto analysis for flood plain studies and stressed the usefulness of airphotos in providing comprehensive information of an interdisciplinary nature about the flood plain region as a whole.

Cain[1] suggested that landform analysis by airphoto interpretation could be used to delineate general flood plain districts for regulatory purposes. He visualized the method being used primarily in rural areas where adequate topographic maps and engineering data, or detailed soil maps would not be available. He also suggested that airphoto interpretation be used in conjunction with other sources of information where the latter was available.

Parker[2] reported on an airphoto study of flood plains along the Root River, which drains a youthful glaciated landscape of generally low relief in southern Wisconsin. Flood plain boundaries determined by interpretation of panchromatic airphotos were compared with boundaries plotted by engineering methods. The best agreement between boundaries determined by the two methods was along a reach on the main stem of the river where it was possible to identify various elements of the landscape by airphoto interpretation. Along this reach, about 90 percent of the 100-year flood plain determined by engineering methods, was included within the flood plain delineated by airphoto interpretation. However, the agreement was poor in another area around the confluence of two branches of the river.

One of the problems involved in using airphotos to delineate the boundaries of rare floods results from the fact that such boundaries do not always correspond with those of the physiographic flood plain. In Wisconsin, this is particularly true of glaciated areas where rare floods often exceed areas of alluvial soils as mapped by soil scientists because these floods occur so infrequently that they do not leave diagnostic deposits of alluvial sediments, or other permanent evidence to mark their areal extent (Parker, Lee, and Yanggen, 1970).

Studies by Cain and Beatty (1968), Parker[2], and Viaene[3] have shown, however, that non-alluvial soils which are subject to inundation by flood water can often be recognized. Usually these are nearly level soils, lacking good drainage, that are adjacent to or connected with alluvial soils and flood plains. It should be possible for experienced interpreters who are cognizant of these field relationships to recognize such soil areas on airphotos and include them in the flood plain.

Area Studied and Methods Used

The area selected for the present study was a 14-mile reach of Turtle Creek in Rock County, Wisconsin. This reach is between miles 8 and 22 in the U. S. Army Corps of Engineers report on Turtle Creek (1967). An aerial photograph of part of the area studied is shown in Figure 1.

The total length of Turtle Creek is about 32 miles; it has a drainage area of about 238 square miles. Except for a small part in the city of Beloit, most land within the watershed is devoted to farming and other rural uses.

The area is glaciated, and along part of the reach the creek flows through glacial outwash deposits. In some places well defined terrace escarpments are along the flood plain; in other places no definitive landscape features are associated with the edge of the flood plain and the land slopes gently upward from the stream.

In general the gradient of Turtle Creek is convex and becomes steeper in the downstream direction. According to Viaene[3], the channel is being eroded in its lower reaches and some associated alluvial soils are no longer subject to flooding.

An *Old Delft* scanning stereoscope, Model ODSSIII (N. V. Optische Industrie, Delft, Holland) was used to interpret landscape features and determine flood plain boundaries on: (1) panchromatic (black and white) photographs (scale 1:20,000), and (2) Aero Ekta-

[1] Cain, John M., 1968. The use of soil maps and landform analysis in flood plain delineation. Paper presented at the Wisconsin Department of Natural Resources Workshop on Flood Plain Construction. Madison, Wisconsin.

[2] Parker, Dale E., 1968. Use of soil mapping units and aerial photographs to delineate flood plains in a glaciated area. M.S. Thesis, University of Wisconsin, Madison.

[3] Viaene, Robert M., 1969. Evaluation of flood plain delineations based on soil maps in the Turtle Creek and Kickapoo River watersheds, Wisconsin. M.S. Thesis, University of Wisconsin, Madison.

