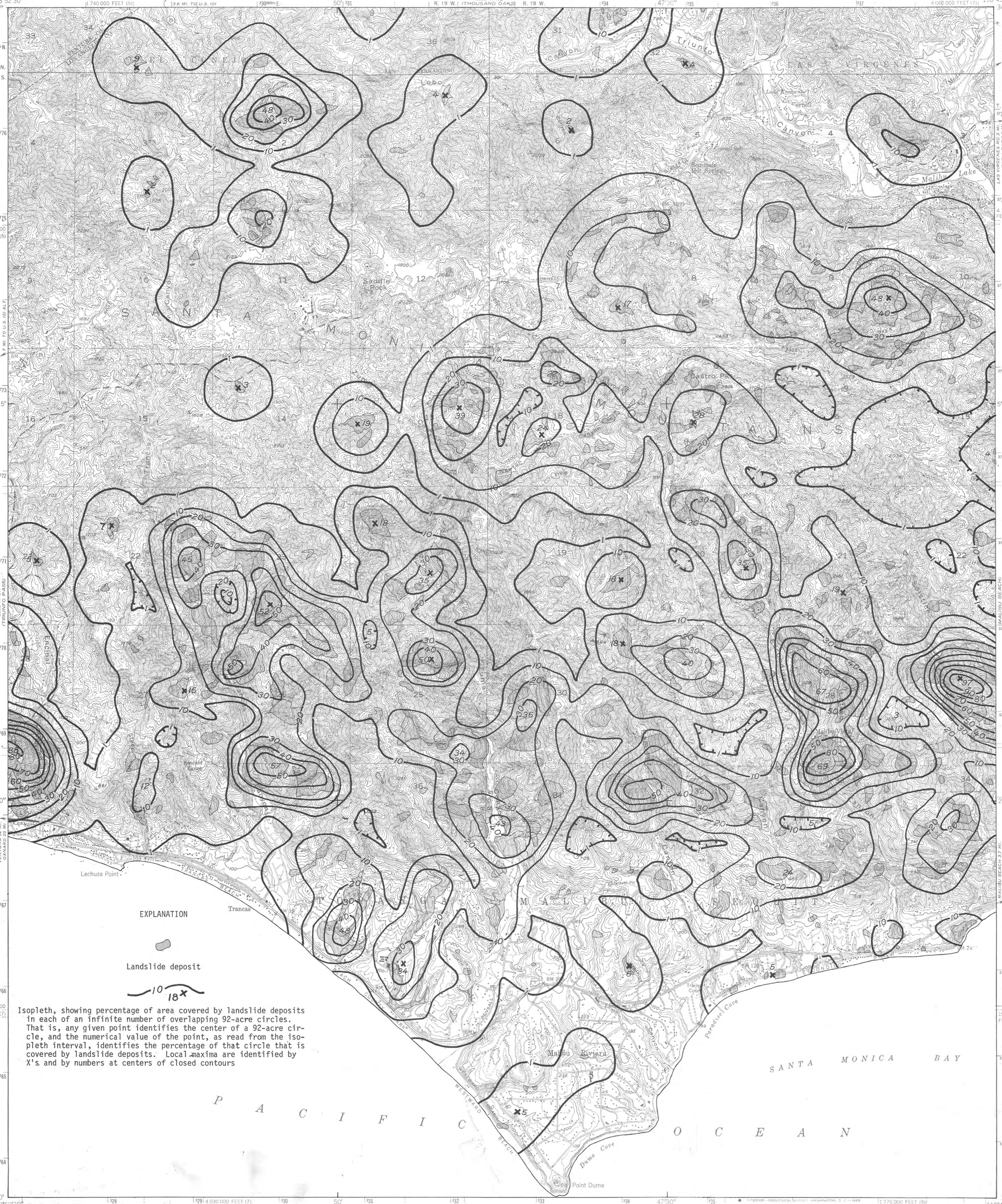
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE DEPARTMENT OF THE
COUNTY ENGINEER, LOS ANGELES COUNTY, CALIFORNIA

MISCELLANEOUS FIELD STUDIES
MAP MF-535



Base by U. S. Geological Survey, 1967

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 25 FEET
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

For sale by U. S. Geological Survey, price $.50

ISOPLETH MAP OF LANDSLIDE DEPOSITS, POINT DUME QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA; AN EXPERIMENT IN GENERALIZING AND QUANTIFYING AREAL DISTRIBUTION OF LANDSLIDES

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1973

INTRODUCTION

The accompanying isopleth map[1/] is an experimental attempt to "smooth" landslide inventory data in order to make some quantitative comparisons between different parts of the quadrangle. Landslide inventory maps record the sites where past or present conditions (for example, slope, bedrock and soil character, geologic structure, ground-water table, and climate) have combined, with or without external triggering effects (for example, earthquakes), to cause slope failures. Generally, historic landslide activity is more common in areas where older landslide deposits can be recognized than in areas where no prehistoric landslides have occurred. Therefore, maps showing the distribution of recognized and suspected landslide deposits are useful guides to the kinds of problems that may attend engineering development of a given area. Of course, the likelihood that landslides will occur may change in time as a result of changes in climate, in frequency or strength of shaking by earthquakes, in ground-water table, or in slope by either natural erosion or the activities of man. Geologic controls for the localization of individual landslides can generally be worked out by careful, detailed study. Less-detailed areal inventories, however, record only whether or not a landslide has left recognizable remains, and the map may or may not disclose clustering that is easily recognized to be associated with some geologic unit or structure. To show less obvious associations, the landslide inventory map must be converted to a form in which quantities are gradational, rather than landslide or not landslide.

