GUIDES FOR CHOOSING SLOPE LENGTHS

In training sessions, more questions are asked about slope length than about any other RUSLE factor. Slope length is the factor that involves the most judgment, and length determinations made by users vary greatly. Figure 4-1 illustrates the major slope-length situations that are found in the field. However, additional guides are useful, especially for rangelands and forest lands.

Actually, an infinite number of slope lengths exist in the field. To apply RUSLE, erosion can be calculated for several of them and the results averaged according to the area represented by each slope length. Sometimes a particular position on the landscape is chosen as the location for a slope length. To establish the ends of the slope length, the user walks upslope from that position, moving perpendicular to the contour, until the origin of overland flow is reached. Often this point is not at the top of the hill but at a divide down the nose of a ridge (illustrated in fig. 4-2).

The lower end of the slope length is located by walking downslope perpendicular to the contour until a broad area of deposition or a natural or constructed waterway is reached. These waterways are not necessarily eroded or incised channels, and this lack of channels can make it difficult to determine the end of slope. One aid is to visualize the locations on the landscape where eroded channels or gullies would naturally form. Figure 4-2 illustrates one area where such waterways are located.

If a slope flattens enough near its end, deposition may occur. When erosion and deposition rates are low and erosion has not recently occurred, deposition begins at the point where slope has decreased to about 5%. Deposition does not necessarily occur everywhere a slope flattens.

Sometimes slope decreases as shown in figure 4-3. On those slopes, deposition can end and erosion can occur on the lower end of the slope. To approximate where deposition ends, the user should do the following: First calculate the ratio of the slope steepness at the end to the slope steepness where deposition begins. Subtract that ratio from 1.0, multiply that difference by the distance from where deposition begins to the end of the slope, and add that product to the distance where deposition begins. To illustrate, assume a 400-ft-long slope with a 2% slope at the end. Assume that deposition begins at 250 ft, where the slope is 5%.

The ratio of the slope steepness is 0.40, and the distance from where deposition begins to the end of the slope is 150 ft. The location where deposition ends is 250+(1.0-0.40)(150) = 340 ft. This procedure, an approximation to results of CREAMS simulations, is for gently curving slopes. When the change of slope is very abrupt, deposition may occur over only a 20- to 40-ft distance.

In the case just described, the water is assumed to flow uniformly as broad sheet flow over the depositional area and onto the downslope eroding area, or from a relatively flat area at the top of the slope onto a steep area. The distance to the origin of flow must be considered in computing soil loss. To compute average erosion for the slope, only the segments experiencing erosion are used in the computations. In this case, RUSLE does not compute sediment yield for the slope. Of course, a diversion ditch across the slope would end the slope length and a new one would begin immediately below the ditch. Also, broad sheet flow does not occur in natural riparian vegetation.

All the situations discussed previously have been simplified. A few specific examples may help the user visualize field slope length. Figure 4-4 is a photo of rill erosion on a steep small-grain field in the Pacific Northwest. Although the small watershed is concave, a relatively straight, closely spaced rill pattern has resulted on most of the slope. The pattern is from the top to the bottom of the slope or to the flow concentration at the bottom of the swale. For these particular conditions alone, slope length can be obtained fairly accurately from U.S. Geological Survey (USGS) 7½-min contour maps with a 20-ft contour interval.

Figure 4-5A shows a row cropped watershed after a series of storms during the early stages of crop growth. The concentrated flow channels are spaced rather closely together, leading to fairly short slope lengths for RUSLE computation. Even with the 1-ft contour interval map in figure 4-5B, realistic slope lengths are difficult to estimate without the aerial photograph for guidance.

The effect of different crop managements on the upper and lower portions of a slope is illustrated in figure 4-6. The boundary between the two managements occurs at about the middle of the slope. Presence of the snow drift on the upper part of the slope causes measured slope length to be a poor predictor of soil loss; the distance to the top of the ridge does not provide a realistic estimate of the length that actually provides the snowmelt. Other than the area where a drill wheel track diverts the runoff and creates a flow concentration, the rill pattern is fairly straight and closely spaced. The bottom of the slope where the runoff collects into a larger channel, or deposits sediment at the toe of the slope, is not shown.

