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Annotated Bibliography on Soil Erosion and Erosion Control in Subarctic and High-Latitude Regions of North America

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Abbreviations

A = Author was the abstractor.
C = Compilers were the abstractors.

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Annotated Bibliography on Soil Erosion and Erosion Control in Subarctic and High-Latitude Regions of North America

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Abstract

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This annotated bibliography emphasizes the physical processes of upland soil erosion, prediction of soil erosion and sediment yield, and erosion control. The bibliography is divided into two sections: (1) references specific to Alaska, the Arctic and subarctic, and similar high-latitude settings; and (2) references relevant to understanding erosion, sediment production, and erosion control. Most of the cited works were published prior to 1981. Annotations generally consist of the author's abstract or summary.

Keywords: Bibliographies, erosion, erosion control, subarctic environment.

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Introduction

Landscape manipulation in central and northern Alaska has historically been limited by harsh climates, remote areas, and sparse populations typical of Arctic and subarctic regions. More recently, development of the Alaskan interior and North Slope has accelerated dramatically. Development of the Prudhoe Bay oil field resulted in completion of a trans-Alaska oil pipeline and construction of a road from the Yukon River to Prudhoe Bay. A major hydroelectric complex in interior Alaska is being planned. Passage of the Alaska Native Claims Settlement Act of 1971 (PL-92-746) substantially increased the amount of land in private ownership, making that land more accessible to timber harvesting and to all types of development.

To prevent unnecessary soil erosion, site deterioration, and possible degradation of water quality, land managers and construction personnel must be familiar with erosion and erosion-control principles and practices. Because information pertaining specifically to erosion in subarctic and Arctic Alaska is limited, a literature review should be useful to persons charged with formulating erosion control practices suitable for high-latitude environments.

This bibliography provides land managers and construction personnel with information on literature pertaining to erosion control principles and practices. In most cases the annotation is quoted from the author's abstract or summary; information relevant to this literature review but not included in the author's abstract has sometimes been added.

The physical processes of upland soil erosion, prediction of soil erosion and sediment yield, and erosion control are emphasized. References pertaining to bank and channel erosion, sediment movement in rivers, and coastal erosion have generally been excluded.

The bibliography is divided into two sections: (1) references specific to Alaska, the Arctic and subarctic, and similar high-latitude settings; and (2) references to work in other settings that we consider relevant to understanding erosion, sediment production, and erosion control.

Literature reviewed was primarily from the United States and Canada. Most of the cited works were published prior to 1981; although we included a few important works published in 1981, coverage of the more recent literature is not comprehensive. Published works are readily accessible in major libraries or through the USDA Forest Service FS INFO information system. Availability of unpublished documents is given in the reference.

References are listed alphabetically by author. An author index, a subject matter index, and a glossary are included.

Review of the literature confirms that the basic processes of soil erosion are understood, and techniques for controlling erosion are well documented. Procedures for making gross estimates of soil erosion from disturbed and undisturbed lands are now available, as are procedures for predicting sediment deposition and yield.

These processes and techniques, largely derived from work in temperate regions, generally hold for subarctic and Arctic settings. A short growing season, cold climate, and occurrence of permafrost (perennially frozen earth material) underlying an "active layer" (zone of seasonal thaw) of varying thickness are the principal distinguishing features of the far north. In particular, ice-rich (high proportion of ice to soil volume) permafrost, which is very sensitive to thermal disruption by any increase in net heat, makes much high-latitude terrain susceptible to degradation.

Available knowledge concerning erosion prediction and control can be broadly applied to high-latitude Arctic and subarctic conditions. Review of the references in section 1, however, indicates need for more attention to techniques for predicting the influence of specific resource management practices on thermal and physical stability (and hence erosion) of permafrost-affected terrain. Many of the references in section 1 deal with sensitivity of specific landscapes to disturbance and with questions about permafrost-related erosion and restoration. Little attention has been paid to the potential for modifying land use practices (other than simply avoiding the site) to best utilize permafrost-affected landscapes. Little work has been devoted to economic analysis of site stabilization and erosion-control practices in high-latitude settings. Resource management in high-latitude regions would benefit from increased attention to these facets of erosion and erosion control.

Acknowledgments

Thanks are extended to Dr. John D. Fox, University of Alaska Fairbanks, for provision of materials from his personal library; to personnel of FS INFO, University of Washington Library, for assistance in searching for and validating citations; to personnel of the Institute of Water Resources, University of Alaska Fairbanks, for provision of office and secretarial facilities; and to secretarial personnel of the Institute of Northern Forestry, U.S. Department of Agriculture, Forest Service, Fairbanks—including Clara Huggins, Cheryl Peters, Sage Patton, and Kelly Wenzlick—for continuing patience and major assistance with word processing tasks in preparation of this bibliography.

SECTION 1: Subarctic and High-Latitude Environments

1. Abele, G.; Johnson, L.A.; Collins, C.M.; Taylor, R.A. 1978. Effects of winter military operations on cold regions terrains. Spec. Rep. 78-17. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 35 p.

"Observations were made on the 1977 winter military maneuver sites south of Fairbanks to obtain base line data for monitoring terrain and vegetation recovery from the impact of winter trail preparation, and vehicular and troop activities in various terrains and vegetation types.

"Removal of the snow cover and surface vegetation above or even with the soil surface does not significantly disturb the root system and, therefore, encourages rapid revegetation by shrubs and grasses. The extent of potential revegetation decreases as the depth of bulldozer blade penetration increases. In addition, exposed soil and standing water can increase the thaw depth in areas of shallow (<1m) frost line as a result of a decrease in albedo and a decrease in the insulation properties of the terrain surface (lack of vegetation mat). In the case of exposed standing water, caused by excessive excavation combined with settlement due to frost line depression, continued degradation with time, instead of recovery, can occur.

"The most severe terrain surface damage, caused by the trail preparation (bulldozing), occurred in areas with prominent microrelief, such as the tussock areas. The relatively level bog areas experienced the least impact.

"Vehicular traffic had been confined to the prepared trails; therefore, no assessment could be made on the effects of off-road traffic. The trails constituted the only easily visible signatures of maneuver activities. Other troop activity signatures, such as bivouac sites, could be detected only during close reconnaissance on the ground. Troop concentration areas had been policed quite thoroughly after the 1977 winter maneuvers.

"In general, it appears that, except for the trail cutting, military maneuvers such as those conducted by the 172nd Infantry Brigade during the winter of 1977, do not result in any significant environmental impact. This conclusion is made as a result of: (1) the apparently thorough cleanup after the exercises, and (2) the absence of any major off-road vehicle traffic, which may have left some noticeable impact had heavy off-road vehicles been used. However, the bulldozer-cut trails, which were required in the absence of off-road vehicles, result in a significant impact, although the damage is limited to a relatively narrow, but long, area." (A)

2. Abele, G.; Walker, D.A.; Brown, J. [and others]. 1978. Effects of low ground pressure vehicle traffic on tundra at Lonely, Alaska. Spec. Rep. 78-16. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 63 p.

"Traffic tests were conducted with two low-pressure-tire Rolligon-type vehicles and a small, tracked Nodwell for 1, 5, and 10 vehicle passes on tundra near Lonely, Alaska. The traffic impact was limited to compression of the vegetation and the organic mat and a maximum terrain surface depression of several centimeters, with virtually no shearing or disaggregation of the mat. After one year, the visibility of the traffic signatures had increased, surface depression remained the same, and the thaw depth below the multiple pass tracks had increased a few centimeters." (A)

The report includes many photographs of vehicle effects. (C)

3. Alaska State Legislature. 1978. An Act relating to Forest Resources and Practices. AS41, Chapter 17: Forest Resources and Practices. Juneau, AK. 13 p.

The Alaska Forest Practices Act provides for establishment of the Division of Forest, Land, and Water Management within the Department of Natural Resources. This Division "...shall manage state forests and...provide technical advice to the division of lands on sound forest practices necessary to ensure the continuous growing and harvesting of commercial forest species on other state land." The Act also establishes a Board of Forestry and prescribes certain "Regulatory and Administrative Standards," including the provision that "environmentally sensitive areas and best management practices shall be recognized in the implementation of any nonpoint source pollution control measures authorized under this chapter." (C)

4. Aldrich, J.W.; Johnson, R.A. 1979. Surface erosion and sedimentation associated with forest land use in interior Alaska. Rep. IWR-99. Fairbanks, AK: Institute of Water Resources, University of Alaska. 87 p.

Investigations of the magnitude of sheet-rill erosion indicated that stripping all vegetation from the soil surface increased rainfall erosion 18 times above that produced on a forested site. Removing the trees from a forested site, disturbing the ground cover only slightly, did not increase erosion. Comparisons of the actual erosion and the quantity of erosion predicted with the Universal Soil Loss Equation indicated that the equation overestimated annual rainfall erosion by an average of 21 percent; it overestimated individual storm erosion by an average of 174 percent. Data are also presented on sheet-rill erosion on a permafrost trail, distribution of the rainfall erosion index, and suggested cover and management factors for various forest management activities. (C)

5. Anderson, D.M.; Brown, J.; Reynolds, R.C. 1968. Bentonite debris flows in northern Alaska. Tech. Note. Hanover, NH: U.S. Army Terrestrial Sciences Center. 8 p.

"Seasonal freezing and thawing and the extreme cold of the arctic lead to the development of a variety of characteristic geomorphic features. A new one, bentonite debris flow channels, has been identified near Umiat, Alaska. These flows form when bentonite-rich Cretaceous shales are exposed to surface water on slopes of five to thirty degrees. The characteristic land form developed is a U-shaped channel one to two meters deep and from eight to ten meters in width. The channel shows a fluted floor and walls and is commonly flanked by a levee. The flow material is apparently derived from the entire surface of the head portions of associated gullies. When this surface layer hydrates during snow melt and runoff or during prolonged rain, the bentonite imbibes water and swells to a point at which its viscosity is lowered sufficiently to initiate creep or viscous flow." (A)

6. Andrews, M. 1977. Selected bibliography of disturbance and restoration of soils and vegetation in permafrost regions of the USSR (1970-1976). Spec. Rep. 77-7. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 116 p.

"This compilation of literature published in Russian since 1970 comprises 898 bibliographic citations relating to disturbance and restoration of soils and vegetation. Seventy-five per cent of these were found by a manual search of CRREL Bibliographyvols. 25-30; the others were obtained through off-line searches from the relevant computerized data bases and personal files. Only one of these data bases, that of the National Agricultural Library, is shown to be of significance in providing a valuable checking source. The literature is discussed in chronological fashion, with general statements followed by highlights of each year's contributions (with three tables and two appendices for amplification). The years 1972 and 1973 produced the most publications, and by 1975 there was a noticeable lag in pickup of publications by the indexing services. A trend is apparent from a reconnaissance and description approach in earlier papers toward an integrated ecosystem approach in more recent publications. Certainly, increased consciousness of the effects of disturbance on the permafrost environment, and the importance of restoration and preservation of these environments, are reflected in the recent literature, particularly in symposium proceedings." (A)

7. Andrews, M. 1978. Selected bibliography of disturbance and restoration of soils and vegetation in permafrost regions of the USSR (1970-1977). Spec. Rep. 78-19. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 178 p.

"This compilation of literature published in Russian since 1970 comprises 1225 bibliographic citations relating to disturbance and restoration of soils and bibliographic citations relating to disturbance and restoration of soils and vegetation. Sixty-five percent of these were found by a manual search of CRREL Bibliography vols. 25-32; the others were obtained through off-line searches from the relevant computerized data bases and personal files. Only one of these data bases, that of the National Agricultural Library, is shown to be of significance in providing a valuable checking source. The literature is discussed in chronological fashion, with general statements followed by highlights of each year's contributions (with two tables and two appendices for amplification). The years 1972 and 1973 produced the most publications, and by 1976 there was a noticeable lag in pickup of publications by the indexing services. A trend is apparent from a reconnaissance and description approach in earlier papers toward an integrated ecosystem approach in more recent publications. Certainly, increased consciousness of the effects of disturbance on the permafrost environment, and the importance of restoration and preservation of these environments, are reflected in the recent literature, particularly in symposium proceedings." (A)

8. Babb, T.A.; Bliss, L.C. 1974. Susceptibility to environmental impact in the Queen Elizabeth Islands. Arctic. 27(3): 234-237.

"While biological diversity and plant cover are far less in the High Arctic than in the warmer mainland Arctic, there are numerous areas where the land is susceptible to disturbance. The most common forms of degradation are sheet and gully erosion in areas of sparse plant cover, and the softening in summer of slightly disturbed surfaces on moist, fine-grained substrates. This situation contrasts with that in the Low Arctic where removal of vegetation and potential thermokarst are of great concern.

"In relatively small areas of high plant cover, surfaces have a susceptibility similar to the extensive tundra areas farther south. The biological consequences of disturbance can be much greater, however, not because of deleterious effects on the landscape alone, but because these isolated rich sites comprise the bulk of the energy base for the remainder of the terrestrial food web." (A)

9. Barnett, D.M.; Edlund, S.A.; Hodgson, D.A. 1975. Sensitivity of surface materials and vegetation to disturbance in the Queen Elizabeth Islands: an approach and commentary. Arctic. 28(1): 74-76.

This is largely a commentary on the paper by Babb and Bliss (1974). (C)

"...'the softening in summer of slightly disturbed surfaces' as a 'common form of degradation' is a concept the present writers have not encountered, and they do not agree that sheet erosion and gullying are the most common forms of erosion; it is currently mass wasting....

"The present writers have spent several years attempting to achieve similar ends to those sought by Babb and Bliss. They feel a need to refute mistaken generalizations which might gain ready currency because of a sense of urgency and the desire for simple rules-of-thumb. Sampling at sites already disturbed is satisfactory for historical studies, but does not necessarily yield the answer to the pertinent question: 'What are the critical variables in sensitivity?'

"The map and text of Babb and Bliss do not seem an acceptable accompaniment to the Arctic Ecology Map Series, for the detail that they recognize as necessary is not forthcoming." (A)

10. Bellamy, D.; Radforth, J.; Radforth, N.W. 1971. Terrain, traffic and tundra. Nature. 231: 429-432.

Oil and gas exploration on the Arctic slope of North America necessitates vehicular traffic over previously undisturbed terrain. Off-road vehicles traversing permafrost-underlain tundra produce tracks, and often erosion. "...the severity of damage is related to the 'wetness' of the terrain and therefore to the type of vegetation. Three main processes of damage may be recognized: (a) the destruction of the living vegetation; (b) the destruction of the secondary terrain structure; (c) the production of ruts which destroy the active layer and expose the permafrost to solar radiation; this results in thawing and slumping which, in turn, can be expected to lead to erosion in sloping areas....It would seem safe to postulate that the more advanced the process of destruction, the longer it will take for complete regeneration to occur." (C)

11. Berg, R.; Smith, N. 1976. Observations along the pipeline haul road between Livengood and the Yukon River. Spec. Rep. 76-11. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 83 p.

Periodic observations over a 6-year period along the TAPS road were evaluated with respect to construction and slope stabilization techniques in ice-rich roadway cuts and embankment subgrades. Lateral drainage ditches wide enough to handle excavation equipment enhanced natural processes of slope stabilization when near-vertical slope cuts were made with hand-cleared tops equal in width to 1-1/2 times the height of the cuts. Right-of-way clearing limited to the toe of embankment fill slopes minimizes subsidence of the roadway and its shoulder slopes. Seeding the slopes of extremely ice-rich soil cuts should not be attempted until late in the first thaw season for best results. Natural woody growth would probably have a substantial stabilizing effect after five or six thaw seasons but could be accomplished sooner if tree seedlings were planted. Attempts to stabilize ice-rich cut slopes with applications of insulation are not very effective and seem to prolong the natural stabilization process. (C)

12. Blanchard, D. 1972. Seeding research project CDRS-12 and reseeding project X13210: addendum number 2. Anchorage, AK: State of Alaska, Department of Highways. 28 p. Unpublished report for D.W. Herman, Central District Materials Engineer. On file with: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.

About 40 percent of the test plots in the 1971 seeding project exhibited severe erosion. A plot-by-plot summary is given as well as details of a reseeding project conducted on the severely eroded plots. In general, annual spring rye grass showed impressive growth. The asphalt-straw mulch was fair in controlling erosion and was valuable in promoting seed growth. Aerospray 70 prevented erosion, except where the crust failed. Plots with excelsior mat showed very little erosion; growth through the mat was slow, but growth under the mat was prominent. Hand-planted alder and willow exhibited a 30-percent survival rate and slow growth. (C)

13. Bolstad, R. 1971. Catline rehabilitation and restoration. In: Slaughter C.W.; Barney, R.J.; Hansen, G.M., eds. Fire in the northern environment—a symposium: Proceedings of a symposium; 1971 April 13-24; Fairbanks, AK. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 107-116.

"Severe erosion has resulted in the past from bulldozer-constructed firelines in permafrost terrain. In an attempt to reduce erosion and gullying, several water-barring techniques and seeding treatments were tested on permafrost and non-permafrost catlines. Standard water bars and berm dikes constructed at 30- to 50-yard intervals on sloping terrain were effective in reducing erosion. Vegetative check dams on permafrost soils were ineffective. Seed growth was more successful on permafrost than on nonpermafrost soils. Fertilized lines resulted in better seed success than unfertilized lines." (A)

14. Brown, J. 1973. Environmental consideration for the utilization of permafrost terrain. In: Permafrost: North American contribution, 2d international conference: Proceedings of a conference; 1973 July 13-28; Yakutsk, USSR. Washington, DC: National Academy of Sciences: 587-590.

"Current utilization of the permafrost landscapes is still relatively low as a result of its vastness, remoteness and inaccessibility, and low population usages. However, where population and industrial centers do exist, the solutions of problems caused by the presence and potential degradation of permafrost are expensive. Frequently, symptoms of permafrost degradation occur regardless of the care exercised to avoid them. As man increases his activities on the permafrost landscape, increased disruption of the permafrost is likely to occur. These changes are characteristically generated at the ground surface as the energy exchange processes are modified; however, these surface effects are transferred into the permafrost. In many cases, they are cumulative and often lead to adverse consequences. The problem besetting the planner, developer, environmentalist, and others is to define, in advance and under differing permafrost regimes, the types and degrees of modification the permafrost landscape can sustain without adversely affecting its original quality. This definition should include both human or aesthetic values and the physical or thermal constraints imposed by the permafrost. Unsightly vehicle impressions across the uninhabited tundra may be acceptable to some, but an accelerated and headward eroding channel resulting from a poorly designed facility, road, or entrenched vehicle trail is no longer tolerated. The definition of that fine line between permissible and nonpermissible use of the permafrost terrain, both in time and space, should prove to be an excellent point of discussion and cooperation between Northern American, Soviet, and other researchers and planners." (A)

15. Brown, J.; Berg, R.L., eds. 1980. Environmental engineering and ecological baseline investigations along the Yukon River-Prudhoe Bay Haul Road. CRREL Rep. 80-19. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 203 p.

"During the period 1975-1978 the Federal Highway Administration sponsored a series of environmental engineering investigations along the Yukon River to Prudhoe Bay Haul Road. In 1976 the Department of Energy joined these investigations with a series of ecological projects which continue to the present. Both agencies' research efforts were conducted on a cooperative basis with CRREL's in-house research program. The objectives of the research focused on (1) an evaluation of the performance of the road, (2) an assessment of changes in the environment associated with the road, (3) documentation of flora and vegetation along the 577-km-long transect, (4) methodologies for revegetation and restoration, and (5) an assessment of biological parameters as indicators of environmental integrity. In support of these objectives, specific studies were undertaken that investigated the climate along the road, thaw and subsidence beneath and adjacent to the road, drainage and side slope performance, distribution and properties of road dust, vegetation distribution, vegetation disturbance and recovery, occurrence of weeds and weedy species, erosion and its control, revegetation and restoration, and construction of the fuel gas line. This report presents background information on the region, detailed results of the road thaw subsidence and dust investigations, and summaries of revegetation, fuel gas line, vegetation distribution, soil, and weed studies." (A)

16. Brown, J.; Grave, N.A. 1979. Physical and thermal disturbance and protection of permafrost. Spec. Rep. 79-5. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 42 p.

"This report is based on a review paper presented at the Third International Conference on Permafrost held in July 1978 at Edmonton, Canada. It reviews the literature covering 1974-1978 and covers subjects related to natural and human induced disturbance of terrain underlain by permafrost. Subjects included regard investigations undertaken in conjunction with oil and gas pipelines, terrain mapping, methods for estimating terrain sensitivity, methods of protecting terrain, and the thermal effects of off road transportation, oil spills, fire, removal of the surface soil layers, snow conditions, mining and other construction practices. Methods of protecting and restoring permafrost in the USSR are presented in tabular form. An appendix summarizes results of modeling and microclimatic investigation, and the distribution and properties of subsea, land-based, and alpine permafrost." (A)

17. Brown, J.; Hemming, J.E. 1980. Workshop on environmental protection of permafrost terrain. The Northern Engineer. 12(2): 30-36.

“A workshop on Environmental Protection of Permafrost Terrain was held 12-15 May 1980 at the University of Alaska's Geophysical Institute. The U.S. Army Cold Regions Research and Engineering Laboratory and the Geophysical Institute conducted the Workshop; the Committee on Permafrost of the U.S. National Research Council's Polar Research Board provided valuable advice in the early organization of the Workshop. The meeting was attended by approximately 100 engineers, scientists and students representing state and Federal agencies, industry, and universities from the U.S., Canada, and the United Kingdom.

“A number of workshop topics should be highlighted:

(1) Interdisciplinary teams should be utilized in all phases of large projects.

(2) Effective communications among all disciplines involved should be established early and maintained. Surprises should be avoided.

(3) Monitoring prior to, during, and after construction should be an integral part of the project design. Analysis of data to assess impacts should be a continuing part of the process.

(4) Case histories should be documented and published in readily available sources.

(5) Engineering designs based on recent innovative practices should be incorporated into revised doctrine, manuals, or specifications.

(6) Data acquired on a project should be readily available to all interested parties and only patentable or otherwise competitive data treated as proprietary.

“Although this Workshop was not intended as a forum for research needs, several questions require prompt or continuing attention. These are listed in no specific order of priority.

(1) For arctic areas and along a north-south transect, snow accumulation data (as a function of time, wind direction, velocity, and obstacles such as snow fencing) should be measured early in the winter. This will enable an objective assessment of the feasibility of using snow for early winter construction.

(2) The harvesting and use of both snow and ice aggregates as substitutes for gravel construction pads should be evaluated under typical loads and temperature ranges as experienced under arctic conditions.

(3) Research approached should be applied to develop stipulations and permit conditions needed to protect environmental quality during the construction of large projects, the development of management systems for government, and public involvement programs.

(4) There is a need to develop research approaches to the short- and long-term effects of various types of streambed disturbances on fishery resources, particularly research directed towards developing rational non-engineering criteria. Related research on modifying drainage structures for fish passage is also indicated." (A)

18. Brown, J.; Rickard, W.; Vietor, D. 1969. Effect of disturbance on permafrost terrain. Spec. Rep. 138. Hanover, NH: U.S. Army Corps of Engineers. 15 p.

"The influence of surface cover on thaw penetration in alpine and arctic soils of Alaska was determined. Several manipulated treatments were employed: removal of all vegetation, mulching, shearing and fire. Thaw and subsidence more than doubled on the bare and sheared plots and increased up to 50 percent on the burned areas. Bulldozing of and traffic over ice-rich permafrost terrain resulted in considerable erosion and thaw." (A)

19. Brown, R.W.; Johnston, R.S.; Van Cleve, K. 1978. Rehabilitation problems in alpine and arctic regions. In: Schaller, F.W.; Sutton, P., eds. Reclamation of drastically disturbed lands. ASA-CSSA-SSA. Madison, WI: American Society of Agronomy: 23-44.

"Disturbances in tundra regions are caused by many factors, but recently man has had by far the greatest impact....The ecosystem recovery rates by both natural and artificial means to date have been extremely slow or, more commonly, nonexistant....

"In summary, the major rehabilitation problems in alpine and arctic tundra regions that should be considered are:

(1) Climatic factors:

(a) Low summer temperatures depress growth, development, and nutrient availability,

(b) High winds cause desiccation, soil water evaporation, and erosion of fine soil particles,

(c) High radiation (in alpine tundra) enhances evaporation and high surface temperatures,

(d) Frost action, particularly needle-ice, is common throughout the growing season,

(e) The growing season is short, ranging from 45 to 90 days, and

(f) Low precipitation is common during the growing season in alpine tundra; often it is only 10% of the total mean annual amount.

(2) Soil factors:

(a) Soils are poorly developed and rocky, resulting in low waterholding capacity (alpine tundra),

(b) Exposed subsoils are infertile,

(c) Oxidation of pyritic subsoils results in low pH,

(d) Permafrost retards water percolation and results in perched water tables following surface disturbance (mainly arctic tundra), and

(e) High concentrations of toxic heavy metals and other chemicals are present (mainly alpine tundra).

(3) Biological factors:

(a) Seed and plants of adapted species are not commercially available,

(b) Most commercially available species are unadapted,

(c) Seed production in tundra regions is sporadic,

(d) Seed collection is expensive,

(e) Native species have low germination rates and low vigor,

(f) The annual life form is unadapted,

(g) Shoot growth is slow the first year or two: most initial growth occurs in root system,

(h) Most reproduction is by vegetative means,

(i) Biological activity in soil is slow to reestablish following disturbance,

(j) Physiological requirements of native species are largely unknown, and

(k) Roles that primary and secondary successional processes play in shaping ultimate vegetation on tundra disturbances are unknown." (A)

20. Burrows, R.L. 1980. Cross-section, velocity, and bedload data at two erosion sites on the Tanana River near Fairbanks, Alaska, 1979. Open-File Rep. 80-699. Anchorage, AK: U.S. Geological Survey, Water Resources Division. 32 p. Unpublished report. On file with: U.S. Geolgoical Survey, Water Resources Division, Anchorage, Alaska.

"In an effort to relate river processes to vertical and lateral erosion at two sites on the Tanana River in the vicinity of Fairbanks, measurements of depth, velocity, and bedload-transport rates were made at several sections at each site. To facilitate comparison of the river processes and ongoing erosion, compilation and graphic presentation of the velocity distributions and bedload-transport rates are presented in conjunction with cross-section configuration immediately adjacent to the area of erosion. Dry sieve analyses of the bedload samples give particle-size distribution. Approximately 85-95 percent of the material in transport at both sites was in the sand range (>0.062 millimeter <2.0 millimeters)." (A)

21. Chapin, F.S.; Shaver, G.R. 1981. Changes in soil properties and vegetation following disturbance of Alaskan Arctic tundra. Journal of Applied Ecology. 18: 605-617.

"Soil characteristics and vegetation were studied in vehicle tracks and adjacent undisturbed tundra along local moisture gradients at four tundra sites in northern Alaska. Vehicle tracks generally had 2°C higher soil temperatures, deeper thaw, and higher concentrations of available soil phosphate than adjacent undisturbed tundra, but did not differ consistently from controls in soil bulk density, volumetric moisture content, pH, or soil organic content.

"Vegetation in vehicle tracks had fewer species than controls, reflecting decreased abundance of shrubs, particularly evergreens, and increased dominance by a few species of graminoids.

"Wet and mesic tracks exhibited a 2- to 15-fold increase in above-ground standing crop of nitrogen and phosphorus as a result of increased leaf nutrient concentrations and increased leaf biomass of graminoids, a consequence of increases in both shoot density and shoot weight.

"We reject our original hypothesis that the known temperature effects upon root growth, nutrient absorption, and organic matter mineralization account for the increased standing crop of biomass and nutrients in vehicle trails. We conclude that other factors, perhaps related to soil water and nutrient movement, are in large part responsible for the increased nutrient status and production in vehicle tracks and exert an important control over growth in undisturbed tundra." (A)

22. Claridge, F.B.; Mirza, A.M. 1981. Erosion control along transportation routes in northern climates. Arctic. 34(2): 147-157.

"The widespread occurrence of permafrost in northern climates dictates the use of specialized measures to protect the terrain from adverse impacts associated with the construction of transportation facilities. Through the adoption of appropriate construction techniques and by providing proper drainage and erosion control facilities within the right-of-way, serious environmental degradation can be avoided. The most appropriate type of erosion control measure is selected according to local terrain and drainage conditions, including a Soil Erosion Code (SEC).

"Erosion control begins with the provision of effective drainage across the right-of-way. Typical erosion control measures include the use of permanent linings such as granular blankets, rock riprap and gabions and temporary linings, such as plastic sheets and fiberglass rovings. Ditch checks, rock aprons, energy dissipators and siltation basins may be used to minimize erosion of exposed soils along the route and attendant siltation of streams. Cut slopes may be protected with insulation in ice-rich, fine-grained soils to ensure stability and prevent slump material from reaching the drainage system. Ultimately, long-term erosion protection along transportation corridors is provided through appropriate revegetation techniques, periodic surveillance and regular maintenance of drainage and erosion control facilities." (A)

23. Clark, E.F.; Simoni, O.W. 1976. Survey of road construction and maintenance problems in central Alaska. Spec. Rep. 76-08. Hanover, NH: U.S. Army Corps of Engineers. 36 p.

"A survey of road construction and maintenance problems in central Alaska is presented. The problems of poor fill and foundation material, permafrost degradation under pavement and shoulders, slope instability, water erosion, road icing from subsurface seepage, and culvert icing are described. Possible solutions to road maintenance problems in central Alaska include the use of insulating materials in permafrost areas, MESL construction when non-frost-susceptible soils are unavailable, and the use of improved drainage in areas where extensive icing occurs. Bridge damage, erosion of sidehill cuts and embankment instability are also discussed and potential solutions are given." (A)

24. DeLeonardis, S. 1971. Effects of fire and fire control methods in interior Alaska. In: Slaughter, C.W.; Barney, R.J.; Hansen, G.M., eds. Fire in the northern environment—a symposium: Proceedings of a symposium; 1971 April 13-14; Fairbanks, AK. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 101-105.

"The taiga forest of interior Alaska lies within a broad zone of discontinuous permafrost. Although the gross effects of wildfire on vegetation and wildlife are fairly well known and understood, there is still a lack of knowledge on the effects of fire on interior soils and especially in permafrost soils. Serious erosion problems can occur in fine textured frozen soils with a high ice content. Fireline construction with tractors in silty permafrost soils can lead to gross gully erosion unless proper safeguards are undertaken. In some areas, catline construction has been estimated to have caused more erosion in the past than the actual effects of the fires." (A)

25. Dick, J.E. 1973. Seeding research project CDRS-12 and reseeding project X13210: addendum number 3. Anchorage, AK: State of Alaska, Department of Highways. 33 p. Unpublished report for D.W. Herman, Central District Materials Engineer. On file with: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.

Test plots of 1971 and 1972 seeding and reseeding projects were inspected. Plots that had fair growth (growth over most of the slope) during the first season no longer remained an erosion problem. Slopes that had very good to excellent growth the 1st year were very thick with both seeded grasses and native vegetation. Severe erosion still existed where no growth took hold in 1971. Of all the seed types used, clover did the most poorly; the red and hard fescues seemed to be the hardiest survivors. (C)

26. Dick, J.E. 1974. Final evaluation of seeding research project CDRS-12 and reseeding project X13210: addendum number 4. Anchorage, AK: State of Alaska, Department Highways. 47 p. Unpublished report for D.W. Herman, Central District Materials Engineer. On file with: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.

Test plots in the seeding and reseeding project were observed and categorized (north south, silt sand). Hard (or Durar) and red fescue had the most consistent good growth. Timothy and Kentucky bluegrass had only fair to good growth. Of the mulches used, the combination of straw and asphalt produced the best results. Where excelsior mat was used, good (although spotty) growth occurred. The mat was expensive, however, and did not decompose as well as expected. Areas within bulldozer tracks appeared to provide a superior seed bed. Filter-X down drains were recommended for use in channeling water directly down slopes. (C)

27. Ebisu, J.M. 1971. Seeding research project CDRS-12: addendum number 1. Anchorage, AK: State of Alaska, Department of Highways. 86 p. Unpublished report for D.W. Herman, Central District Materials Engineer. On file with: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.

On the basis of a site inspection 1 month after seeding, the following conclusions were drawn: (1) evenness of application in hydro-seeding can be achieved by adding an organic dye to the mixture (the area sprayed and amount sprayed is then visible); (2) a fan nozzle should be used on the hydro-seeder during one pass to cover the shoulders and slopes close to the hydro-seeder; subsequent passes should be made with nozzles that will cover slopes farther away; (3) machine mulching should continue on future test projects because hand mulching is inefficient, expensive, and frequently results in too heavy an application; (4) a rate of 1,000-1,500 pounds per acre of straw mulch be used where a straw mulch is necessary; (5) asphalt alone was effective in fine sand but was less effective on coarse material; (6) excelsior mat was as good as mulch for holding seed but should not be used on slopes steeper than 2:1; (7) a fertilizer high in nitrogen should be used with the excelsior mat to break down the mat; (8) spikes larger than those provided by the manufacturer (which were 8 inches long) should be used when placing the excelsior mat on fine grain soils; and (9) seed and mulch should be selected that are compatible with in situ soil. (C)

28. Evans, M.N., ed. 1976. Proceedings of the surface protection seminar: theme—travel and transportation practices to prevent surface destruction in the northern environment; 1976 January 19-22; Anchorage, AK. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, Alaska State Office. 298 p.

These proceedings include papers in 10 categories: Federal and State statutes, laws, and regulations for surface protection; ecological and environmental consequences of off-road traffic in northern regions; effects of vehicle travel on surface; effects of industrial development on surface; construction of public facilities and utilities; fire control and disturbance of surface; agency and corporation policies and procedures; resource data needs; regulation of type and use of equipment, and equipment development; and stabilization and maintenance of disturbed surfaces. (C)

29. Evans, M.N., ed. 1978. Proceedings of the symposium, surface protection through prevention of damage (surface management): focus—the Arctic Slope; 1977 May 17-20; Anchorage, AK. BLM/AK/PROC/78/01. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, Alaska State Office. 302 p.