One way of characterizing the general distribution of landslide deposits in an area is to note the percentage of the area that is covered by them. Thus, some specific area, such as a quadrangle, a section, a drainage basin, or a proposed subdivision, might be characterized as having "X percent covered by landslide deposits," by which it can be compared with other quadrangles, sections, drainage basins, or proposed subdivisions. Another form of characterization may be constructed by selecting an area of constant size and taking a moving average of the percent covered by landslide deposits. As the location of the constant area is shifted around the map, the percentage is noted at each map position of the center of the constant area. These numerical values (percentages) may be contoured, yielding an isopleth map (Schmid and MacCannel, 1955; see especially p. 234-239) that provides a quantitative basis for comparing different parts of the map area. The accompanying map was constructed to show the percentage of landslide coverage in a circle having a total area of 92 acres (radius, 1,128 feet; equivalent to a 0.564 in. radius and a 1 in.^{2} area on a map at 1:24,000 scale) that is centered at any specified point on the map. In other words, any given point identifies the center of a 92-acre circle and the numerical value of the point, as read from the contour intervals, identifies the percentage of that circle that is covered by landslide deposits.

The map reader should bear in mind that the isopleths do not simply enclose areas having the percentage of landslide cover of the contour label. Instead, they enclose areas within which the centers of overlapping equal circles have a percentage of landslide cover represented by the contour labels. Consequently, a contour may enclose an area in which landslide deposits cover much more than the percentage of the contour label (see, for example, the 40 percent contour on fig. 1F). Indeed, a contour having a label of less than 100 percent may enclose an area that is entirely within a landslide deposit.

METHOD OF MAP PREPARATION

The map was constructed by graphic procedures from the landslide inventory data on the geologic map of the quadrangle at 1:12,000 scale (Campbell and others, 1970), photographically reduced to 1:24,000 scale. The deposits attributable to origin by landslide and related slope processes (see fig. 1A) were then sampled by overlaying and registering a grid of 0.10 in. x 0.10 in. squares, and each intersection that fell within or on the boundary of a landslide deposit was assigned a value of 1 and marked by a dot (fig. 1B, C, D)--all other intersections were assigned a value of 0. This yielded a map on which each dot ("1") or each "0" represented 1 percent of the total possible evenly spaced points within any 1 in.^{2} area. A circle of 1 in.^{2} area was then moved across the map. At each ½-in. grid interval (fig. 1D), the total number of dots was counted and noted at the center of the circle (fig. 1E). Where the circle included areas outside the quadrangle boundaries, the distribution was assumed to be the same as that for the part of the circle inside the boundaries. Areas seaward of the shoreline were assumed to have no landslide deposits. Where the changes in percentage from one counting center to another were large, counts were made on intermediate centers in order to improve contour placement. Contours were drawn (see figs. 1E, F) at 1 percent and at multiples of 10 percent. Local maxima were determined by moving the circles until they enclosed maximum percentages and by locating the centers. Where the maxima were symmetrically enclosed by nearby contours, their positions were marked with the number only. Where the maxima were asymmetrically distributed or at some distance from the nearest contour, their position was marked with an X.

The distribution of the dots is probably a good representation of the areal distribution of the mapped landslide deposits (figs. 1B, C). In practice none of the mapped landslide deposits was excluded by the 10 x 10-per-inch grid used in the construction of the isopleth map. (Because of scale limitations, few landslides of less than 0.01 in.^{2}--equivalent to about 1 acre--were included in the landslide inventory; the smallest is about 0.003 in.^{2}.)

The contours constructed using counting centers spaced ½-inch apart should be located no more than ±¼-inch (equivalent to 500 feet) out of position. In practice, with supplemental ¼-inch spacing to aid in the placement of selected parts of the 1-, 10-, and 20-percent contours and centroid location of some of the peak positions, the contours are probably no more than ±1/8-inch (equivalent to 250 feet) out of position in most of the map area. Thus, the contour precision is generally of the same order as the diameter of a circular area of 1 acre in size--about 236 feet--or about the size of the smallest landslides generally recorded on the landslide inventory. Of course, contour positions can be improved by the use of more closely spaced counting centers.