Determination of slope lengths on rangeland and forested watersheds is generally more difficult than determination of slope lengths on cropland because of the permanent vegetation and the frequently irregular topography of the former. Three selected small watersheds from the Lydle Gulch and Blacks Creek drainages east of Boise, Idaho, are shown on a portion of the 7½-min USGS quad sheet for Indian Creek Reservoir in figure 4-7. Figure 4-8 is an example of a steep rangeland watershed with little shrubby permanent vegetation. Because of the steepness of the watershed, there are few depositional areas. However, the hillslopes are rough and the ridgetops rounded, slightly complicating the determination of slope length. Even for this simple case, the determination of slope lengths by inspecting a 7½-min quad sheet with a 20-ft contour interval would lead to slope lengths longer than those determined in the field or from a low-level aerial photograph. The slopes of the transects are irregular, but to conserve space in this publication, LS in figure 4-8 was calculated from the total horizontal slope length and total fall.

Figure 4-9 is a photograph of a more complex rangeland watershed. The slope is flatter than that on the area in figure 4-8, and numerous large mounds make the topography very uneven. The drainage channels are rather broad, vegetated, and poorly defined, and the watershed boundaries are difficult to delineate. The shrubby permanent vegetation is more prevalent than that on figure 4-8, obscuring the flow paths on aerial or oblique photographs. Slope lengths are best determined by field inspection. The use of maps with even a 2-ft contour interval will lead to slope lengths much longer than those determined in the field.

The complex and irregular rangeland watershed that appears on figure 4-10 exemplifies conditions frequently found in the field. The watershed is of low slope, has undulating topography with numerous hummocks or mounds, and has shrubby permanent vegetation that masks the drainages. The determination of slope lengths even by field inspection is difficult, particularly when the grass cover is at its maximum and not yet reduced by grazing.

Figure 4-10 shows a complicated flow system where shrubs, grass clumps, and litter are isolated in hummocks scattered over rangeland, and in effect where water flows down a local slope to a locally concentrated flow area. This flow system may be treated as follows: If flow patterns around and among the hummocks are basically parallel, do not treat the flow concentrations as the end of a short slope length. Choose slope lengths by visualizing the surface as being smooth without the hummocks. If, however, major deposition occurs upstream of the hummocks and/or the flow pattern meanders without a direction, treat the slope lengths as short. Note that on figure 4-10, some of the transects pass through clumps of shrubby vegetation.

ACKNOWLEDGMENT

The assistance of Clifton W. Johnson (retired), hydraulic engineer, USDA-ARS, Northwest Watershed Research Center, Boise, ID, in obtaining photographs and field documentation is gratefully acknowledged.