"Approximately 26 papers and five workshop reports are presented. Subjects concern surface protection on the Arctic Slope of Alaska and include legal, technical, andenvironmental considerations for land planners, managers, and natural resource developers. Objectives of the symposium and a 1976 seminar on surface protection were to develop all-season guide stipulations for all land management agencies' use and to eliminate multiple standards for users of land north of the Brooks Range, Alaska." (A)

30. Everett, K.R. 1966. Slope movement and related phenomena. In: Wilimovsky, N.J.; Wolfe, J.N., eds. Environment of the Cape Thompson region, Alaska. Oak Ridge, TN: U.S. Atomic Energy Commission, Division of Technical Information: 175-220.

"The measurement of slope movement, moisture, and temperature by linear-motion transducers, Coleman soil-moisture units, and thermistors indicates the following: (1) Downslope movements are most pronounced during freeze-up and thaw and are erratically distributed over a particular slope. (2) The amount of movement in unvegetated circles, stripes, and similar areas during freeze-up depends upon the amount of soil moisture and its rate of conversion to ice. (3) The amount of heave depends upon the type of ice formed, which is, in turn, controlled by the moisture content and soil texture. (4) The amount of heave decreases with depth owing to soil texture, type of ice formed, and load pressure. (5) Movements occurring during thaw and during the summer months are largely expansive and contractive and are related to the wetting and drying of the peat or mineral soil. (6) Movements during the initial phases of thaw are governed by diurnal fluctuations across $0^{o}C$ at a particular depth. (7) Individual movements range from less than 0.5 mm to more than 1 cm. (8) The rate and amount of downslope movement is greater on the southeast-facing slope than on the northwest-facing slope by a factor of 2 or 3. (9) Runoff, wind action, landslides, and surface freeze and thaw are important contributors to slope movement." (A)

31. French, H.M. 1975. Man-induced thermokarst, Sachs Harbour Airstrip, Banks Island, Northwest Territories. Canadian Journal of Earth Sciences. 12: 132-144.

"The disturbed terrain adjacent to the airstrip at Sachs Harbour is an example of man-induced thermokarst processes operating within the High Arctic environment. An irregular topography of mounds and linear depressions has appeared and evidence indicates preferential subsidence along ice wedges. The underlying sands and gravels are ice-rich with approximately 20-35% excess ice and natural water (ice) contents of between 50 and 150%. Examination of air photographs indicates that the terrain developed within three years of the initial disturbances. Detailed leveling in 1972 and 1973 suggests that subsidence and permafrost degradation is still active over 10 years later. Gullying of the airstrip is a problem partly associated with the thermokarst activity. A comparison is made with man-induced thermokarst terrain in Siberia." (A)

32. French, H.M. 1976. The periglacial environment. New York: Longman Group Limited. 309 p.

"I have divided the book into three parts. Part 1 is a general introduction to periglacial conditions in which the extent of the periglacial domaine and the variety of periglacial climates are briefly considered. Part 2 presents a systematic treatment of the various geomorphic processes operating in present-day periglacial environments. Wherever possible, I have attempted to show the relationship between process and form and to stress the multivariate nature of many landforms....Part 3 serves only as an introduction to Pleistocene periglacial phenomena. Emphasis in this part is upon forms rather than processes and their interpretation in the light of our understanding of similar phenomena in present-day periglacial environments." (A)

Part 2 includes chapters dealing specifically with thermokarst, hillslope forms and processes, and fluvial processes and landforms. (C)

33. Gaskin, D.A.; Graham, J. 1974. The effects of land use practices on land quality at Fort Wainwright, Alaska. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 12 p. Unpublished report. On file with: U.S. Army Cold Regions Research Engineering Laboratory, Hanover, New Hampshire.

"The long term effects of permanent military construction at Fort Wainwright, Alaska, have resulted in minimal environmental damage in relation to erosion....However, in areas where tracked vehicles operated off the permanently constructed roads and cleared areas, there has been damage to the vegetation mat and underlying permafrost. This has resulted in semi-permanent scars that remain as shallow depressions because of the damage to the insulating vegetation layer and the resulting degradation of the underlying permafrost. Also, there have been erosion problems resulting from the construction of the temporary and permanent roads leading to the storage and recreation facilities located on the Yukon-Tanana Upland." (A)

34. Gaskin, D.; Johnson, L. 1978. Draft preliminary results of the Chena Lakes embankment revegetation project. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 48 p. Unpublished report prepared for U.S. Army Corps of Engineers, Alaska District. On file with: U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

The purpose of this study was to determine the optimum treatment that would enable establishment of permanent vegetation on the flood control embankment at Chena Lakes in Alaska. A total of 70 test sections were installed that included four main variables: mulch, fertilizer, topsoil over the gravel base, and vegetation. Five varieties of mulch and two basic vegetation covers were tested. The six basic groups of treatments providing the best protection were: seed, fertilizer, and Conweed Hydro Mulch 2000; seed, fertilizer, peat moss, and wood cellulose fiber; seed, fertilizer, and hay; seed, fertilizer, and peat moss; seed, fertilizer, and wood cellulose fiber; and seed and fertilizer. (C)

35. Gaskin, D.A.; Johnson, L.; Rindge, S.D. 1978. Second year results of the Chena River Lakes embankment revegetation project. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 83 p. Unpublished report prepared for U.S. Army Corps of Engineers, Alaska District. On file with: U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

Revegetation and erosion control on the Moose Creek embankment in North Pole, Alaska, were studied for two growing seasons. The purpose of the study was to determine the optimum treatment that would enable establishment of permanent vegetation cover on the gravel flood control embankment. (C)

"Several major points have emerged from the study after two years:

(1) Refertilization in the second year produces much greater biomass, cover and maximum height of grasses than those produced in the same treatments without refertilization. (2) In most years, moisture, not temperature, is a major factor limiting grass growth. (3) Fescue did very well and was the dominant perennial grass cover on the embankment during the second year. (4) Topsoil, although it doesn't completely eliminate the need for refertilization, can partially offset the need for it. (5) Willow cuttings offer a viable means of revegetating the embankment, even with a very poor substrate such as gravel fill. (6) Grasses should not be seeded simultaneously onto the areas of willow cuttings. However, during the second and later years grasses may rapidly reestablish themselves on their own under willows from seed in the straw mulch or other sources. (7) In many instances treatment with seed and fertilizer alone produces as much growth as treatment with mulch. (8) Unlimed sludge looks very promising as a revegetation technique." (A)

36. Geidl, V.A. 1971. Seeding research project CDRS-12. Anchorage, AK: State of Alaska Department of Highways. 14 p. Unpublished report for D.W. Herman, Central District Materials Engineer. On file with: Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.

"This report considers slope preparation, seed and mulch application techniques, use of the special products involved, and transplanting activities. Due to the short time period since project completion no general evaluation of its success or failure can be made." (A)

Thirty-seven plots were established near Willow, Alaska, in July 1971. Except for two plots left unseeded, each plot was seeded with one of the following: (1) hard fescue, at 20 pounds per acre; (2) red fescue, at 20 pounds per acre; (3) smooth brome, at 15 pounds per acre; (4) timothy, at 6 pounds per acre; (5) Kentucky bluegrass, at 10 pounds per acre; (6) hard fescue and alsike clover, at 15 pounds and 16 pounds per acre, respectively; (7) hard fescue and alsike clover, at 15 and 4 pounds per acre, respectively; or (8) red fescue, white Dutch, clover and timothy, at 20, 4, and 6 pounds per acre, respectively. All seeded plots received 10 pounds per acre of annual rye grass. In addition, some plots received a mulch of either: (1) straw and asphalt, at 1.5 tons per acre and 300 gallons per acre, respectively; (2) asphalt, at 400 gallons per acre; (3) American Cyanamid Aerospray 70, at 5 parts water to 1 part Aerospray 70; (4) Aerospray 70, at 10 parts water to 1 part Aerospray 70; or (5) excelsior and asphalt. All plots were fertilized with 16-13-10 fertilizer at a rate of 500 pounds per acre. Besides seeding and mulching, transplanting of alder, willow, and native grasses was attempted on certain areas. Filter-X cloth was used to stabilize ditches. (C)

"The effective range of the hydro-seeder was found to be 60 to 80 feet on cut slopes when operating from the road shoulder and 100 to 120 feet on fill slopes. The effective range of the mulcher was found to be 50 to 70 feet on cut slopes and 100 feet on fill slopes. These ranges were determined under favorable conditions and are reduced appreciably by wind speeds over approximately 10 miles per hour." (A)

37. Guymon, G.L. 1974. Regional sediment field analysis of Alaska streams. Journal of the Hydraulics Division, American Society of Civil Engineers. 100(HY1): 41-51.

"Sparse suspended sediment data for Alaska were evaluated to verify previous work on regional sediment yield relationships and test alternative regression correlations using readily obtained watershed parameters. Glacier-fed streams in the south central region of Alaska were emphasized, although one nonglacial stream in the interior region of Alaska was included for comparison. Results indicate that plausible, simple relationships can be developed for stream reaches well downstream from the glacier which delivers a high fraction of the total suspended sediment load. A great deal of uncertainty is associated with correlation attempts for short stream reaches near the glacier delivery source." (A)

38. Helmers, A.E. 1976. Fire access in the Alaskan interior. In: Evans, M.N., ed. Proceedings of the surface protection seminar: theme—travel and transportation practices to prevent surface destruction in the northern environment; 1976 January 19-22; Anchorage, AK. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, Alaska State Office: 169-175.

"Fire access usually should be via ridges, where soil tends to be shallow, erosion hazards minimal, and timber cover most open. Dry slopes with deep permafrost or none are useable [usable], but any slope is a potential erosion hazard. Permafrost areas, muskegs, and poorly drained sites should be crossed only as a last resort, to avoid trafficability problems and long-lasting environmental damage. Access trails should be rehabilitated as needed. Pre-attack planning in zones accessible to ground vehicles will develop all facets of access so that information is available to dispatchers when needed. Cat bosses should air-check routes before taking off with equipment. An urgent need is for the development of low ground-pressure vehicles and aerial alternatives to dozers for fire suppression." (A)

39. Hok, J.R. 1969. A reconnaissance of tractor trails and related phenomena on the North Slope of Alaska. Anchorage, AK: U.S. Department of Interior, Bureau of Land Management. 66 p.

Observations and conclusions are presented concerning disturbance to the land surface from power-driven vehicles operating on permafrost terrain in Alaska. Limited use of the "weasel" or "bombardier" (both broad-tracked, light, personnel carriers) may not cause long lasting disturbance. The use of heavier vehicles, particularly caterpillar-type tractors, often resulted in marked changes in the disturbed surface. Magnitude of change depends on several variables: the season (which determines whether the ground is frozen or thawed) during which the disturbance took place, degree to which the surface material has been bladed aside, water content of the substrate (for example, ice-rich or well drained), and degree of slope. The single most important variable is the season during which the operation was conducted. Surface movement of heavy equipment during summer months resulted in the most drastic changes. (C)

40. Johnson, L. 1978. Biological restoration strategies in relation to nutrients at a subarctic site in Fairbanks, Alaska. In: Proceedings, 3d international conference on permafrost; 1978 July 10-13; Edmonton, AB. Ottawa, ON: National Research Council of Canada: 460-466.

"The results reported in this paper suggest an alternative means (nutrient manipulation) for controlling the competitive outcomes of vegetation mixes in order to meet management goals. The use of a nurse crop such as annual rye does not always increase long-term vegetation cover despite such claims in some of the arctic and subarctic revegetation literature. It should probably not be used unless rapid vegetative cover is essential for erosion control or some other purpose. The effect of a nurse crop of a rapid-growing perennial species upon other perennial species varies depending upon the fertilizer levels used....Therefore, it is important to select the species and the fertilizer levels in unison when devising a management plan for restoration in the Arctic and Subarctic." (A)

41. Johnson, L.; Quinn, W.; Brown, J. 1977. Revegetation and erosion control observation along the trans-Alaska pipeline: 1975 summer construction season. Spec. Rep. 77-8. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 36 p.

"Procedures for revegetation and erosion control of the Trans-Alaska Pipeline System during the initial construction phase are reviewed. Fertilizer and seed rates and scheddules of application by major areas (sections) are presented. During the field season of 1975 CRREL personnel observed revegetation and erosion control practices along the entire length of the pipeline route. The types of problems and early successes are discussed. Thirty-eight photographs are presented of characteristic areas on which revegetation was initiated." (A)

42. Johnson, L.; Van Cleve, K. 1976. Revegetation in arctic and subarctic North America, a literature review. CRREL Rep. 76-15. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 32 p.

"A literature review of revegetation and biological aspects of restoration research was completed for arctic and subarctic North America. Although there is a great deal of climatic variation in this region it is generally characterized by extreme conditions, such as a short growing season and permafrost. Most of the revegetation research has been undertaken in the last six years as a result of increased natural resource development. The primary goal has been erosion control, with aesthetics, minimization of thermokarst, and production of browse as other objectives. Revegetation and long-term restoration methods depend upon such variables as the site conditions, nutrient regime (especially as this is influenced by the climatic conditions in the Arctic and Subarctic), plant adaptations, and the selection of native or introduced species. Technologies which have been developed to meet these conditions primarily include seedbed preparation, use of seed mixes, and fertilization and seeding methods. Most of the research has focused on the use of agronomic grasses and legumes. These are selected on the basis of a number of factors, such as cold hardiness and growth form prior to evaluation in the laboratory and the field. The most successful species to date have been Arctared fescue and Nugget bluegrass in the Arctic, while these two as well as creeping red fescue, meadow foxtail, Frontier reed canarygrass, Durar hard fescue, slender wheatgrass, and Icelandic poa did well in the Subarctic. Similar methods have been attempted to a more limited extent with evaluation of native herbaceous and woody species which seem promising on the basis of natural succession studies. There are a number of continuing research needs for arctic and subarctic revegetation. These include fertilization strategies, development of specialized techniques (such as sprigging) for native species, and longer term studies. It is particularly important to integrate short-term revegetation methods with long-term restoration goals." (A)

43. Kryuchkov, V.V. 1976. Sensitive subarctic. TL-566. Hanover, NH: Cold Regions Research and Engineering Laboratory. 129 p.

"This book will acquaint the reader with the special features of nature in the Subarctic, a huge region occupying 20 percent of the Soviet Union's territory, where nature is extremely vulnerable and easily destroyed. Normal temperature variations in the Subarctic that would be almost unnoticeable in southern zones and areas lead to changes in relief and intensify ground creep on slopes. This book contains a large amount of factual material—the result of more than 20 years of research in the Far North on the part of the author." (A)

44. Lavkulich, L.M.; Rutter, N.W. 1975. Terrain sensitivity and the arctic land use research program in the Mackenzie Valley, N.W.T. In: Bernier, B.; Winget, C.H., eds. Forest soils and forest land management: Proceedings, 4th North American forest soils conference; 1973 August; Quebec, PQ. Quebec, PQ: Les Presses de l'Université Laval: 559-570.

"The Terrain Classification Program carried out in the Mackenzie Valley Corridor is based on recognition of the landscape as a whole composed of nonliving and living components. The landscape is systematically stratified on the basis of its stable components—surficial geology, landforms—followed by integration of the more dynamic aspects of the physical environment, namely, soils and vegetation. An attempt is made to focus attention on generic characteristics as much as possible in order to extrapolate data and permit confident interpretations. As a result of the large area involved and the short period of time to complete the program, reliance is placed on air photographic interpretations and limited detailed studies on representative terrain types. The program conducted in the Mackenzie Valley Corridor is one of the few studies that has encompassed a wide variety of expertise and attempted to integrate the information for land use and environmental considerations in an interdisciplinary fashion. The project is also an example of various government agencies and universities cooperating to achieve this goal." (A)

45. Lawson, D.E.; Brown, J.; Everett, K.R. [and others]. 1978. Tundra disturbances and recovery following the 1949 exploratory drilling, Fish Creek, northern Alaska. CRREL Rep. 78-28. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 91 p.

"A 1949 drill site in the Naval Petroleum Reserve Number 4, Alaska, the Fish Creek Test Well 1, was examined in August 1977 to determine the disturbance caused by drilling activities and to analyze the response and recovery of the vegetation, soils, permafrost, and surficial materials to that disturbance. Man-made disturbances include bladed and unbladed vehicular trails, a winter runway, excavations, pilings, remains of camp structures, steel drums and other solid waste, and hydrocarbon spills. The most intense and lasting disturbance to the vegetation, soils, and permafrost resulted from bulldozing of surface materials, diesel fuel spills, and trails developed by multiple passes of vehicles. Thermokarst subsidence and thermal erosion, caused by increased thaw of permafrost due to disturbance, resulted in the development of a hummocky topography and water-filled depressions at the drill site. Some ice wedges disturbed in 1949 are still melting. Soil disturbance ranges from minor modification to complete destruction of the soil morphology. The effects of hydrocarbon spills are still detectable in the soils. Little of the original vegetation remains in the intensely disturbed area, such as around the drill pad where a grass-dominated community prevails. After 28 years, the vegetation cover is closed over most mesic sites, shallow wet sites are well vegetated, and xeric sites, areas of diesel fuel spills and areas of severe erosion remain mostly bare. Pioneering plant species on bare, disturbed areas are members of mature vegetation assemblages from the undisturbed tundra which have high reproductive and dispersal capacities. A hypothetical model of natural revegetation and vegetation recovery is proposed. Vascular plants, bryophytes, and lichens were collected from the Fish Creek site area for the first time. Recommendations on cleanup and restoration of sites are presented." (A)

46. Linell, K.A. 1973. Long-term effects of vegetative cover on permafrost stability in an area of discontinuous permafrost. In: Permafrost: Proceedings, 2d international conference on permafrost; 1973 July 13-28; Yakutsk, USSR. North American Contribution. Washington, DC: National Academy of Sciences: 688-693.

"A comparison of three 61-meter square test sections near Fairbanks, Alaska (one kept in its natural tree-covered condition, a second cleared of trees but not stripped, and a third section stripped of all vegetative cover to a depth of about 0.4 meters) has shown that only the original densely tree-covered section has remained free from permafrost degradation over an observation period of 26 years. In both the cleared and stripped sections, permafrost degradation is still continuing, though at a distinctly slower rate in the area that was only cleared. It is concluded that in an environment like that at Fairbanks the maintenance or reestablishment of a random, mixed-type low vegetative cover cannot be counted on to stop or prevent permafrost degradation in an area subject to surface disturbance. If thermal stability under vegetative cover is to be accurately predictable for engineering purposes on other than an empirical basis, much additional research is still needed to achieve better quantitative information, understanding, and procedures." (A)

47. Loeffler, R.M.; Childers, J.M. 1978. Channel erosion surveys along the TAPS route, Alaska, 1977. Open-File Rep. 78-611. Anchorage, AK: U.S. Geological Survey, Water Resources Division. 90 p. Unpublished report. On file with: U.S. Geological Survey, Water Resources Division, Anchorage, Alaska.

"Channel surveys were made along the TAPS route during 1977 at the same 28 sites that were studied in 1976. In addition, a new site at pipeline mile 22 near Deadhorse (alignment No. 134) along the Sagavanirktok River was put under surveillance. Except for changes wrought by the completion of construction, most of the sites showed very little change. Significant events include: virtual completion of all construction activities along the pipeline, the pipeline start-up, and the breakup flood along the Sagavanirktok River which breached many river-training structures. In general, 1977 saw heavy flooding on the streams draining the north and south slopes of the Brooks Range and moderate flooding on streams further south.

"Aerial photogrammetric surveys were used again in 1977 on the same seven sites as in 1976. Results document the applicability of the method for channel erosion studies, especially those on large braided rivers. However, it requires engineering judgement [judgment] and personal knowledge of the particular site to avoid being occasionally led to inaccurate conclusions." (A)

48. Londagin, H.E.; Harding, F.H. 1977. Revegetating silt cutback erosion control. Rep. AK-RD-77-2. Valdez, AK: State of Alaska, Department of Transportation and Public Facilities, South Central Region. 49 p.

"Field experiments were conducted at various locations in the State of Alaska, South Central Region of the Department of Transportation in order to evaluate the adaptability of plant species, methods, materials and equipment for establishing a grass cover on silted back slope soils. The field experiments consisted of replicated tests of fertilizer rates, seeding rates, species adaptation, asphalt emulsion, and mulches. The tests included the major erodible glacier silted soils that are encountered in the interior of Alaska.

"The tests showed the importance of refertilization and the use of mulch materials. Wood excelsior mulch plus asphalt emulsion proved to be the most effective mulch for fast sod formation by providing the best combination micro environment, and at the same time, slope protection from erosion." (A)

49. Lotspeich, F.B. 1971. Environmental guidelines for road construction in Alaska. Rep. 1610 GOI 08/71. College, AK: Alaska Water Laboratory, U.S. Environmental Protection Agency. 127 p.

This report summarizes road construction methods that could minimize environmental degradation in Alaska. Potential pollution hazards are broadly defined and suggestions for preventive measures are offered. Sections address route selection, engineering design, construction activities, maintenance, and problems of the true Arctic. (C)

50. Lotspeich, F.B. 1972. Effects of Wickersham Dome fire on water quality of Washington Creek. Work. Pap. 14. College, AK: U.S. Environmental Protection Agency. 17 p.

"Based on field observations during three visits to the Wickersham Dome fire area, and analyses of water samples collected on each trip, the following conclusions and recommendations are offered: (1) Retardants used on this fire did not appear to cause high phosphate or nitrogen concentrations in Washington Creek, the major stream draining the burned over area. (2) Suspended sediment load increased a few days after the fire as a result of thermal erosion of fire trails. Most of this erosion was brought under control by constructing water diversion dams across fire lines to divert melt water from streams to vegetated areas. (3) Where possible, retardants should be confined to areas some distance from running water to prevent adding loads of these concentrated chemicals to streams. There appeared, however, to be little damage under the conditions of this fire, even after sufficient rain had fallen to cause Washington Creek to rise. (4) Bulldozed firelines should terminate before reaching stream banks and diversion dams should be installed at frequent intervals across firelines as as part of the overall fire plan. (5) Followup work on diversion dams should be done at critical points to insure that melting permafrost does not cause failure as was ob-served in the field. (6) Where possible, firelines should be located in areas of rocky ridges, rather than at midslope with deep soils, to prevent erosion." (A)

51. Lotspeich, F.B.; Helmers, A.E. 1974. Environmental guidelines for development roads in the subarctic. Rep. EPA-660/3-74-009. College, AK: Arctic Environmental Research Laboratory, U.S. Environmental Protection Agency. 63 p.

"This set of guidelines is based on Federal and State regulations that set standards to protect the total environment. Although major highway construction is under stringent regulation, pioneer type access roads such as are needed by loggers, miners, land developers, etc. have been neglected. These smaller roads frequently pose serious erosion hazards because planning, design, and construction of them is not as thorough as it is for major roads; this results in erosion, fire, insect traps, and generally unattractive roadways.

"Suggestions and recommendations contained in these guidelines are for the use of operators with limited engineering and planning staffs. Although all examples of poor practice are from the vicinity of Fairbanks, all suggested treatments are taken from the literature from the conterminous United States, with some modifications for subarctic conditions. Most of these recommendations are simple in concept, and if properly applied, do prevent erosion and result in superior access roads which are esthetically pleasing." (A)

52. Lotspeich, F.B.; Mueller, E.W.; Frey P.J. 1970. Effects of large scale forest fires on water quality in interior Alaska. College, AK: Alaska Water Laboratory, Federal Water Pollution Control Administration. 115 p.

This report describes the effects of a forest fire, covering a quarter million acres in interior Alaska, on water quality. It concludes that (1) the burning was not severe enough, in general, to destroy the entire organic layer, (2) the fire did not affect the depth of thaw, (3) only fire trails exhibited evidence of increased erosion, (4) biochemical oxygen demand increased for streams in the burned area, (5) potassium concentrations were greater in streams draining burned areas, (6) fire control methods may cause more serious and long-lasting damage to the aquatic ecosystem than the fire itself, and, (7) if burning is not severe or if a nearby seed source exists, natural processes will revegetate a burn more rapidly than will artificial means. Authors recommended that "artificial revegetation not be attempted where burning was not severe enough to remove the entire organic horizon or where revegetation would expose mineral soil and cause melting of permafrost." (A)

53. Mackay, J.R. 1970. Disturbances to the tundra and forest tundra environment of the western arctic. Canadian Geotechnical Journal. 7: 420-432.

"The more important physical disturbances to the tundra environment are discussed with examples. Thermokarst subsidence, not thermal erosion, is shown to be the dominant result of man-induced disturbances, such as those caused by the bulldozing of seismic lines and firebreaks. It is shown that a clear distinction between thermokarst subsidence and thermal erosion is necessary, if the causes of the disturbances are to be prevented and minimized, or the results treated. The typical surface disturbance to the tundra results in a deepening of the active layer. Therefore, foreknowledge of the effect of a disturbance on deepening the active layer, together with information on the ice content of the permafrost affected, makes it possible to predict the amount of thermokarst subsidence likely to take place. Three practical examples of three types of ground disturbance are given: a fire near Inuvik, N.W.T.; a patch of vegetation trampled and killed by a dog at Garry Island, N.W.T.; and seepage down a walking trail in an ice-wedge area at Garry Island, N.W.T. The effects of the disturbances are illustrated and discussed." (A)

54. Madison, R.J. 1981. Effects of placer mining on hydrologic systems in Alaska—status of knowledge. Rep. BLM/AK/TR-81/07. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, Alaska State Office. 32 p.

"Nearly all significant information about effects of placer mining on hydrologic systems in Alaska is referenced in available reports. Addition of sediment in quantities and sizes that cause significant changes in normal relationships among stream discharge and sediment size and concentration (and indirect changes generated) appears to be the primary impact of placer mining on Alaskan hydrologic systems. Other potential water-quality effects to be considered are: increases in organic loading and minor element content; potential for acid drainage; and impacts on aquatic biota. Existing information adequately defines parameters that may be affected by placer mining but cannot quantify hydrologic changes resulting from individual operations or predict magnitude or duration of impacts in unmined areas. Studies that would improve current knowledge include: short term assessments, using aerial photography, satellite imagery, and existing hydrologic records, to document historical changes and active placer-mining features; short-term studies involving minimum data-collection efforts and using empirical sediment-transport formulas to estimate effects of mining activities; and river-quality assessments of selected basins affected by placer mining. These studies will not provide the quantitative information that could be gained from long-term detailed study of specific placer-mining activities, but will provide qualitative information for management decisions needed in the near future." (A)

55. Muskeg Research Institute. 1970. Tests to define levels of terrain damage by tracked vehicles operating on tundra. Fredericton, NB: University of New Brunswick. 32 p.

"In order to relate known amounts of vehicle traffic to various aspects of terrain disturbance, an experimental program was established during the summer of 1970. This report is an account of the findings of that program. Also included are recommendations for the implementation of standards regarding off-road tracked vehicle traffic based on the results of the program."

Conclusions drawn include:

1. "Moisture content, vegetation composition and depth to permafrost appear to be the primary factors controlling terrain sensitivity to disturbance."

2. "Traffic should be avoided in areas where open water is visible on the ground surface."

3. "The most influential factor of tracked vehicle design affecting terrain disturbance is weight."

4."Flat tracks having no detent in the center are beneficial in reducing terrain disturbance."

5. "Based on the terrain disturbance classification system described earlier, disturbance level 4 has been selected tentatively as a tolerable maximum disturbance level. Level 4 consists of 10 percent damage to vegetation and scuffing and flattening of annuals."

6. "The effect of season on terrain sensitivity cannot be neglected. Sensitivity appears to be directly related to proximity of frost to the ground."

7. "A minimum turning radius of 60 feet for 5 passes of any tracked vehicle of the type tested results in terrain surface disturbance equal to or less than level 4."

8. "Conclusions concerning stream crossings cannot be drawn until longterm observations of test sites have been completed."

9. "In operating tracked vehicles as tractors towing loads or as carriers climbing slopes, slip should be less than 20 percent to limit terrain disturbance to level 4. This amount of slip is consistent with net tractive effort amounting to 30 percent to 45 percent of the vehicle's gross weight."

10. "Even for disturbance exceeding level 4, considerable vegetative regrowth of all species present is possible immediately following the disturbance provided the disturbance occurs early in the growing season. Disturbance occurring during the latter third of the growing season results in no significant appearance of vegetative regeneration."

11. "A final decision on tundra sensitivity classification must await observation of test sites over a two to three year period."

12. "Effective use of a tundra disturbance and sensitivity classification system will depend on effective mapping procedures." (A)

56. Neiland, B.J. 1978. Rehabilitation of bare sites in interior Alaska. Agroborealis. 10(1): 21-25.

"Insufficient attention has been paid to use of native and naturalized plant species for disturbed site rehabilitation in interior Alaska, despite availability of many species suited for rapid invasion, establishment, and persistance under adverse physical conditions....Not only might use of natural species and processes require little or no effort or money on our part, but our native animals might benefit to a greater extent, and the landscape might be more ecologically satisfying in many places, than when more conventional agronomic species and processes are used." (A)

Initial results are summarized on use of various mulches and on several wild and naturalized species: peavine, alsike clover, fireweed, horsetail, bluejoint grass, *Polytrichum* sp. mosses, creeping red fescue, and manchar smooth brome. (C)

57. Onesti, L.J. 1980. Erosion rates on disturbed sites in a permafrost environment. Contract Rep. DACA 89-79-M-1268. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 40 p., plus illustrations.

"The study of erosion rates on disturbed sites, initiated during the summer of 1978 along the Haul Road in the central Brooks Range, was continued during the field season. Data were collected from May through August which included the late spring snowmelt runoff and summer precipitation seasons. This study was expanded in 1979 by the addition of four erosion plots and the monitoring of soil moisture and soil temperature as well as rate of ground thaw. The impact of snowmelt runoff on erosion rates was also assessed." (A)

58. Patterson, W.A.; Dennis, J.G. 1981. Tussock replacement as a means of stabilizing firebreaks in tundra vegetation. Arctic. 34(2): 188-189.

"Although firebreaks in tundra areas will not always be constructed in areas of tussock and dwarf shrub vegetation, the results of our study suggest that vegetation replacement or mulching should be attempted wherever the nature of the topography suggests that post-fire erosion might occur. Natural revegetation of firebreaks in tundra areas is extremely slow, and artificial stabilization techniques may be the only alternative, despite their high cost." (A)

59. Rickard, W.E.; Slaughter, C.W. 1973. Thaw and erosion on vehicular trails in permafrost landscapes. Journal of Soil and Water Conservation. 28(6): 263-266.

Two types of off-road access trails constructed on permafrost terrain in central Alaskawere monitored to determine the environmental consequences of off-road vehicular traffic. Tractor-cleared trails showed severe permafrost thaw and soil movement the first season after use, whereas a hand-cleared controlled-access trail was markedly more stable, showing lower levels of soil movement even after three seasons of frequent use. Recommendations are to: (1) take care in determining route to be followed, (2) avoid permafrost sites with high ice content soils, (3) restrict traffic to low-ground-pressure vehicles, (4) leave surface organic material intact, and (5) provide an insulating or wearing surface for the trail. (C)

60. Shamanova, I.I. 1972. Permafrost erosion in Yamal. Izvestiya Akademii Nauk SSSR: Seriya Geograficheskaya. 2: 92-98; 1971. Draft Translation 377. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 9 p.

"The region under study is a distinctly terraced, gently rolling aggradation plain with erosion-thermokarst runoff belts and numerous thermokarst lakes. The climate in the region is severe; the average many years' air temperature is -9.5°C. The thickness of the frozen layers in a large part of the territory exceeds 300 to 400 m; their most typical temperature at the base of the layer of annual heat exchanges is -6 to -7°C. The thickness of the seasonally thawing soil layer under the influence of a grouping of natural factors (composition of sediments, depth of mossy-lichen layer and peaty horizon, position of sector in relief, etc.) will fluctuate from 0.25 to 0.3 m (in the peat bogs) to 1.3 m (in the watershed sectors with mottled microrelief). Observations indicated that in the region under study, the presence of low-temperature permafrost soils occurring near the daylight not only failed to obstruct the development of the erosion process, but in many cases, it intensifies the erosional effect both near the rivers and in the drainage areas on the high geomorphological levels." (A)

61. Slaughter, C.W.; Collins, C.M. 1981. Sediment load and channel characteristics in subarctic upland catchments. Journal of Hydrology (NZ). 20(1): 39-48.

"Sediment load in low-order streams of the unglaciated Yukon-Tanana Uplands of central Alaska may be related to drainage basin characteristics and to stream channel morphology. This has been investigated by analysis of selected physical, hydrological and water quality data for the 104 km^2 Caribou-Poker Creeks Research Watershed, located at 65°09'N, 147°30'W in a region of rolling to steep uplands and discontinuous permafrost. Channel morphology data are available for first-, second- and third-order streams. Sediment load for selected points was determined over 45 weeks during summers of 1978 and 1979. Consistent differences in sediment yield, hydrologic regime and channel morphology have been determined between permafrost and non-permafrost drainages." (A)

62. State of Alaska, Department of Environmental Conservation. 1979a. Timber harvesting water quality management study: draft for review. Juneau, AK: Alaska Water Quality Management Planning Program. 184 p.

"The proposed management plan for the Timber Harvesting element of the Alaska Statewide 208 Water Quality Management Plan...is a combination of institutional and technical elements that were determined to provide the best protection and enhancement of freshwater quality and habitat as they may be impacted by timber harvesting and ancillary activities such as logging road construction." (A)

63. State of Alaska, Department of Environmental Conservation. 1979b. Water quality management related to design, construction and maintenance of transportation corridors: draft for review. Juneau, AK: Alaska Water Quality Management Planning Program. 192 p.

"As a portion of the 208 Planning Study undertaken by the Alaska Department of Environmental Conservation, this report is specifically concerned with Transportation Corridors, namely roads, railroads, railroads and pipelines constructed and maintained within the state. The overall intent of the report is to: identify the problem of transportation system construction and existing solutions to the problem, both technical and institutional; develop a management plan for control and enforcement of design, construction and maintenance activities; and implement the management plan. The conclusions...are summarized as follows: (1) to date in the State of Alaska, existing transportation systems have created relatively minor impact upon water quality, (2) the technical solutions to adequately prevent or minimize water quality degradation resulting from erosion and sedimentation are, for the most part, readily available but not uniformly practiced, and (3) the principal problem lies in effective and equitable regulation and enforcement of erosion control standards." (A)

64. State of Alaska, Department of Highways. 1972. Beauty with grasses. Fairbanks, AK. 7 p.

"This pictorial review shows man made erosion problems solved with satisfying results." (A)

65. State of Alaska, Department of Natural Resources. 1981a. Alaska forest resources and practices regulations, first edition. Juneau, AK. 20 p.