The degree to which the data are smoothed by this kind of construction depends on the size of the counting circle. As the diameter of the counting circle is decreased, more counting circles centered in landslides will have higher percentages and circles centered outside of landslides will have lower percentages. The spacing between the contours will be decreased toward the limiting case where the 1-percent and 100-percent contours coincide with each other and with the boundaries of the landslides themselves. As the diameter of the counting circle is increased, peak percentages are decreased and the areas of less than 1 percent are also decreased, tending to spread the pattern in the direction of a single limiting value that is the percentage for the entire quadrangle. Within limits, the choice of the size of the counting circle for maps of this type could be made to serve the specific needs of a potential user (for example, some users might be interested in 80-acre or 160-acre areas, others might be interested in a specific percentage of the total land area of the map).

USES

The principal use of this kind of map is to compare the relative slope stability history of different areas solely on the basis of a landslide inventory. It might serve as a guide to potential slope stability problems in planning the use of a land area where a wider spectrum of geologic data are lacking. It is not a complete, self-contained landslide susceptibility map. In transparent overlay form, the isopleth map is easily combined with other maps at the same scale (for example, topographic, slope, geologic, soils, and vegetation maps). It may also be combined with contour maps of other data (for example, isohyetal maps) to generate derivative maps of higher order.

This map groups many different kinds of landslides into a single category, but because the construction of isopleth maps of this kind is relatively rapid and is probably amenable to computer processing and contouring techniques, these maps could be prepared for each of several classes of landslides in order to compare generalized settings and illustrate any significant differences.

PRECAUTIONS TO USERS

The user must remain aware that the accompanying map is constructed solely on the basis of proximity to recognized and suspected landslide deposits. Individual factors that affect slope stability, such as slope steepness, bedrock and soil type, geologic structure, climate, ground-water table, and earthquake shaking, may vary with time and from place to place and have not been considered independently--only in the interdependent context of the mapped landslide distribution. For example, past climatic episodes of much greater rainfall may have resulted in landslides in areas where they would not be so likely to occur under present climatic conditions. The accuracy of the generalized map depends on the completeness of the original landslide inventory from which it is derived. The scale of the inventory map may affect its completeness. For example, many failures of ¼ to ½ acre in size are too small to be shown to scale on a map at 1:24,000 scale and must either be omitted or their size exaggerated. Errors in the inventory map, either by excluding landslide deposits because of nonrecognition or by including features incorrectly identified as landslide deposits, are perpetuated in the generalized map, though the effects are diminished by the smoothing process.

1/ Schmid and MacCannel (1955, p. 220) define "isopleth" as follows: "The term 'isopleth,' Gr. isoplethes, equal in quantity or number, ... designates maps in which the lines (isopleths) connect equal rates or ratios for specific areas. In the other type of isoline map, ... lines (isometers) are drawn through points of equal value or intensity. ... A population density map with lines showing equal densities is an example of the 'isopleth' map, and a topographic map with lines connecting a series of points of equal elevation ('isohypses,' or more commonly, contour lines) is an example of the 'isometric' map."

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Schmid, C. F., and MacCannel, E. H., 1955, Basic problems, techniques, and theory of isopleth mapping: Jour. American Statistical Assoc., v. 50, no. 269, p. 220-239.

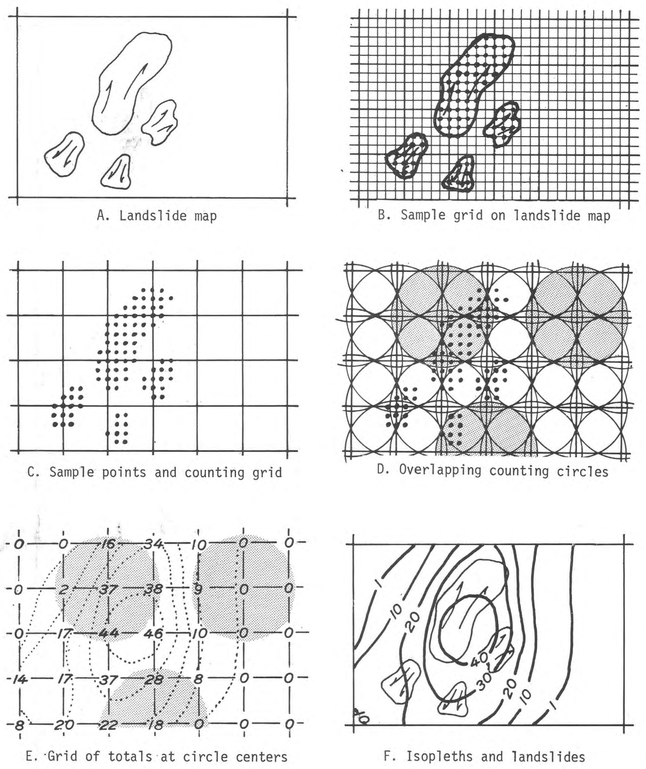

Figure 1.--Steps in the construction of the isopleth map. Note that the isopleths of step F are contours drawn on the distribution of numerical values of step E and do not simply enclose areas having the percentage of landslide cover shown by the contour label.

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