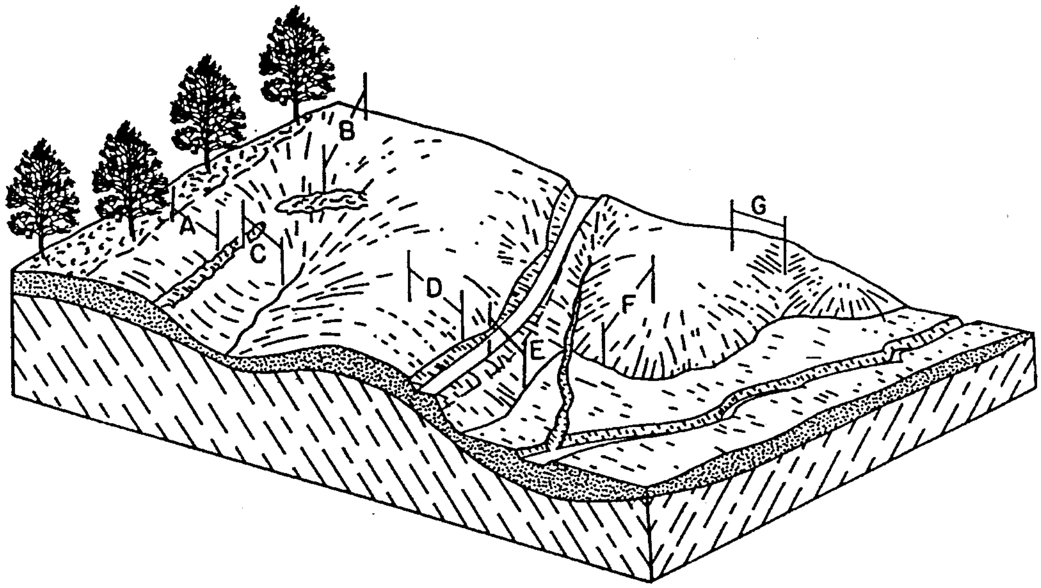


Figure 4-1. Typical slope lengths (Dissmeyer and Foster 1980). Slope A— If undisturbed forest soil above does not yield surface runoff, the top of slope starts with edge of undisturbed forest soil and extends down slope to windrow if runoff is concentrated by windrow. Slope B—Point of origin of runoff to windrow if runoff is concentrated by windrow. Slope C—From windrow to flow concentration point. Slope D—Point of origin of runoff to road that concentrates runoff. Slope E—From road to flood plain where deposition would occur. Slope F—On nose of hill, from point to origin of runoff to flood plain where deposition would occur. Slope G—Point of origin of runoff to slight depression where runoff would concentrate.