"The Alaska Forest Resources and Practices Act has been in effect since January 1, 1979. The Act was passed as a practical and effective means to assure continuous growth and harvest of timber and to protect Alaska's forest wildlife soil and water resources....This publication contains the Forest Practices Procedures and Standards, a^ well as the Forest Fire Protection Regulations in effect at this time reflecting an increasing public concern in the management of the forest land of Alaska." (A)

Regulations include explicit concern with effects of forest operations on the water resource; for example, "Road design standards and specifications must be adapted to the terrain and soil materials in order to minimize surface disturbance and to minimize impact on water quality"; "Areas of exposed soil must be stabilized to the extent feasible at the normal angle of repose or less, to minimize soil erosion and subsequent siltation of surface waters"; "Felling, bucking, and yarding must be conducted so as to...minimize soil erosion from the cutover area"; and "Unstable or erodible exposed soils must be stabilized by a suitable method to minimize siltation of surface waters." (C)

66. State of Alaska, Department of Natural Resources. 1981b. Forest practices field manual, first edition. Juneau, AK. 31 p.

"The Forest Practices Field Manual contains a listing of best management practices (BMP's), which are set forth by region and type of activity.

"The BMP's constitute state-of-the-art methods that may be used to achieve the standards contained in the Forest Practices Regulations. They are not mandatory, but serve as guidelines for forest operators to assure continuous growth and harvest of timber and to protect Alaska's forest, wildlife, soil, and water resources." (A)

67. State of Alaska, Rural Development Council. 1977. A revegetation guide for Alaska. Fairbanks, AK: Cooperative Extension Service, University of Alaska. 74 p.

This guide provides information on plant materials for revegetation of disturbed sites and for forage production. The cultural practices necessary for optimum results in revegetation and forage production are given. The guide is an extensive revision of the bulletin "A Vegetative Guide for Alaska, 1972."

Major sections include culture and management for establishment of vegetation (including topics of site preparation; seed specifications; time of seedling or planting; seeding and planting methods; fertilization and liming for the establishment of grasses, other herbaceous plants, and woody plants); soil and site groups; and seeding recommendations for grasses and other herbaceous plants, lawns and turf, and woody plants. (C)

68. Stednick, J.D. 1980. Alaska water quality standards and BMPs. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 721-730.

"The Alaska Forest Resources and Practices Act of 1978 requires land managers to meet water quality standards through defined Best Management Practices (BMPs). Water quality standards developed by the State are used as a basis for BMP definition and enforcement actions. These water quality standards were established from water quality data and standards from the Pacific Northwest states and have not been subject to field testing in Alaska.

"Significant degradation of water quality associated with timber harvesting and roading in Southeast Alaska has not been documented. Quantification of suspended sediment effects on water quality is difficult since insufficient pre- and post-treatment data have been collected. Furthermore, methods to assess the degree of water quality degradation from non-point source pollution are presently less than adequate. Monitoring of suspended sediment production in undisturbed watersheds of the Tongass National Forest indicate sediment concentrations exceeding State water quality standard for turbidity, with variable relationships between NTUs and mg/l. Water quality monitoring of slash burning and bridge removal activities indicate that detection of potential impacts to water quality from prescribed BMPs are often masked by natural sedimentation, since localized and short-term sediment production is difficult to separate from long-term changes. These examples indicate that State enforcement actions should be directed to the implementation of BMPs and not water quality standard compliance." (A)

69. Sykes, D.J. 1971. Effects of fire and fire control on soil and water relations in northern forests—a preliminary review. In: Slaughter, C.W.; Barney, R.J.; Hansen, G.M., eds. Fire in northern environment—a symposium: Proceedings of a symposium; 1971 April 13-14; Fairbanks, AK. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 37-44.

"Research data and literature are sparse on fire in the taiga and subarctic zones, especially regarding effects of fire on soil and water relations and on associated resource management considerations. In the scattered existing work, there is disagreement regarding effects of fire on soil temperatures, permafrost degradation, destruction of the organic mat, soil erosion, and other factors; but this is partially expected considering the wide variation in soils, geology, climate, and vegetation of subarctic data sources. Some observers indicate more serious damage from past suppression methods than from the fires themselves. A brief, preliminary review of work pertaining to effects of fire in northern forests is presented." (A)

70. Tyler, R.W.; Gibbons, D.R.; Salo, E.O. 1973. Effect of logging on small streams in the Thorne Bay area of SE Alaska. Loggers Handbook. 33: 24-26, 78, 96, 98.

"Preliminary data were gathered toward determining the effect of clearcut logging on small coho salmon-producing streams of Southeast Alaska. The parameters which were measured during July 1972 on logged and unlogged tributaries in the Staney Creek and Thorne River watersheds include water temperatures, abundance of juvenile coho salmon, insect abundance, concentrations of organic leachates, and gravel composition.

"Preliminary findings include:

1) Maximum stream temperatures occurred about 4:30 p.m., 2-1/2 hours after the peak of solar radiation.

2) Stream temperatures increased much more rapidly in logged than in unlogged study areas.

3) Juvenile coho salmon and Dolly Varden char apparently were unharmed by temperature peaks which reached as high as 24.2°C (75.5°F) but which were of short duration.

4) As the result of a 6-day drought, during which streamflow (cfs) decreased by 50% and current velocities decreased by 75%, the exposure to solar radiation of stream waters flowing through unforested areas increased fourfold.

5) The removal of logging debris from rearing habitats, as is presently required, is important in maintaining adequate current velocity through clearcut areas, thereby minimizing exposure to solar radiation; however, some logs would be retained for shelter and maximum velocity control. The optimum amount and method is not known.

6) The abundance of salmonids (as determined by repetitive visual counts) apparently declined by about 50% in both the logged and unlogged streams during the period July 16 to August 12.

7) Mayflies (Ephemeroptera) were the most abundant aquatic insects found in study streams. The production of mayflies, caddisflies (Trichoptera) and miscellaneaous flies (Diptera) was greatest in logged Stream A." (A)

71. URS Company; Environaid. 1977. Timber harvesting/water quality, problem description: draft for review. Juneau, AK: Alaska Water Quality Management Planning Program, State of Alaska, Department of Environmental Conservation. 143 p. Unpublished report. On file with: Alaska Department of Environmental Conservation, Juneau, Alaska.

"The report is divided into five chapters. Following the introduction and a general statement of the problem, is a review of literature pertaining primarily to Southeast Alaska, an examination of existing timber sale contractual provisions, and a summary of the existing situation.

"The summary of pertinent literature primarily concerns Southeast Alaska which has extensive commercial timber stands and where the majority of Alaskan logging takes place, mostly on National Forest Lands. Research has concerned various facets of local conditions, the timber resource, the fishery resource, and the effects of logging.

"Based on the review of literature and the evaluation of the existing situation, several observations are made. Firstly, the range of unique conditions in Alaska necessitates site-specific resource planning. Secondly, logging and water quality problems can and do occur throughout the forested areas of the State.

"The most important existing problem is sediment as it affects water quality and fish habitats, especially in the Southeast and Southcentral regions where there is the greatest relationship between the forests and the fishery resource. Sediment problems result from several activities, including among others: roadbuilding, use and removal; stream crossings and in-stream use of equipment; ground and streambank disturbance; and improper activity on steep slopes. Other problems include changes in temperature (both in summer and winter), reduction in dissolved oxygen levels (especially in intragravel water as related to sediment and fine debris), accumulation of debris, and blockage of fish passages." (A)

72. U.S. Department of the Interior, Bureau of Land Management. 1973. Influence of man-caused surface disturbance in permafrost areas of Alaska. Anchorage, AK. 19 p.

"Most surface disturbance is caused by vehicles which are operated off surfaced roads. Such vehicle use is included in activities like seismograph exploration, mining, and control of wildfires.

"Surface disturbance resulting in destruction of vegetation or tearing of the surface organic mat is followed by thawing of permafrost. This often results in surface subsidence, soil erosion, and siltation. These reduce water quality, aesthetic values, and access.

"Methods are recommended to minimize surface disturbance through improved procedures for control of wildfires and application of regulations for off-road vehicle use. Also recommended are methods to control effects of surface disturbance by thermal insulating, revegetation, and drainage control structures.

"The primary objective in land management of permafrost areas should be to prevent accelerated soil erosion through the following guidelines: Identify thaw-unstable permafrost areas and zone them for strict management control to prevent or minimize surface disturbance; zone other areas for development and resource use with management control of surface disturbance; and rehabilitate all areas that are damaged." (A)

73. Viereck, L.A. 1973. Wildfire in the taiga of Alaska. Journal of Quaternary Research. 3: 456-495.

"The taiga of Alaska consists of a vegetation mosaic resulting primarily from past wildfires. Today, both lightning- and man-caused wildfires burn an average of 400,000 hectares annually, creating vast areas of successional ecosystems. However, although the number of reported fires is increasing, fire control is becoming more effective in limiting the average size of fires and the total area burned. One of the important influences of fire in the taiga ecosystem is its effect on permafrost and the soil nutrient cycle. Construction of firelines in permafrost areas has a greater effect on soil erosion and siltation than does the fire itself. Some wildlife species, such as moose and snowshoe hare, depend upon fire and its resultant successional plant communities, whereas fire may have deleterious effects on caribou winter range. Fire has both positive and negative effects on esthetic and recreational values. Fire has always been a part of the Alaskan taiga ecosystem; if it is totally excluded from the environment, some major ecological changes will result. Fire-suppression alternatives are discussed and additional research on fire effects suggested." (A)

74. Viereck, L.A.; Schandelmeier, L.A. 1980. Effects of fire in Alaska and adjacent Canada—a literature review. Tech. Rep. 6. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, Alaska State Office. 124 p.

"Alaska land and resource managers are moving from a policy of fire control to one of fire management. To use fire as a tool to reach resource management objectives, managers need information on fire effects and the role of fire in the northern environment. The authors searched and reviewed all the available literature on fire effects in Alaska and adjacent Canada, in both the northern forest (taiga) and the tundra. They report and interpret this literature, discussing fire effects information sources, fire history and fire regimes, and the effects of fire on soils, watersheds, vegetation, and animal life. They also point out information gaps that need to be filled." (A)

75. Walker, D.A.; Webber, P.J.; Everett, K.R.; Brown, J. 1977. The effects of low-pressure wheeled vehicles on plant communities and soils at Prudhoe Bay, Alaska. Spec. Rep. 77-17. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. 49 p.

"An off-road vehicle test utilizing a smooth-tired Rolligon weighing approximately 25,000 pounds was conducted at Prudhoe Bay, Alaska, on 25 June 1976. Vehicle impact on the vegetation and terrain was documented at 32 stations selected as representative of the coastal tundra terrain. Twenty-seven stations were of a single-pass track and five were multiple-pass lanes of up to 30 passes. The report documents the impacts with photographs and numerical ratings." (A)

76. Washburn, A.L. 1973. Thermokarst. In: Washburn, A.L., ed. Periglacial processes and environments. New York: St. Martin's Press: 232-239.

"...the term thermokarst designates topographic depressions resulting from the thawing of ground ice. There are many kinds of thermokarst including linear and polygonal troughs, collapsed pingos, thaw lakes, and alases. Some thermokarst features are due to climatic change but many are caused by such changes of surface conditions as disturbance of tundra vegetation, shift of stream channels, fire, or other non-climatic equilibrium changes that promote thawing." (A)

77. Washburn, A.L. 1980. Geocryology. New York: Halsted Press (John Wiley & Sons). 406 p.

"This book is intended as a rather comprehensive overview of periglacial processes and their effects, present and past. Geocryology is included in the title to emphasize the pervasive influence of ice and its phase changes in these processes." (A)

The chapters "Frozen Ground," "Mass-Wasting Processes and Forms," "Fluvial Action," and "Thermokarst" are particularly relevant to understanding soil erosion in high-latitude settings. (C)

78. Zoltai, S.C.; Pettapiece, W.W. 1973. Studies of vegetation, landform and permafrost in the Mackenzie Valley: terrain, vegetation and permafrost relationships in the northern part of the Mackenzie Valley and northern Yukon. Rep. 73-4, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Ottawa, ON: Information Canada. 105 p.

"The moisture content of the near-surface permafrost can be related to landforms (texture, slope) and vegetation within various Land Regions. The iciest near-surface permafrost occurs in fine grained, but permeable soil materials on gentle slopes or on relatively well drained plains under undisturbed vegetation of spruce-lichen. Massive ground ice, occurring at depth, can be found with increasing frequency from south to north; the presence of such icy bodies is not indicated by the vegetation. It was noted, however, that these occur in areas which were at one time occupied by lakes or ponds.

"Peatlands occupy large portions of the land surface. Bogs occur as peat plateaus and palsas elevated by permafrost. Wet fenlands, however, are not frozen above the mineral subsoil in the southern Regions. This causes a great difference in the properties of these peatlands: bogs, although containing up to 90% moisture, provide firm footing as they are frozen beneath the surface. Fenlands, being unfrozen, act as drainage channels or water reservoirs during the summer....

"The susceptibility of the surface to disturbance was determined by correlating vegetation, near-surface permafrost, active layer, soil materials, and slope patterns. Surface susceptibility, defined as a reaction to a moderate surface disturbance, was determined for the landforms in the study area and ranked on a six point scale. Maps at a scale of 1:250,000 were prepared, showing the surface susceptibility of the study area....The most important function of the vegetation is the insulation of the surface from excessive heat transfer. The quality of vegetation is important: vegetation is usually re-established soon after a disturbance (as fire), but the pioneer vegetation is a poor insulator and thermal subsidence occurs. Ponding on differentially subsided areas further alters the thermal conductivity of the ground, leading to aggravated conditions. Any interdiction of surface drainage on permafrost ground which causes ponding is dangerous. Such interference with drainage can result when building berms or roads across slopes, blocking often indistinct, but active drainage-ways. Blockage of drainage can result when putting a refrigerated pipeline across unfrozen fenlands, with subsequent upstream ponding and thermokarst development." (A)

79. Al-Jabbari, M.H.; Al-Ansari, N.A.; McManus, J. 1980. The effect of farming and housing upon sediment transport in a gravelly river. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 257-263.

"Continuous monitoring of water level and suspended sediment concentration was undertaken in the 176 km^2 Almond catchment during the winter 1975-1976. The inter-relationships during a major storm event in which 26 per cent of the annual sediment budget was transported, during a period of harvesting throughout which water flow was constant, and foundation excavation for a housing scheme development was carried out, are analysed. The enhanced sediment yields resulting from human impact were 35 t from farming and 128 t from the initial excavations. In local terms both are significant contributions to the soils loss." (A)

80. American Society of Agricultural Engineers. 1977. Soil erosion and sedimentation: Proceedings, national symposium on soil erosion and sedimentation by water; 1977 December 12-13; Chicago, IL. ASAE Publ. 477. St. Joseph, MI. 151 p.

This volume contains 13 papers dealing with soil erosion, sediment production, and control of erosion. (C)

81. Amimoto, P.Y. 1978. Erosion and sediment control handbook. EPA 440/3-78-003. Sacramento, CA: Division of Mines and Geology, Department of Conservation. 198 p.

This handbook describes procedures for determining the need for and preparing an erosion control program. Major sections cover a model erosion control ordinance; assessment of need for erosion and sediment control; description of erosion and sediment control practices, including tree protection; establishment of protective vegetation; surface protection with mulches and other materials; protection of slopes and other graded areas from runoff; roadway protection; channel protection; grade control and realignment of channels; installation of culverts, paved fords, and bridges; sediment traps and detention basins; and dissipating the energy of runoff water. (C)

82. Anderson, C.H.; Bisal, F. 1969. Snow cover effect on the erodible soil fraction. Canadian Journal of Soil Science. 49: 287-296.

"The effect of snow cover on the overwinter breakdown of medium-textured soils in southwestern Saskatchewan was studied during the winter of 1967-1968. Where a continuous snow cover was provided artificially (with snow fencing), there was a decline in the percentage of soil particles <1mm in diameter from October to April with a marked drop from February to March when the snowmelt was high. The percentage of fine soil aggregates in the unprotected field depended upon the amount of natural snow cover and the moistening effect of snowmelt which occurred from time to time. Where a snow cover was prevented artificially, surface drying occurred and the exposed soil layer became highly erosive, particularly during February and March when air temperatures fluctuated widely. The fact that this occurred on treatments where air circulation was permitted and not under polyethylene cover is interpreted as evidence of the importance of water loss by sublimation in the process of deaggregation." (A)

83. Anderson, E.W.; Brooks, L.E. 1975. Reducing erosion hazard on a burned forest in Oregon by seeding. Journal of Range Management. 28(5): 394-398.

"A burned private forest was revegetated by seeding to grasses, legumes, shrubs and trees. The sequence of events in carrying out this stabilization program provides a guideline for others handling similar situations; timeliness and ecological adaptation of species used is important. A field study (1969-72) compared results obtained on three ecological sites. A satisfactory vegetational cover was established by seeded grass the first year after seeding on all three sites, whereas natural revegetation did not provide satisfactory cover on an unseeded area in 4 years. Common legumes seeded for deer forage did not survive, indicating the need for additional study of species adaptation. Broadcasting tree seed was a failure. Seeded grasses apparently suppressed development of some native shrubs, which was detrimental to wildlife habitat. Herbage production on seeded areas was about four times greater than on the unseeded area. Two years of soil loss from seeded watersheds totaled less than 5 tons per acre as measured by the amount of sediment in debris basins. Fire-killed ponderosa pine snags were most susceptible to windthrow; grand fir was the least." (A)

84. Anderson, H.W. 1954. Suspended sediment discharge as related to streamflow, topography, soil and land use. Transactions of the American Geophysical Union. 35(2): 268-281.

"The results of suspended-sediment sampling were used to obtain average annual suspended sediment discharge from 29 watersheds of western Oregon by relating sediment-sampling results to streamflow and by using streamflow frequencies. The values of average suspended sediment thus obtained were related by regression analysis to average watershed values of two streamflow variables, two topographic variables, two soil variables, and one channel bank variable. The soil variables were functions of particle size and aggregation determined by analyzing samples of the surface soil taken at standardized locations in the major geologic types. The other variables were functions of data published in maps and other secondary sources. The regression results were used (1) to construct a map of the sediment producing potential of lands in western Oregon under average land use condition; (2) to estimate how the actual production of sediment would differ from the potential with deviation of land use from average; and (3) to distribute present sediment production to the three major source areas: forest land, agricultural land, and channel banks of the main river." (A)

85. Anderson, H.W. 1957. Relating sediment yield to watershed variables. Transactions of the American Geophysical Union. 38(6): 921-924.

"The yield of sediment from watersheds depends upon three sets of variables: (1) inherent watershed characteristics such as geology and topography; (2) land use, condition of vegetation, and management and protective measures; and (3) nature of storms and streamflow which produce and transport sediment. Measured quantities of yield also depend on the sediment measuring device and on which fraction of total sediment yield is measured. The sources of variation in sediment yield between and within watersheds can be evaluated by study of the yield from many watersheds which have wide differences in variables affecting sediment yields. Such studies are useful to determine and evaluate the principal sources of sediment, to evaluate the probable effects of conservation programs on yield, and to provide criteria for design of reservoirs and channels. This paper summarizes some recent studies in which multiple regression analysis was used in relating sediment yield to watershed variables. The studies are discussed in the light of methods of selecting watersheds, data, variables, and functions; and the effects of neglected variables, errors in variables, and exclusion of nonsignificant variables." (A)

86. Anderson, H.W. 1971. Relative contributions of sediment from source areas, and transport processes. In: Morris, J., ed. Forest land uses and stream environment: Proceedings of a symposium; 1970 October 19-21; Corvallis, OR. Corvallis, OR: Oregon State University: 55-63.

"The paper reports new findings, offers a reanalysis of older studies, and summarizes pertinent results in the literature. Past land use, forest fires, road building, 'poor logging', and conversion of steep lands to grass have increased sediment discharge by factors ranging from 1.24 to more than 4. Projected future use is expected to increase sediment production by a factor of 4, with 80 percent associated with roads and 20 percent with logging. Major floods have increased subsequent turbidity of streamflow by a factor of 2. The increases were greater in logged areas of watersheds where roads were next to streams and landings were in draws than in undisturbed watersheds. Most landslides were associated with road development, next most with logged areas, and least with undisturbed forest area. The number of turbid days in streamflow varied by a factor 2.34 with differences in silt plus clay content of soils,by 8.55 with differences in erodibility, and by 4.3 with the percent of gravel. Further, these soil characteristics were predictable from geologic rock types. In a sample calculation, 89 percent of channel bedload became suspended load enroute down-stream. Soil creep contributed 15 percent to total sediment discharge from watersheds; channel bank erosion contributed 54 to 55 percent." (A)

87. Anderson, H.W. 1974. Sediment deposition in reservoirs associated with rural roads, forest fires, and catchment attributes. In: Effects of man on the interface of the hydrological cycle with the physical environment: Proceedings of the Paris symposium; 1974 September; Paris, France. IASH Publ. 113. Washington, DC: International Association of Hydrological Sciences: 87-95.

"Deposition of sediment was measured in 48 northern California reservoirs having catchment areas exceeding 5 km^2. The measurements were related by principal components analysis to four categories of variables: catchment, streamflow, snow, and land use. Intensity of land use was characterized by roads built for timber harvesting, mining, and recreation, and by uses not primarily related to roads, such as grazing and forest fires. Roads were of five classes—ranging from highways to dirt roads—and three locations: ridge top, slope, and streamside. Forest fire variables included current fire history and the extent of high-elevation brushfield associated with burning and grazing. Explained variance in sediment deposition ranged from 78 to 83 per cent, depending on the model used in analysis. Variables contributing the most to explained variance were, in decreasing order, snow, geology, streamflow, forest fires, roads, and reservoirs. Roads located near streams contributed the most deposition, twice as much as did roads located elsewhere. And improved secondary roads near streams were the single greatest contributor." (A)

88. Anderson, H.W. 1975. Sedimentation and turbidity hazards in wildlands. In: Watershed management: Proceedings of a symposium; 1975 August 11-13; Logan, UT. New York: American Society of Civil Engineers: 347-376.

"To evaluate the impact of land uses on sedimentation and stream turbidity, the resource planner must (a) select units of measurement useful in decision-making, (b) set up a baseline of expected sedimentation and water quality expressed in these units, and (c) select units to express the changes to be expected in sedimentation and water quality with changes to land uses....The paper focuses on a system for selecting units that measure sedimentation and water quality, and for defining a unit area in which water quality might be monitored and sedimentation predicted. Five subsystems characterize the basic sediment-producing potential of meteorological, geologic, topographic, vegetative, and land use conditions. Information about indices of sediment hazards, production coefficients that alter those hazards, and techniques for appraising sediment potential, dilution potential of streams, and deposition in reservoirs is brought together here. Results of current and older studies are reported to illustrate how sedimentation and streamflow hazards can be judged. The effect of certain logging practices and road location and design on sedimentation and water quality are evaluated. The effects of forest fires, conversion of steep forest and brushland to grass, and unstable stream channels are explored in their relation to sedimentation." (A)

89. Anderson, H.W. 1976. Reservoir sedimentation associated with catchment attributes landslide potential, geologic faults, and soil characteristics. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-35 to 1-47.

"Deposition measurements in 48 northern California reservoirs were found related to precipitation amount, rain-snow frequency, road standards and location, forest fires, geology, and physiography, and also to differences among watersheds (catchments) in landslide classes, extent of geologic faults, clay content of watershed soils, and density of reservoir sedimentation. The data were analysed by reduced rank principal component techniques. The final regression equation had an explained variance of 0.86 and a standard error of 0.138 log units. Difference in average annual deposition associated with reservoir density was 39 percent; with landslides, 100 percent; with faults, 41 percent; and with clay in watershed soils, 32 percent. Some geologic rock types with geologic faults and high landslide potential had a predicted sediment rate as much as 17 times that of areas without faults. Roads located near streams contributed the most to deposition—twice as much as did roads located elsewhere. And improved secondary roads near streams were the single greatest contributor, especially in area of steep terrain. Roads in steep topography produce twice as much acceleration in sedimentation as do those in less steep terrain. Preliminary appraisal of bedload (difference between reservoir deposition and suspended sediment discharge) indicate it varies from 90 percent to less than 20 percent of "total load" in different areas." (A)

90. Anderson, H.W. 1979. Sources of sediment induced reductions in water quality appraised from catchment attributes and land use. In: Proceedings, 3d world congress on water resources; 1979 April 23-27; Mexico City. Pap. v. 8. Mexico City, Mexico: World Congress of the International Water Resources Association: 3603-3613.

"Throughout the world, mountainous regions provide the principal sources of water supply. The usefulness of the water supply depends in part on the quality of the water, which is most often dependent on the sediment concentration. In periods of floods and from areas with unstable terrain, the sediment concentration may be naturally high. On the other hand, man's activities may create unstable areas and thereby decrease the quality of water from catchments. Catchments themselves give us the best means of determining both the natural and the man-accelerated sediment concentration of streamflow from mountain catchments. Suspended sediment measurements from 61 catchments in California were used to relate suspended sediment discharge to 10 catchment attributes. Suspended sediment was normalized by using long-term streamflow of each catchment. Factor analysis showed no confounding among the 10 attributes; regression on principal components gave an explained variance: land-use variable 30 percent; streamflow and rain-snow frequency 14 percent; geology, including faults, 11 percent; and tributary channel slope the other 3 percent. Catchment shape was the least important variable, with palm-shaped catchments having only 13 percent more sediment discharge than dendritic-shaped catchments. Differences in landslide classes produced the greatest differences in sediment discharge: sediment discharge from landslide class 6 was 12 times that from class 1. A separate analysis gave a basis for calculating landslide classes from catchment attributes. The use of results are illustrated in separating natural from accelerated sediment discharge and sediment concentration in the Redwood Creek Basin." (A)

91. Anderson, H.W.; Hoover, M.D.; Reinhart, K.G. 1976. Forests and water: effects of forest management on floods, sedimentation and water supply. Gen. Tech. Rep. PSW-18. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 115 p.

"From the background of more than 100 years' collective experience in watershed research and from comprehensive review of the literature of forest hydrology, the authors summarize what is known about the forest's influence on the water resource, particularly the effects of current forestry practices. They first examine the fundamental hydrologic processes in the forest. They then discuss how water supply, floods, erosion, and water quality are affected by timber harvesting, regeneration, tree planting, type conversion, fire, grazing, and the application of fertilizers and pesticides. They consider and present the special problems of fire-prone chaparral, phreatophytes, wetland forests, and surface-mined sites. Finally, they assess potential increases in water yield that might be achieved by forest management in each of six major forest regions in the United States and venture some predictions about future management of watersheds. Nearly 600 references provide a fairly comprehensive overview of the literature." (A)

92. Anderson, H.W.; Wallis, J.R. 1965. Some interpretations of sediment sources and causes, Pacific coast basins in Oregon and California. In: Proceedings, Federal interagency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 22-30.

"Differences in sediment discharges from watersheds can be attributed to differences in erosion from watershed slopes and channels and to differences in the transport of eroded material from the watersheds. The rates of sediment discharge from watersheds represent an integrated average of the sediment discharge from all parts of the watershed. The rates from the individual parts of the watershed—the sediment sources—may be evaluated by analyzing data from many watersheds. Between watersheds, the discharges of sediment vary in response to differences in streamflow, soils, topography, and land use. Within the parts of single watersheds, similar responses occur. Thus, sediment sources and causes can be expressed in terms of sediment production from whole watersheds as related to variables of the meteorological potential, topographic potential, soil erodibility, and land use and condition." (A)

93. André, J.E.; Anderson, H.W. 1961. Variation of soil erodibility with geology, geographic zone, elevation, and vegetation type in northern California wildlands. Journal of Geophysical Research. 66(10): 3351-3358.

"Samples of the surface 6 inches of mineral soil were taken at 168 places in northern California and analyzed for the physical characteristics which index erodibility of the soil. The samples were selected in the major soil-geologic types of California, under standard conditions of slope (west, 20%), at 1000-foot intervals in elevation, by vegetation types (forest, brush, and grass), and in three separate zones. A multiple regression analysis related the 'surface-aggregation' and 'dispersion' ratios, as the indexes of erodibility, to geologic type, vegetation type, zone, and elevation and to their interactions. The surface-aggregation ratio was somewhat more significantly related to soil erodibility than was the dispersion ratio. Soil developed from acid igneous rock was about 2-1/2 times as erodible as soil developed on basalt. Erodibility was highest for soils under brush, next under trees, and least under grass. No clear-cut relation of erodibility to elevation was found. The prediction equation explains 52% of the variability in erodibility in soils. By combining predicted erodibility from this equation with chemical base status, for a sample of 20 soils, the explained variance was improved. Application of these relationships in studies of sedimentation from watersheds is illustrated." (A)

94. Arnoldus, H.M.J. 1977. Predicting soil losses due to sheet and hill erosion. In: Kunkle, S.H.; Thames, J.L., eds. Guidelines for watershed management. FAO Conservation Guide 1. Rome: Food and Agriculture Organization of the United Nations: 99-124.

This paper explains use of the Universal Soil Loss Equation (USLE) for erosion prediction. Each parameter of the USLE is considered in detail, and appropriate tables and nomographs are provided for application of the USLE in predicting soil loss. (C)

95. Ashida, K.; Takahashi, T.; Sawada, T. 1981. Processes of sediment transport in mountain stream channels. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 166-178.

"In mountain stream channels, various modes of sediment movement including debris flow occur, depending on channel slope, discharge, and sediment properties. Equations predicting these modes are obtained based on mechanical conditions. Other characteristics of sediment transport are: the armouring phenomenon due to the wide range of grain size distribution; the effect of channel configurations—especially the longitudinal profile of stair-like formation with falls and pools which may be common in the stable armouring bed; and the effect of sediment storage on the river bed due to the inequilibrium conditions between sediment yield and transport capacity. These characteristics are based on observations in an experimental basin where the rate of erosion is the greatest in Japan and where the various modes of sediment transport can be observed." (A)

96. Ateshian, K.H. 1976. Comparative costs of erosion and sedimentation control measures. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-13 to 2-23.

"Cost information on erosion and sediment control measures for 25 methods in current widespread use are presented in a manner to provide a sound basis for estimating local costs. Using three principal cost elements: materials, labor and equipment, the detailed unit costs presented can also be up-dated to reflect inflationary trends in conjunction with an accepted cost index such as the ENR Construction Cost Index.

"The simplified procedures developed for estimating rainfall erosion index permit the prediction of soil loss (using the Universal Soil-Loss Equation) for selected watersheds. The cost data, when applied to soil losses, will reflect comparative costs per ton of soil retained. Control effectivenenss and economic life of each method can then be used to determine comparable annual cost figures. With this final step, the process of engineering decision-making and selection can be greatly simplified." (A)

97. Ateshian, J.K.H. 1974. Estimation of rainfall erosion index. Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers. 100(IR3): 293-307.

"The rainfall erosion index in the Universal Soil-Loss Equation has been intensively studied using an analytic approach. Simplified procedures for its computation have been developed and presented. The methodology ties together the eastern and western portions of the United States and is based primarily upon the rainfall distribution curves as published by the Soil Conservation Service and secondarily upon the kinetic energy and rainfall intensity relationship. With this improvement it is hoped that the Soil-Loss Equation will become truly 'universal'." (A)

98. Bagnold, R.A. 1979. Sediment transport by wind and water. Nordic Hydrology. 10: 309-372.

"In connection with the 50th anniversary of Aarhus University, 11 September 1978, brigadier R.A. Bagnold, F.R.S., was conferred the honorary degree of Doctor of Science. The present paper is the manuscript of the lecture R.A. Bagnold was giving at the faculty of science. In the lecture R.A. Bagnold expresses his views on several aspects of sediment transport in air and water. Among the most famous works by R.A. Bagnold are the monograph The Physics of Blown Sands and Desert Dunes, 1941 (Chapman & Hall, London) and the paper Flow of Cohesionless Grains in Fluids, 1956 (Royal Soc. London, Phil. Trans. A.249, 235-297). Many of the thoughts presented in the present paper have their roots in these two works." (A)

99. Balci, A.N. 1968. Soil erosion in relation to properties of eastern and western Washington forest soils. Soil Science Society of America Proceedings. 32(3): 430-432.

"Soil was sampled under Douglas-fir stands located on similar parent materials in eastern and western Washington. Simulated rainfall applied to soil blocks showed real differences in erodibility of east and west side soils. All soil properties tested, except texture, differed significantly between the two locations.

"Over 70 percent of the variation in soil erodibility was accounted for by a multiple regression equation using erodibility as the dependent variable and loss on ignition, permanent wilting percent, and percent silt as independent variables. Differences in soil properties were attributed to influences of climate on production of plant litter and ensuing decomposition and incorporation of litter into the soil by organisms." (A)

100. Barfield, B.J.; Hayes, J.; Barnhisel, R.I. 1978. The use of grass filters for sediment control in strip mine drainage. Volume II: Predictions based on theoretical studies. IMMR 39-RRR4-78. Lexington, KY: Institute of Mining and Minerals Research, University of Kentucky. 19 p.

"In Section I, a steady state model is presented for determining the sediment filtration capacity of a grass media under varying flow rates, sediment loads, particle sizes, flow durations, channel slopes, and media density. Each component of the model was tested during laboratory studies on artificial media. It is possible to use the model to predict the required media spacing, channel slope, and length of media to give a desired outflow concentration for given flow conditions. Based on simulations using the model, it appears that, for a given flow condition, the outflow concentration depends primarily on channel slope and spacing, whereas the time required to completely inundate the filter with sediment depends primarily on sediment load.

"In Section 2, a nonsteady state model is presented for determining the sediment filtration of an artificial grass filter under varying flow rates, sediment loads, particle sizes, channel slopes, and media density. Each individual component of the model has been tested in laboratory studies. The model allows prediction of media spacing, channel slope, and length of media to give a desired maximum outflow concentration for given flow conditions and inflow hydrograph. Simulations using the model indicate that for a given set of inputs, the outflow concentration depends on channel slope and spacing until the filter approaches inundation. However, the time to inundation is directly proportional to incoming sediment load." (A)

101. Barfield, B.J.; Hayes, J.C. 1980. Modeling sediment filtration by vegetative filters. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 98-113.

