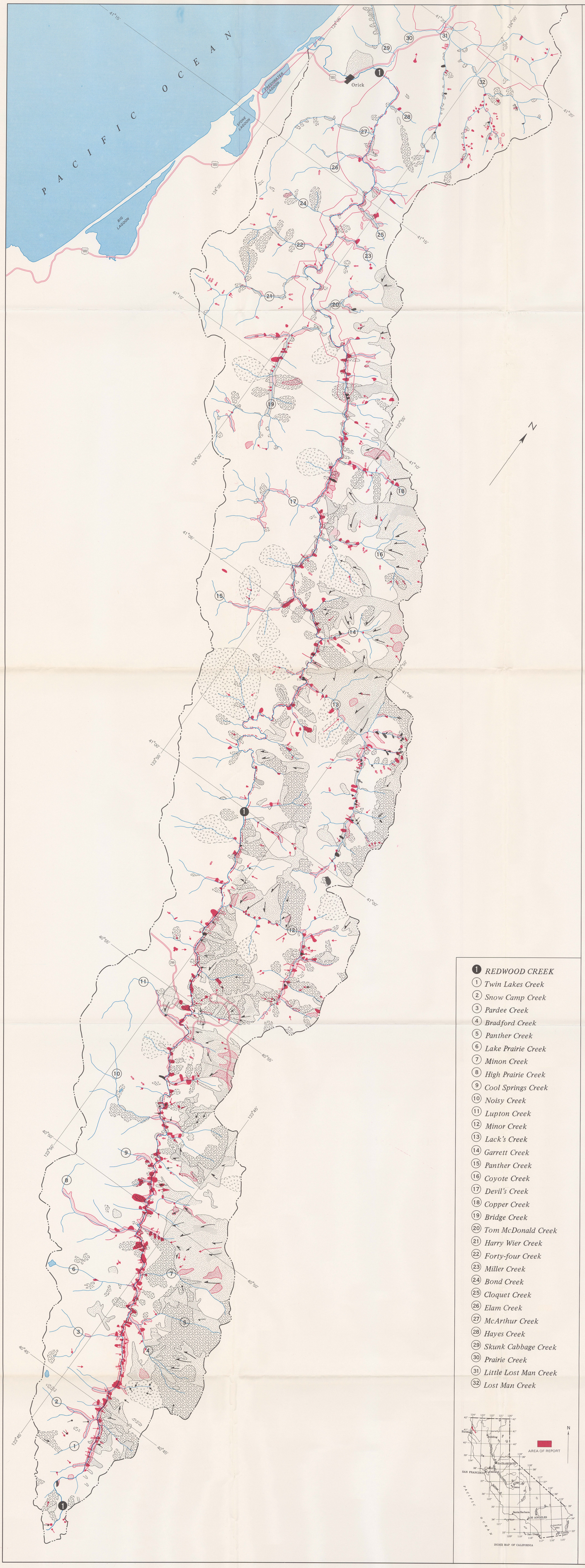
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

WATER-RESOURCES INVESTIGATIONS 76-42
OPEN-FILE REPORT



INDEX MAP OF CALIFORNIA

Base from 15' (1:62,500) U.S. Geological Survey Topographic Quadrangles (Orick, Trinidad, Tectah Creek, Coyote Peak, Blue Lake, Willow Creek, Pilot Creek, and Iaqua Buttes)

SCALE 1:62 500

1 ½ 0 1 2 3 4 5 MILES

1 .5 0 1 2 3 4 5 6 7 KILOMETRES

EROSIONAL LANDFORM MAP OF THE REDWOOD CREEK DRAINAGE BASIN, HUMBOLDT COUNTY, CALIFORNIA 1947 - 1974

By

K. M. Nolan, D. R. Harden, and S. M. Colman

1976

INTRODUCTION

The regional erosion rates of north coastal California, including the Redwood Creek basin, are the most rapid of any unglaciated terrain in North America (Ritter, 1968; Holeman, 1968). These rates result from a combination of several factors. The complexly deformed Franciscan assemblage of rocks throughout much of this area has weathered to a suite of soils possessing little cohesion or shear strength. In addition, these soils occur on steep hillslopes and receive large amounts of rain during the winter months. Erosion rates appear to have been accelerated over the last 30 years by a combination of large-scale, clearcut timber harvesting and the occurrence of floods in 1953, 1955, 1964, and 1972. These floods, when viewed from an historical perspective going back to the late 19th century, appear exceptionally intense (Colman, 1973).