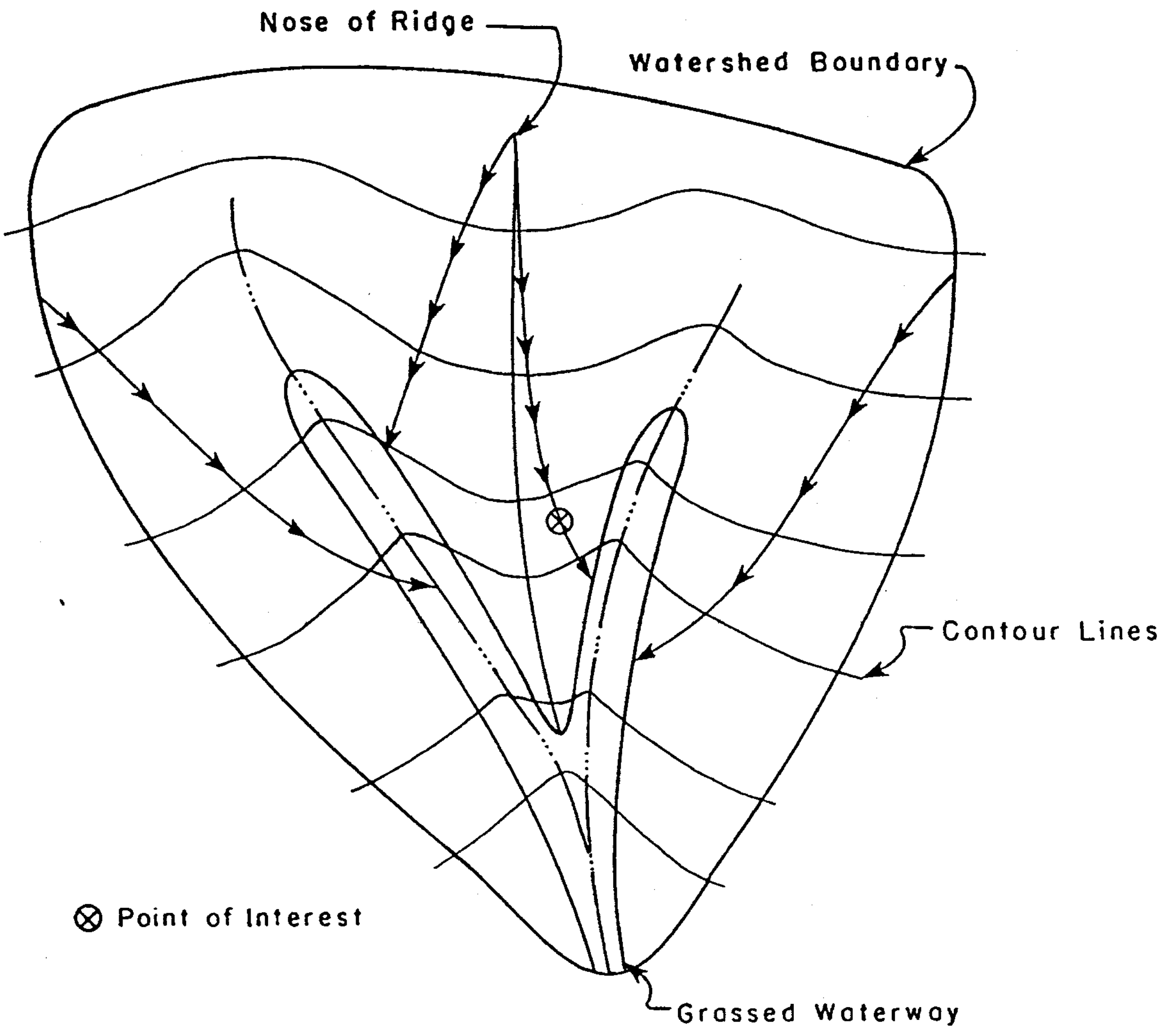


Figure 4-2. Illustration of some RUSLE slope lengths

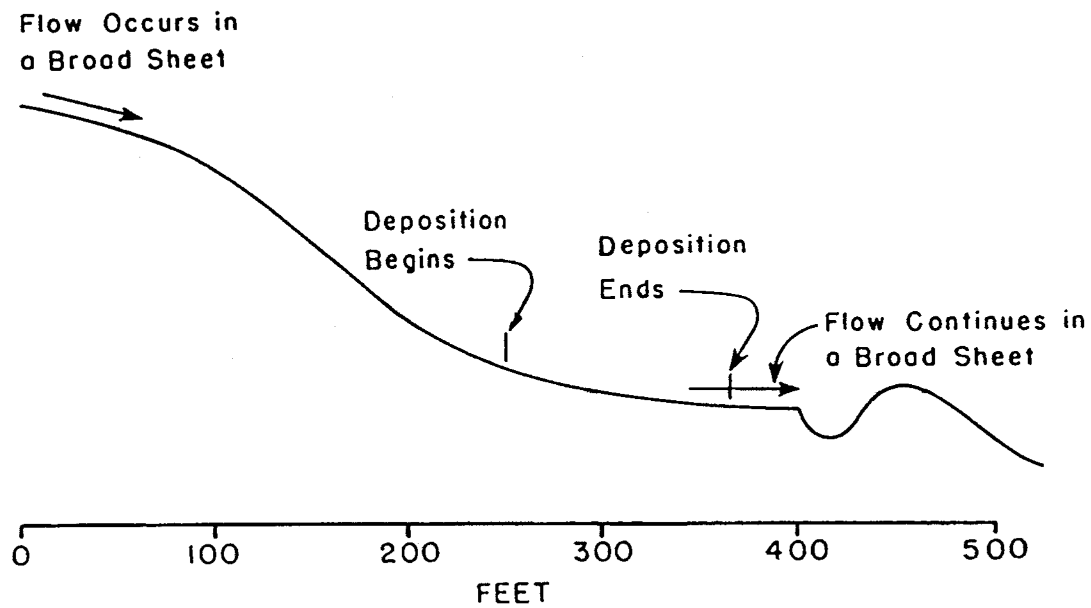


Figure 4-3. Illustration of deposition beginning and ending on a slope

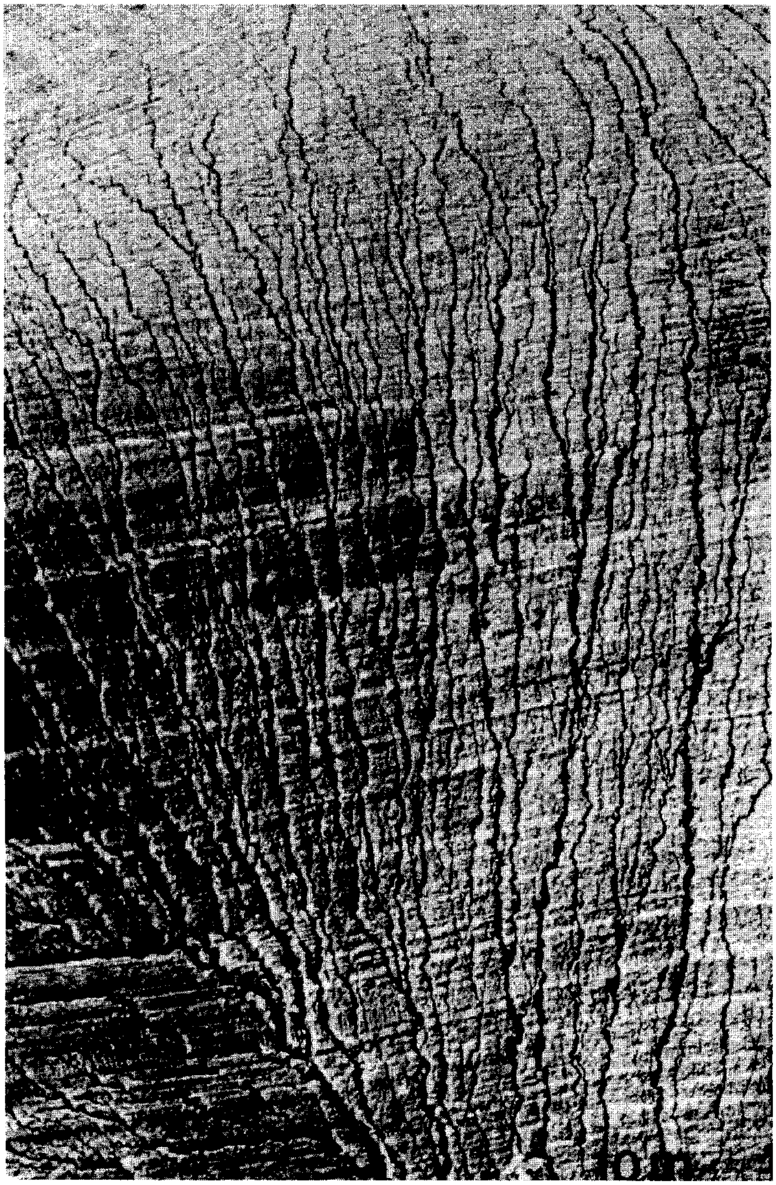