"A vegetative filter design model is described that estimates the filter effectiveness of grass subjected to sediment-laden runoff in a number of laboratory and field studies. This model possesses the capability of serving as a working tool for estimating fraction trapped and outflow concentration as a function of inflow hydraulic and sediment conditions. Additional necessary inputs include the dimensions of the filter and vegetation. Analysis of complex situations where channel slope and grass characteristics change along the filter length is permissible. An additional feature is the capability to recalculate particle size distribution as a function of the sediment trapped in the filter. Evaluation of the model based on verification studies using real grasses in laboratory flumes and in outdoor channels is described. The results from each set of tests indicated that over 94 percent of the inflow sediment load was typically accounted for by this design." (A)

102. Barfield, B.J.; Kao, T.Y.; Tollner, E.W. 1975. Analysis of the sediment filtering action of grassed media. Rep. 90. Lexington, KY: Water Resources Resources Institute, University of Kentucky. 49 p.

"The movement of sediment in non-submerged flow through a rigid grass media was studied experimentally by simulating the media with cylindrical nails. Models of sediment movement were developed from probalistic reasoning and from the use of existing parameters describing total bed material in open channel flow. In the probability analysis, the percent sediment trapped was found to be a power function of the number of potential fall paths, N_f, a particle could make from the surface to the bed while traveling through the filter media. The percent trapped was also found to to be an inverse power function of the Reynolds number Re_T. The characteristic length used in the Reynolds number was a hydraulic radius calculated assuming rectangular open channel flow with a width equal to the spacing between elements and a depth equal to the depth of flow. This is defined as the spacing hydraulic radius, R_s. The percent trapped was finally related exponentially to a combined power function of N_f and Re_T.

"Total bed material transport functions of Graf and Einstein were modified and evaluated as predictors of suspended and bed load. Bed shear was assumed to be equal to YR_sS where Y is the weight density of water and S is channel slope. Both Graf's and Einstein's parameters were found to be good predictors of suspended and bed load.

"Based on the results of the study, procedures are proposed for analyzing the trapping capability of sediment by grass filters." (A)

103. Barnett, A. 1958. How intense rainfall affects runoff and soil erosion. Agricultural Engineering. 39(11): 703-707.

Easily measured rainfull characteristics were correlated with the erosion from 98 intense rain storms to derive a usable mathematical relationship. The factors studied were rainfall amount; duration; maximum 5-, 10-, 15-, 30-, and 60-minute intensities; time of occurrence; runoff; and antecedent soil moisture. Of the rainfall characteristics studied, no single characteristic or combination of chacteristics was found to adequately predict the expected erosion from a given storm. The maximum 60-minute intensity, however, was found to be the single factor most closely related to erosion and accounted for 59.1 percent of the variation in erosion. (C)

104. Barnett, A.P.; Diseker, E.G.; Richardson, E.C. 1967. Evaluation of mulching methods for erosion control on newly prepared and seeded highway backslopes. Agronomy Journal. 59(1): 83-85.

"Evaluation of several mulching methods used by different highway departments showed that 2 tons of grain straw per acre provided adequate protection to newly prepared and seeded 2.5:1 backslopes when subject to 1-year frequency storms, 1.3 inches in 30 minutes. However, when subjected to a 10-year frequency storm, 2.7 inches in 60 minutes, two treatments stood out as superior. These were 'whisker dams', called the Florida method, which permitted 40 percent runoff and 11 tons per acre soil loss.

"In all cases where asphalt spray was a part of the treatment, the effectiveness of mulch was decreased when tested by the 10-year frequency storm. Runoff and soil loss from mulch and mulch plus asphalt were 1.1 inches and 11 tons per acre and 1.3 inches and 32 tons per acre, respectively. Mulch mixed and mulch mixed plus asphalt were the same—1.3 inches and 27 tons per acre—indicating that the asphalt had no beneficial effect.

"The California method was a checkerboard arrangement of straw pressed into the surface. This treatment was inferior to the 'whisker dams' because the staggered arrangement permitted more soil transport by overland flow. Runoff and soil loss for these two treatments were 1.2 inches and 44 tons per acre and 1.1 inches and 10 tons per acre, respectively.

"Bare, unprotected backslopes eroded at the rate of 97 tons per acre and permitted 62 percent runoff. Six months or more after planting, satisfactory stands had been established with all mulch treatments." (A)

105. Barton, B.A. 1977. Short-term effects of highway construction on the limnology of a small stream in southern Ontario. Freshwater Biology. 7: 99-108.

"A limnological investigation was carried out to document the effects of constructing a modern highway across a small stream in southern Ontario. During construction, suspended solids increased to as high as 1390 mg/l but later returned to pre-construction levels of <5 mg/l. Similiarly, sediment deposition increased tenfold to 0.61 g dry wt/ cm^2 day directly below the construction site during stream rechannelization after completion of the culvert. Decreased proportion of organic matter in sediments indicated that they came from the construction site. Sediments were readily removed by spates and apparently settled out in downstream ponds. There was no change in water chemistry...." (A)

106. Becker, B.C.; Mills, T.R. 1972. Guidelines for erosion and sediment control planning and implementation. Environ. Prot. Tech. Ser. EPA-R2-72-015. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Monitoring. 243 p.

"The principal purpose of the 'Guidelines' is to help those responsible for, or engaged in, urban construction prevent the uncontrolled movement of soil and the subsequent damage it causes. The 'Guidelines' presents a comprehensive approach to the problem of erosion and sediment control from beginning of project planning to completion of construction. It provides (1) a description of how a preliminary site evaluation determines what potential sediment and erosion control problems exist at a site being considered for development, (2) guidance for the planning of an effective sediment and erosion-control plan, (3) procedures for the implementation of that plan during operations.

"Technical information on 42 sediment and erosion control products, practices, and techniques is contained in four appendices. In addition, a cross-index and a glossary of technical terms used in the document are provided." (A)

107. Bell, M.A.M.; Brown, J.M.; Hubbard, W.F. 1974. Impact of harvesting on forest environments and resources. For. Tech. Rep. 3. Ottawa, ON: Canadian Forestry Service, Department of the Environment. 237 p.

This bibliography of 1,608 references is intended to facilitate retrieval by researchers and managers of information on the influence of harvesting and related practices on forest ecosystems and on forest land values. Articles originate from British Columbia, from adjacent areas in Canada and the United States, and from ecologically analagous areas in other parts of the world. References are grouped under five major headings: felling, extraction, hauling, site treatment, and timber management in relation to other uses. (C)

108. Bennett, F.W.; Donahue, R.L. 1976. Techniques of researching information for the development of a manual to vegetate soils of low productivity disturbed by construction activities. In: Proceedings, 3d Federal interagency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-148 to 2-157.

"This paper explains the strategy, planning procedure, resource personnel used, documentation, and special problems encountered by the Midwest Research Institute in the process of developing a manual under contract with the United States Environmental Protection Agency on vegetating soils of low productivity disturbed by construction activities. The manual emphasizes the control of soil erosion and the reduction in emission of sediment. Persons, agencies, and institutions contacted for resource information totalled 203, and more than 1000 documents were studied, 420 of which were considered sufficiently useful to be included in the references." (A)

109. Bennett, J.P. 1974. Concepts of mathematical modeling of sediment yield. Water Resources Research. 10(3): 485-492.

"A deterministic structure imitating a sediment yield model should mathematically approximate the behavior of two distinct phases of the phenomenon, the upland phase and the lowland channel phase. For upland erosion, research is most needed in quantifying gully erosion, whereas for lowland streams it is most needed to explain the influence of meanders on bed material transport and to develop a floodplain accounting component. In both phases, research is needed to explain the effects of unsteadiness and flow nonuniformities on transport. Sensitivity analysis studies of sediment yield models are needed to illustrate how well the models can be calibrated and what ouput precision can be expected from input data with known statistical characteristics. Present estimates indicate that although a regression of annual sediment discharge on annual water discharge might be expected to give a prediction within 20 percent of the observed value, even a well-calibrated digital model might give an error greater than 40 percent for a single storm on a small watershed." (A)

110. Benoit, C.R. 1978a. Fluvial sediment delivery as percent of erosion: the relationship between landslope and effective streamside buffer strip width. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 3 p. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Region 6, Portland, Oregon.

A nomograph was developed as an interpretation of data on quantified erosion and fluvial sediment collected from forested lands in the Tillamook, Oregon, and the Yakima and Entiat, Washington, U.S. Department of Agriculture River Basin Studies. The nomograph was developed from 39 observations on areas with significant erosion resulting from roads, landslides, or fire disturbance. (C)

111. Benoit, C.R. 1978b. Soil and water effects from applied use of the Peewee Yardee, Pack Forest, Washington. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, State and Private Forestry. 13 p. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Region 6, Portland, Oregon.

"Water Yield—there was no measurable increase in water yield from the area due to the low intensity of the thinning and the use of the increased soil moisture by a viable residual stand.

"Soil Compaction—there was a slight but measurable increase in soil compaction from the thinning. The greatest impact was at the yarder landing sites. Bulk density greater than 1.10 g/cc greatly reduces root penetration.

"Erosion—gross erosion on the 40-acre study area increased 303.4 pounds the first year or 60 percent. However, 300 pounds or about 99 percent of the increase was directly attributable to the yarder access road landings. The balance of 3.4 pounds occurred within the actual thinned areas and was primarily evident on the skyline corriders where full suspension was not achieved due to inadequate deflection.

"Sediment—the gross mean annual fluvial sediment increased from 25 to 88 pounds on the 40 acres. However, about 98 percent of this originates from the skid road and yarder landings. This road resulted in a 246 percent increase in pretreatment sediment yield....

"The Peewee Yarder is an environmentally superior machine based on its effects on soil compaction, soil erosion, and the fluvial sediment parameter of water quality resulting from the Pack Forest commercial thinning experiment. However, it is important to realize that other running skyline yarding systems would also produce similar beneficial environment effects, when properly used, to the soil and water resource." (A)

112. Beschta, R.L. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. Water Resources Research. 14(6): 1011-1016.

"Suspended sediment production after road construction, logging, and slash disposal was significantly increased (P=0.95) on two watersheds in Oregon's Coast Range. A 25% patch-cut watershed showed increases during 3 of 8 posttreatment years. These increases were caused primarily by mass soil erosion from roads. Monthly sediment concentrations before the occurrence of the annual peak flow were increased more than those following the annual peak. Surface erosion from a severe slash burn was the primary cause of increased sediment yields for 5 posttreatment years on a watershed that was 82% clearcut. Monthly sediment concentrations were generally increased throughout the winter runoff period on this watershed. The flushing of suspended sediment in Oregon Coast Range watersheds is apparent from seasonal changes of suspended sediment rating curves." (A)

113. Beschta, R.L. 1980. Turbidity and suspended sediment relationships. In: Symposium on watershed management 1980 April 21-23; Boise, ID. New York: American Society of Civil Engineers: 271-282.

"Turbity and suspended sediment concentrations were analyzed for streams draining three forested watersheds in western Oregon. At the Oak Creek and Flynn Creek watersheds, suspended sediment concentration and turbidity correlated significantly (90% confidence level) for 24 of 26 storm events, confirming suspended sediment as the most important factor influencing the turbidity of Oregon's Coast Range streams. Correlation developed for an individual period of storm flow, however, usually differed significantly from correlations for other streamflow periods. Futhermore, relationships between suspended sediment and turbidity were significantly different between drainages, illustrating that prediction equations must be developed on a watershed-by-watershed basis. At Oak Creek, the correlation between suspended sediment and turbidity did not differ significantly from year to year over a three-year period." (A)

114. Beschta, R.L. 1981. Patterns of sediment and organic sediment and organic-matter transport in Oregon Coast Range streams. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 179-188.

"The concentrations of suspended sediment during periods of storm runoff in Oregon's coastal streams are related to streamflow, rate of streamflow rise and fall, and the sequence of storm events. Bedload transport of particles >0.2 mm increases with streamflow, but rates of transport fluctuate greatly during the recession phase of a storm hydrograph. Coarse particulate organic matter (>0.2 mm) may comprise 10 to 50 percent of the material transport along the stream bottom." (A)

115. Bethlahmy, N. 1967. Effect of exposure and logging on runoff and erosion. Res. Note INT-61. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 7 p.

"High-intensity rainfall was applied artificially to plots on eight steep, forested areas in the Payette National Forest in central Idaho. Logged and unlogged sites on northeast and southwest exposures were represented equally. Results show that runoff and erosion are greater on southwest than on northeast exposures, and that even after careful logging, erosion increases on southwest but not significantly on northeast exposures." (A)

116. Bethlahmy, N.; Kidd, W.J., Jr. 1966. Controlling soil movement from steep road fills. Res. Note INT-35. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 4 p.

"Eight test plots were established on the fill slope of a newly constructed road. One plot was retained as a control, while different soil stabilizing treatments were used on each of the other plots. These consisted of various combinations of seeding, fertilizing, mulching, and surface netting. Treatments that included both straw mulch and netting effectively controlled erosion." (A)

117. Bevan, K. 1981. The effect of ordering on the geomorphic effectiveness of hydrologic events. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 510-527.

"A certain confusion exists between geomorphic effectiveness as defined by Wolman and Miller (1960) and as defined by Wolman and Gerson (1978). The difference between the concepts is discussed and it is shown that both definitions are limited in practical application to specific cases. The problems of defining effectiveness are illustrated with reference to a theoretical analysis of some simple systems containing geomorphic threshold components. In particular it is shown that event interarrival times and event ordering may play an important role in governing the resulting 'effectiveness' of an event." (A)

118. Bjornn, T.C.; Brusven, M.A.; Molnau, M.P. [and others]. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Bull. 17. Moscow, ID: Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences, University of Idaho. 43 p.

"We assessed the transport of granitic bedload sediment (<6.35 mm diameter) in streams flowing through central Idaho mountain valleys and the effects of the sediment on juvenile salmonids and aquatic insects. We measured bedload sediment transported in the streams during the spring snowmelt runoff and the summer low-flow periods for 2 years, to test the applicability of the Meyer-Peter, Müller equation for estimating such transport. In both years the streams transported all the sediment available, including that under the armor layer of the stream bottom in the first year. The modified Meyer-Peter, Müller equation proved accurate in estimating the transport capacity of such streams using measurements of slope, hydraulic radius and mean diameter of streambed material.

"In artificial stream channels, benthic insect density in fully sedimented riffles (>2/3 cobble imbeddedness) was one-half that in unsedimented riffles, but the abundance of drifting insects in the sedimented channels was not significantly smaller. In a natural stream riffle, benthic insects were 1.5 times more abundant in a plot cleaned of sediment, with mayflies and stoneflies 4 and 8 times more abundant, respectively. Riffle beetles (Elmidae) were more abundant in the uncleaned plot.

"During both summer and winter, fewer fish remained in the artificial stream channels where sediment was added to the pools. The interstices between the large rocks in the pools provided essential cover necessary to maintain large densities of fish. Fish in sedimented channels exhibited hierarchical behavior, while those in unsedimented channels were territorial in behavior. In small natural pools (100 to 200 m^2), a loss in pool volume or in area deeper than 0.3 m from additions of sediment resulted in a proportional decrease in fish numbers. We did not, however, find significant correlations between riffle sedimentation and fish density in the two natural streams we studied. Fish abundance was significantly correlated with insect drift abundance in one stream, but not in the other. The amounts of sediment in the two streams studied did not have an obvious adverse effect on the abundance of fish or the insect drift on which they feed." (A)

119. Blackbourn, R.A. 1975. Grasses & legumes for erosion control. Eugene, OR: Upper Willamette Resource Conservation & Development Project. 53 p.

"This booklet has been prepared at the request of the Woodland Committee of the Upper Willamette Resource Conservation & Development Project. The RC&D Project is an over-all program for accelerating resource development of the Project Area—-Benton, Lane, Lincoln and Linn counties.

"The publication, using pictures, charts and tables, was prepared to acquaint you with examples and causes of erosion. It also illustrates how it can be controlled through the use of vegetation." (A)

120. Blackburn, W.H. 1980. Universal soil loss equation and rangelands. In: Symposium on watershed management 1980; 1980 April 21-23; Boise, ID. New York: American Society of Civil Engineers: 588-597.

"Several soil erosion prediction models have been developed during the past 40 years. The Universal Soil Loss Equation (USLE) is the most widely used model. This model was designed to predict average annual sheet and rill erosion from cropland east of the Rocky Mountains (Wischmeier and Smith 1965), and does not account for soil deposition or gully, streambank, and streambed erosion. The USLE as now used has been studied and refined for more than two decades and is generally considered the state-of-the-art erosion model.

"The USLE erosion model is designed to predict the long-term average field soil losses in runoff under specified conditions. This model enables planners to estimate the average rate of soil erosion for each feasible alternative combination of crop system and management practices in association with a specified soil type, rainfall patterns, and topography. When these predicted losses are compared with given soil loss tolerances, they provide specific guidelines for effecting erosion control within specified limits (Wischmeier and Smith 1978).

"The Environmental Protection Agency's identification of sediment as the nation's number one pollutant, water quality planning as a result of section 208 (Federal Water Pollution Control Act Amendments of 1972, PL 92-500), and additional pressures for more intensive management of western rangelands, has created the need for a soil erosion prediction model. Because of this demand the USLE has been expanded to include western crops, range and forest lands." (A)

121. Bockheim, J.G.; Ballard, T.M.; Willington, R.P. 1975. Soil disturbance associated with timber harvesting in southwestern British Columbia. Canadian Journal of Forest Research. 5: 285-290.

"Soil disturbance associated with timber harvesting was evaluated in five localities in southwestern British Columbia, along transects located away from main haul roads and associated sidecast soil material. Small skid trails and associated sidecast material were included in the evaluation. Of the several disturbance indices evaluated, the percentage of area occupied by exposed mineral soil (EMS) appears to be most useful. For 13 high-lead logged sites, EMS averaged 29% and ranged from 5 to 56%. Low EMS (9%) was associated with a high-lead site logged over snow. High EMS was associated with steep slopes (greater than 70%) and shale-rich soils. Less disturbance occurred on soils derived from granitic parent materials. On two tractor-logged sites with 25 to 60% slopes, EMS was 71 and 68%, respectively. On a helicopter-logged site, EMS was only 5%. These data are compared to estimates of soil disturbance caused by logging in other regions of western North America." (A)

122. Bordas, M.P.; Canali, G.E. 1980. The influence of land use and topography on the hydrological and sedimentological behaviour of basins in the basaltic region of south Brazil. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 55-60.

"Small experimental basins were instrumented to measure outflows of water and sediment associated with daily rainfall for the purpose of estimating sedimentation risks in reservoirs located in a region with relatively steep topography where deforestation is common. The results obtained during the first six months show that the erosion rate in deforested areas was more than 4500 times greater than for those with natural cover (1 kg km^{-2} $month^{-1}$), that slope steepness had little effect on erosion rate under forest cover, and that land use changes brought about by agriculture would have a greater effect on erosion than the topography. These conclusions were also valid for surface runoff production; in this case the first consequence of deforestation was to increase the surface runoff coefficients by more than three. The data also provided opportunities for simulating the hydrological and sediment responses of three experimental basins for three types of rainfall." (A)

123. Boughton, W.C. 1976. Runoff and erosion. In: Heady, H.F.; Falkenborg, D.H.; Riley, J.P., eds. Watershed management on range and forest lands: Proceedings, 5th workshop of the United States/Australia rangelands panel; 1975 June 15-22; Boise, ID. Logan, UT: Utah Water Research Laboratories, College of Engineering, Utah State University: 117-122.

"The subjects of runoff and erosion are both wide in scope. In order to cover runoff with clarity in the limit of this paper, the subjects of water yield and floods are discussed separately. The quantity of water yield from a catchment which is available for practical use is determined by sustained periods of low flow in protracted droughts; while at the other extreme, floods occur in very short periods of very high rainfall and runoff. From the viewpoint of management of watersheds, it is simplest to consider these as separate issues under the headings: Water Yield and Floods.

"The effects of range and forest management on erosion are well known in qualitative terms from rationalized experience of conservation activities over many years. But at the present time, there is no established knowledge in Australia for quantitative management of sediment production, transport, and deposition. Research activity which could improve this situation is minimal.

"Considering research over the whole field of runoff and erosion, most research effort in Australia would be directed towards water yield and least effort towards erosion. When it is considered that the factors which influence the overall water balance and water yield are best understood and those which influence erosion are least understood, it seems that research interest is attracted to those areas where some success seems most likely." (A)

124. Bowie, A.J.; Bolton, G.C.; Spraberry, J.A. 1975. Sediment yields related to characteristics of two adjacent watershed. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 89-99.

Runoff, sediment yield, and land use data were evaluated for two similar watersheds in northern Mississippi. Although average precipitation on the two watersheds was about the same for the 14-year period studied, runoff and sediment yields on watershed 5 were approximately double those on watershed 4. Sediment yield per inch of runoff, however, was essentially the same on the two watersheds. The results of this study provide a good example of how closely sediment yield is related to runoff and of the difficulty of predicting runoff from ungaged watersheds. (C)

125. Brna, P. 1977. Forest management effects on the environment: a bibliography. Tech. Note. Denver, CO: U.S. Department of the Interior, Bureau of Land Management. 23 p.

"This bibliography contains a listing of research conducted mainly on the western United States detailing effects of timber management (with special emphasis on the Colorado riparian) on the environment. Intended primarily for use by the Colorado State Office of the Bureau of Land Management, it contains references which may be useful in areas other than the Central Rocky Mountain Region." (A)

126. Brookes, W.M.; Cline, R.G. 1979. Linear program evaluation of management alternatives using literature-landform based sediment values: a method. Soil-Air-Water Note 79-1. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 9 p.

"Sediment production from a variety of landforms was estimated using literature sources to determine natural (undisturbed) rates on similar landforms. Landforms were ranked according to estimated erosion hazard and natural erosion rates applied to each, keeping values within two standard deviations of the mean derived from literature. Sediment acceleration factors derived from literature for various management activities were applied to estimated natural landform based rates. The resultant values were used in a linear program to estimate sediment production for alternative mixes of management activities. These values were also used to impose constraints on the linear program." (A)

127. Brooks, F.L.; Turelle, J.W.; Wischmeier, W.H.; McCool, D.K. 1975. Universal Soil Loss Equation. Conserv. Agron. Tech. Note 32. Portland, OR: U.S. Department of Agriculture, Soil Conservation Service, West Technical Service Center. 12 p.

This report describes data that must be available to adapt the Universal Soil Loss Equation to environmental conditions existing west of the Rocky Mountains. The point is made that while some data are available, other information will have to be developed on a State-by-State basis. (C)

128. Brown, G.W. 1973. The impact of timber harvest on soil and water resources. Ext. Bull. 827. Corvallis, OR: Oregon State Extension Service, Oregon State University. 16 p.

The diversity of impacts that timber harvesting may exert on soil and water resources is illustrated. The impacts discussed and the practices that cause them are neither uniformly good nor bad, but depend on the specific situation. (C)

129. Brown, G.W. 1980. Forestry and water quality. Corvallis, OR: OSU Book Stores, Oregon State University. 124 p.

"...water flow is a key component of the environment, linking together the atmosphere, soil, plant community, and stream compartments of this system. Understanding the processes which affect water quality in forest streams presupposes an understanding of these hydrologic processes, for water acts as a carrier of materials and energy between the atmospheric and terrestrial portions of the system and the stream. Examples of this 'carrier' function of water are the erosion of soil particles and leaching of certain soil nutrients, fertilizers, and pesticides through the forest soil to the stream." (A)

This text includes a 38-page chapter "Erosion and Sedimentation in Forested Watersheds." (C)

130. Brown, G.W.; Krygier, J.T. 1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resources Research. 7(5): 1189-1198.

"The impact of road construction, two patterns of clear-cut logging, and controlled slash burning on the suspended sediment yield and concentration from three small watersheds in the Oregon Coast Range was studied for 11 years. Sediment production was doubled after road construction but before logging in one watershed and was tripled after burning and clear-cutting of another watershed. Felling and yarding did not produce statistically significant changes in sediment concentration. Variation in the relation between sediment concentration and water discharge on small undisturbed streams was large. Conclusions about the significance of all but very large changes in sediment concentration are limited because of annual variation for a given watershed, variation between watersheds, and variation with stage at a given point." (A)

131. Brown, H.E.; Hansen, E.A.; Champagne, N.E. 1969. A system for measuring total sediment yield from small watersheds [Mimeo]. Paper presented at fall meeting, American Geophysical Union; 1969 December 15-18; San Francisco, CA. 18 p. On file with: Institute of Northern Forestry, Fairbanks, Alaska.

"Design and calibration data are presented from eight sediment-measuring installations that have been constructed and tested by the U.S. Forest Service on the Beaver Creek Pilot Watershed in Arizona. Each installation includes a low dam and basin to trap coarse sediments, and a series of splitters that collect a representative portion of the suspended sediment leaving the basin. The first splitter, a Barnes runoff sampler, is a sharp-edged slot, extending downstream from the dam spillway. With a 12-foot-wide spillway, it extracts a theoretical split of 1/600 of the total volume of flow. The second splitter, an inclined slot mounted at the lower end of the Barnes sampler, extracts a theoretical 0.1 sample. The sample, 1/6000, enters an intermediate storage tank which leads from the middle of the stream channel to a final storage tank on the bank. The third splitter is a single slot, extracting a 0.1 sample, mounted below a small rectangular weir in the end of the intermediate tank. The slot, which carries a 1/60,000 sample, enters the final storage tank. Calibration data are presented to characterize sampler performance, and a procedure is outlined for calculating total sediment yield. Errors in estimating total sediment are usually less than 18%." (A)

132. Brown, R.W.; Johnston, R.S. 1978. Rehabilitation of alpine tundra disturbances. Journal of Soil and Water Conservation. 33(4): 154-160.

Some activities that create surface disturbances in alpine tundra are identified, and factors affecting rehabilitation are discussed. Subjects include the characteristics of alpine tundra; climate; geology and soils; vegetation; adaptations required by plants; plant breeding potential; rehabilitation of alpine disturbances; and some rehabilitation recommendations concerning contouring and shaping, revegetation, and post-planting management. (C)

133. Brown, W.M. 1976. Sediment problems and planning in the San Francisco Bay region, California. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-149 to 1-162.

"A procedure has been developed to define the relations among terrain properties, human activities, and erosional and depositional processes and problems. The procedure involves four basic steps: (1) Identifying the critical physical elements that control erosion of the land, the transport of eroded materials, and the deposition of transported material; (2) analyzing the land surface using high-resolution aerial imagery; (3) mapping the erosional and depositional features and provinces; and (4) developing a planning matrix that relates land use to human activity. The procedure has been applied in the San Francisco Bay region, California, and the Willamette River Basin, Oregon." (A)

134. Brown, W.M.; Hines, W.G.; Rickert, D.A.; Beach, G.L. 1979. A synoptic approach for analyzing erosion as a guide to land-use planning. Circ. 715-L. Arlington, VA: U.S. Department of the Interior, Geological Survey. 45 p.

"A synoptic approach has been devised to delineate the relationships that exist between physiographic factors, land-use activities, and resultant erosional problems. The approach involves the development of an erosional-depositional province map and a numerical impact matrix for rating the potential for erosional problems. The province map is prepared by collating data on the natural terrain factors that exert the dominant controls on erosion and deposition in each basin. In addition, existing erosional and depositional features are identified and mapped from color-infrared, high-altitude aerial imagery. The axes of the impact matrix are composed of weighting values for the terrain factors used in developing the map and by a second set of values for the prevalent land-use activities. The body of the matrix is composed of composite erosional-impact ratings resulting from the product of the factor sets. Together the province map and the problem matrix serve as practical tools for estimating the erosional impact of human activities on different types of terrain. The approach has been applied to the Molalla River Basin, Oregon, and has proven useful for the recognition of problem areas. The same approach is currently being used by the State of Oregon (in the 208 assessment of nonpoint-source pollution under Public Law 92-500) to evaluate the impact of land-management practices on stream quality." (A)

135. Bryan, R.B. 1968-69. The development, use and efficiency of indices of soil erodibility. Geoderma. 2: 5-26.

"The development and use of indices of soil erodibility during the past thirty years are reviewed. The ambiguous record of some of the indices is noted, and a theoretical assessment is made of their validity and limitations. Testing of index efficiency against a standard reference of soil loss from samples subjected to artificially simulated rainfall is described. The efficiency of each index is measured by statistical analysis, and the most efficient indices of soil erodibility are shown to be percentage-weight of water-stable aggregates (W.S.A.) >3 mm, percentage-weight of W.S.A. >0.5 mm, erosion ratio, surface-aggregation ratio, modified surface-aggregation ratio, and clay ratio. Further statistical analysis is used to show that percentage-weight of W.S.A.>3 mm, is the only completely reliable index or erodibility." (A)

136. Bryan, R.B. 1977. Assessment of soil erodibility: new approaches and directions. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 57-72.

"Most of the indices of soil erodibility proposed over the past 45 years were designed for agricultural purposes and, though differing in detail, essentially were based on one concept of the erosion process. In this, the soil surface was envisaged as dominated by discrete non-coherent particles, either in the form of textural separates or aggregates. Entrainment could be by raindrops or runoff, but the main transporting agent was Hortonian runoff generated by restricted infiltration. Indices accordingly stressed particle size as determining erosion resistance, and properties influencing infiltration as determining the amount and frequency of runoff. Some indices, notably aggregation measures, have been demonstrated as highly efficient, but only in tests conforming to the same erosional concept, in which soils are dominated by discrete particles and very high intensity rainfall generates Hortonian runoff.

"The indices based on this erosional concept are open to criticism on several counts. Firstly, Hortonian runoff is rather rare, especially in humid mid-latitude regions; but runoff is quite frequently generated in the form of saturated overflow. This is commonly completely unrelated to soil infiltration characteristics. Secondly, emphasis on particle size assumes homogeneous particles and a direct relationship between size and weight. This assumption is manifestly incorrect. Thirdly, the traditional erosional concept envisages the entrainment of submerged particles. Recent work suggests that much thinner and more frequently recurring flows may be competent to entrain material which projects into or through the flow. In these circumstances particle shape and size may be highly significant.

"Assumption of surfaces dominated by discrete particles may be justified on agricultural soils. Interest in erodibility, however, now extends well beyond agriculture. Assessment of erodibility is significant in forestry operations, wildlife habitat management, and recreational carrying capacity planning, and most particularly in any consideration of the processes of hillslope development. In all these cases the surface is most commonly not dominated by discrete particles, but by a coherent soil body, except after long exposure to weathering. In these cases the only soil property of significance in erodibility should be the shearing strength. The present extended applications of erodibility assessment would appear to require development of new indices of erodibility based on this property." (A)

137. Buckhouse, J.C.; Gifford, G.F. 1976. Sediment production and infiltration rates as affected by grazing and debris burning on chained and seeded pinyon-juniper. Journal of Range Management. 29(1): 83-85.

"Sediment production and infiltration rates were measured in conjunction with an analysis of burning and grazing treatments in a chained Pinyon-Juniper study in southeastern Utah. While high natural variability was present among sites, no significant changes in sediment production were detected following our prescribed burning or grazing treatments. Following treatment, however, both the burned and grazed sites exhibited significantly depressed infiltration rates during certain time intervals in comparison to the 'undisturbed, natural' woodland control location." (A)

138. Bullard, W.E. 1965. Effect of highway construction and maintenance on stream sediment loads. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 52-56.

"Thousands of miles of freeway, highway, country road, and forest access roads are built in the United States every year. Nearly every foot of this construction is in a watershed and except for overpasses and viaducts and bridges, nearly every foot of it involves soil disturbance. Whenever there is soil disturbance, there is a potential sediment source. Too often in highway construction this potential is realized; disturbed soil erodes and erosion products are carried to streams and become damaging sediments. Maintenance operations subsequent to construction often accelerate the process....This paper describes the adverse effects of road construction and maintenance on stream sediment loads and points out how to avoid or reduce them." (A)

139. Burgess, J.S.; Rieger, W.A.; Olive, L.J. 1981. Sediment yield change following logging and fire effects in dry sclerophyll forest in southern New South Wales. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 375-385.

"Changes in sediment yield following fire and logging of dry sclerophyll forest in southern New South Wales have been substantial. Most of the load increases in the forested catchment are attributed to erosion of logging roads while increases in load following burning are considered a function of the complete removal of ground cover. It is suggested that sediment loads following fire will be more substantial than those following clear-fell logging given similar flow regimes." (A)

140. Burroughs, E.R., Jr.; Chalfant, G.R.; Townsend, M.A. 1976. Slope stability in road construction: a guide to the construction of stable roads in western Oregon and northern California. Portland, OR: U.S. Department of Agriculture, Bureau of Land Management, Oregon State Office. 103 p.

"There is no question that road construction is an extremely important activity in western Oregon and northern California. Many thousands of man hours are expended each year to locate, design, construct, and maintain road systems. The construction of stable roads can sometimes be difficult because of the steep terrain, weak geologic material, and the heavy winter rainfall that is common to the coastal mountains. Road failures can exert a tremendous impact on natural resources and can cause serious economic losses because of blocked streams, degraded water quality, destroyed bridges, ruined spawning sites, lowered productivity of forest lands, and damage to private property. It is vital that those personnel engaged in road building activities be aware of the basic principles of slope stability and understand how these principles can be used to construct stable roads through various geologic materials with specific conditions of slope and soil.

"This booklet presents a general outline of the geology of western Oregon and northern California to provide a background for discussion of specific problems of road construction. Basic slope stability is illustrated by a description of the balance of forces that exists in undisturbed slopes, how these forces change as the road is constructed, and how ground water affects slope stability and causes road failures. The final section of this publication discusses techniques for constructing stable roads on specific geologic materials and soils. Several appendices are included which discuss certain concepts in soil mechanics in greater detail together with basic techniques in slope stability analysis for those readers who desire this information." (A)

141. Burton, T.M.; Turner, R.R.; Harriss, R.C. 1977. Suspended and dissolved solids exports from three north Florida watersheds in contrasting land use. In: Watershed research in North America: workshop to compare results; 1977 February 28-March 3; Edgewater, MD. Edgewater, MD: Chesapeake Bay Center for Environmental Studies, Smithsonian Institution: 471-485. Vol. 2.