Mass movement (the downslope movement of soil and rock under the influence of gravity) appears responsible for sculpturing large areas of north coastal California and contributes significantly to stream sediment loads. Fluvial processes (the downslope, down-channel movement of surficial soil and rock by running water) have also contributed to the erosional development of this landscape. The potential hazards to life and property associated with mass movement are not great in the north coast area because the steep, inherently unstable hillslopes are sparsely populated. Nonetheless, these processes sometimes do have destructive impacts upon the transportation network and valuable timberland in the area. Furthermore, increased fluvial sediment loads resulting from mass movement may alter stream channel morphology and adversely affect riparian vegetation and aquatic organisms, including anadromous fishes.

The erosional landforms resulting from large-scale mass movement and fluvial processes in the Redwood Creek basin are shown on this map. The map is intended to show basin conditions as of the end of the 1973–74 winter season and also the way in which those conditions have changed since 1947. This map is modified from Colman's 1973 map and description of the history of mass movement within the basin. The modification utilizes information shown on more recent aerial photographs, portrays fluvial as well as mass movement processes, and emphasizes the recent changes in erosional activity. When used in conjunction with more detailed geologic, pedologic, and hydrologic data, the map should help identify potential highly erosive areas.

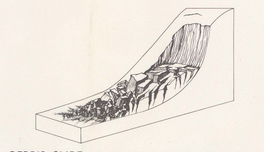
EROSIONAL LANDFORMS

MASS MOVEMENT

The classification of mass-movement processes used is slightly modified from that developed by Sharpe (1938). The modification and descriptions that follow reflect field observations and interpretations of aerial photographs of the Redwood Creek basin. Debris slides, rockfalls, and rockslides have been combined into one inclusive category, slides. The distinction between these three forms of movement was impracticable because of the sheared and fractured nature of the bedrock. Although the categories of movement processes represent idealized end members of a continuous spectrum, the mapped landforms are mostly combinations of these processes and have been forced into one of the categories.

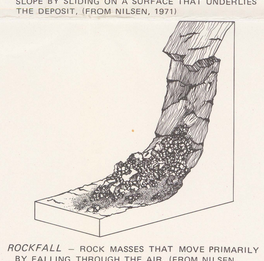
MAP SYMBOLS

LANDFORMS THAT WERE LARGER OR MORE ACTIVE IN 1947 THAN IN 1974	LANDFORMS THAT DID NOT CHANGE IN SIZE OR ACTIVITY BETWEEN 1947 AND 1974	LANDFORMS THAT WERE INITIATED OR THAT INCREASED IN SIZE OR ACTIVITY BETWEEN 1947 AND 1974
	SLIDES	

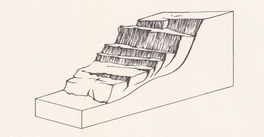

DEBRIS SLIDE – INCOHERENT OR BROKEN MASSES OF ROCK AND OTHER DEBRIS THAT MOVE DOWNSLOPE BY SLIDING ON A SURFACE THAT UNDERLIES THE DEPOSIT. (FROM NILSEN, 1971)

SLIDES – The initiating and (or) dominant movement in these features appears to be translational along a clearly defined failure surface or zone that is essentially parallel to the hillslope. Varying amounts of soil, fragmental rock, and bedrock are generally completely removed from their original location, leaving an unvegetated scar. Although the initial movement normally involves little internal disruption, most of these slide blocks commonly become intensely disrupted as movement progresses. Following initial failure, ground disruption often propagates upslope or laterally, or both.

This map unit is identified on the basis of unvegetated or partially vegetated scars which commonly lack pronounced crown scarps or bulbous toes. Individual episodes of movement take place in a relatively short time (seconds to minutes). Some of the larger slides appear to have had multiple episodes of movement separated by hours or even years. Field inspection of numerous slide areas indicates that small-scale ground disruption may extend slightly beyond those boundaries recognizable by aerial photo interpretation.