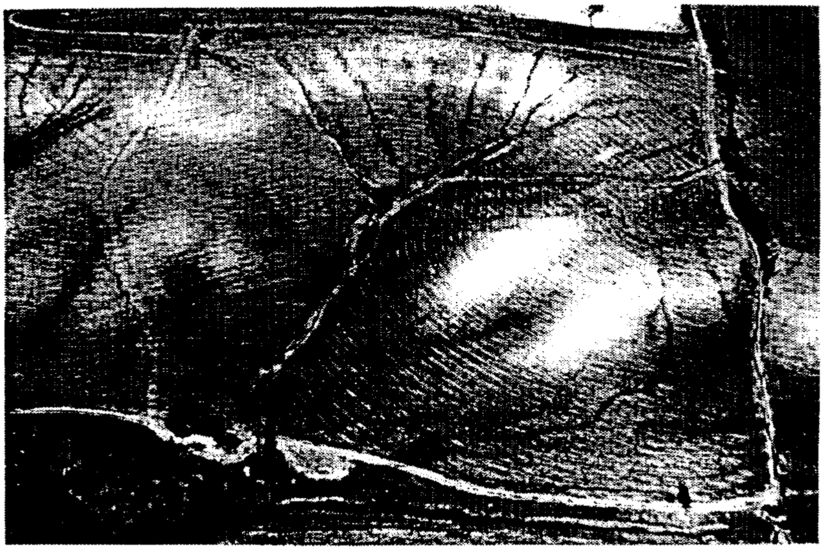


Figure 4-4. Dendritic rill pattern on a concave, north-facing slope. Estimated soil loss was 82 ton · acre^{-1}. From Frazier et al. (1983), reprinted by permission of Soil and Water Conservation Society.