"Exports of suspended (SS), volatile suspended (VSS), dissolved (DS), and volatile dissolved (VDS) solids from three north Florida watersheds were monitored from 1973 to 1975. The forested-agricultural water shed exported 40 kg/ha/yr SS, 11 kg/ha/yr VSS, 71 kg/ha/yr DS, and 29 kg/ha/yr VDS. There was a 126-fold increase in sediment exports from the urban watershed, a 28-fold increase in VSS exports, a 6-fold increase in DS, and a 4-fold increase in VDS compared to the forested-agricultural watershed. The low-density suburban watershed exported intermediate amounts of all solids, but these increases were attributable primarily to highway construction within the watershed and are not typical of high forested, low residential areas. The dramatically increased sediment losses resulted in large increases in total and particulate phosphorus exports. Corrective measures to minimize losses from the urban watershed have been undertaken and are discussed briefly." (A)

142. Case, A.B.; Donnelly, J.G. 1979. Type and extent of ground disturbance following skidder in Newfoundland and Labrador. Inf. Rep. N-X-176. St. John's, NF: Newfoundland Forest Research Centre. 25 p.

"Six cutovers throughout Newfoundland and Labrador were investigated one year after logging to determine the type of extent of ground disturbance associated with skidder logging. Data on bulldozed areas were collected by direct measurement, and on unbulldozed portions of cutovers using two hundred 20 m^2 sample plots along parallel line transects.

"Bulldozing exposed mineral soil on 5.9% of the cutover area and left debris on 3.7%, for a total disturbance of 9.6%. Greatest bulldozer disturbance was attributable to extraction roads (including skid-trails). Bulldozing on winter logging operations caused 50-60% less disturbance than on summer-logged areas. The amount of Newfoundland's forest land area that is potentially lost to fibre production through bulldozing was calculated to be 1500-2000 ha/yr. In terms of productivity, the average loss in allowable cut was estimated at 0.15 m^3/ha/yr.

"Ground disturbance on unbulldozed portions of cutover was patchy. About 14% of the area suffered moderate to heavy disturbance of which 3% was exposed mineral soil. About 30% of the unbulldozed cutover suffered some degree of compaction with greatest compaction on unbulldozed landings and skidtrails where it appeared to be limiting successful establishment of softwood regeneration. Up to 4000 ha annually are potentially affected in this manner. Reductions in allowable annual cut due to compaction may amount to 0.36 m^3/ha/yr in second-growth stands.

"Slash cover was relatively moderate and uniformly distributed on most cutovers. Dense accumulations of slash occupied a mean of 29% of the unbulldozed cutover area." (A)

143. Chepil, W.S.; Woodruff, N.P.; Siddoway, F.H.; Armbrust, D.V. 1962. Mulches for wind and water erosion control. Rep. ARS 41-84. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service. 23 p.

Of the mulching materials tested, well-anchored vegetative mulch was the least costly and most effective in controlling wind and water erosion of denuded land. Except for those forming water-soluble surface films, other materials controlled such erosion when applied in sufficient quantity and concentration but at a generally higher cost. Resin-in-water emulsion was the only nonvegetative material that produced a surface film resistant to wind and water erosion yet porous enough for water to percolate and for seedlings to emerge. But the surface film sufficiently retained these characteristics only on sandy and medium-textured soils, not on clays and silty clays. Cutback asphalt, asphalt emulsion, and latex emulsion, when applied in quantities sufficient to control wind and water erosion, produced nonporous films that restricted percolation of water into the soil, thereby reducing emergence of seedlings when soil moisture was inadequate. Excessive dilution of organic and inorganic liquids reduced their effectiveness in controlling erosion. A fine spray produced a more durable film than a coarse spray. Concentrated liquid asphalts had to be heated to produce a fine spray. Materials that produced water-soluble surface films were inadequate for erosion control because the films washed away with the first substantial rain; however these materials might have some benefit in arid regions. Gravel and stone mulches effectively controlled wind erosion, even on dune sand. (C)

144. Clark, R.D. 1980. Use of physical data for estimating sediment yield. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 836-845.

"A method for estimating sediment yield on ungaged watersheds, with little available hydrologic data, has been used for the past ten (10) years in the BLM. The method has been used to quantify sediment for the present and future situations which provides input to environmental-impact statements, resource activity plans, and other proposed land use actions affecting the soil and water resources.

"The inventory data base generally consists of extensive ground cover, soils, erosion condition assessment, surface geology, climate, topographic, and land use data as shown in planning area physical profile documents. Inventory data was the basis for correlating estimates with gaged sediment yield. Data source was incorporated into the Pacific Southwest Interagency Committee (PSIAC) methodology estimates on 17 Watersheds ranging in size from 0.67 to 149.5 square miles in the arid and semi-arid areas of the Western United States.

"Estimates vary from 1.3 to 48.1 percent of calibrated sediment yields depending upon accuracy of sampling hydrologic response units, inventory personnel's technical knowledge and experience, and length of record on calibrated watersheds.

"The method provides a rapid and inexpensive quantitative method to derive reliable estimates of sediment production for comparison of present and planned land uses." (A)

145. Clayton, J.L. 1981. Magnitude and implications of dissolved and sediment elemental transport from small watersheds. In: Baumgartner, D.M., comp., ed. Interior west watershed management: Proceedings of a symposium; 1980 April 8-10; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 83-98.

"A small but increasing number of watershed studies that include information about sediment and dissolved chemical transport, as well as the water balance, provide a framework for evaluating rates of chemical and erosional denudation and nutrient budgeting studies within a watershed. In most large basins of the world, annual dissolved load is considerably less than annual sediment load. However, in small, forested basins, dissolved load generally exceeds sediment load in average runoff years. The interacting effects of climate, vegetation, and parent material influence the relative ratios of dissolved and sediment load. Denudation rates in watersheds can be calculated from total load information if data on precipitation chemistry are available. Natural denudation rates allow evaluation of the magnitude of change in erosion and chemical loss from a watershed following management disturbance. Mass balances of precipitation, stream water and sediment chemistry coupled with changes in elemental storage on the watershed may be used to construct a nutrient budget. Techniques for estimating rates of nutrient supply from rock weathering based upon chemical fluxes are described. Sampling techniques, data analysis to generate annual loads, and requirements for mass balance studies are explored." (A)

146. Clyde, C.G.; Israelsen, C.E.; Packer, P.E. [and others]. 1978. Manual of erosion control principles and practices during highway construction. Hydraul. and Hydrol. Ser. UWRL/H78/02. Logan, UT: Utah Water Research Laboratory, Utah State University. 96 p.

"The MANUAL focuses on techniques for predicting the erosion potential of highway construction sites, and for estimating the effectiveness of various erosion-control measures. A wide variety of erosion-control measures is listed and described, and information that will aid in selecting measures to meet specific site requirements is presented.

"To develop the erosion-control MANUAL on which the project effort was centered, means had to be established for estimating the water and wind soil erosion potentials on highway construction sites and the effectiveness of various measures that might be considered for controlling the erosion. The universal soil loss equation, developed by the Agricultural Research Service, was modified and extended to serve as a basis for estimating water soil loss potentials. An equation developed by Chepil and associates was adapted for estimating wind soil loss potentials. Appropriate maps, graphs, and tables that provide information necessary for the solution of the equations for the United States and Puerto Rico were prepared and included in the MANUAL. Nomographs were constructed and included in the MANUAL for solving the equations and the process illustrated by detailed examples." (A)

147. Colby, B.R. 1963. Fluvial sediments—a summary of source, transportation, deposition, and measurement of sediment discharge. Contributions to General Geology, Geol. Surv. Bull. 1181-A. Washington, DC: U.S. Department of the Interior, Geological Survey. 47 p.

"This paper presents a broad but undetailed picture of fluvial sediments in streams, reservoirs, and lakes and includes a discussion of the processes involved in the movement of sediment by flowing water.

"Sediment is fragmental material that orginates from the chemical or physical disintegration of rocks. The disintegration products may have many different shapes and may range in size from large boulders to colloidal particles. In general, they retain about the same mineral composition as the parent rocks.

"Rock fragments become fluvial sediment when they are entrained in a stream of water. The entrainment may occur as sheet erosion from land surfaces, particularly for the fine particles, or as channel erosion after the surface runoff has accumulated in streams.

"Fluvial sediments move in streams as bedload (particles moving within a few particle diameters of the stream bed) or as suspended sediment in the turbulent particle size and a type of effective shear on the surface of the stream bed. The discharge of suspended sediment depends partly on concentration of moving sediment near the streambed and hence on discharge of bedload. However, the concentration of fine sediment near the streambed varies widely, even for equal flows, and, therefore, the discharge of fine sediment normally cannot be computed theoretically. The discharge of suspended sediment also depends on velocity, turbulence, depth of flow, and fall velocity of the particles.

"In general, the coarse sediment transported by a stream moves intermittently and is discharged at a rate that depends on properties of the flow and of the sediment. If an ample supply of coarse sediment is available at the surface of the streambed, the discharge of the coarse sediment, such as sand, can be roughly computed from properties of the available sediment and of the flow. On the other hand, much of the fine sediment in a stream usually moves nearly continuously at about the velocity of the flow, and even low flows can transport large amounts of fine sediment. Hence, the discharge of fine sediments, being largely dependent on the availability of fine sediment upstream rather than on the properties of the sediment and of the flow at a cross section, can seldom be computed from properties, other than concentrations based directly on samples, that can be observed at the cross section." (A)

148. Copeland, O.L. 1965. Land use and ecological factors in relation to sediment yields. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 72-82.

The relationship between ecological factors, land use, and sediment yield is discussed to highlight some basic tenets that can be used to reduce sediment yield. (C)

149. Copeland, O.L. 1969. Forest Service research in erosion control. Transactions of the American Society of Agricultural Engineers. 12(1): 75-79.

The article presents an overview of USDA Forest Service participation in erosion control research, factors affecting erosion on National Forest lands, practices to prevent erosion, and practices in erosion control. (C)

150. Corinth, R.L. 1965. Effects of watershed characteristics on reservoir sediment deposition. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 59-64.

"This paper attempts to set out a pattern of understanding of sediment movement in Illinois. Sediment measurements within the watershed and the reservoir are combined with knowledge of physical laws to gain understanding of happenings between the sediment-producing areas of a watershed and the deposition in the reservoir. In this 'between' zone, little or no data are available." (A)

151. Costa, J.E. 1977. Sediment concentration and duration in stream channels. Journal of Soil and Water Conservation. 32(4): 168-170.

"Establishment of water quality standards for suspended sediment has been delayed partially by lack of information on sediment persistence in channels. In streams with dominantly suspended sediment loads, suspended sediment concentrations can be studied by correlating these concentrations with turbidity. In the stream studied, both discharge and sediment concentration increase downstream during floods because of the confluence of sediment-laden tributaries. Duration of suspended sediment concentrations in channels is reduced by higher rates of preceding flows, increased volumes of groundwater, and through-flow contributions to flood hydrographs, multi-peaked hydrographs, and sediment concentration peaks preceding water discharge peaks." (A)

152. Cromack, K.; Swanson, F.J.; Grier, C.C. 1978. A comparison of harvesting methods and their impact on soils and environment in the Pacific Northwest. In: Youngberg, C.T., ed. Forest soils and land use: Proceedings, 5th North American forest soils conference; 1978 August; Fort Collins, CO. Fort Collins, CO: Colorado State University: 449-476.

"Effects of forest harvest on soils, vegetation succession, nutrient status, and aquatic (small streams) environment are discussed; a small watershed study (H.J. Andrews Watershed 10) is summarized as an exemplary case study." (A)

153. Cruse, R.W.; Larson, W.E. 1977. Effect of soil shear strength on soil detachment due to raindrop impact. Soil Science Society of America Journal. 41(4): 777-781.

"Soil strength was altered in three different ways to test the hypothesis that soil splash from raindrop impact is related to soil strength parameters. Bulk density changes were used to alter direct solid particle-to-particle contact; changes in matric potential were used to change contact relations between soil particles and liquid films; and additions of polyvinyl alcohol (PVA) provided a direct bonding mechanism between solid particles. The amount of soil detached by a single simulated 4.8 millimeter raindrop falling from a height of 177 centimeters was closely correlated with the shearing strength as measured by a triaxial compression test." (A)

154. Curtis, N.M.; Darrach, A.G.; Sauerwein, W.J. 1977. Estimating sheet-rill erosion and sediment yield on disturbed western forest and woodlands. Woodland 10. Portland, OR: U.S. Department of Agriculture, Soil Conservation Service, West Technical Service Center. 33 p.

Use of the universal soil-loss equation for computing sheet-rill erosion on disturbed forest lands is described in detail. The equation SD = 1 - (L/(50 + 4S)), where SD is sediment delivery ratio, L is slope length from beginning of buffer strip to channel, and S is percent slope of buffer strip, is suggested for computation of a sediment-delivery ratio when estimating sediment yield. (C)

155. Cushwa, C.T.; Hopkins, B.S. 1971. Soil movement in established gullies after a single prescribed burn in the South Carolina Piedmont. Res. Note SE-153. Asheville, SC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 4 p.

"The effect of prescribed burning on soil movement in 25 established gullies was studied on Sumter National Forest, South Carolina. One intense backfire in Piedmont pine communities did not have a measurable effect on soil movement in these gullies." (A)

156. Cuskelly, S.L. 1969. Erosion-control practices on National Forest lands. Transactions American Society of Agricultural Engineers. 12(1): 69-70, 85.

A general description of watershed rehabilitation techniques used in the Intermountain Region of the USDA Forest Service is presented. (C)

157. Czapowskyi, M.M. 1976. Annotated bibliography on the ecology and reclamation of drastically disturbed areas. Gen. Tech. Rep. NE-21. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 98 p.

"This bibliography contains 591 annotated references to literature, mainly on mining effects and reclamation in the coal regions of the United States. Each reference is indexed by area, material (coal, ore waste, etc.), and general subject." (A)

158. Daniel, T.C.; McGuire, P.E.; Stoffel, D.; Miller, B. 1979. Sediment and nutrient yield from residential construction sites. Journal of Environmental Quality. 8(3): 304-308.

"Runoff from three residential construction site watersheds in southeastern Wisconsin was monitored for a 2-year period. Automatic water quality monitoring equipment was established which sampled each event proportional to flow. Loading rates for sediment and nutrients were developed on an event basis and summed to produce annual loads.

"Concentrations for suspended solids (SS), organic plus exchangeable N[(Or + Ex)-N], and total P preceded and paralleled the flow rate during runoff events. With the exception of nitrate plus nitrite nitrogen (NO_3 + NO_2)-N, the soluble water quality parameters were independent of flow. Commonly, the (NO_3 + NO_2)-N concentration was 1.0 mg/liter and varied inversely proportional to flow. The most common concentrations of dissolved phosphorus and ammonium were 0.05 and 0.10 mg/liter, respectively.

"Average sediment yield for the three single land use watersheds was 19.2 metric tons/ha per year. Concentrations of 60,000 mg/liter SS were observed for major events; 15,000 to 20,000 mg/liter were common for moderate events. Regression analyses of several independent variables identified flow (Q) as the single most important variable examined for explaining sediment load. Considered in combination, the product of flow and flow rate (Qqp) best explained sediment yield (r^2 = 0.62).

"Yields of contaminants from residential construction sites are inherently variable and site dependent. Strict extrapolation or comparison of results to other areas or existing literature values is difficult. However, when compared to runoff data from a simultaneous agricultural watershed investigation, the yield of contaminants from construction sites is considerably higher (19.2 vs. 1 metric ton/ha per year of sediment)." (A)

159. Darrach, A.G.; Curtis, N.M., Jr.; Sauerwein, W.J. 1978. Estimating sheet-rill erosion and sediment yield on rural and forest highways. Woodland 12. Portland, OR: U.S.Soil Conservation Service, West Technical Service Center. 41 p.

"A procedure to evaluate sheet and rill erosion on rural and forest roadways has been developed. This method, which utilizes the universal soil loss equation (USLE), can be of value to those working on the evaluation of nonpoint pollution in Section 208 Planning. It should also be a valuable tool in assisting managers responsible for roadway design and maintenance." (A)

160. Davis, R.C. 1977. Controlling the water quality impact of timber harvesting oper-rations in the eastern slopes. In: Swanson, R.H.; Logan, P.A., eds. Alberta watershed research program proceedings; 1977 August 31-September 1; Edmonton, AB. Inf. Rep. Nor-X-176. Edmonton, AB: Northern Forest Research Centre, Forestry Service, Fisheries and Environment Canada: 320-335.

"The Alberta Forest Service attempts to minimize the water quality impact of timber harvesting in the eastern-slopes region through the implementation of operational programs of watershed management. Watershed management considerations are integrated at the planning and operational stages of logging operations to minimize the impairment of water quality.

"Inorganic sediment, when it is the product of accelerated erosion, is the main water pollutant associated with timber harvesting. The most frequent source of stream sedimentation from logging is the erosion of haul roads. Planning the location and design of roads to maximize their stability and to avoid the disturbance of stream channels and implementing effective erosion-control measures during and shortly after construction will reduce the amount of stream sedimentation.

"Protection of the small watercourses that are associated with the cut-blocks is essential to control sedimentation of larger streams having important fishery and recreation values. Controls are, therefore, placed on log-skidding and scarification operations to minimize the disturbance of intermittent and small permanent streams. Protection of the large streams involves the provision of buffer strips.

"In order to control the accelerated erosion of stream channels, controls are placed on the area of a watershed that can be cut-over as well as on the location of cut-blocks." (A)

161. Dawdy, D.R. 1967. Knowledge of sedimentation in urban environments. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. HY6: 235-245.

"During the 50 yr from 1910 to 1960 the population of the United States has grown from 92,000,000 to 180,000,000, an increase of 96%. During the same period, the urban population has grown from 41,000,000 to 110,000,000, an increase of 168%. The growth in population has exerted a stress on the environment, with greatest stress being exerted on the urban environment. The response to this stress often has been pollution of the environment. One important aspect of pollution not often considered and seldom fully understood is that of pollution through sedimentation.

"The movement of sediment is a natural part of the hydrologic system, yet even in a natural environment the prediction of rates and volumes of sediment movement are imperfectly understood. The stresses of urbanization alter the natural controls, and thus make the problem of prediction more difficult. Therefore, in order to understand the present knowledge of sedimentation in the urban environment, we must first summarize the understanding of sedimentation in the natural environment, consider how urbanization changes the natural controls, and summarize those studies that consider the effects of urbanization on sedimentation...

1. Data that measure sediment yield from urbanized areas are deficient.

2. Analyses of sediment yield for nonurban areas may yield some insight into relations to be expected for urban areas.

3. Broad approaches similar to the Wischmeir universal soil-loss equation may give some insight into effects of construction practices on sediment yield.

4. General hydrologic and hydraulic principles should be used to structure and to judge derived prediction equations.

5. Increase in sediment yield that results from increased peakedness of runoff should be assessed.

6. The transient yield during construction is a major unmeasured and unpredictable relation. A prediction relation might be developed and should include soil type and construction methods.

7. Geomorphological effects downstream should be assessed. Quantitative geomorphology should aid in structuring relations for prediction.

8. Highway construction is analogous to urbanization in its effect on sediment yield, and often is a side effect of urbanization. Sediment yield from both causes should be studied together, for both data and relations may have transfer value." (A)

162. DeBano, L.F.; Conrad, C.E. 1976. Nutrients lost in debris and runoff water from a burned chaparral watershed. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 3-13 to 3-27.

"Runoff water and movement of debris were measured on a chaparral-covered watershed, in southern California, that was prescribe-burned in summer 1973. Plant nutrients in the runoff water and debris during the first rainy season were analyzed. The amounts of N, P, Ca, Mg, K, and Na in the soil, litter, and plant material after burning, but before erosion occurred, were measured. In the first year, an area with 50 percent slopes had about 7300 kg/ha (6300 lb/ac) of material eroded from the plots on the burned sites as compared to only 210 kg/ha (187 lb/ac) on similar unburned sites. On the burned area, less debris was lost from the plots having 20 percent slopes than from those on steeper sites. No erosion occurred on unburned slopes with a 20 percent slope. The total amount of nutrients lost in debris and runoff water from the steep slopes that burned, in kg/ha (lb/ac), were: nitrogen—15.1 (13.5); phosphorus—3.4 (3.0); potassium—27 (24.1); magnesium—31.6 (28.2); calcium—67.4 (60.2); and sodium—4.6 (4.1). Nutrients lost represented less than 6 percent of the total nutrients found in the upper 2 cm (0.79 in) of the soil and litter layer immediately after the fire." (A)

163. DeByle, N.V. 1976. Fire, logging, and debris disposal effects on soil and water in northern coniferous forests. In: Proceedings, 16th IUFRO world congress; [Dates of meeting unknown]; Oslo, Norway. Oslo, Norway: International Union of Forest Research Organizations: 201-212.

"Many seral northern coniferous forest types are dependent upon periodic wildfire for their perpetuation. Man partially mimics the role of wildfire by clearcut logging of these forests and often by subsequent burning of the logging debris. Mineral soil is exposed and conditions are provided for forest regeneration.

"Impacts on the environment sometimes are associated with these sudden disturbances. Most obvious, and best documented, are increased soil erosion, channel cutting, and siltation of streams. Some more subtle impacts are: decreased evapotranspiration and increased streamflow, increased insolation and altered microclimate, induced water repellency of soils by fire, changes in the nutrient-cycling processes, and flushes of dissolved materials out of the system and into the aquatic environment. Most subtle and difficult to measure is the possibility of long-term site quality changes.

"Particularly during the past decade there has been unprecedented concern about these impacts. This concern has resulted in much research, some of which is summarized and interpreted in this paper. An explanation is given that shows why, under some conditions, clearcutting or fire has severe impacts on the environment and why, under others, the impacts are minimal or not even detectable. The variables or soils, geology, topography, climate, and forest type are considered." (A)

164. Degens, E.T.; Paluska, A.; Eriksson, E. 1975. Rates of soil erosion. In: Nitrogen, phosphorus and sulfur—global cycles. Scope Rep. 7. Ecological Bulletin. 22: 185-191.

"To exemplify and estimate the influence from human activities on soil-erosion rates sediment cores from the Black Sea were studied. The geomorphological characteristics of drainage areas supplying the Black Sea are given as well as the background for calculations of the denudation rates. The present mean denudation rate for the entire Black Sea source is 0.063 $mm \cdot yr^{-1}$. High noise levels in sedimentation rates from A.D. 200 to present was accounted for by agricultural activities and deforestation. This also indicated an acceleration of soil erosion by a factor of about 3 due to man's impact." (A)

165. De Vera, M.R. 1981. Assessment of sediment yield using the universal soil loss equation. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 400-414.

"Eighteen watersheds in Luzon island, Philippines with drainage area ranging from 52 to 1177 sq. kilometers were selected for the study based on the applicability and adequacy of data on topography, land use, soils and rainfall intensity. The parameters of the universal soil-loss equation were evaluated using standard tables and nomographs which are available for its solution. Estimated soil-loss ranges from 223 to 1017 tons per sq. kilometer while observed sediment yield ranges from 85 to 2213 tons per sq. kilometer. Regression analysis performed with sediment yield Y as dependent variable and soil loss X as independent variable resulted in equation Y = 2.702 - 526.68 with a correlation coefficient 0.896 which means that about 80 percent of the variation in sediment yield from the mean has been accounted for by the regression equation. With the results of the analysis, it is possible to assess the sediment yield of watersheds where no sediment data are available provided the drainage area is within the range of watershed sizes studied and the hydrophysical conditions are similar." (A)

166. Dickerson, B.P. 1975. Stormflows and erosion after tree-length skidding on coastal plain soils. Transactions American Society of Agricultural Engineers. 18(5): 865-868.

"Tree-length skidding up 20 slopes with a rubber-tired skidder resulted in stormflow volumes that averaged 28.4 area cm, or about 11 percent of the total rainfall, during the 2-year study. Soil loss averaged 14.8 kg per trail in the first year but diminished rapidly as herbaceous vegetation occupied bared soil." (A)

167. Dietrich, W.E.; Dunne, T. 1978. Sediment budget for a small catchment in mountainous terrain. Zeitschrift für Geomorphologie N.F. Supplementband. 29: 191-206.

"Geomorphic processes are often slow and highly variable in time and space. Data from short-term monitoring at a few localities are not easily extrapolated to compute the sediment budget for a catchment. Before designing a monitoring network to measure components of the sediment balance, the investigator can construct an approximate budget from data that can be obtained quickly through field mapping, laboratory experiment, petrographic studies, and measurements in similar catchments. Emphasis should be placed on field recognition of the linkages between processes of sediment transfer and storage, as well as the changes which particles undergo. We have computed an approximate sediment budget for a small catchment. Dissolution is responsible for 60% of the denudation; the average residence time of soil on hillsides is 20,000 yrs; and the soil characteristics change systematically as the soil moves downhill. The estimated rates of soil creep and sediment discharge from the basin are in balance. One half of the soil discharged to channels is carried away as suspended load while the remainder is stored temporarily in tributaries, debris fans, and the floodplain. The residence times of sediment in these storage elements increase downvalley from decades to about 10,000 yrs. During the migration, weathering and attrition alter 80% of the bedload to suspended load sizes." (A)

168. Diseker, E.G.; Richardson, E.C. 1962. Erosion rates and control methods on highway cuts. Transactions American Society of Agricultural Engineers. 5(3): 113-155.

Runoff, erosion, and sediment deposition were measured on erosion plots established on highway cuts near Cartersville, Georgia. Results indicated that: (1) rate of annual soil loss on bare road cuts and highway ditches averaged 148 tons per acre annually for flat, medium, and steep slopes, and ranged from 41 to 359 tons per acre annually; (2) aspect affects the amount of erosion; (3) adaptable plants can develop an effective cover that will control erosion; and (4) mulches are essential for cover development on cuts equal to or greater than 2:1 slope, and for plants that are slow in developing a complete cover. (C)

169. Dissmeyer, G.E. 1976. Erosion and sediment from forest land uses, management practices and disturbances in the southeastern United States. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-140 to 1-148.

"The data and information presented defines [sic] the nature, extent and magnitude of erosion and sediment sources from forested [sic] in several river basins in the Southeastern United States. Data shows [sic] that not all sediment from forest land is related to silviculture, but in some areas past abusive agriculture and present woodland overgrazing are the most important sources of sediment. It shows that forest practices acts, which contain blanket regulations, are likely to be inappropripriate for some areas, insufficient for others or sometimes unnecessary. Control of forest sediment needs to be prescriptive and site specific in nature to meet not only water quality, but other resource needs." (A)

170. Dissmeyer, G.E.; Foster, G.R. 1980. A guide for predicting sheet and rill erosion on forest land. Tech. Publ. SA-TP11. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry, Southeastern Area. 40 p.

"Managing forest soils requires knowledge of factors that cause and reduce soil losses. Forests are often managed to produce multiple goods and services; most of these products are dependent upon the basic resource—soil. How the forester manages a site influences the productivity of the soil and the amount of goods and services produced on that site. Forest management practices vary in impact upon sheet and rill erosion. The soil loss prediction procedure presented in this handbook provides a method for estimating sheet and rill erosion for various practices. The same procedure is useful for planning forestry practices that will minimize erosion, and for understanding the cause and effect relationships between management practices and erosion.

"The procedure presented is based upon an empirical equation, the Universal Soil Loss Equation (USLE)....The USLE has been modified to better predict sheet and rill erosion on forest land.

"This handbook's goal is to provide consistent application and interpretation of sub-factors in the field. Words alone will not suffice; therefore, the text is accompanied by illustrations. Where appropriate, these illustrations are given numerical values to provide consistent rating of field conditions." (A)

171. Dohrenwend, R.E. 1977. Raindrop erosion in the forest. Res. Note 24. L'Anse, MI: Ford Forestry Center, Michigan Technological University. 19 p.

The author reviews past research concerning median raindrop size under a forest canopy and uses the information to calculate the kinetic energy of falling raindrops under various forest canopy geometries. The calculations indicate that the forest canopy will normally increase the erosive impact of rainfall by increasing raindrop diameter rather than decreasing erosive impact as commonly believed. (C)

172. Dortignac, E.J.; Hickey, W.C. 1965. Surface runoff and erosion as affected by soil ripping. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 156-165.

"Sedimentation is the most critical watershed problem in the arid and semiarid Southwest....Past misuse and mismanagement has resulted in a deteriorated vegetation cover on the lower lying foothills, mesas, escarpments or bluffs, and valley floors.... The deterioration of the vegetation has been accompanied by a great reduction in ground cover, leaving most of the land with exposed or bare soil....Soil ripping increases the water storage capacity of the land until the fissures become filled with washed-in or blown-in soil and until weathering levels the roughened surface....Soil ripping may derive its greatest hydrologic benefit by increasing the water absorbing area and allowing surface runoff water to penetrate directly into the less permeable subsoil....

"Soil ripping with the Jayhawk Soil Saver reduced surface runoff about 97 percent the first year. The effect of this treatment persisted even without vegetation improvement during the 3 years. The third year following the soil-ripping operation, an 83-percent reduction in surface runoff was experienced. Erosion was likewise reduced, amounting to 86 and 30 percent for the first and third years following the soil-ripping operation. Soil ripping is effective in reducing surface runoff and erosion from deteriorated rangelands in this area." (A)

173. Douglass, J.E.; Swift, L.W., Jr. 1977. Forest Service studies of soil and nutrient losses caused by roads, logging, mechanical site preparation, and prescribed burning in the southeast. In: Watershed research in eastern North America: a workshop to compare results; 1977 February 28-March 3; Edgewater, MD. Edgewater, MD: Chesapeake Bay Center for Environmental Studies, Smithsonian Institution: 489-502. Vol. 2.

"Soil and nutrient pollution of streams caused by woods roads, log skidding, mechanical site preparation, and prescribed burning are being studied in the Piedmont and Appalachian Mountains of the Carolinas. Stormflow from disturbed areas is measured by 1-foot H-flumes. Proportional samples for sediment and nutrient analysis are collected by 2-foot Coshocton wheels. Objectives of nonpoint-source pollution studies are to establish baseline level of soil and nutrient loss, determine increases in losses due to certain forestry practices, and develop methods of estimating losses for other practices and other locations." (A)

174. Dunne, T. 1977. Evaluation of erosion conditions and trends. In: Kunkle, S.H.; Thames, J.L., eds. Guidelines for watershed management. FAO Conservation Guide 1. Rome: Food and Agriculture Organization of the United Nations: 53-83.

"This paper describes a range of field techniques for assessing rates of erosion by various processes. The methods are cheap to use by comparison with most other schemes for monitoring environmental change, and land managers would benefit greatly from the information to be gained from such simple hydrologic and geomorphic measurements.

"The measurement of erosion by a variety of processes and at a variety of scales is relatively simple to perform. By comparison with the benefits to be gained from improved quantitative knowledge of the relation of soil loss to its controlling factors, a measurement program is inexpensive. The value of such measurements increases with their duration and with the care with which they are planned." (A)

175. Dunne, T.; Leopold, L.B. 1978. Water in environmental planning.
San Francisco, CA: W.H. Freeman and Company. 818 p.

"In this book we show how a knowledge of hydrology, fluvial geomorphology, and river quality is useful in planning. Many specialists in such disciplines as biology, engineering, forestry, geography, geology, hydrology, landscape architecture, and regional planning have taken up the challenge of applying their knowledge to the avoidance or solution of environmental problems....

"Water is central to many planning problems concerned with natural and altered environments. It is often a focus for interdisciplinary analysis and planning that brings together an engineering hydrologist and a plant ecologist, a forester and a sanitary engineer, or a geomorphologist and a specialist in urban design. The awareness of mutual concerns and the value of shared experience is growing. The central position of water in planning the avoidance or the rectification of environmental problems is leading specialists to discover new and interesting problems to which their talents can be applied." (A)

The book includes chapters dealing with hillslope processes, river channels, and sediment production and transport, within the general framework of geomorphology (one of four major text sections). (C)

176. D'yakov, V.N. 1973. Erosion processes in felled areas in the mountain forests of the Carpathians. Soviet Hydrology: Selected Papers. 3: 273-276.

"The dependence of soil erosion during logging operations in the Carpathians on felling and skidding methods, the dimensions of felled areas, the seasonality of logging operations, and other factors are examined. Data are presented on surface runoff and the dynamics of water erosion." (A)

177. Dyer, E.B. 1977. Use of the universal soil-loss equation: a river basin experience In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Rep. 21. Ankeny, IA: Soil Conservation Society of America: 292-297.

"Based on the comprehensive resource planning experience in one river basin, the universal soil loss equation can be used to estimate gross erosion for large areas. Such use of the equation is made possible by computer systems that allow for rapid manipulation of data inputs.

"The ability to interpret and display technical data through a marriage of the universal soil loss equation and MIADS or similar computer systems is extremely important to the decision-making processes for wise conservation planning and application. Land users can and will make sound judgments when the effects of their decisions can be displayed visually." (A)

178. Dyhouse, G.R.; Williams, D.T. 1980. Case study—stream deposition and changing land use. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 215-227.

"An analysis of channel modifications for Harding Ditch necessitated an estimate of depositional changes between existing and future land use conditions, along with dredging information. The STORM computer program was applied to generate discharge and sediment runoff data for existing and future land use. Transformed STORM output was supplied to an HEC-6 sediment transport model of 11 miles of Harding Ditch to evaluate depositional patterns. Comparison of 1982 and 2020 thalweg profiles showed less deposition under future land use conditions. Dredging analysis indicated a 10-year excavation interval was required to maintain a with-project rating curve relationship." (A)

179. Dyrness, C.T. 1965. Soil surface condition following tractor and high-lead logging in the Oregon Cascades. Journal of Forestry. 63(4): 272-275.

"Soil surface condition and bulk density were investigated after tractor and high-lead logging. Surface area of four clearcut units was classified into four disturbance classes. High-lead and tractor areas had about the same proportion of the slightly disturbed and deeply disturbed classes (approximately 23 percent and 9 percent, respectively). The tractor-logged area had about three times more area within the compacted class than did the high-lead (27 vs. 9 percent) and a corresponding decrease in the amount in the undisturbed class (36 percent of the tractor area vs. 57 percent after high-lead logging). Surface soil bulk densities of samples from undisturbed and slightly disturbed areas were the same as prelogging values. Values for both the deeply disturbed and compacted classes were significantly higher, indicating a decrease in soil porosity. Compaction caused by tractor logging undoubtedly results in some increase in runoff and erosion. However, these undesirable effects are minimized if slopes do not exceed 20 to 30 percent and skidroads are located on the contour." (A)

180. Dyrness, C.T. 1966. Erodibility and erosion potential of forest watersheds. In: Sopper, W.E.; Lull, H.W., eds. Forest hydrology. New York: Permagon Press: 599-611.