ROCKFALL – ROCK MASSES THAT MOVE PRIMARILY BY FALLING THROUGH THE AIR. (FROM NILSEN, 1971)

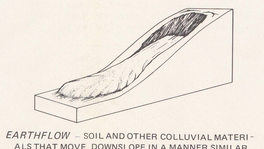
SLUMPS

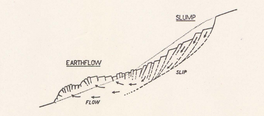

SLUMP – COHERENT OR INTACT MASSES THAT MOVE DOWNSLOPE BY ROTATIONAL SLIP ON SURFACES THAT UNDERLIE AS WELL AS PENETRATE THE LANDSLIDE DEPOSIT. (FROM NILSEN, 1971)

SLUMPS – Slumps shown on the map are intact blocks of soil and rock that have moved with a backward rotation primarily along a concave-upward failure surface or zone. Complex associations of slumping and flowing are much more common than pure slumps in this drainage basin.

This unit is identified on the basis of clearly defined crown scarps, bulbous toes, and surface disruption suggestive of backward rotation of intact blocks. Movement at the toe often involves some flowage. Some of the mapped slumps are presently (1974) stable, whereas others move during the wet season of the year. Slumps on hillslopes adjacent to major channels tend to move more rapidly than those on the upper hillslopes. Observed rates of movement of the active slumps are highly variable but range up to several tens of feet per year.

EARTHFLOWS


EARTHFLOW – SOIL AND OTHER COLLUVIAL MATERIALS THAT MOVE DOWNSLOPE IN A MANNER SIMILAR TO A VISCOUS FLUID. (FROM NILSEN, 1971)



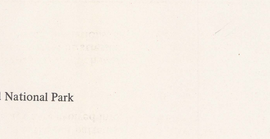
EARTHFLOW – LONGITUDINAL SECTION THROUGH EARTHFLOW SHOWING TYPICAL ASSOCIATION OF FLOWAGE AND SLUMPING (FROM SHARPE, 1938)

LARGE COMPOUND EARTHFLOWS – The earthflows shown on the map reflect a distinctive combination of slumping, translational sliding, and flowing. Either slumping or sliding is generally found at the top and is gradually replaced by flow movement in a downslope direction. This sequence may be repeated several times in one large earthflow. Most of the areas underlain by this map unit have subdued hummocky and lobate microtopography with vegetated scarps and flats. Vegetation is primarily grass and grass-bracken fern prairies, and (or) grass-oak woodland; coniferous forests occur only rarely. Dense thickets of young conifers (primarily Douglas-fir) and various hardwoods commonly separate earthflow areas from more stable areas bearing mature coniferous forests of mixed ages and species. The vegetation and surface morphology of earthflows suggest that although entire flows have been continuously active over long periods of time the loci of maximum movement within some flows have shifted repeatedly. Field examination of the surface morphology and comparison of sequential aerial photographs suggest that surficial rates of movement are less than a few feet per year. Depths of movement probably range from a few feet to several tens of feet. Rates and depth of movement appear to increase downslope. Some grassy areas that are included in this unit may be stable near drainage-basin divides.

The most active parts of earthflows are indicated on the map by a dense stipple pattern. These active areas display prominent hummocky and lobate microtopography unvegetated or partially vegetated scarps, open tension cracks, ponded drainage, closed depressions, and disrupted surface vegetation. Field measurements of the more active earthflows within the Redwood Creek basin and in nearby comparable terrain suggest that surficial rates of movement of these features are probably between a few feet and a few tens of feet per year.

The general direction of movement is indicated by heavy one-sided arrows (⟶).