Transcect	Slope length (λ) (ft)	Slope steepness (s) (%)	LS
1	280	12	3.14
2	325	13	3.84
3	240	11	2.53
4	205	13	2.97

Figure 4-5A. Erosion resulting from a series of storms on a row crop field during early stages of crop growth

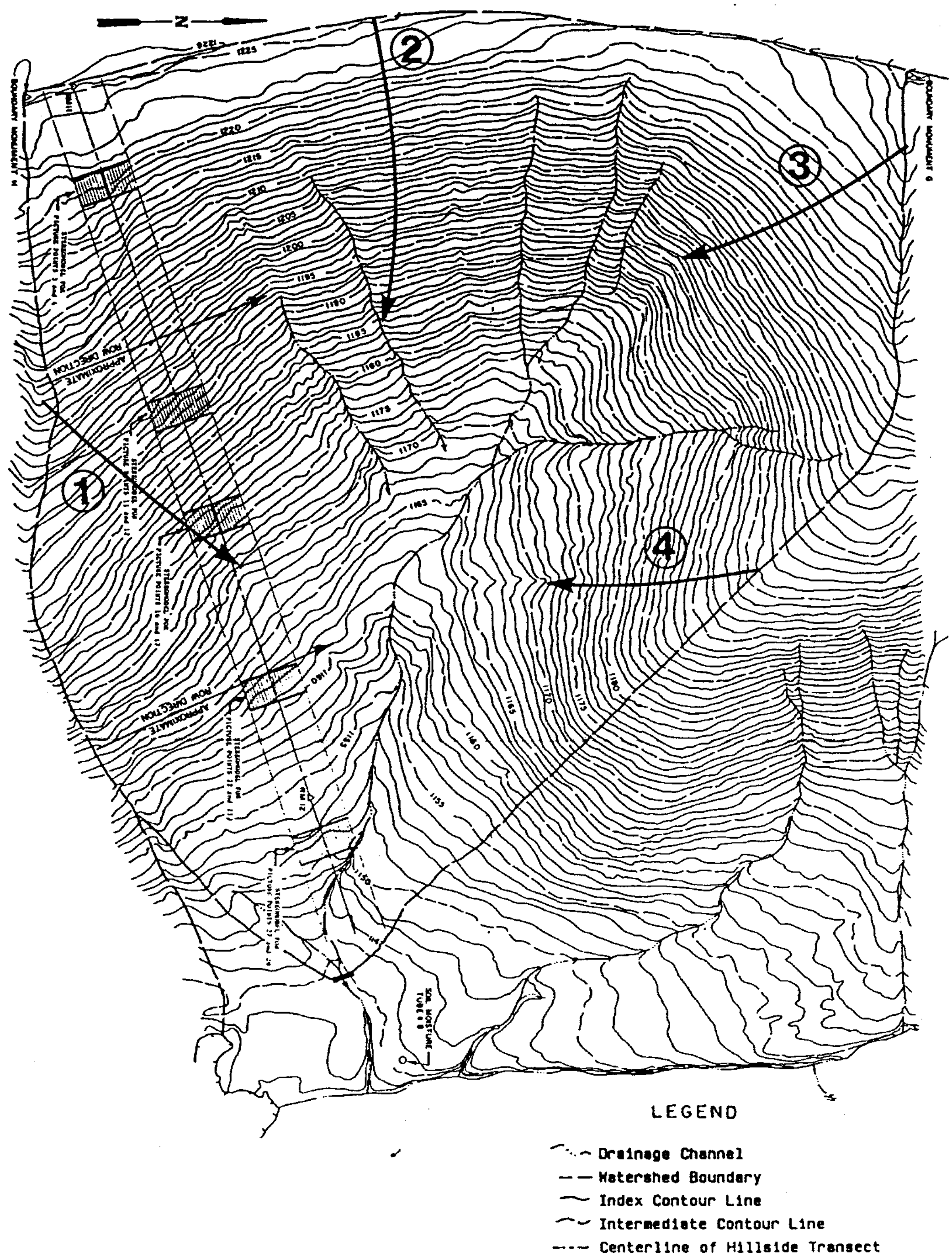


Figure 4-5B. One-ft contour interval map of the row crop field shown in figure 4-5A