"This paper reviews a portion of the literature dealing with forest soil erosion and erodibility. Two main aspects of forest soil erodibility are generally stressed—resistance of soil particles to detachment and transport, and soil infiltration rate. Resistance to detachment and transport is controlled to a large extent by amounts of water-stable aggregation. Several erodibility indices, utilizing different measurements of surface soil aggregation, have been developed. Factors strongly influencing these erodibility indices include soil parent material, organic matter content, climatic conditions, and soil chemical properties. Many studies have shown that infiltration rate decreases considerably when plant and litter cover is removed, thus exposing the mineral soil surface to the destructive action of rain.

"Some accelerated erosion is generally a necessary consequence of road construction and logging in forest watersheds. Primary causes are reported to be exposure of bare mineral soil and surface soil compaction. Both controlled burning and wildfires in forested areas are often followed by increased rates of surface erosion. Although severe burning may cause increased erodibility, light burning apparently has little effect on soil properties. A change of primary importance caused by fire is removal of protective vegetation and litter.

"Research needs in this field include development of methods for quantitatively estimating forest soil erosion potential and establishment of erosion tolerances for individual forest watershed." (A)

181. Dyrness, C.T. 1967. Soil surface conditions following skyline logging. Res. Note PNW-55. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p.

There was little difference in the amount of surface disturbance created by yarding when skyline and high-lead logging were compared; however, because skyline logging requires about one-third the length of road that high-lead requires, the use of skyline logging could reduce the amount of sediment reaching streams within the timber harvest. (C)

182. Dyrness, C.T. 1970. Stabilization of newly constructed road backslopes by mulch and grass-legume treatments. Res. Note PNW-123. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 5 p.

"Amounts of soil loss from an unprotected newly constructed backslope were two to four times greater than loss from a comparable slope 5 years after construction. Of six roadside treatments studies; the two showing consistently large amounts of soil loss during the first critical rainy period were the only ones without a straw mulch covering." (A)

183. Dyrness, C.T. 1975. Grass-legume mixtures for erosion control along forest roads in western Oregon. Journal of Soil and Water Conservation. 30(4): 169-173.

"Attempts were made to identify legume species that would be compatible with grasses in roadside seeding mixtures for use in the mountains of western Oregon. Despite successful germination and early establishment, legumes were unable to compete with grasses and largely disappeared from most roadside stands after 1 year. Grass-legume seed, fertilizer, and straw mulch applied to road backslopes for the most part successfully halted erosion. Rates of erosion from unmulched and bare control plots during the first year after seeding were substantially higher on newly constructed backslopes than on a backslope that was several years old at the time of plot installation. Results indicated that a mulch, as well as seed and fertilizer, should be placed on roadside slopes if soil erosion is to be minimized during the first rainy season following road construction. In addition, infertile subsoils failed to maintain a viable vegetative cover and required refertilization 7 years after plots were initially seeded and fertilized. Bare, unprotected roadside slopes continued to erode at a rather constant rate throughout the course of the study. The loss amounted to about 0.2 inch of soil per year." (A)

184. Dysart, B.C.; Langdon, C.H. 1976. Sediment transport in a South Carolina mountain stream. In: Environmental aspects of irrigation and drainage. New York: American Society of Civil Engineers: 56-73.

"Sediment inputs to streams are a major environmental concern at the site of any sizeable construction project, and an assortment of measures are available to reduce such inputs.

"However, there is typically little information gathered on sediment loads and transport rates in those streams prior to initiation of construction activities. Such data would provide a baseline for determining the impact of construction on the stream system, and could indicate the streams' potential to recover over time from sediment impacts.

"Duke Power Company proposes to build the Bad Creek pumped-storage hydroelectric project in the mountainous terrain of Oconee County, South Carolina. Due to the extensive earth-moving activities that will occur, it is possible that increased amounts of sediment may enter Howard Creek, a small mountain stream in the headquarters of the Savannah River drainage....

"The objectives of the study...were to analyze the pre-construction sediment condition in Howard Creek, including the rate of suspended and bed load transport through the system under various flow conditions." (A)

185. Ekern, P.C. 1954. Rainfall intensity as a measure of storm erosivity. Soil Science Society of America Proceedings. 18(2): 212-216.

"The erosivity of storms should be proportional to the additive kinetic energy from the impact of falling rain and shallow flow of water. The erosivity of shallow water should be proportional to the proximity of the maximum velocity thread to the soil surface and the square of that maximum velocity." (A)

186. Ekern, P.C. 1977. Turbidity and sediment-rating curves for streams on Oahu, Hawaii. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings of a national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 242-254.

"The sharp, short-duration peaks of runoff from small Hawaiian watersheds make them particularly sensitive to sediment concentration and runoff discharge interrelationships. However, concentration of sediment in the streams is relatively low, despite high rainfall erosional hazard. This low concentration must stem in part from the low erosion susceptibility of the aggregated red clays that make up the watersheds. The low transmittance and high back scatter of these red clays precludes the measurement of turbidity as a field index of sediment concentration, though turbidity can serve as a laboratory index of sediment concentration in diluted samples. This low transmittance and high scatter make even low concentrations of sediment very detrimental to the optical properties that determine water quality." (A)

187. Ellison, W.D. 1945. Some effects of raindrops and surface-flow on soil erosion and infiltration. Transactions of the American Geophysical Union. 26(3): 415-429.

"This presentation summarizes the findings from a number of experiments in which the effects of raindrop-impacts and the flow of surface-water on soil erosion and infiltration were studied. Some implications drawn from this work are discussed. Many of the experiments were exploratory in nature, and many of the data have only qualitative significance." (A)

188. Engelund, F.; Hansen, E. 1967. A monograph on sediment transport in alluvial streams. Copenhagen: Teknisk Forlag. 62 p.

"The present short text on sediment transport in alluvial streams does not pretend to give a complete review on the present state of knowledge. Neither has it been the purpose to account for the historical development of this particular branch of hydraulic science. The immediate reason for writing has been a need for a short textbook as a basis for lectures to be given at the Technical University of Denmark for students specializing in hydraulic or coastal engineering.

"As the general understanding of the basic mechanism of sediment transport is at its beginning, it has been the aim of the authors to avoid all mathematical sophistication, so that the presentation is based on simple 'engineering methods' only. Although a short account of basic hydraulics is included to ensure continuity, the text requires knowledge of elementary fluid mechanics." (A)

189. Epstein, E.; Grant, W.J. 1971. Soil erodibility as affected by soil surface properties. Transactions American Society of Agricultural Engineers. 14(4): 647-648, 655.

Soil erodibility is described in relation to changes in soil surface properties as a result of raindrop impact. The study found that after 10 minutes of artificial rainfall, the soil loss at various kinetic energies remained constant at a rate of 625 grams/joule per square centimeter. This was probably caused by a thin layer shearing accompanied by the continual formation of a consolidated seal resulting from the physical impact of the raindrops. There were no discernible changes in soil texture below the 0.5 millimeter region of the crust. (C)

190. Falletti, D.A. 1977. Sediment prediction in wildland environments: a review. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings of a national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 183-192.

"Models available for use by field scientists to predict sediment from wildland environments lag behind those used by the research and academic communities. Most existing sediment models identified deal with surface erosion and were developed for agricultural lands. For in–channel erosion and sedimentation, some models will simulate aggradation and degradation in stable channel systems. The review did not find any process–oriented models that predicted sedimentation from unstable channels or mass–wasting sources. Total sediment output has been described mainly by regional regression models that are provincial in nature and may be difficult to relate to management alternatives.

"In many wildland environments channel erosion and/or mass–wasting, rather than surface erosion, are the dominant sediment–producing processes. The review showed a definite lack of process–simulation models that can be used to evaluate management activities in terms of their effects on channel erosion or mass–wasting processes.

"A comprehensive sediment loading model that is comparative in nature and contains modular components describing surface runoff, channel erosion, and mass-wasting erosional processes is needed to describe the effects of wildland management on the sediment outputs from upland watersheds. The model is needed to provide a physical basis to evaluate the initial effects and trends in recovery time for massive site disturbances as well as the direct and secondary effects of vegetative manipulation in a wildland environment. For maximum utility a sediment-predictive model should have the following characteristics: (a) be modular in structure within a comprehensive framework; (b) be able to predict sediment loading of all orders of streams, but particularly first order; (c) facilitate comparative evaluation of alternatives; (d) represent time and probability variables; (e) represent spatial variability of conditions and activities within a diverse landscape; (f) utilize available or readily obtainable data; (g) be available for use by field-level scientists and be compatible with the decision-making process." (A)

191. Farmer, E.E.; Fletcher, J.E. 1977. Highway erosion control systems: an evaluation based on the universal soil loss equation. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings of a national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 12-21.

A modification of the universal soil-loss equation (USLE) is presented; it simplifies use of the equation in highway erosion-control work. The modification involves replacing the cropping and practice factors of the USLE with an erosion-control factor. A detailed example demonstrates use of the modification in highway erosion-control design. (C)

192. Farmer, E.E.; Van Havern, B.P. 1971. Soil erosion by overland flow and raindrop splash on three mountain soils. Res. Pap. INT-100. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

"This was a laboratory study of soil erosion, performed on bare soil plots under simulated rainfall. The variables having the greatest effect on erosion by overland flow were rainfall intensity, slope steepness, and the percentage by weight of soil particles greater than 2 millimeters. The variables having the greatest influence on raindrop splash erosion were rainfall intensity, slope steepness, percentage by weight of soil particles between 60 and 2,000 microns, and soil bulk density." (A)

193. Flaxman, E.M. 1972. Predicting sediment yield in western United States. Journal of the Hydraulics Division, American Society of Civil Engineers. 98(HY12): 2073-2085.

"Watersheds vary widely in their susceptibility to erosion, and it is important to determine the major factors that cause this variation. The western half of the United States, considered for this purpose, is a region widely varied in climate, geology, topography, soils, vegetation, and land use. The objective is to find if a few watershed variables could describe the variation and influence of changes in land use on sediment yield." (A)

The analysis provides an equation that describes 92 percent of the variation in sediment yield: $\log (Y + 100) = 6.21301 - 2.19113 \log (X_1 + 100) + 0.06034 \log (X_2 + 100) - 0.01644 \log (X_3 + 100) + 0.04250 \log (X_4 + 100)$, where Y is sediment yield, X_1 is the ratio of the average annual precipitation to the average annual temperature, X_2 is the weighted average slope of the watershed, X_3 is the percent of soil particles coarser than 1 mm in the surface 2 in, and X_4 is an indication of the aggredation or dispersion characteristics of clay-size soil particles based on soil pH and the fraction of soil which is clay. (C)

194. Flaxman, E.M. 1975. The use of suspended-sediment load measurements and equations for evaluation of sediment yield in the West. In: Present and prospective technology for predicting sediment yields and sources: Proceedings of the sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 46-56.

Procedures provide a method of analyzing suspended sediment data so the following information can be inferred: (1) the dominant sources of sediment yield; (2) the approximate effect of these sources on sediment concentrations; (3) the approximate percentage of increase in sediment yield caused by present watershed conditions compared to yield with undisturbed watershed conditions; and (4) the effects of land treatment on the reduction of erosion and sediment yield. This ability is lost in the conventional means of securing sediment yield by use of the flow duration, sediment-rating curve procedure to extend short-time sediment load records. (C)

195. Fleming, G.; Leytham, K.M. 1976. The hydrologic and sediment processes in natural watershed areas. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-232 to 1-246.

"The widespread practical application of conceptual sediment models would appear to be limited by serious shortages of basic data. This is true even for simple models such as Negev's, although it is hoped that sufficient data may be obtainable for its use to be viable within the U.S.A., as outlined in this paper. One problem is perhaps the fact that in this multi-disciplinary subject data sources are widely scattered often in obscure places. The establishment of some control archive for data concerned with land-use activities and management could be of considerable value. Another problem that has been recognized is the chaotic state of sediment transport study with its enormous variety of definitions and terms, units, methods of measurement and a very confusing array of formula and equations that often do not explicitly state assumptions of limits of applicability. Again it is hoped that this conference may provide some impetus to the rationalization of work in this field." (A)

196. Fogel, M.M.; Hekman, L.H.; Duckstein, L. 1977. A stochastic sediment yield model using the modified universal soil loss equation. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 226-233.

"Soil erosion is the first step in an environmental degradation process that includes the transportation and deposition of sediment. Sediment-yield estimates are necessary for the design of water-control structures and for evaluating land management practices. In addition to being a pollutant itself, sediment may carry other pollutants, such as pesticides, nutrients, and radioactive materials.

"We intend to present a method of forecasting watershed sediment yield within a framework that will allow land managers to select an optimal solution to the problem. To do so, we will use existing relationships, such as the universal soil loss equation...coupled with a previously developed, event-based stochastic model of precipitation....

"While the approach is particularly applicable to small watersheds, less than 50 square miles (130 square kilometers) recent progress in routing sediment yield may make this procedure suitable for large areas...." (A)

197. Fogel, M.M.; Hekman, L.H.; Duckstein, L. 1980. Predicting sediment yield from strip-mined land. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 176-187.

"An emerging national energy policy has accelerated the development of Western coal reserves, predominantly by surface mining operations. Recently enacted Federal legislation requires that the disturbed lands be managed to control adverse environmental effects such as erosion and sedimentation. By using small representative watersheds and erosion plots, water and sediment-yield data have been collected for six years. The data were analyzed to obtain estimates of parameters used in the Soil Conservation Service and Universal Soil Loss Equations. Values for runoff curve numbers, soil erodibility factors, and the crop management factors were obtained for pre-mined and post-mined conditions. Then, to overcome the highly variable precipitation regime, an event-based model which could simulate precipitation data served as an input into the equations that estimate water and sediment yields. With the final Federal regulations requiring a three-year minimum sediment storage volume for ponds, the above methodology was used to develop probability distributions for three-year sediment yield totals as a means for comparing pre-mined and reclaimed situations." (A)

198. Fortier, D.H.; Molnau, M.; Saxton, K.E. 1980. Sediment from a small summer grazed watershed. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 790-801.

"The sediment yield from grazed pastureland is a nonpoint source which is not well defined. Adjacent grazed and ungrazed areas in northern Idaho were studied. The two watersheds behaved similarly only in response to rain on frozen soil but there were no consistent patterns for either water or sediment discharge for normal rainfall or snowmelt events. The major effect of the cattle on sedimentation is the cattle paths which intercept runoff and become small erosion channels. The sediment yields were low (381 kg/ha) and well within or below the range to be found from grazed and forested watersheds elsewhere." (A)

199. Foster, G.R., ed. 1977. Soil erosion: prediction and control: Proceedings of a national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America. 393 p.

"Development and application of erosion-control techniques in the past few decades have successfully controlled erosion on much of our 438 million acres of cropland and reduced sediment from some nonagricultural lands. However, erosion and sediment are still major national problems in the United States. This is partially due to a reluctance to adopt control practices voluntarily. But it is also largely a result of recent developments that have intensified erosion hazards and have made some previously effective control practices less acceptable....By the early seventies, many developers of our erosion research and control programs had retired and were replaced by younger leaders who are very capable but much less familiar with the merits and limitations of the research on which our present erosion control technology is founded. Because of these factors, a national conference to review the present and future of soil erosion prediction and control was highly appropriate." (A)

The Proceedings includes 44 papers, grouped under these major headings: "Applications of the Universal Soil Loss Equation," "Erosion Research," "Erosion and Sediment Yield Modeling," "Use of the Universal Soil Loss Equation in Planning," "Soil Erosion Control," "Conservation Needs." (C)

200. Foster, G.R.; Huggins, L.F. 1977. Deposition of sediment by overland flow on concave slopes. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 167-180.

"We developed a model simulating deposition of uniform sand on concave slopes by shallow overland flow from the continuity equation for mass transport; an equation expressing a first order reaction between deposition rate and the difference between the transport capacity and sediment load; a sediment transport capacity equation; and a laminar, uniform flow equation. Simulated results agreed well with observed data for a 450-mm sand, while the results varied for a 180-mm sand. The results seemed to verify the influence of the first order reaction relation and indicated that the effect is strongest under rainfall. An accurate evaluation of flow hydraulics and an appropriate sediment transport capacity equation are needed for accurate estimates of deposition." (A)

201. Foster, G.R.; Lane, L.J.; Knisel, W.G. 1980. Estimating sediment yield from cultivated fields. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 151-163.

"The erosion/sediment yield component of CREAMS, a field scale model for Chemicals, Runoff, and Erosion from Agricultural Management Systems, estimates erosion and sediment yield from agricultural fields. The model uses fundamental erosion concepts to describe erosion, deposition, and sediment transport by overland flow and concentrated flow, and deposition in small ponds. Sediment yield is computed for particle classes ranging from primary clay to large aggregates. An enrichment ratio is computed as the ratio of the specific surface area of the sediment to that for the residal soil. Use of tested relationships reduced the need for calibrating the model with site-specific data. Sediment yield computed without calibration of the model agreed well with observed values for several small watersheds. Model application was demonstrated with two field situations." (A)

202. Foster, G.R.; Meyer, L.D. 1972. A closed-form soil erosion equation for upland areas. In: Shen, H.W., ed. Sedimentation. Fort Collins, CO: H.W. Shen: 12-1 to 12-19.

"Erosion by water on upland areas was mathematically described by the continuity-of-mass transport equation and an equation expressing an interrelationship between detachment by runoff and sediment load. The latter equation was:

$$\frac{\text{Detachment Rate by Flow}}{\text{Detachment Capacity of Flow}} + \frac{\text{Sediment Load of Flow}}{\text{Transport Capacity of Flow}} = 1$$

The detachment and transport capacities were each taken as a function of the 3/2 power of the flow's shear stress....With the interaction equation, predictions of deposition where the slope flattens and flow loses its transport capacity are possible without using a gradually varied flow analysis." (A)

203. Foster, G.R.; Meyer, L.D. 1975. Mathematical simulation of upland erosion by fundamental erosion mechanics. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 190-207.

The method of predicting upland soil erosion rates presented is based on the continuity equation for mass transport and interrelationships between sediment load, flow, and detachment. Prediction of overland flow is an integral part of the model.

Four subprocesses describe the mechanics of detachment by rainfall, transport by rainfall, detachment by runoff, and transport by runoff. A model is tested against data from erosion plots; both observed and predicted results are presented. Similar equations are developed for plots of nonuniform slope and are used to compare the predicted with observed results from erosion plots. Effects of vegetation, plant residues, and other mulches are discussed. A method for adjusting these equations to consider the mulch rate is described. (C)

204. Foster, G.R.; Meyer, L.D. 1977. Soil erosion and sedimentation by water—an overview. In: Soil erosion and sedimentation: Proceedings, national symposium on soil erosion and sedimentation by water; 1977 December 12-13; Chicago, IL. ASAE Publ. 477. St. Joseph, MI: American Society of Agricultural Engineers: 1-13.

"Soil erosion and sedimentation by water primarily involve the processes of detachment, transportation, and deposition of sediment by raindrop impact and flowing water. Erosion and sedimentation are major problems that reduce the productivity of cropland, degrade water quality, carry polluting chemicals, and reduce the capacity of water conveyance structures. The erosion-sedimentation system is composed of upland and channel components. While the uplands act somewhat independently of the channels, the behavior of the channels is directly influenced by the upland inputs. Spatial and temporal variations in erosion are common with time lags in sediment yield as great as several decades. Climate, soil, topography, and land use are major factors influencing erosion and sedimentation." (A)

205. Foster, G.R.; Meyer, L.D.; Onstad, C.A. 1977. An erosion equation derived from basic erosion principles. Transactions American Society of Agricultural Engineers. 20(4): 678-682.

"An erosion equation is derived from the continuity equation for sediment transport and other equations describing rill and interrill erosion. The resulting equation is a useful model for explaining the behavior of the erosion process. The equation might serve as the basis for an operational equation for estimating soil loss for specific storms." (A)

206. Foster, G.R.; Wischmeier, W.H. 1974. Evaluating irregular slopes for soil loss prediction. Transactions American Society of Agricultural Engineers. 17(2): 305-309.

"The effects of slope irregularities (i.e. changes in inherent soil erodibility or slope) on soil erosion by water were analyzed on the basis of recent progress in mathematical simulation of the basic erosion process. This report presents the analysis and extends it to routine field applications. A technique is proposed for evaluating the universal soil-loss equation's topographic factor, LS, for irregular field or construction-site slopes.The technique also provides a means of evaluating the effects of differences in soil erodibility that may be associated with changes in slope steepness. It does not however, predict deposition that may occur on a slope." (A)

207. Foster, R.L.; Martin, G.L. 1969. Effects of unit weight and slope on erosion. Journal of the Irrigation and Drainage Division, American Society of Civil Engineers. 95(IR4): 551-561.

A laboratory study was performed to determine the separate and combined effects of unit weight and slope on erosion and runoff. Results indicate that: (1) slope has an effect on both the weight of solids eroded and the volume of runoff, and (2) the effect of unit weight on the weight of solids eroded is only important during early post-treatment time, (3) the effect of interaction between unit weight and slope is significant at all time periods, (4) both unit weight and the interaction between unit weight and slope affect the volume of runoff, and (5) for a given unit weight of soil there is a unique slope from which the maximum erosion will occur. (C)

208. Fredriksen, R.L. 1965a. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. Res. Pap. PNW-104. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 15 p.

"In two steep headwater drainages, landslides were the predominant source of increased sedimentation of streams following timber harvest. Patchcut logging with forest roads increased sedimentation compared with a control by more than 100 times over a 9-year period. Landslide erosion was greatest where roads crossed high gradient stream channels. In an adjacent clearcut watershed with no roads, sedimentation increased three times that of the control." (A)

209. Fredriksen, R.L. 1965b. Sedimentation after logging road construction on a small western Oregon watershed. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 56-59.

"During the summer of 1959, 1.65 miles of logging road were constructed in a 250-acre forested watershed that rises 2,000 feet in a distance of 1 mile. This study evaluates the change in sedimentation subsequent to road construction. Runoff from undisturbed watersheds in this area remains clear during the summer low-flow months and reaches concentrations of 100 parts per million during winter storm peaks. Runoff from the first rainstorms after road construction carried 250 times the concentration carried in an adjacent undisturbed watershed. Two months after construction, sediment had diminished to levels slightly above those measured before construction. Sediment concentrations for the subsequent 2-year period were significantly different from preroad levels. In about 10 percent of the samples, sediment concentrations were far in excess of predicted values, indicating a stream-bank failure or mass soil movement. Annual bedload volume the first year after construction was significantly greater than the expected yield, but the actual increase was small. A trend toward normalcy was evident the second year." (A)

210. Fredriksen, R.L. 1972. Impact of forest management on stream water quality in western Oregon. In: Pollution abatement and control in the forest products industry, 1971-72: Proceedings, 26th annual meeting of the Forest Products Research Society; 1972 June 18-23; Dallas, TX. Madison, WI: Forest Products Research Society: 37-50.

The author briefly reviews previous work and discusses the effects of clear felling, slash burning and fertilizer treatment on sedimentation, nutrient concentration and water temperature in streams, with special reference to old-growth Douglas-fir (*Pseudtosuga menziesii* (Mirb.) Franco) forests in western Oregon. Some suggestions are made for minimizing undesirable effects on these characteristics of streams. (C)

211. Fredriksen, R.L.; Moore, D.G.; Norris, L.A. 1975. The impact of timber harvest, fertilization and herbicide treatment on stream water quality in western Oregon and Washington. In: Biernier, B.; Winget, C.H., eds. Forest soils and forest land management: Proceedings, 4th North American forest soils conference; 1973 August; Quebec, PQ. Quebec, PQ: Les Presses de l'Université Laval: 283-313.

"Sedimentation of forest streams after timber harvest increased exponentially with increasing angle of slope in three experimental watersheds in western Oregon. Forest roads that crossed steeply inclined stream channels caused much greater levels of sedimentation than roads on ridge tops. More time was required for soils to stabilize from clearcutting and forest roads in the steeper country. In gentle topography, increased sedimentation of streams can be prevented by well planned and administered timber harvest. Although there may be moderate increases in sedimentation on stable slopes of intermediate steepness following logging, rates may return to normal within four to five years when revegetation is rapid. In very steep topography, where soil strength is nearly in balance with the potential for downsliding, the largest sedimentation increases are expected as a result of frequent mass erosion events. These levels persisted for more than 11 years after harvest at one site.

"Nutrients are lost following clearcutting, but the loss decreases rapidly with revegetation. Maximum NO3-N concentration increases in streams have remained well below toxic levels. More research is needed to relate the nutrient concentrations in streamflow to uptake by vegetation, digestion, and decomposition by soil animals and microorganisms, and logging residues. Nutrient losses by soil erosion are undoubtedly of greater importance on steeper slopes.

"Forest fertilization-water quality studies indicate that N concentration in streams does not increase to levels exceeding published standards. Total loss of applied nutrient is small and should not have any measurable impact on eutrophication in downstream impoundments.

"The biological effects of forest fertilization on N transformations and movement in forest soils should be investigated. Long-term consequences of repeated forest fertilization on water quality must be determined.

"The drift or direct application of spray materials to surface waters is the principal route of herbicide entry to streams. Overland flow and leaching of herbicide are relatively unimportant factors in forest stream pollution. Carefully controlled herbicide applications are not expected to have a significant impact on forest stream quality." (A)

212. Froehlich, H.A.; Aulerich, D.E.; Curtis, R. 1981. Designing skid trail systems to reduce soil impacts from tractive logging machines. Res. Pap. 44. Corvallis, OR: Forest Research Laboratory, Oregon State University. 15 p.

"Logging on skid trails restricted to 10 percent or less of the harvested stand can reduce the area of compacted soil by at least two-thirds. In a comparative study, productivity of Douglas-fir logs per hour was just as great in an area with designated trails as in an adjacent area logged conventionally. Logging on designated trails required more winching time, but this increase was offset by a reduction in skidding time. Furthermore, there was less damage to residual trees on the area with designated trails. The use of such trails is economical and efficient if trees are felled to the lead of the trail." (A)

213. Gallup, R.M. 1974. Roadside slope revegetation: past and current practice on the National Forests. Equip. Development and Test Rep. 7700-8. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 37 p.

"Effective revegetation is a primary method of protecting roadside slopes from erosion. Information on current practices and equipment use was gathered from 25 National Forests and from other sources. In seedbed preparation, seeding, fertilizing, mulching, etc., a variety of methods and equipment is used, depending primarily on conditions in specific locations. A review of earlier and current literature yields suggestions for possible improvements in techniques. New equipment is needed, and suggested equipment for scarification, planting, and seeding of steep slopes is sketched." (A)

214. Gardner, R.B.; Hartsog, W.S.; Dye, K.B. 1978. Road design guidelines for the Idaho Batholith based on the China Glenn Road study. Res. Pap. INT-204. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 20 p.

"Erosion caused by road construction on the steep, fragile, decomposed granitic soils of the Idaho Batholith resulted in a 1965 moratorium on road construction in the South Fork of the Salmon River and its tributaries.

"In 1970, the China Glenn Road was built to salvage trees attacked by the Douglas-fir beetle and protect the residual stand. It was constructed well back of the river-break zone on slopes averaging 40-50 percent. A key objective was to build a road with as little environmental impact as possible. A single-lane (12-foot...) road following the contour without a ditch, and with special design features, has proved adequate for logging, with little adverse impact." (A)

215. Gaskin, D.A.; Hannel, W.; Pallazzo, A.J. [and others]. 1976. Results of the 1974-1975 CRREL terrain stabilization research/demonstration study. Hanover, NH: U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory. 47 p. Unpublished report. On file with: U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

Fourteen erosion control plots (10 ft by 40 ft) with individual 350-gallon tanks to collect sediment and runoff were installed on a 35.6-percent slope in Hanover, New Hampshire. In 13 of the 14 plots, various combinations of nutrient source (commercial fertilizer, sludge, or primary wastewater), moisture (irrigated or nonirrigated), and erosion control material (jute netting, straw tacked with a tacking compound, or no erosion control material) were studied. All plots except the control were seeded with a seed mixture commonly used by the New Hampshire Highway Department.

The plots treated with sludge generally produced the least erosion, apparently by reducing runoff velocity and absorbing moisture; the sludge was also a source of nutrients. Nonirrigated plots produced less erosion than irrigated plots. All treatments reduced erosion by at least 90 percent from erosion of the bare soil control. (C)

216. Gibbons, D.R.; Salo, E.O. 1973. An annotated bibliography of the effects of logging on fish of the western United States and Canada. GTR-PNW-10. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 145 p.

"This bibliography is an annotation of the scientific and nonscientific literature published on the effects of logging on fish and aquatic habitat of the Western United States and Canada. It includes 278 annotations and 317 total references. Subject areas include erosion and sedimentation, water quality, related influences upon salmonids, multiple logging effects, alteration of streamflow, stream protection, multiple-use management, streamside vegetation, stream improvement, and descriptions of studies on effects of logging. A review of the literature, a narrative on the state of the art, and a list of research needs determined by questionnaires are included." (A)

217. Gilbreath, J.L. 1979. The state of the art of erosion and sediment control for surface mined areas. Columbus, OH: The Ohio State University. 127 p. M.S. thesis.

"This thesis attempts to define the state of the art of sediment and erosion control for surface mined areas with emphasis on sediment ponds. Additionally, pertinent hydrologic aspects, sediment characteristics, and the erosion processes are briefly reviewed. Consideration is given to the use of computer models as design or analysis tools. Finally, the thesis is summarized in tabular form providing a convenient index for all referenced material. Also included in the last chapter is a list of current research, a list of needed research, and the author's conclusions and recommendations." (A)

218. Gottschalk, L.C. 1957. Problems of predicting sediment yields from watersheds. Transactions American Geophysical Union. 38(6): 885-888.

"Three methods in general use for predicting sediment yields from watersheds are: (1) Direct sediment-load measurements, (2) estimating yield on the basis of measurements in nearby watersheds, and (3) estimating the rate of erosion in a watershed and the delivery rate of sediment. The third method is a relatively new approach to determination of sediment yield. The objective of the Symposium on Watershed Erosion and Sediment Yields is to assemble existing information and knowledge on sediment yields as a guide to technicians engaged in research and field studies for solution of erosion and sedimentation problems." (A)

219. Gottschalk, L.C. 1964. Reservoir sedimentation. In: Chow, V.T., ed. Handbook of applied hydrology. New York: McGraw-Hill Book Company: 17-1 to 17-34.

"This section deals with the general subject of erosion and sediment yields from watersheds as related to processes and rates of reservoir sedimentation. The processes of erosion, entrainment, transportation, and deposition of sediment are complex. Methods have not yet been developed to extrapolate existing results of fundamental research to broad, complex areas, such as watersheds, for prediction of the expected rate or processes of reservoir sedimentation. Although considerable basic data have been assembled and comprehensive research has been initiated in the past quarter century, much yet remains to be done before the prediction of rates and processes of reservoir sedimentation can achieve the degree of accuracy desired. The purpose of this section is to outline results of fundamental research and technological studies related to reservoir sedimentation. Basic considerations are outlined for those areas where research is lacking to aid the technician to recognize specific problems and develop sound solutions. Finally, general guide lines are presented for developing control measures applicable to specific watershed and reservoir conditions." (A)

220. Greb, B.W. 1967. Percent soil cover by six vegetative mulches. Agronomy Journal. 59(6): 610-611.

"Estimates of percent-soil cover by straw or stalk type vegetative mulches can be calculated by means of measuring the average length, diameter, and weight of a random sample of clean, oven-dry material. Efficiency of soil cover per unit weight for mulches at Akron, Colorado were spring barley greater than winter wheat greater than spring oats greater than sudangrass greater than grain millet greater than grain sorghum." (A)

The amount of straw needed for 100-percent cover was 2300, 3600, 3600, 6800, 8100, and 16 400 kilograms per hectare, respectively. (C)

221. Guy, H.P. 1965. Residential construction and sedimentation at Kensington, MD. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 30-37.

"Sediment transported in storm runoff near Kensington, Md., during the transformation of part of a 58-acre area from rural to residential land use was measured for 25 storm events from July 1959 to January 1962. These data were used with the water discharge record of nearby Rock Creek in a multiple regression analysis to show the magnitude and trend of sediment movement with time.

"Total sediment discharged from the area affected by urbanization was 189 tons per acre for the entire period of construction and the subsequent return to a reasonably stable residential area. The high yield of sediment from the Kensington area is attributed to (1) the rolling topography, 3 to 25 percent slope, (2) a very friable soil and subsoil, (3) the construction of a street in the major drainage channel, (4) a tendency for construction methods to expose extensive areas of the soil for a long period of time, and (5) a substantial amount of the 42 inches of annual rainfall occurring at a rate in excess of the infiltration capacity of unprotected soil." (A)

222. Guy, H.P. 1967. Research needs regarding sediment and urbanization. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. HY6: 247-253.

"It is desirable to group the problems of sediment from urbanization into categories which, in turn, can also fit specific areas of research....Most of the specific research items are implied in a general discussion of problems likely to be encountered as a result of urbanization. The problem categories include (1) the basic processes of sediment erosion, transport and deposition, (2) the impact on existing channels, (3) the impact on water resources, (4) research methods, and (5) planning concepts." (A)

223. Guy, H.P. 1970. Sediment problems in urban areas. Circ. 601-E. Washington, DC: U.S. Department of the Interior, Geological Survey. 8 p.

"Much of the disturbed soil in urban construction areas erodes and becomes sediment in streams; the sediment damages water-control works and aquatic habitat, degrades water quality, increases flood damages, and lowers the environmental attractiveness. During the process of stabilization of an area after construction, streams tend to erode their beds and banks as a result of increased runoff. All such sediment, whether from construction erosion or from channel erosion, is transported by streams and often deposited somewhere downstream at a location previously assigned to the movement or storage of water.