DEBRIS AVALANCHES



DEBRIS-AVALANCHE – THE AVALANCHE TRACK IS CHARACTERISTICALLY LONG AND NARROW, SOMETIMES THOUGH NOT ALWAYS EXPOSING A SLIP SURFACE ON BEDROCK. AFTER THE INITIAL SLIPPAGE THE SATURATED MASS QUICKLY LOSES SHAPE AND FLOWS DOWNWARD, COMMONLY FOLLOWING A STREAM CHANNEL. (FROM SHARPE, 1938)

DEBRIS AVALANCHES – Debris avalanches involve the rapid downslope movement of soil, colluvium, and associated organic debris along narrow, clearly defined tracks. The moving material becomes completely disrupted shortly after inception of movement. The basal failure surface is generally less regular and less sharply defined than in the case of slides. The avalanche tracks in the Redwood Creek basin mostly follow natural drainageways or man-induced gullies. Levees are occasionally found along the margins of these tracks. Some debris flows and channels that have been scoured by debris torrents are included within this unit.

UNSTABLE STREAM BANKS

UNSTABLE STREAM BANKS AND ADJACENT HILLSLOPES – These areas are hillslopes that are immediately adjacent to stream channels and that contain scattered, tilted conifers and thickets of alders and other vegetation indicative of recently exposed mineral soil. Most of these hillslopes also contain small-scale gullies, slides, and debris avalanches. Field inspection suggests that some mapped areas of streambank instability are the toes of slowly moving earthflows or translational slides, the upslope parts of which bear intact stands of old growth timber. Comparison of time-sequential aerial photography indicates that unstable streambank areas are susceptible to slope failure, especially following major floods or road construction.

SMALL MASS MOVEMENTS

SMALL MASS MOVEMENTS – Various isolated examples of recent mass movement that are too small to portray accurately at the scale of the map are included in this unit.

QUESTIONABLE OR INACTIVE LANDSLIDES

QUESTIONABLE OR INACTIVE LANDSLIDES – Areas displaying suggestive or stream-modified landslide topography or a distinctive type or age class of vegetation are included in this unit. The boundaries of these areas are usually much less clearly defined than the boundaries of more active landslides. The size and density of forest vegetation as observed on aerial photographs, and the degree of soil-profile development as discerned by soil-vegetation surveys and in the field indicate that many of these areas have been inactive for centuries.

DEEPLY INCISED AMPHITHEATER-SHAPED DRAINAGE BASINS

DEEPLY INCISED AMPHITHEATER-SHAPED DRAINAGE BASINS – These bowl-shaped basins with steep cirquelike rims are eroded into relatively smooth hillslopes bearing mature coniferous forest. Although these areas are presently stable, they appear to have been carved primarily by one or more past episodes of large-scale mass movement. Deeply incised streams and strongly developed soil profiles indicate that these areas have not undergone mass movement for many thousands of years.

FLUVIAL PROCESSES

SMALL ACTIVELY ERODING WATERCOURSES

SMALL ACTIVELY ERODING WATERCOURSES – Discernible perennial and ephemeral water courses that display recently exposed unvegetated banks of mineral soil and rock are included in this unit. Most of these features were recently initiated or greatly enlarged in length and (or) cross-sectional area.

ACTIVELY ERODING STREAMBANKS ALONG REDWOOD CREEK

75-50 Percent 100-75 Percent

ACTIVELY ERODING STREAMBANKS – Areas of extensive active bank erosion adjacent to the main channel of Redwood Creek are indicated by red lines. More than 50 percent of such banks show steep to vertical exposures of recently exposed unvegetated sediment or soil with exposed roots.

Boundary of the Redwood Creek unit of Redwood National Park

Drainage divide

METHODS OF INTERPRETATION AND MAP PREPARATION

Recognition of mass movement and fluvial landforms was based primarily on stereoscopic inspection of vertical black and white aerial photographs taken in 1936, 1947, and 1974. Interpretation was augmented by studies of 1974 U–2 NASA-ERAP infrared photographs. Field inspection further augmented much of this interpretation. Identified landforms were transferred by hand to 1:62,500 scale base maps. The areas of active bank erosion along the main channel of Redwood Creek were defined by field inspection in the autumn of 1974.