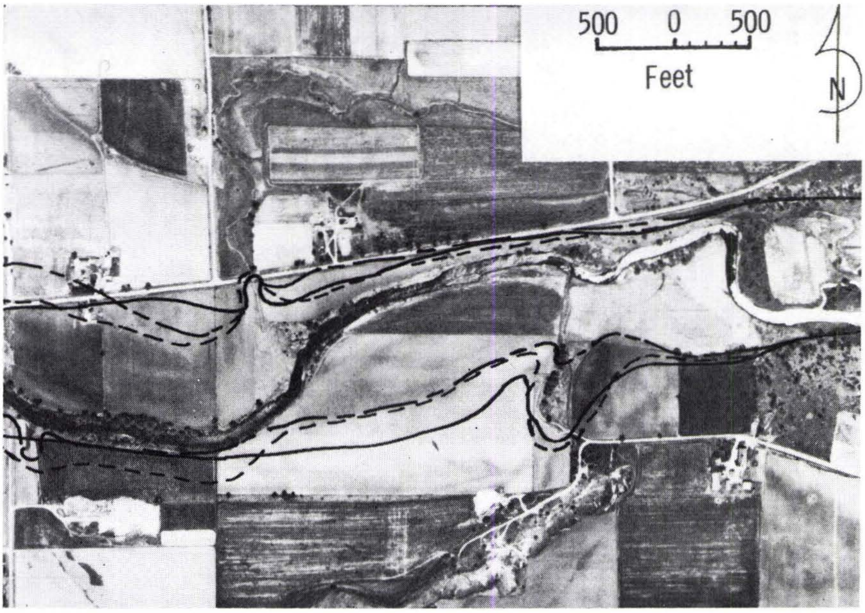

FIG. 1. Intermediate Regional Flood Boundary (solid line) and interpreted flood boundaries (short dash for panchromatic and long-short dash for color) along part of Turtle Creek in Rock County, Wisconsin.

chrome (MS type 2448, Eastman Kodak Co.) color photographs (scale 1:12,000). In both instances, flood plain boundaries were drawn on acetate overlays. The overlays were enlarged with an overhead projector and redrawn on 1:7,200-scale topographic maps showing the Intermediate Regional Flood boundary as published by the U. S. Army Corps of Engineers (1967).

Criteria used to identify the flood plain included kind of landform, landscape position, slope and relief, type of vegetation, vegative pattern and soil features such as natural drainage. Inferences based on cultural patterns such as the location of buildings, roads, farm crops and drainage ditches, were also used. A flood plain appears low in the landscape and is relatively smooth compared to many glacial landforms when viewed stereoscopically. Flood plain features such as natural levees, oxbow lakes, backwater swamps and current scars appear as different tones on the photographs. For example, a natural levee, which rises above the general level of the flood plain, and is better drained, can often be identified by a slightly lighter tone. By contrast, poorly drained sloughs in oxbows and old channel scars often appear as dark areas. These and other flood plain features have unique characteristics that facilitate identification by a trained airphoto interpreter.

Dense vegetation may sometimes hinder interpretation by hiding diagnostic features of the flood plain landscape. It can also be very useful; for example, marsh and swamp vegetation are indicative of low, wet areas, whereas certain species or associations of shrubs or trees indicate slightly higher, relatively well drained soil. Scour damage to brush and trees caused by floating ice cakes and debris deposited by flood water is sometimes visible on airphotos.

The degree of correlation between the flood plain boundaries, based on airphoto interpretation, and the boundary of the Intermediate Regional Flood plotted by the U. S. Army Corps of Engineers (1967) was determined by measuring the distance (to the nearest 50 feet) from the centerline of the stream to each of the boundaries. Measurements were made normal to the stream at 29 cross sections, spaced at one-half mile intervals along the steam. Data obtained by these measurements were analyzed statistically.

RESULTS AND DISCUSSION

Flood plain boundaries determined by interpretation of both panchromatic and color aerial photography agreed with the boundaries established by the U. S. Army Corps of Engineers at 28 percent of the measured cross sections (Table I). More importantly, however, they were within 100 feet of the engi-

TABLE I. RELATIONSHIP OF THE INTERPRETED FLOOD PLAIN BOUNDARIES TO THE INTERMEDIATE REGIONAL FLOOD PLAIN BOUNDARY ALONG TURTLE CREEK IN ROCK COUNTY WISCONSIN[a]

Percent of Time the Interpreted Flood Plain Boundary:	*Interpreted Boundary*	
	Color	*Black & white*
1. Agreed with Intermediate Regional Flood Boundary	28	28
2. Was Within 100 Feet of The Intermediate Regional Flood Boundary	66	67
3. Was Within 300 Feet of The Intermediate Regional Flood Boundary	95	95

[a] Based on measurements made to nearest 50 feet at 29 sample cross sections spaced ½ mile apart as marked on the topographic maps in the Flood Plain Information Report (1967).

neering boundary, at 67 percent of the cross sections, and within 300 feet at 95 percent of the cross sections. Deviation of the interpreted boundaries was about equal on each side of the engineering boundary. Figure 1 shows the three boundaries along a short reach of the stream.

Results of a statistical comparison of distances from the centerline of the stream to the engineering boundary, and to each interpreted boundary (Figures 2 and 3) gave correlation coefficients r of 0.88 for panchromatic and 0.89 for color photographs. The line of best fit Y was linear, with a slope of nearly 1 for both types of photos. The standard deviation S was 167 feet for panchromatic and 160 feet for color photography.