"Documentation of erosion sources and amounts, of sediment concentration in runoff, of stream-channel changes, and of the location and amounts of deposition together with an economic analysis of sediment damages and a pertinent research program will provide the knowledge needed to find the best solutions to a wide variety of existing and future urban sediment problems. Aside from the knowledge needed for better design of systems, documentation of sediment conditions will provide baseline information from which damages, both on site and downstream, can be evaluated. Defense against damage claims often rests upon attempts to demonstrate that the claimant had no knowledge of preexisting conditions, that the source of damages was not discernable, or that conditions had always been so.

"Increasing numbers of communities will likely attempt to alleviate their many sediment problems because of the adverse effects of such problems on the local environment. The public sentiment needed to support such programs to control sediment is built from a series of events that restrict, offend, or otherwise concern people." (A)

224. Hadley, R.F. 1977. Some concepts of erosional processes and sediment yield in a semiarid environment. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 73-82.

"Sediment yield is dependent on the gross erosion in the drainage basin and transport efficiency of the channel network. Stream channel characteristics, diversity in landforms, and floodplain development all are important factors in determining conveyance, or sediment delivery to downstream points.

"A large amount of information on sediment yield from drainage basins less than five square miles has been collected to evaluate land use or land treatment practices. An even greater amount of data has been collected on experimental plots, generally less than one-tenth acre in area, for the purpose of determining on-site erosion. There are few records of the changes in sediment discharge from the headwater basins to the downstream end of the system on major streams. A satisfactory method of extrapolating sediment yield information from small headwaters areas to downstream areas is necessary before most of the available information will have any transfer value." (A)

225. Hadley, R.F.; Shown, L.M. 1976. Relation of erosion to sediment yield. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-132 to 1-139.

"Sediment yield is dependent on the gross erosion in the drainage basin and the transport efficiency of the channel network. Stream channel characteristics, diversity in landforms, and floodplain development all are important factors in determining conveyance, or sediment delivery to downstream points.

"Qualitative evaluation was made of sediment conveyance, on a scale of zero to one for Ryan Gulch basin, northern Colorado. The presence of alluvial fans, dams and irrigation works, headcuts and ungullied reaches of valley floor and general channel condition were considered. An average conveyance for the basin was computed by weighting ratings of individual reaches. The estimated conveyance for the whole basin indicates that only a very small part of the eroded material is presently being transported through the system." (A)

226. Hamon, W.R.; Bonta, J. 1980. Design for erosion loss studies on disturbed lands. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 27-39.

"Regulations pertaining to the (Federal) Surface Mining Control and Reclamation Act of 1977 require an a priori prediction of runoff, erosion losses, sediment yield and water quality at surface mine sites. Significant stated requirements are as follows: (a) surface mining shall be planned and conducted to minimize disturbance to the hydrologic balance; (b) sediment control measures shall minimize erosion and sediment contribution to streamflow; (c) sediment ponds shall provide a sediment storage volume equal to the accumulated sediment volume from the drainage area to the pool for a minimum of 3 years, as determined by the Universal Soil Loss Equation (USLE), gully erosion rates and sediment delivery ratios, or by other empirical methods established by the regulatory authorities and based upon actual sedimentation pond studies; (d) an alternate sediment storage volume of 0.1 acre-foot for each acre disturbed may be reduced to no less than 0.035 acre-foot by regulatory authority approval if it is demonstrated that sediment removal by other control measures is equal to the reduction in sediment storage volume; (e) rills or gullies deeper than 9 inches formed after reclamation are to be stabilized and reclamation practices applied; and (f) the regulatory authority shall specify that rills and gullies of lesser size be stabilized if the rills and gullies are disruptive to the approved postmining land use or may result in additional erosion and sedimentation. The mining operators, to meet such requirements, need accurate estimate of potential erosion losses, rill and gully development, and sediment yield.

"The principal soil loss estimating procedure available and specified for use, the USLE, is inadequate in present form for such estimates for several reasons:

a. The equation was developed to estimate long-term erosion losses from agricultural soils on the basis of a rainfall erosivity factor and, in general, should not be used for specific storm events or time periods (a requirement for surface mined areas), (Wischmeier, 1976).

b. The minesoil erodibility factors have not been evaluated on the basis of field data.

c. The slope-length and slope factors were derived from data obtained on cropland for slopes ranging from 3 to 18 percent in steepness and about 30 to 300 feet long. (In the Appalachian coal fields, mined slopes often approach a steepness of 100 percent).

"Correcting the shortcomings of the USLE will require data, collected on regional bases, from natural rainfall plots and rainfall simulator plots. Several studies are underway at different universities and by State and Federal agencies that could augment such endeavors to produce a generally applicable erosion loss predictive procedure for surface mined lands. A general experimental design to reach this objective is outlined in the following sections on research approach, procedures and facilities." (A)

227. Hartman, P.J.; Wanielista, M.P.; Baragona, G.T. 1977. Prediction of soil loss in nonpoint-source pollution studies. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 298-302.

"Current definitions identify nonpoint sources as locations and/or land uses from which pollutants are usually dispersed at an unmanaged rate and cannot be controlled by National Pollutants Discharge Elimination System (NPDES) permits from the U.S. Environmental Protection Agency (EPA)....Since soil can carry many classes of pollutants, an understanding of the factors involved, erosion control practices, and methods of predicting soil loss is extremely important." (A)

228. Hartung, R.E.; Kress, J.M. 1977. Woodlands of the Northeast, erosion and sediment control guides. Broomall, PA: U.S. Department of Agriculture, Soil Conservation Service, National Technical Service Center; Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 25 p.

"This handbook is designed to guide practitioners in planning and applying erosion and sediment control measures to forest lands of the northeastern United States. The material includes current information on the subject and practices that have existed for many years." (A)

Chapters cover general information, guides for seeding roadbeds and roadbanks, water control on roads and skid trails, logging road bridges, and filter strips. (C)

229. Haupt, H.F. 1959. A method for controlling sediment from logging roads. Misc. Publ. 22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

A method is described for protecting stream channels and intervening slopes from the damaging effect of sediment originating from roads higher on the slope. The method employs the equation:

$$\mathrm{Sfd} = 1.2871(\mathrm{Soi}) + 0.0030(\mathrm{Cdi})^2 + 3.4918(\mathrm{Esl}) + 0.0468((\mathrm{Cdi})(\mathrm{Rg})) - 66.2395,$$

where Sfd is sediment flow distance, Soi is slope obstruction index, Cdi is cross-ditch interval, Esl is embankment slope length, and Rg is road grade. The equation was derived from data collected on logging roads in southwestern Idaho and can be used to determine the cross-ditch width and/or spacing of slope obstructions necessary to prevent sediment deposition further than the sediment flow distance from the road. The publication explains the use of the equation during road layout and when putting a road to bed. Tables and examples are presented to simplify use of the equation. (C)

230. Haupt, H.F. 1967. Infiltration, overland flow, and soil movement on frozen and snow-covered plots. Water Resources Research. 3(1): 145-161.

"This small plot study shows how ground cover, furrowing, and the presence of frost in soils of the Sierra Nevada affect infiltration from prolonged simulated winter rains. A rapidly melting snowpack over soil containing dense frost may accelerate on-site runoff. The presence of stalactite soil frost promotes rapid absorption of snowmelt and reduces overland flow. Conversely, porous concrete frost usually reduces infiltration capacity and increases overland flow on burned or sparsely vegetated sites but does not impair infiltration where plant and litter cover are appreciable. Snow cover, by cooling rain water, tends to preserve soil frost and keep it visibly intact.

Snow absorbs raindrop energy much as dense vegetation does. Soil losses from snow-covered plots, regardless of vegetative cover, are practically nil. Generally, plants, litter, and snow cover dissipate raindrop energy and increase infiltration, but exposed rock usually accelerates overland flow and erosion. Shallow contour furrowing seemed to facilitate infiltration and controlled overland flow adequately." (A)

231. Haupt, H.F.; Kidd, W.J., Jr. 1965. Good logging practices reduce sedimentation in central Idaho. Journal of Forestry. 63(9): 664-670.

"From the inception of a study of cutting ponderosa pine on 16 small watersheds in the Boise Basin Experimental Forest, sedimentation was checked reasonably well because of careful advance planning, close supervision of logging, and application of intensive measures for controlling erosion promptly after harvest. Sediment that reached the stream channels originated primarily on haul roads. Proximity of a road to a stream affected the frequency with which sediment flows reached that stream. Sediment reached channel bottoms through undisturbed buffer strips averaging 8-feet wide, but did not reach them if the strips were more than 30-feet wide. After 3 years, movement of sediment 'en route' had almost halted." (A)

232. Haupt, H.F.; Richard, H.C.; Finn, L.E. 1963. Effect of severe rainstorms on insloped and outsloped roads. Res. Note INT-1. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 8 p.

"Three heavy rainstorms that produced from about 7.5 to 10.0 inches of rain in central Idaho in a 10-day period in October 1962, caused considerable damage to newly constructed logging roads. Insloping a roadbed under the time, topographic, soil, and storm conditions described is more desirable than outsloping as a measure for preventing erosion and damage to the roads." (A)

233. Haussman, R.F.; Pruett, E.W. 1978. Permanent logging roads for better woodlot management. NA-FR-18. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 43 p.

"This guide is directed to the need for proper construction and maintenance of a transportation system on a typical woodlot. It applies to situations most commonly encountered in the Northeast and provides the principles for a generally applicable type of low-cost, low-speed road. Good judgment must be used in applying these principles because of the wide variety of topography, soils, climate, and other factors which prevail in different parts of the Northeast." (A)

234. Hay, D.R.; Kibler, D.F.; Busey, C.E. 1970. Erosion control on Air Force bases. Tech. Note WLC-TN-70-018. Kirtland Air Force Base, NM: Civil Engineering Division, Air Force Weapons Laboratory. 20 p.

"A state-of-the-art review of the soil erosion field as it relates to the erosion control needs of the US Air Force was conducted. The review will serve as a guide for preparation of a Base Civil Engineer erosion control handbook. Typical military construction activities which have exposed large areas of unprotected soil and subsequently have led to serious erosion problems are presented. Factors involved in the wind and erosion processes are discussed and soil loss equations and soil erodibility indices are reviewed. The erodibility K-factor in the ARS soil-loss equation is evaluated for land management planning techniques. Guidelines for effective erosion control practices to protect exposed land surfaces against soil particle detachment and transport by either water or wind are presented. Further efforts to establish a more reliable erodibility index which can be used to define areas of highly erodible soils, especially for subsurface soils that are exposed during construction are indicated." (A)

235. Hayes, W.A. 1977. Estimating water erosion in the field. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings of a national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 6-11.

"The Soil Conservation Service uses the universal soil loss equation, A=RKLSPC, to estimate the quantity of soil erosion (sheet and rill) caused by water and to design water erosion control systems. Soil loss estimates are first made during the development of a conservation plan, when evaluating the present resource management system on the land. Soil loss from both water and wind are determined if both water and wind erosion are problems. Where water erosion is the dominant problem, but wind erosion is a secondary problem, a resource management system for water erosion control is first considered, using practices that also reduce wind erosion. Then we evaluate the water erosion control system for its effectiveness in controlling wind erosion using the wind erosion equation, E=f(IKCLV). If the combined soil loss from water and wind does not exceed the soil loss tolerance for the soil, the resource management system is satisfactory. If the soil loss does exceed the soil loss tolerance, the resource management system is not satisfactory." (A)

236. Heede, B.H. 1965. Multipurpose prefabricated concrete check dams. Res. Pap. RM-12. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 16 p.

"The dam consists of nine major parts: six prestressed wall slabs of conventional concrete, and three buttress-footing units of light-weight reinforced concrete. It can be placed in 3 hours (except for excavation and backfill) with two laborers and a backhoe." (A)

237. Heede, B.H. 1966. Design, construction, and cost of rock check dams. Res. Pap. RM-20. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p.

"Loose-rock, wire-bound, single-fence, and double-fence dams and one type of head-cut control were designed and installed in gullies on the White River National Forest. Motorized equipment proved to be suitable for installation of the structures. Hand labor ranged from 2 to 8 percent of the cost. Gully control was least expensive with double-fence rock check dams. Higher double-fence structures are more economical on gully gradients steeper than 5 percent. The investigations indicated that rock check dams should maintain their place in modern gully control." (A)

238. Heede, B.H. 1968a. Conversion of gullies to vegetation-lined waterways on mountain slopes. Res. Pap. RM-40. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 11 p.

"Four gullies were successfully converted to waterways on slopes of the Rocky Mountains in Colorado. Three years after treatment, the treated gullies had lost only 9 percent as much soil as comparable untreated gullies. Careful engineering survey and design, close construction supervision, and good response to revegetation measures were responsible for the success. Since limits of applicability could not be established, the method is proposed for application on sites comparable to those of the study area." (A)

239. Heede, B.H. 1968b. Engineering techniques and principles applied to soil erosion control. Res. Note RM-102. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

"Two basic approaches to erosion control are: (1) resisting natural forces, and (2) utilizing them. Examples of (1) are check dams and grassed waterways; of (2), Italian hydraulic reclamation where erosive forces are used to stabilize watersheds. Objective of both is to establish vegetative cover." (A)

240. Heede, B.H. 1970. Morphology of gullies in the Colorado Rocky Mountains. Bulletin of the International Association of Scientific Hydrology. 15(2): 79-89.

"A classification of gullies into discontinuous and continuous channels not only expresses differences in channel morphology and stage of development, but also presents helpful criteria for design of gully control. The term critical location was introduced for those locations within gullies that are obviously susceptible to changes, and whose direction of change is suggested. Regression analyses underlined the fact that the gullies constituted channels of youthful stage if relations between components in channel geometry were considered." (A)

241. Heede, B.H. 1971. Characteristics and processes of soil piping in gullies. Res. Pap. RM-68. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

"Exchangeable sodium percentage showed a highly significant difference between soils with and without pipes. Layer permeability of piping soils was only 2 to 12 percent of that of soils without pipes. Gullies, high exchangeable sodium percentage, low gypsum content, and fine-textured soils with montmorillonite clay appeared to be prerequisite to the formation of pipes." (A)

242. Heede, B.H. 1975. Stages of development of gullies in the West. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 155-161.

An attempt is made to relate the development and morphology of ephemeral gully systems to stages of development. Gully development is defined in terms of landform evaluation, proceeding from youthful to old age. A comparison of the hydraulic geometry of rivers is made to that of gullies, as a means of characterizing the mature stages of gully development. Sediment production and yield are discussed in terms of gully evolution. (C)

243. Heede, B.H. 1976. Gully development and control: the status of our knowledge. Res. Pap. RM-169. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 42 p.

"Gully formation is discussed in terms of mechanics, processes, morphology, and growth models. Design of gully controls should draw on our understanding of these aspects. Establishment of an effective vegetation cover is the long-term objective. Structures are often required. The least expensive, simply built structures are loose-rock check dams, usually constructed with single or double wire fences. Prefabricated concrete dams are also effective. Functional relationships between dams, sediment catch, and costs, as well as a critical review of construction procedures, should aid the land manager in design and installation of gully treaments." (A)

244. Heede, B.H. 1977. Gully control structures and systems. In: Kunkle, S.H.; Thames, J.L., eds. Guidelines for watershed management. FAO Conserv. Guide 1. Rome: Food and Agriculture Organization of the United Nations: 181-222.

"The mechanics of gully erosion can be reduced to two main processes: down cutting and head cutting. Down cutting of the gully bottom leads to gully deepening and widening. Head cutting extends the channel into ungullied headwater areas, and increases the stream net and its density by developing tributaries. Thus, effective gully control must stabilize both the channel gradient and channel headcuts." (A)

This paper provides detailed engineering criteria for the design and for field installation of gully control structures. (C)

245. Heede, B.H. 1978. Designing gully control systems for eroding watersheds. Environmental Management. 2(6): 509-522.

"Effective design of gully control systems must consider the gully network as a whole and be based on geomorphologic indicators such as type of network, stream order, and stage of development. Consideration of geomorphologic characteristics allows a ranking of gully treatment priorities that, in turn, promises the highest return for expenditures. Relationships between sediment catch, channel gradient, treatment cost, and height of check dams in a treatment system are presented. Return is considered within a physical rather than economic framework. Future soil savings are the main focus." (A)

246. Heede, B.H. 1979. Deteriorated watersheds can be restored: a case study. Environmental Management. 3(3): 271-281.

"A project in west-central Colorado demonstrated that a watershed dissected by a dense gully network can be stabilized and rehabilitated. Check dam systems, aided by improved vegetative cover through reduced cattle grazing and plantings, stabilized not only the structurally treated gullies, but also gullies within the network that were not structurally treated. Comparision with untreated gullies located outside of the project area, showed that the outside gullies widened three times as much as the structurally untreated inside gullies. Statistical analysis indicated that precipitation was normal during the treatment and evaluation period.

"Check dams decreased gully depth by accumulating sediment deposits. In turn, gully bank stabilization was hastened and alluvial aquifer volumes increased. This increase, plus higher infiltration rates as a result of denser vegetation, led to renewed perennial streamflow after 7 treatment years.

"Within 11 years after treatment, check dam systems and improved vegetation reduced sediment loads in the flows by more than 90 percent, providing a substantial benefit to farmlands and ponds downstream.

"From this work we are able to conclude that only part of a gully network requires structural treatment. The mainstem gully, and those tributaries controlling the local base levels of others, are the critical segments that should be structurally treated." (A)

247. Heede, B.H. 1981. Rehabilitation of disturbed watersheds through vegetation treatment and physical structures. In: Baumgartner, D.M., comp., ed. Interior west watershed management: Proceedings of a symposium; 1980 April 8-10; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 257-268.

"A case study of a disturbed watershed in the Southern Rocky Mountains of Colorado demonstrated a watershed can be successfully rehabilitated by combining physical structures with vegetation treatment. This combination of treatments reduced suspended sediment by 95% in 11 years, reduced erosion rates in the vegetation-lined waterways by 80% after 12 years, and produced perennial streamflow in a formerly ephemeral gully system 7 years after treatment. The results of this study indicated that stabilization could be achieved by placing physical structures only in the mainstream gully, the larger tributary gullies and the headcuts of discontinuous gullies. Placing physical structures only at strategic locations could have reduced treatment cost 30%. The results of this study clearly demonstrated the need for basing successful watershed rehabilitation treatments on basic geomorphic processes." (A)

248. Heede, B.H.; Mufich, J.G. 1974. Field and computer procedures for gully control by check dams. Journal of Environmental Management. 2: 1-49.

"Computerized design of gully control by check dams eases field survey and design procedures. Only a minimum of data is required to generate the design of gully treatments and to yield essential information on costs and materials. Flexibility within the program is given by providing several design choices. Graphical computer output shows the relationships between the choices by effective dam height, total cost of treatment, and benefits from expected sediment deposits. Since key equations and their derivations are presented, the program can be adapted to dam types that differ from those used. The simplification of survey and design procedures makes feasible the inventory of gully control needs for larger tracts of lands. The program is operational." (A)

249. Heinemann, H.G.; Piest, R.F. 1975. Soil erosion sediment yield research in progress. Transactions of the American Geophysical Union. 56(3): 149-159.

The report discusses research in progress in the United States "...by Federal, State, and other groups under the three components of the sedimentation process (erosion, transport, and deposition) and then discusses the research of the integrated sedimentation process. Channel transport and deposition processes are mentioned only as they relate to sediment yield research." (C)

250. Helvey, J.D.; Fowler, W.B. 1979. Grass seeding and soil erosion on a steep, logged area in northeastern Oregon. Res. Note PNW-343. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p.

"This case study tested the common belief that grass seeding is needed to prevent erosion after areas are clearcut in the Blue Mountains. Changes in the soil surface height at about 500 points each in a seedbed and an unseeded area were measured on four dates covering a 20-month period. Average vertical displacement was not consistently related to seeding nor to degree of disturbance. Variability of vertical displacement within areas treated alike was almost as great as variability between treatments.

"Size-graded flourescent material (Willemite) was placed on 10 sites to characterize downslope soil movement. The maximum movement (240 centimeters) occurred on a severely disturbed area." (A)

251. Herb, W.J.; Yorke, T.H. 1976. Storm-period variables affecting sediment transport from urban construction areas. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-181 to 1-192.

"Eight small drainage basins, ranging in size from 0.91 to 25.2 square kilometers (0.35 to 9.73 square miles), located in the suburbs of Washington, D.C., were studied to determine sediment transport characteristics of streams draining urban construction areas. Annual construction ranged from less than 1 percent of basin area to more than 15 percent. Five hundred and twenty-four storms were analyzed to determine the effects of 14 storm-period variables on sediment load. Factors found to be most significant were storm runoff and peak discharge. Rainfall intensity, runoff peakedness, percentage of basin under construction, and a time-trend factor were found to be less significant. Multiple correlation coefficients for best regression equations with four independent variables ranged from 0.85 to 0.96, and standard errors range from 0.300 to 0.221 log units. The equations reflect the significant impact of both construction activities and summer storms on the sediment discharge of urban streams." (A)

252. Hetherington, E.D. 1976. Dennis Creek: a look at water quality following logging in the Okanagan Basin. Inf. Rep. BC-X. Victoria, BC: Pacific Forest Research Center. 33 p.

"The effects of forest harvesting on water quality in Dennis Creek, a high elevation tributary of Penticton Creek in the Okanagan Valley, British Columbia, were monitored during the second year following clearcutting of 25% of the measured portion of the Dennis Creek watershed. Water samples were taken above and below the logged areas, from an adjacent unlogged watershed and from the main Penticton Creek. Logging appears to have resulted in a significant increase in water colour and minor increases in potassium, sodium chloride, electrical conductivity, total organic carbon and dissolved solids. Sediment concentrations increased, but remained at negligibly low levels. Calcium, silica, and hardness also increased slightly, but the changes could not definitely be attributed to logging effects. No significant changes were detected in total Kjeldahl nitrogen, nitrate, total phosphorus, magnesium, alkalinity, pH, sulphate or total inorganic carbon. With the exception of colour, values of all parameters remained well within desirable drinking water standard limits. In addition, with the exception of one sample, nitrogen levels also remained below the minimum threshold limit for potential over-production of aquatic plants." (A)

253. Hicks, B.G. 1976. Geotechnical management of forest lands in granitic terrane. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-83 to 2-90.

"Weathered granitic rocks have historically created problems for forest land management. Specialists are working to minimize the environmental damage resulting from road construction and logging impacts. Problems result when entry is made into steep granitic terrane with high rainfall where road construction and logging is planned. The damage is largely due to liquefaction type failures which produce greatly accelerated mass wasting as a result of debris landslides and flows. This geotechnical scheme is a unique plan for forest land management which produces a quantitative program for an environmentally safe operation and will yield an economically feasible project. The format of the scheme is: 1. Select a granitic area with stability problems, prepare detailed topographic map and obtain color and color infrared photography. 2. Hydrologic monitoring. 3. Engineering geologic study: mapping, drilling, sampling, geophysical surveys, field testing for stability parameters. 4. Soil engineering: lab and model test representative samples and compute stability parameters. 5. Correlate field properties with lab and model tests. 6. Prepare stability unit map. 7. Develop logging and road construction project using stability map and road design data." (A)

254. Highfill, R.E.; Kimberlin, L.W. 1977. Current soil erosion and sediment control technology for rural and urban lands. In: Soil erosion and sedimentation: Proceedings, national symposium on soil erosion and sedimentation by water; 1977 December 12-13; Chicago, IL. ASAE Publ. 477. St. Joseph, MI: American Society of Agricultural Engineers: 14-22.

"Erosion and sedimentation are important factors in managing land and water resources. Agricultural land, especially cropland, produces the largest amount of sediment annually. The next largest source is geologic erosion. Range and forest lands and construction activities are about equal in the amount of sediment produced. Erosion control is important to maintain productivity on agricultural and forest lands and to aid in sediment pollution control. Procedures have been developed for predicting erosion and sediment yield. Technology is available to reduce the amount of erosion and sediment induced by water from most land areas. In some places, additional research or data are needed to improve the performance of erosion control systems or reduce the costs, or both. The quality of installation and maintenance of erosion control measures is still one of the major problem areas." (A)

255. Hindall, S.M. 1976. Prediction of sediment yields in Wisconsin streams. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-205 to 1-218.

"A method has been developed to predict sediment yields at any point on 95 percent of Wisconsin streams. The procedure is simple and requires only data that are readily available. It consists of equations that relate sediment yield to the geographic or physical factors that control sediment production and transport. The equations were developed through regression techniques using physical factors such as topography, soils, land use and cover, stream hydraulics, and climate as independent variables and sediment yield as the dependent variable. The equations are only valid for areas in which the geography is similar to that of Wisconsin, but the procedure used to develop the predictive equation may be applicable in any area where there is sufficient sediment-yield data." (A)

256. Holberger, R.L.; Truett, J.B. 1976. Sediment yield from construction sites. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-47 to 1-58.

"Two sediment loading functions were fitted to sediment loss data from eight field studies of construction sites. Both are adaptions of the universal soil loss equation, and involve an empirically-fitted factor to account for effects of intervening terrain between construction site and point of sediment measurement in a nearby watercourse. One function uses the distance from the foot of the exposed area to the nearest perennial stream, while the second uses the percent of the drainage basin undergoing construction. Comparison of predicted sediment yields (in tons/acre) with observed yield indicates that, for the first loading function, about 54 percent of the predictions fall within a range of + 50 percent of observed values. Approximately 30 percent of the predictions generated by the second method fall within + 50 percent of the observed values." (A)

257. Holcomb, G.J.; Durgin, P.B. 1979. Ash leachate can reduce surface erosion. Res. Note PSW-342. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 4 p.

"In laboratory analyses of the Larabee soil from northwestern California, ash leachate flocculated the clay factions. As a result, the soil quickly settled out of suspension. To test the hypothesis that field plots on disturbed areas treated with ash leachate would be more resistant to erosion than nontreated plots, a study was done in July and August 1978, on two skid trails on the Humboldt State University Forest near Freshwater, in northwestern California. A rainfall simulator was used to measure differential erosion rates. Ash-leachate treated plots had 36 percent less erosion than nontreated plots. Differences in total sediment yield were statistically significant at the 97.5 percent level of confidence, as shown by a paired t-test of seven plots." (A)

258. Holeman, J.N. 1968. The sediment yield of major rivers of the world. Water Resources Research. 4(4): 737-747.

"The amount of suspended sediment transported by rivers to the seas each year is tabulated. The major rivers are ranked in order of tons of sediment transported per year and drainage area and water discharge data are included. The rivers are listed by continents in subsequent tables with data on drainage area, annual sediment yields in tons, sediment production rates in tons per square mile per year, the years of sediment measurement, and the sources of data. This sample represents more than one-third of the land contributing water-borne sediment to the seas and, if representative, indicates an annual world sediment yield of 20 billion (20 X 109) tons. The data suggest that Africa, Europe, and Australia have very low sediment yields (x tons per square mile per year), South America's rate is low, North America's is moderate, and Asia's is high to the degree of yielding up to 80% of the sediment reaching the oceans annually." (A)

259. Holeman, J.N. 1975. Procedures used in the Soil Conservation Service to estimate sediment yield. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 5-9.

The four basic procedures used by the Soil Conservation Service, U.S. Department of Agriculture, to estimate average annual sediment yield for a wide variety of engineering and land management applications are described. The procedures used, depending on data availability and the environment, are (1) gross-erosion and sediment-delivery ratio determinations, (2) predictive equations, (3) suspended-sediment load measurements, and (4) sediment accumulation measurements. The author suggests using more than one method for verification. (C)

260. Hollingshead, M.F. 1971. Effectiveness of increasing mulch rates in reducing soil movement on steep slopes, and mulch volume weight and texture as conditions in estimating mulch needs. TN-Agronomy-22. Berkeley, CA: U.S. Department of Agriculture, Soil Conservation Service. 3 p.

The author reviews recently published articles concerning (1) effectiveness of increasing mulch rates in reducing soil movement, and (2) mulch volume, weight, and texture as conditions in estimating mulch needs. Data presented substantiate acceptance of the standard 2 tons-per-acre mulch rate used in most recommendations of the U.S. Department of Agriculture, Soil Conservation Service. Approximations provided are as follows: "One ton of straw or grass hay equals 1 ton wood fiber mulch, equals 1 ton wood shavings, equals 2 tons coarsely chopped or shredded corn or sorghum stalks, equals three tons corn cobs, wood chips, or bark in ability to reduce soil losses from rainfall when the materials are spread evenly over the surface and anchored in place." (C)

261. Hollingshead, M.F. 1972. Commercially available alternatives for anchoring straw mulches. TN-Agronomy-25. Berkeley, CA: U.S. Department of Agriculture, Soil Conservation Service. 3 p.

The best method of anchoring straw mulches for temporary protection of critical areas depends upon topography, soil type, size of project, materials and equipment available, and other factors. This report is an attempt to itemize commercial materials and equipment available for anchoring straw mulch. Methods of anchoring discussed include stubble punchers, asphalt stabilizers, and nettings. Companies from which the information was obtained are listed along with information on their products. (C)

262. Holman, G.T.; Knight, F.B.; Struchtemeyer, R.A. 1978. The effects of mechanized harvesting on soil conditions in the spruce-fir region of north-central Maine. Bull. 751. Orono, ME: Life Sciences and Agriculture Experiment Station, University of Maine at Orono. 13 p.

"Soil bulk density and organic pad depth measurements were made after mechanized harvesting operations in the spruce-fir region of north-central Maine. Both age and seasonal interactions were observed. From these measurements the following conclusions are drawn:

1) The top three inches of mineral soil absorbed more of the compactive force of the mechanized harvesting system than did the 3-6 inch depth. This is important for future root penetration and infiltration capacity.

2) In terms of compaction, (a) bulk densities in random cut areas returned to preharvest levels after one overwintering period; (b) skid trails in winter harvested strips were restored after two overwintering periods; and (c) skid trails on summer harvests, however, which were compacted twice as much as those on winter harvests, were not restored to pre-harvest levels after three complete overwintering periods (the time frame of the study).

3) The organic pad depth decreased, at least along the skid trails, but probably not enough to create erosional hazards.

"In general, the mechanically harvested tree-length operation in north-central Maine seemed to be disruptive to the site and soil conditions for a relatively short period of time." (A)

263. Holzhey, C.S.; Mausbach, M.J. 1977. Using soil taxonomy to estimate K values in the universal soil loss equation. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 115-126.

"Plots of the soil erodibility factor (K) in the universal soil loss equation versus specific family particle size classes are presented and discussed. It is suggested that by using the descriptions in the soil classification systems of the National Cooperative Soil Survey the variability in the K factors is predictable and thus, soil taxonomy can be useful in estimating the soil erodibility factor." (A)

264. Honkala, R.A. 1974. Surface mining and mined land reclamation: a selected bibliography. Washington, DC: The Old West Regional Commission. 154 p.

"This bibliography is a project of the Old West Regional Commission. It was conceived as an aid to those who are engaged in studies related to western coal development and to those who may be contemplating such studies.

"The 1337 citations come from many sources, many of them existing bibliographies listed in the first section under 'Books, Bibliographies and Reviews.'

"An effort was made to select material that has application to mining and reclamation problems in the Great Plains. Foreign works were listed where a climatic or physiographic parallel could be drawn. No specific cutoff year was used, otherwise, valuable information would have been ruled out. For example, impact on aquifers can be evaluated only if background material on water levels in wells and similar information is available. Much of this is contained in older publications." (A)

265. Hornbeck, J.W. 1967. Clearcutting and the erosion hazard. Northern Logger and Timber Processor. 16(4): 14-15, 38-39, 43.

"Studies on the Fernow Experimental Forest showed that erosion was not related to the volume of timber cut, but was influenced by the care taken in logging. One site was cut heavily and employed poor skid trail layout and construction, as was common practice on early clearcuts. The other site, was cut lightly and employed strict standards for skid trail layout and construction. While the carefully logged watershed yielded a maximum turbidity of 83 ppm, the haphazardly logged area yielded a maximum turbidity of 56,000 ppm." (A)

266. Hornbeck, J.W.; Reinhart, K.G. 1964. Water quality and soil erosion as affected by logging in steep terrain. Journal of Soil and Water Conservation. 19(1): 23-27.

"The influence of different forestry practices on streamflow has been investigated since 1951 on 5 forested watersheds, 38 to 96 acres in area, on the Fernow Experimental Forest in the mountains of West Virginia. The effects of cutting and logging practices on water quality are reported in this article.

"Practices ranged from a commercial clearcutting without regard to water values or the future value of the property to an intensive selection cutting with useful planning and careful logging. The experiment demonstrated that excessive damage to water quality can be avoided even when logging on steep terrain. Measured maximum turbidities of streams were 56,000 ppm on the commercial clearcut area and only 25 ppm on the intensive selection cut watershed. Most of the damage to water quality occurred during and immediately after logging.

"Recommended forestry practices discussed include: planning of the logging operation; proper location, drainage, and grade of skidroads; and timely completion of the operation of any specific area. In most respects, practices recommended for watershed protection also contribute to the overall efficiency of the logging operation." (A)

267. Howell, R.B.; Racin, J.A. 1978. A comparison of highway slope erosion estimates by the mechanical slope template, sediment collection trough, and slope erosion transect survey methods. Rep. CA-TL-78-20. Sacramento, CA: California Department of Transportation. 39 p.

"Erosion measurements are conducted to determine potential water quality impacts from sediment as part of the environmental assessment. The two most common methods used by the California Department of Transportation arethe: 1) Slope Erosion Transect Survey, and 2) Sediment Collection Trough. A third method involves the use of a mechanical slope template. The template is used to obtain information on changes in slope configuration after various storm periods. This information is then analyzed to determine an estimate of the volume of eroded sediment.

"This report discusses a comparison of measuring slope erosion by the Mechanical Slope Template, Sediment Collection Trough, and Slope Erosion Transect Survey Methods for a highway slope on Route 50 at Camino (03-ED-50, P.M. 23.8). The study was conducted during a portion of the 1977-78 winter. The data show that the Mechanical Slope Template method produced unusually high estimates compared to the other two methods." (A)

268. Ice, G.G. 1979. A review of current knowledge and research on the impact of alternative forest management practices on receiving water quality. Stream Improve. Tech. Bull. 322. New York: National Council of the Paper Industry for Air and Stream Improvement. 223 p.

"The current state of knowledge was assessed through a literature review, personal contact with hydrologists and foresters, and attendance at Non-Point Source (NPS) conferences, workshops and meetings....