The 1936 photographs portray the northern part of the basin from a point slightly upstream of the mouth of Minor Creek at a scale of 1:30,000 and are from the private collection of T. Hatzimanolis, Redwood National Park. The 1947 photographs are on file with the U.S. Geological Survey, Topographic Division, Menlo Park, California and portray the basin above Copper Creek at a scale of 1:45,000. In portraying the distribution of landforms as of 1947, it was assumed that basin conditions in 1947 closely resembled those in 1936. This assumption seems reasonable in view of long-term weather records, the history of basin land use, and the lack of significant change noted between 1936 and 1947 in the limited area where the two sets of photos overlap. Photographs taken in 1974 portray the entire basin. Areas downstream from the mouth of Lacks Creek and the main channel of Redwood Creek below Snow Camp Creek are covered by photographs (scale 1:10,000) on file with the National Park Service, Crescent City, Calif. The 1974 photographs showing all remaining upstream areas are in the possession of the Humboldt County timber assessor and are at a scale of 1:12,000. The 1974 U–2 photography depicts the entire basin at a scale of 1:32,500 and is on file with the EROS Data Center, Sioux Falls, S-Dak., accession number 01638.

The distribution of landforms in 1947 (prior to the recent major floods and the initiation of large-scale timber harvesting) which have maintained their morphology until 1974 are shown in black. Land forms which appear to have increased in size and (or) activity, or which were formed between 1947 and 1974 are shown in red. Features or portions of features which appear to have become less active and (or) expansive during this period are shown as gray areas. Basin conditions as of 1947 are, therefore, depicted by the black plus the gray patterns. The conditions in 1974 are depicted by the black plus the red patterns. Where red patterns overlie black patterns the features portrayed in black have evolved into the type of features portrayed in red.

MAP USE

The map should provide a basis for making more detailed, onsite investigations which may be necessary before changes in land-use practices are initiated. However, it must be stressed that because the map is based upon photointerpretation and because of scale limitations, it is not in itself sufficient for land-use decisions.

SELECTED REFERENCES

Alexander, E., Colwell, W., Delapp, J., Gladish, E., Nelson, R., Skoleman, R., Smith, B., 1959–62, Humboldt County soil-vegetation survey: U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, 16 maps, scale 1:31,680.

Bailey, E. H., Irwin, W. P., and Jones, D. L., 1964, Franciscan and related rocks, and their significance in the geology of western California: Calif. Div. Mines and Geol. Bull. 183, 177 p.

Colman, S. M., 1973, The history of mass movement processes in the Redwood Creek basin, Humboldt County, California: Paper presented in lieu of M.S. thesis, Pennsylvania State University, Department of Geosciences, University Park, Pennsylvania, 180 p.

Critchfield, H. J., 1966, General climatology: Prentice Hall, Inc., Englewood Cliff, N. J., 420 p.

Gray, P. H., 1970, Effects of forest clear-cutting on the stability of natural slopes, *in* Assoc. of Engineering Geologists Bull., v. VII, nos. 1 and 2, p. 45–66.

Hicks, B. G., and Collins, T. K., 1970, Use of engineering geology to reduce the impact of road construction and clear-cut logging operations on the forest environment: Association of Engineering Geologists, Annual Meeting, Preliminary Manuscript.

Holeman, J. N., 1968, The sediment load of major rivers of the world, *in* Water Resources Research, v. 4, p. 737–747.

Manning, G. A., and Ogle, B. A., 1950, Geology of the Blue Lake quadrangle, California: California Div. of Mines, Bull. 148, 36 p.

Nilsen, T. M., 1971, Preliminary photointerpretation map of landslide and other surficial deposits of the Mount Diablo area, Contra Costa and Alameda Counties, California: U.S. Geological Survey, Misc. Field Studies Map MF–310.

Ritter, D. F., 1968, Continental erosion, *in* The encyclopedia of geomorphology edited by R. W. Fairbridge, Reinhold Book Corp., New York, p. 169–174.

Sharpe, C. F. S., 1938, Landslides and related phenomena: Pageant Books, Inc., Paterson, New Jersey, 193 p.

Swanston, D. N., 1971, Principal mass movement processes influenced by logging, road building, and fire, *in* Proceedings of a Symposium Forest Land Uses and Stream Environment, edited by J. T. Krygier and J. D. Hall: Oregon State Univ., p. 29–40.

Zaruba, Q., and Mencl, V., 1969, Landslides and their control: Amsterdam, Elsevier Pub. Co., 205 p.