Figure 4-6. Erosion from different crop managements on upper and lower halves of a slope. A large snow drift complicated the situation. From Frazier et al. (1983), reprinted by permission of Soil and Water Conservation Society.

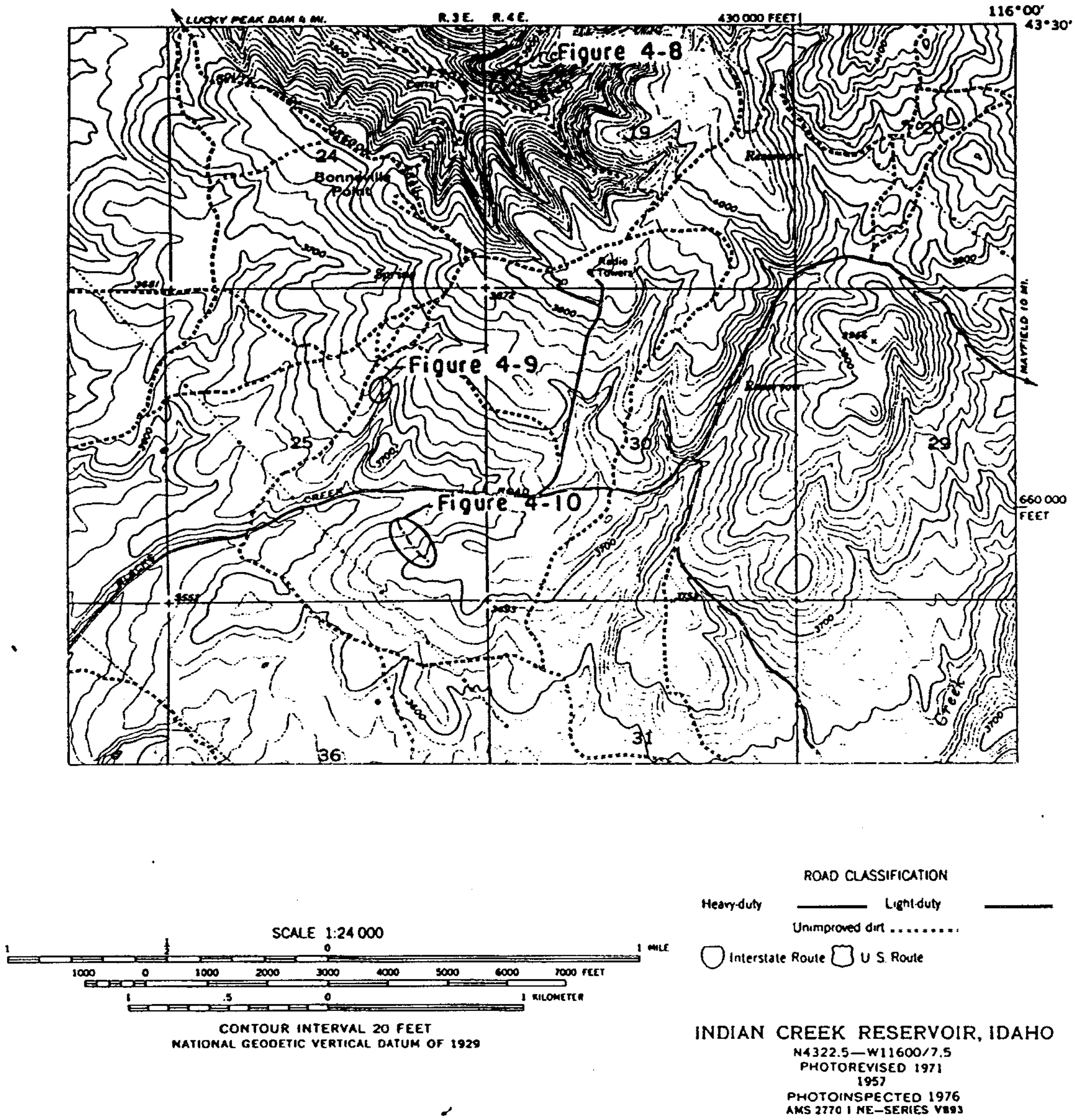
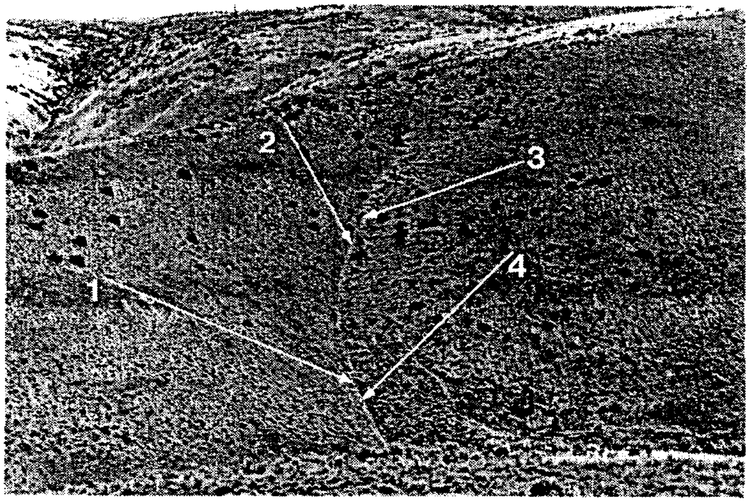
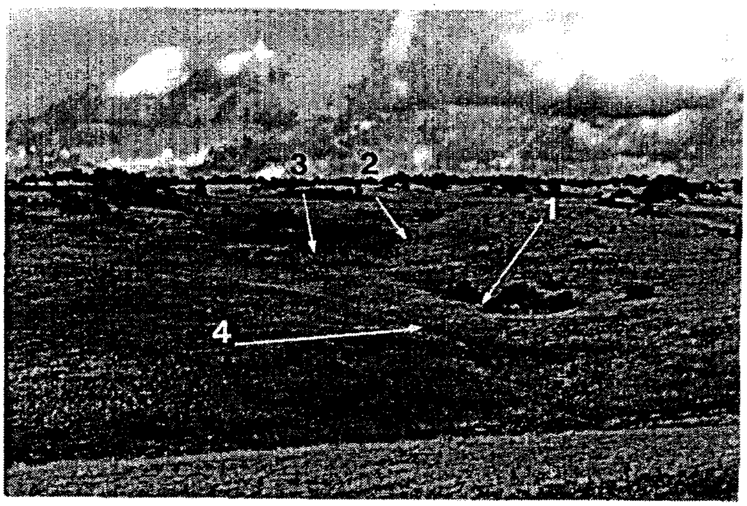


Figure 4-7. Portion of Indian Creek Reservoir USGS 7½-min Quad Sheet showing an area east of Boise, Idaho



Transect	Slope length (λ) (ft)	Slope steepness (s) (%)	LS
1	225	61	15.44
2	135	53	10.32
3	150	45	9.39
4	375	60	20.18

Figure 4-8. Small rangeland watershed on Lydle Creek east of Boise, Idaho



Transect	Slope length (λ) (ft)	Slope steepness (s) (%)	LS
1	165	14	2.53
2	30	6	0.53
3	50	16	1.85
4	60	14	1.70

Figure 4-9. Small rangeland watershed on Blacks Creek east of Boise, Idaho

Transect	Slope length (λ) (ft)	Slope steepness (s) (%)	LS
1	135	10	1.46
2	45	14	1.51
3	65	21	2.81
4	100	11	1.50
5	40	10	0.95

Figure 4-10. Small rangeland watershed on Blacks Creek east of Boise, Idaho