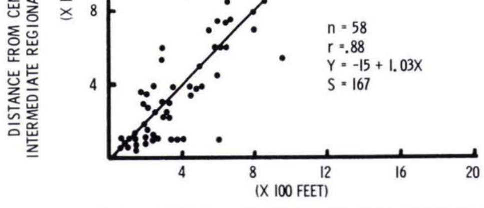

FIG. 2. Correlation-regression analysis of measurements from centerline of stream to Intermediate Regional Flood Boundary and flood boundary interpreted on *panchromatic* photographs.

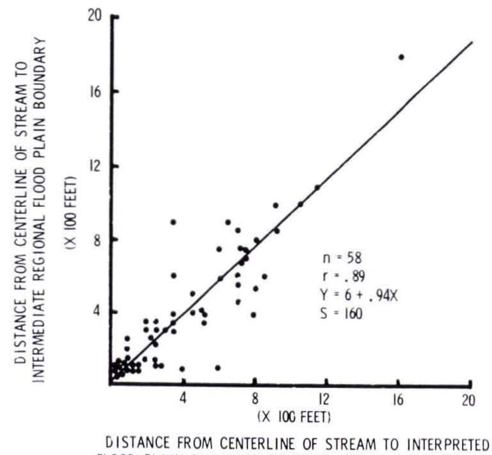

FIG. 3. Correlation-regression analysis of measurements from centerline of stream to Intermediate Regional Flood Boundary and flood boundary interpreted on *color* photographs.

The latter values are larger than would be expected from the results shown in Table I. However, large discrepancies (400–550 feet) occurred at three cross sections which account for about half of the standard deviation in each instance. These same cross sections were identified during airphoto interpretation as questionable areas where field checking would have been desirable. At these sites, a uniform, gentle slope from the stream to the uplands and lack of a well defined flood plain made it very difficult to delineate the flood plain boundary. A slight change in flood water elevation in these areas will cause a substantial displacement of flood plain boundaries. It should be emphasized that in such areas, it is difficult to plot accurately the exact location of flood plain boundaries by any means.

Where the two types of photography used in this study were compared, neither appeared to be consistently more accurate than the other. Their general agreement with the Regional Flood boundary was about the same. It was observed, however, that flood plain boundaries could be drawn with greater ease, rapidity, and confidence on the color photographs. This was partly due to their larger scale, but also because most landforms and small details of the landscape could be more quickly and easily recognized on the color photographs. This agrees with the observation by Anson (1968) that cultural and land use patterns are easier to identify on color than on black and white photographs.

It is entirely possible that the use of other materials, such as color infrared film, or new techniques such as repetitive multiband photography could greatly improve the accuracy of flood plain delineation by airphoto interpretation.

In terms of costs, airphoto interpretation utilizing available photography requires relatively little time and a minimum of equipment as compared with engineering methods. The present study required a total of 5 or 6 hours to draw flood plain boundaries on both sets of photos. It should be emphasized, however, that a trained interpreter is needed and that the best photography taken at the best time to produce the most accurate boundary should be used.

The cost of airphotos will depend on the kind of photography desired and its availability. For example, panchromatic contact prints of the area used in the present study could be purchased from the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service for about $50.00. If special flights were needed the cost would be considerably higher and color prints cost about twice as much as panchromatic photos.

Simple stereoscopes, costing a few dollars each, can be used but more sophisticated scanning models are preferable in most applications.

The results of this study, and the earlier study by Parker[2], both suggest that the boundaries of rare floods can be delineated in many areas by interpretation of panchromatic or color airphotos. The method described here will be most useful in landscapes where the physiographic flood plain is well defined and closely associated with boundaries of rare floods. It is not as well suited for use in areas where the physiographic flood plain is indistinct and where a slight change in flood stage causes considerable lateral displacement of flood boundaries. In any event, it seems advisable in delineating flood plains by airphoto interpretation to field-check questionable areas, and to make use of supplementary data from flood records, soil and topographic maps, and other sources whenever possible.

Where the flood plain is distinct, a trained airphoto interpreter using a stereoscope can delineate the boundary rapidly, and with minimum expense. If however, a more accurate boundary or additional information such as elevation and velocity of flood water, or frequency of flooding is needed, these must be obtained by engineering methods. In choosing between these two methods, decision makers must consider the value of the intended use of the flood plain, the susceptibility of the use to flood damage and the relative expense of a more accurate survey in relation to these factors.

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