"The format for this technical bulletin presents water quality parameters for which standards are or could be developed. Each water parameter or related parameters is discussed in terms of its potential for effecting [sic] water utility, the current understanding of NPS delivery mechanisms, the magnitude of observed responses to forest management practices, models and equations for predicting contributions to receiving waters, and identified research dealing with the impact of forest management parameters on this water quality parameter.

"A detailed discussion of the Universal Soil Loss Equation is provided in **Appendix A** because of its importance in 208 program assessments. **Appendix B** presents the prediction technique for NPS stream nutrient background concentrations proposed by EPA. **Appendix C** provides relative erosion values for site treatments proposed by Dissmeyer and **Appendix D** is a summary of identified research projects. **Appendix E** is a glossary of terms used in the text for those who might be unfamiliar with forestry or regional terminology. **Appendix F** lists common and scientific names for the vegetation discussed in this bulletin." (A)

269. Ice, G.G. 1980. 1979 review of the literature on forest management practices and water quality management. Stream Improve. Tech. Bull. 330. New York: National Council of the Paper Industry for Air and Stream Improvement. 60 p., plus appendix.

"The...literature review, covering the literature dealing with the impact of forest management practices on water quality and its utility...covers 182 literature references. It is arranged so as to deal with the following subjects related to forest management practices and receiving water quality and utility: regulatory, legislative, and research issues, water quantity, sediment, nutrients, forest chemicals, and other topics." (A)

270. Israelsen, C.E.; Clyde, C.G.; Fletcher, J.E. [and others]. 1980. Erosion control during highway construction. Nat. Coop. Highw. Res. Prog. Res. Rep. 220. Washington, DC: Transportation Research Board, National Research Council. 31 p.

"The present project was directed at improving erosion control practice in highway construction....The research is documented in two reports: NCHRP Report 220, 'Erosion Control During Highway Construction—Research Report'; and NCHRP Report 221, 'Erosion Control During Highway Construction—Manual on Principles and Practices.'

"The research team found...that:

1. Technology is available in the United States to control within reasonable limits the erosion and sedimentation that may originate on highway locations both during and following construction.

2. Erosion control specifications currently being prepared for specific highway construction projects are adequate in many instances to maintain erosion within reasonable limits if properly enforced and followed.

3. More effective means of ensuring compliance with erosion control specifications during construction are needed.

4. Over-all construction costs may be lower if erosion control measures are implemented on a project than if they are omitted.

5. Erosion amounts can be significant even in areas where the average annual rainfall is comparatively low.

6. Numerous small erosion control measures implemented at the proper times and locations may be more effective and less expensive than a few large or poorly timed ones.

7. Written erosion control specifications are effective only if they are enforced and followed by design, administrative, and construction personnel.

8. Training courses for administrative, design, and construction personnel are needed both to create an awareness of the importance of controlling erosion and of the advantages that accrue from doing so, as well as to provide information on control measures and techniques that are available.

9. The universal soil loss equation developed by the Agricultural Research Service is probably the best tool presently available for predicting soil loss caused by rill and sheet erosion during highway construction and for estimating the relative effectiveness of various erosion control measures.

10. A soil loss equation developed by Chepil and associates appears to have application to highway construction sites for estimating potential soil losses due to wind.

"The manual on erosion control principles and practices (NCHRP Report 221) focuses on techniques for predicting the erosion potential of highway construction sites, and for estimating the effectiveness of various erosion control measures. A wide variety of control measures are listed and described, and information that will aid in selecting measures to meet specific site requirements is presented. Design standards for control measures, and information on such matters as size selection for mechanical control measures, are not included in the manual because these are already widely available in highway engineering offices." (A)

271. Jicinsky, K.; Paces, T. 1980. The flux of elements in suspended matter from experimental drainage basins in central Bohemia. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 271-276.

"The flux of 10 elements from four experimental drainage basins (0.586-2.039 km^2), parts of the Experimental Trnavka River Basin in central Bohemia (152 km^2) has been studied since November 1975. The drainage basins have the same geology and pedology but are otherwise different. Suspended and dissolved matter constitute the main bulk of the total flux of material. Part of the study has been directed to the relation of the flux of elements in suspended matter to the main characteristics of the basins. Preliminary results (1976-1978) are presented." (A)

272. Jinze, M.; Qingmei, M. 1981. Sediment delivery ratio as used in the computation of watershed sediment yield. Journal of Hydrology (NZ). 20(1): 27-38.

"Sediment delivered from gullied, hilly loess areas on the middle reaches of the Yellow River is essentially the product of gully erosion. In estimating the sediment delivery ratio of this area the total material eroded from the entire watershed is taken as the sum of the quantities yielded by way of sheet, gully and channel erosion.

"Analyses and calculations for typical watersheds in the aforementioned area show that wash load comprises over 95% of the total sediment load during most floods, with the result that the floods are frequently of hyper-concentration (average sediment content during a flood being no less than 500 kg/m^2). This is due to the mechanism of particle suspension, and is the basic reason why the sediment delivery ratio is nearly equal to unity.

"Finally, a formula for computing a modified sediment delivery ratio in the study areas, obtained through correlation analyses and considered to be acceptable, is presented." (A)

273. Johnson, C.W.; Hanson, C.L. 1976. Sediment sources and yields from sagebrush rangeland watersheds. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-70 to 1-80.

"Average sediment yields from the Reynolds Creek Experimental Watershed and three subwatersheds ranged from 1.14 to 1.90 tons/hectare/year (0.51 to 0.85 tons/acre/year) during the study period. Yields were more than tenfold higher in wet than in dry years and about 90 percent of average yearly yield occurred during January, February, and March at the Reynolds Outlet Station. Sediment yields from six upland source areas, 0.7 to 83 hectares (2.25 to 205 acres), were one-third or less per unit area than that from larger downstream watersheds. Bedload transport data collected by use of Helley-Smith bedload samplers showed that bedload averaged about 20 percent of total sediment yield. Analysis of runoff-sediment events by parameter optimization showed excellent correlation between suspended sediment volume and combined peak flow and runoff volume. The procedure should be useful in predicting sediment yields from similar areas having a minimum of sediment data." (A)

274. Johnson, M.G.; Beschta, R.L. 1980. Logging, infiltration capacity, and surface erodibility in western Oregon. Journal of Forestry. 78(6): 334-337.

"Infiltration capacity and erodibility were measured three to six years after portions of forested watersheds in western Oregon had been logged. Overall values on the logged portions did not differ significantly from values on unlogged portions. Areas that had been heavily disturbed—skid trails, cable log paths, and places where slash had been windrowed by tractors and then burned—had reduced infiltration capacity and increased surface erodibility but also had partially recovered to prelogging conditions." (A)

275. Johnson, R.B. 1979. Factors that influence the stability of slopes—a literature review. Rep. FHWA-RD-79-54. Washington, DC: U.S Department of Transportation, Federal Highway Administration, Offices of Research and Development. 123 p.

"The U.S. Geological Survey (USGS), under subcontract to the National Bureau of Standards (NBS) on FHWA contract no. FHWA-7-3-0001, performed the geologic tasks required by the contract. The portion of the project reported in this interim report is part of Phase I requiring documentation of features and conditions which influence stability of natural and manmade slopes in earth materials. The features and conditions described include discrete primary and secondary features or discontinuities such as bedding surfaces, joints, and foliations as well as less distinct anisotropies in an otherwise physically uniform mass. Discussion of secondary factors contributing to slope instability such as rainfall, slope steepness and aspect, and vegetation also is included. Triggering by earthquakes has not been included, nor have mud and debris flows and soil creep unless they have been inseparably grouped by authors with other types of mass movement. Also, rockfalls, rock glaciers, and topples were not investigated. All other mass movement of soil and rock such as earthflows, slumps, and rock or block slide failures are considered to be varieties of landslides and are included in this report. The literature on interaction of landslide-causing factors was reviewed and is summarized." (A)

276. Johnson, W.; Wellburn, V., eds. 1976. Handbook for ground skidding and road building in the Kootenay area of British Columbia. Vancouver, BC: Forest Engineering Research Institute of Canada. 41 p.

"This handbook is to be used by skidder operators, bulldozer operators, fallers, other ground skidding loggers, their supervisors and the logging planners and engineers. The aim is to improve ground skidding and road building practices so that trees can be cut, skidded and hauled efficiently and cause only a minimum of soil disturbance and erosion.

"These instructions are not rigid rules to be applied without flexibility. They are not a substitute for common sense or experience. Rather, they are written to make everyone aware of the problems and to encourage communication so that the best method for logging can be selected, to avoid site damage.

"The safety of men and machines must be the first consideration and safe working practices must be followed at all times.

"Good practices make ground skidding acceptable over a wide range of slope, soil and seasonal conditions. Failure to follow acceptable practices can only result in additional restrictions which will limit the amount of ground skidding permitted.

"The success of the procedures outlined in this handbook is dependent upon a conscientious effort by everyone concerned.

"Co-operation between the Forest Service, Industry and Contractors is essential to make these instructions effective...." (A)

277. Johnson, W.N. 1975. Erosion control and water quality consideration in ski area planning and administration. In: Watershed management: Proceedings of a symposium; 1975 August 11-13; Logan, UT. New York: American Society of Civil Engineers: 275-305.

"The intensity of environmental constraints required for ski area development should be based on land capability. Such key factors as soil erodibility, soil fertility, mass movement potential, drainage and sediment yield should be considered in ski area planning." (A)

278. Johnson, W.N.; Fifer, R.S. [n.d.] Water quality considerations for highway planning and construction: I-70 Vail Pass, Colorado. Glenwood Springs, CO: U.S. Department of Agriculture, Forest Service, White River National Forest. 54 p., plus appendix.

"Soil erosion and sediment control have long been concerns associated with road construction activities. Several manuals have been written on the subject, providing excellent guidelines for estimating costs and implementing control measures. The construction of a four lane highway over Vail Pass, Colorado, has provided the opportunity to implement many of these control measures on a sensitive, high elevation, mountain pass. This report evaluates the performance of these erosion and sediment control structures. The results are considered representative of what might be expected in other steeply dissected, mountainous terrain. These measures are applicable to other land-disturbing activities, including: timber sales, mining operations, ski areas, and all construction sites." (A)

279. Judson, S. 1968. Erosion of the land. Scientific American. 56: 356-365.

"We know today, of course, that vegetation plays an important role in the preparation of material for erosion. We know, also, that although vegetation may slow the removal of material from a slope, it does not stop it completely. Hutton's view is overwhelmingly accepted today. Erosion continues in spite of the plant cover, which, in fact, is conducive to certain aspects of erosion. The discussion now centers on the factors determining erosion, the nature of the products of this process, how these products are moved from one place to another, and at what rates the products are being produced. Hutton, in his day, had no data upon which to make a quantitative estimate of the rates at which erosion progressed. Today we, unlike Hutton, measure rates of erosion for periods of a fraction of a man's lifetime, as well as for periods of a few hundreds [sic] or thousands of years of human history. In addition, radioactive dating and refined techniques of study in field and laboratory allow us to make some quantitative statements about the rates at which our solid lands are wasted and moved particle by particle, ion by ion, to the ocean basins.

"This report sets forth some of what we know about these erosional rates. We will understand that erosion is the process by which earth materials are worn away and moved from one spot to another. As such, the action of water, wind, ice, frost-action, plants and animals, and gravity all play their roles. The destination of material eroded is eventually the great world ocean, although there are pauses in the journey and, as we will see later, the material delivered to the ocean must be in some way reincorporated into the continents." (A)

280. Keller, H.M. 1972. Torrent control in the Alps. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 6; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 296-308.

"The significance of forestry and hydrologic engineering for control of torrents in the Alps is considered. Intensive rainfall and low infiltration capacities of mountain soils are the main causes of torrents. Control is based on the principle that engineering works and biological controls over erosion must work hand-in-hand. The design of engineering works has been based on empirical formulas. Hydraulic parameters for design are much better known than hydrologic effects of climate, geology, soil, vegetation, and land use which are equally important. The main future problem is the design of structures and land treatments based on interdisciplinary basic data of torrent catchments." (A)

281. Kelsey, H.; Madej, M.A.; Pitlick, J. [and others]. 1981. Major sediment sources and limits to the effectiveness of erosion control techniques in the highly erosive watersheds of north coastal California. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 493-509.

"In the northern California Coast Ranges of the U.S., the combination of naturally unstable terrain and intensive landuse has created a need for erosion control programs to rehabilitate heavily disturbed slopes. In large drainage basins, 500-1000 km^2 in size, the major sediment sources generally occupy small, inaccessible portions of the basin that are in the stream channel or on footslopes adjacent to steep stream reaches. The best available erosion control measures, exemplified by those currently in use in Redwood National Park, are effective in dealing with erosion problems on heavily disturbed hillslopes. Early treatment of problems can prevent possible downslope cumulative impacts. However, because of the inaccessibility of the major sediment source areas, there is a limit to effectiveness of erosion control. Total drainage basin rehabilitation is not technically feasible, and basin-wide erosion control becomes, in part, a problem of managing land within recognized geologic constraints." (A)

282. Kenttamies, K. 1980. The effects on water quality of forest drainage and fertilization in peatlands. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 277-284.

"A small peat drainage basin was drained and fertilized after first being monitored for four years. Suspended solids concentration after drainage, expressed as the two-year mean, was six times higher than before. Organic carbon concentration immediately after the drainage was a little lower than before. After fertilization with PK-fertilizer, the phosphorus content in runoff increased from 18 μg P l^{-1} to a mean value of 128 μg P l^{-1}. The highest monthly mean was 300 μg P l^{-1}. The share of phosphate phosphorus of the total phosphorus doubled to 60 percent. Potassium concentrations increased after fertilization by a factor of about four. Suspended solids and organic carbon concentrations are on the same level in old (20-40 years) drained and afforested peatlands as in natural peatlands. The effects of phosphorus fertilization on runoff water quality can be detected for at least 5-10 years, while the effects of potassium fertilization disappear in 1-2 years." (A)

283. Ketcheson, G.; Froehlich, H.A. 1978. Hydrologic factors and environmental impacts of mass soil movements in the Oregon Coast Range. WRRI 56. Corvallis, OR: Water Resources Research Institute, Oregon State University. 94 p.

"Mass soil movements of four types; debris avalanche, debris torrent, debris slide and bank slough, were field inventoried in the Oregon Coast Range. A total of 104 mass movements were located in 21 undisturbed watersheds and 13 clearcuts harvested in the last six years. Failures associated with roads and landings were not included in this inventory. Failure volume ranged from 2 yd^3 to 196 yd^3. The average volume of all failure types ten cubic yards or more in volume is 41 yd^3 in undisturbed watersheds and 47 yd^3 in clearcuts. Failures less than ten cubic yards are of little significance in terms of initial volume moved, but in undisturbed watersheds they account for over one-fourth of the channel impact by mechanical scour and deposition. The frequency of all failures is similar in clearcuts and undisturbed watersheds, one in 19 acres and one in 17 acres, respectively.

"Mass failures travel 1.7 times farther in clearcuts than in undisturbed watersheds. Debris jams from failures in clearcuts contain 3.2 times more inorganic and 2.5 times more organic debris than debris fans from undisturbed watersheds. Eight percent of the Class III and IV stream length (U.S. Forest Service Classification) in forested drainages and ten percent of that within clearcuts is impacted by channel scour and deposition.

"The erosion rate for all soil landtypes encountered in undisturbed watersheds is 0.11 yd^3/ac/yr. This rate increases by 3.5 times in clearcuts. Landtypes with very steep, highly dissected slopes show the largest increase in erosion rate from uncut to clearcut watersheds (10 times). Less than one percent of the forested or clearcut land area is affected by the mass soil movements.

"Half of the failures in undisturbed drainages and nine-tenths of the failures in clear-cuts occurred on slopes of 80 percent or greater. The average volume of failures is greatest on slopes of 80 to 100 percent. No apparent relation exists between failure frequency and aspect in this study.

"The results are compared with other studies in the Pacific Northwest and the differences are discussed. Natural variation accounts for much of the differences. Guidelines are given for assessing the risk of damage by debris avalanche and torrent type failures in proposed timber harvest areas." (A)

284. Khanbekov, I.I. 1972. Erosion and torrent control by biologic and hydrotechnic means in mountainous regions. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 6; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 277-285.

"Describes the character and formation of 'sels', a specific type of torrent containing large amounts of rock, mud and other debris. Greatest hazard occurs in mountain regions with low precipitation, infrequent high-intensity rains and rapidly weathering rock and soil. Activities such as unregulated timbercutting and uncontrolled grazing contribute greatly to these hazards. Control measures include restoration of vegetative cover, improved logging methods, replacement of clearcutting by selective cutting and development of agriculture involving perennial cover such as nut-producing trees and vineyards. Mechanical measures include dams and weirs in the stream channels to control water flow and debris and diversion works such as aqueducts and pipes to control high concentrations of water in sel-producing areas." (A)

285. Kidd, W.J.; Kochenderfer, J.N. 1973. Soil constraints on logging road construction on steep land east and west. Journal of Forestry. 71(5): 284-286.

"To manage and use forest lands, some type of access is required. Access means roads and trails...road networks for timber management on steep land are normally much denser than for most other uses.

"Road building problems common to both east and west [United States] are:

1. The erosion hazard or potential of the particular soils of the area....

2. Slumping, as caused by soil mantle failure.

3. Compaction of the soil by heavy mechanized road building and logging equipment.

4. Lack of proper drainage from the road prism including the cut and full slopes and the road surface.

5. Soil and rock types in the logging area." (A)

286. Kidd, W.J., Jr. 1963. Soil erosion control structures on skidtrails. Res. Pap. INT-1. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 8 p.

"More than 500 measurements of erosion on 105 logging skidtrails showed that: (1) erosion is greater and healing is slower on granitic than on basaltic soils, and is greater in ravine bottoms than on sidehills; (2) the best control structures divert water onto undisturbed forest floor rather than merely retarding its flow; (3) increase in spacing between control structures is accompanied by increase in soil movement and (4) optimum spacing between control structures depends upon slope, location of skidtrail, and soil parent material." (A)

The paper also gives average performance ratings of control structures by type and location, soil parent material, and percent slope. (C)

287. Kidd, W.J., Jr.; Haupt, H.F. 1968. Effects of seedbed treatment on grass establishment on logging roadbeds in central Idaho. Res. Pap. INT-53. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 9 p.

"Deep and shallow scarification treatments, before and after broadcasting seed, were studied to determine if they would be conducive to establishment of a heavier stand of grass than could be obtained by merely broadcasting seed. Mulching with wood chips and fertilizing were also tried. Results show a slight advantage for deep scarification before seeding. Three of five perennial species became well established; the other two did poorly. Crested and intermediate wheatgrass and smooth brome produced good cover; timothy and bulbous bluegrass produced sparse cover. Establishment of seedlings was significantly affected by site aspect and mulch." (A)

288. Kimberlin, L.W.; Moldenhauer, W.C. 1977. Predicting soil erosion. In: Soil erosion and sedimentation: Proceedings, national symposium on soil erosion and sedimentation by water; 1977 December 12-13; Chicago, IL. ASAE Publ. 477. St. Joseph, MI: American Society of Agricultural Engineers: 31-42.

"The universal soil loss equation is a highly useful tool for predicting sheet and rill erosion under various conditions of land use and management. It is widely accepted and used by soil conservationists and others. However, there are some problems associated with its use and some additional needs to supplement its use in the field." (A)

289. Kirkby, M.J.; Morgan, R.P.C., eds. 1980. Soil erosion: a publication of the British Geomorphological Research Group. Chichester, United Kingdom: John Wiley and Sons, Ltd. 312 p.

"Research on soil erosion has been focused on the work of the US Soil Conservation Service since erosion was recognized as a serious agricultural problem in the late 1920s, and the SCS was established to combat it. Current work by Agricultural Engineers in the USA has continued to build on the very considerable experience of the SCS which has been systematized as the Universal Soil Loss Equation.

"Since 1960 substantially new approaches to soil erosion research have been developed, both in the USA and in Europe. The most significant new development is that the geomorphological and hydrological processes of erosion are being re-examined in detail. The basic assumptions of the Universal Soil Loss Equation are being questioned, and workers in separate fields are beginning to make independent contributions to aspects of overland flow, infiltration, soil crusting, and soil removal. This book is an attempt to bring this work together for the first time in a research level text. The authors who have contributed are all active in soil erosion research, and bring a range of current viewpoints together. Each chapter may be read in isolation, but chapter topics have been designed to provide a sequential text which covers the whole of soil erosion as we see it.

"Chapter 1 is an introductory survey of the field, showing some of the important areas for research development. Chapter 2 sets out the Universal Soil Loss Equation and how it may be used and developed further. Chapter 3 reviews established and new methods for measuring soil erosion. Chapters 4, 5, and 6 examine the processes of water erosion in detail, from empirical, theoretical, and modelling viewpoints respectively. Chapter 7 examines wind erosion similarly. Chapter 8 looks at the implications of new research for soil management, and Chapter 9 concludes briefly by looking to the future of erosion research." (A)

290. Klein, S.B. 1980. State soil erosion and sediment control laws: a review of state laws and their natural resource data requirements. Denver, CO: National Conference of State Legislatures. 116 p.

"Removing sediment and other non-point pollution from the nation's waterways is an important part of the water quality improvement effort taking place under Public Law 92-500, the Federal Water Pollution Control Act as amended by the Clean Water Act of 1977 (P.L. 95-217). Section 208 (Water Quality Management) of the Clean Water Act requires development and implementation of areawide water quality management plans containing management and regulatory programs to control point and non-point source pollution. The planning process is generally referred to as '208 Planning'.

"Twenty states, the District of Columbia, and the Virgin Islands have enacted erosion and sediment control legislation during the past decade. These laws provide for the implementation or the strengthening of statewide erosion and sediment control plans for rural and/or urban lands. This report quotes and reviews that legislation and the state programs developed to implement these laws and extracts the natural resource data requirements of each program. The legislation includes amendments to conservation district laws, water quality laws, and erosion and sediment control laws. Also included is a summary of Landsat applications and/or information systems that have been involved in implementing or gathering data for a specific soil erosion and sediment control program (Appendix A). A summary of principal concerns affecting erosion and sediment control laws is also provided for in Section VI of this report." (A)

291. Klock, G. 1973. Mission Ridge—a case history of soil disturbance and revegetation of a winter sports area development. Res. Note PNW-199. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p.

"Areas of soil disturbance caused by construction of a winter sports area are identified, and the private operator's use of forest research findings to reduce the effect of these disturbances are reviewed." (A)

292. Klock, G.O. 1976. Estimating two indirect logging costs caused by accelerated erosion. Gen. Tech. Rep. PNW-44. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 9 p.

"Hypothetical erosion assessment models have been developed for determining some of the onsite and downstream damage possible by logging. By using the soil erosion potential for several yarding systems to determine the erosion assessments, total relative logging costs for each system may be evaluated. This evaluation method may show that environmentally acceptable advanced systems of yarding could cost less than traditional yarding systems at some locations." (A)

293. Klock, G.O.; Helvey, J.D. 1976. Debris flows following wildfire in north central Washington. In: Proceedings, 3d Federal interagency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water ResourcesCouncil: 1-91 to 1-98.

"A combination of rapid snowmelt, high intensity rainstorms, and fire-denuded watersheds resulted in massive debris torrents from numerous tributary streams of the Entiat River in north-central Washington during the spring and summer of 1972. Debris torrents are summarized by location, soil type, topography, and land use history for five adjacent watersheds. Alternative forest management recommendations are suggested for minimizing the impact of possible future debris torrents within the study area." (A)

294. Knisel, W.G., Jr. 1980. Erosion and sediment yield models—an overview. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 141-150.

"Mathematical modeling of the processes in erosion and sediment transport has increased significantly since passage of the Clean Water Act, Public Law 92-500, in 1972. This session of the ASCE conference was planned to compile papers concerned with erosion models. Although erosion and sediment transport will be emphasized, the models generally are components of more comprehensive models that have evolved to meet the needs of PL 92-500. The purpose of this paper is to provide an overview of the modeling activities and at least partly describe the history of model development. It is impossible to give a complete background, but hopefully the more important works will be included to indicate the various developments. Although this session is devoted to erosion and sedimentation, we must consider hydrology as well." (A)

295. Kochenderfer, J.N. 1970. Erosion control on logging roads in the Appalachians. Res. Pap. NE-158. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 28 p.

"Practical methods of controlling erosion on logging roads are summarized through the different stages—planning, location, drainage, maintenance, and care after logging. The material was derived from existing literature, road lore, contact with experienced land managers, and personal experience." (A)

Specific suggestions in the report are that: (1) good planning can reduce skidtrail areas by as much as 40 percent, (2) a minimum road grade of 3 percent is desirable to provide adequate drainage, (3) a minimum of 100 feet is recommended between logging roads or landings and streams, (4) outsloping a road by about 3 percent is an effective way to remove small quantities of water from the road surface, (5) broad-based dips can be used instead of culverts and should be spaced according to Spacing = (44+ slope percent) + 100 feet, and (6) roads should climb away from stream crossing in both directions. The report also provides a table of water bar spacing requirements for roads that have been "put to bed." (C)

296. Kochenderfer, J.N. 1977. Area in skidroads, truck roads, and landings in the central Appalachians. Journal of Forestry. 75(8): 507-508.

"In nine central Appalachian areas logged with wheeled skidders, there was 1 mile of road for every 19.8 acres; roads and landings occupied 10.3 percent of the area. In two areas logged with jammers, there was 1 mile of road for every 31.1 acres; roads and landings occupied 7.8 percent of the area." (A)

297. Krag, R.K. 1980. A method to estimate risk of soil erosion to logging sites in the Kootenay area of British Columbia. Tech. Rep. TR-38. Vancouver, BC: Forest Engineering Research Institute of Canada. 55 p.

"FERIC has tested and adapted a proposed method for classifying timber sites to minimize the impact of timber harvesting. This report presents the revised system for estimating the risk of soil erosion from road-building and logging, and provides procedures for site-specific inspections by field planners and engineers.

"To apply the classification system, the user must estimate slope, soil texture and particle-size distribution, soil depth, and site moisture regime at several sites within the proposed cutting area. Criteria based upon these site variables are presented to identify the risks of surface erosion and slope failures. These risks are combined to classify the site's overall Erosion Hazard, from Very Low to Very High. Field sampling methods are suggested to ensure adequate coverage and representative description of the cutting area.

"Finally, FERIC suggests guidelines for selecting and applying harvesting systems and equipment and road construction practices based on the site conditions." (A)

298. Krammes, J.S. 1965. Seasonal debris movement from steep mountainside slopes in southern California. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 85-88.

A study began in 1953 in the Los Angeles River watershed to determine the cause, rates, and amounts of debris moving downslope and into channels. "Debris that is eroded from the side slopes arrives in the channels through the action of wind, water, and gravity. However, these forces do not act equally or independently. There is always a gradual downslope movement of debris in the San Gabriel Mountains. The gradual soil movement during dry seasons is the 'base flow' and the wet-season movement is analogous to 'storm flow.' Debris movement was separated into dry-season and wet-season movements to determine variations in rate between seasons....Over the years, many tons of debris are deposited in stream channels during both wet and dry seasons. This material remains poised in the channels and will be moved only when winter runoff has sufficient carrying power. Such flows occur on the average of once in every 5 to 6 years. Thus, side slope erosion provides much of the flood debris that is thought of as bank or channel scour." (C)

299. Kroll, C.G. 1976. Sediment discharge from highway cut-slopes in the Lake Tahoe basin, California, 1972-74. Water Res. Invest. 76-19. Menlo Park, CA: U.S. Department of the Interior, Geological Survey. 85 p.

"Streamflow and fluvial-sediment discharge data were collected at selected streams and highway gutters in the Lake Tahoe basin to determine the extent of erosion from highway cuts and to attempt to evaluate the effects of various land-treatment practices to reduce erosion.

"Estimate of long-term annual total-sediment discharge from six streams into the lake is 7,100 tons (6,400 tonnes), of which 2,300 tons (2,100 tonnes) is finer than 62 micrometres. During 1972-74, snowmelt runoff (April-July) accounted for 65 percent of the water and sediment discharge. Appoximately 90 percent of the sediment is transported in suspension.

"Sediment measured at 16 gutterflow stations at the base of highway cut-slopes indicates that less than 100 tons (91 tonnes) of fine sediment per year are contributed to the lake from all California State highway cuts. Sediment-transport rates are highly variable, and an unknown part of the suspended sediment was derived from sources other than highway cuts.

"Data were not adequate to demonstrate the effectiveness of treatments to stabilize cut-slopes." (A)

300. Krygier, J.T.; Brown, G.W.; Klingeman, P.C. 1971. Studies on effects of watershed practices on streams. Res. Ser. 13010 EGA 02/71; [PB-218 266]. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory; U.S. Environmental Protection, Agency Water Pollution Control. 173 p.

"A number of studies were undertaken related to effects of clearcut logging on water quality and the process [sic] affected in small streams. Water temperature studied before and after logging was increased significantly where stream cover was removed. Energy balances of small streams were measured and predictive models were developed. Road building significantly increased sediment yield in clearcut and patch cut watersheds. Logging itself was not an important sediment contributor. Methods for sampling bed load and suspended sediment were developed. Bed load contributed 70 per cent of suspended load during peak discharges." (A)

301. LaFayette, R.A. 1978. Reducing erosion and sedimentation through erosion hazard analysis. In: Proceedings, 2d symposium on Southern hardwoods; 1977 April 20-22; Dothan, AL. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry, Southeastern Area: 54-68.

"An erosion hazard rating system using the universal soil loss equation (USLE) is presented. A graphical method of solving the equation is introduced to aid resource planners in calculating potential soil loss." (A)

302. Lane, L.J.; Foster, G.R. 1980. Modeling channel processes with changing land use. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 200-214.

"Procedures are developed to predict channel morphology for small streams and to relate channel morphology to sediment yield. Sensitivity analysis shows the response or adjustment of stream channels due to changes in discharge and channel characteristics resulting from changing land use. The procedure provides a basis, from hydraulics of open channel flow and a simple erosion equation, to quantitatively evaluate the response of stream channels to changes in discharge, soil properties, and topography. The quantitative method is an improvement over qualitative procedure based on empirical regression equations." (A)

303. Larse, R.W. 1971. Prevention and control of erosion and stream sedimentation from forest roads. In: Morris, J., ed. Forest land uses and stream environment: Proceedings of a symposium; 1970 October 19-21; Corvallis, OR. Corvallis, OR: Oregon State University: 76-83.

"To minimize erosion and resultant stream sedimentation, prevention and control measures must be given consideration in every aspect of road planning, design, construction and maintenance. In mountainous terrain the forest land manager must establish specific objectives and prescriptions to guide road network construction and utilize the combined professional skills of the forester, engineer, geologist, biologist, and others to set standards for the protection of watershed values, identify alternatives, and offer solutions to specific problems.

"The decision to road an area should only be made after the resource-serving benefits have been carefully weighed against the cost and effect of roading on the watershed. The decision not-to-road and to accept other alternatives for land-use management must be strongly considered when the probability of lasting damage to soil, water, and other ecological values is recognized." (A)

304. Lattanzi, A.R.; Meyer, L.D.; Baumgardner, M.F. 1974. Influences of mulch rate and slope steepness on interrill erosion. Soil Science Society of American Proceedings. 38(6): 946-950.

"Soil and water losses from plots representing field areas between rills were studied for four rates of straw mulch at four slope steepnesses. Three simulated rainstorms totaling 2 hours at 6.4 centimeters/hour were applied to a 61 by 61 centimeter test area of Russell silt loam soil.

"Interrill erosion was reduced about 40 percent by mulch applied at a rate of only 0.5 metric tons/hectare (25 percent cover), and about 80 percent by 2 tons/hectare (61 percent cover), as compared with no mulch. Erosion was negligible at the 8 tons/hectare (95 percent cover) rate. Soil losses from the interrill areas at 20 percent slope were only about double those measured at two percent slope, whereas widely used erosion equations show that total field erosion would increase about 20-fold over this range of steepnesses.

"Water loss by runoff was independent of slope steepness, but it was slightly reduced by mulch at a rate of 2 tons/hectare and was greatly reduced by the 8 tons/hectare rate. After 40 minutes of rainfall, sealing of the soil surface by raindrop impact had reduced infiltration rates for treatments with 0 to 2 tons/hectare of mulch to only 20 percent of those with 8 tons/hectare." (A)

305. Leaf, C.F. 1966. Sediment yields from high mountain watersheds, central Colorado. Res. Note RM-23. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

"A study of annual sediment yields from one carefully logged and two undisturbed watersheds in the Fraser Experimental Forest showed good correlation between peak streamflow and accumulated sediment volume. The relationships indicate that a major part of the sediment load is derived from channel erosion. The effects of logging on sediment yields are discussed, and magnitude-frequency relationships are developed for estimating long-term sediment yields." (A)

306. Leaf, C.F. 1970. Sediment yields from central Colorado snow zone. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 96(HY1): 87-93.

Sediment yields are presented from two undisturbed watersheds and one watershed from which half the merchantable timber was removed by careful timber harvesting and road construction. Sediment yield during road construction and after extensive logging on the Fool Creek watershed averaged 200 pounds per acre compared with an average 88 pounds per acre for the pretreatment period of record. Yield decreased rapidly 2 years after timber harvesting despite an estimated 25 percent increase in runoff caused by the harvest. Since the decline in sediment yield, annual sediment yield from Fool Creek has averaged 43 pounds per acre compared with yields of 11 pounds per acre and 21 pounds per acre from the two undisturbed watersheds. (C)

307. Leaf, C.F. 1974. A model for predicting erosion and sediment yield from secondary forest road construction. Res. Note RM-274. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

"One of the more visible and controversial environmental impacts associated with timber harvesting and development in central Colorado is road construction. Better tools are needed to quantify the effect of soil disturbance on erosion sites, and the subsequent yield of sediment downstream.

"This Note summarizes available data, and from this base, proposes a preliminary model for predicting an index of onsite erosion and downstream sediment yield." (A)

The model described is given by the following equation: $S = 0.121 WEn (1 + (\tan p/2) ((1/\tan Oc - \tan p) + (1/\tan Of - \tan p)))$; where S is an index of cumulative erosion in cubic feet, W is the road width in feet, E is an index of the cumulative onsite erosion in cubic feet per acre at time (t) after road construction, t is the number of years after initial disturbance, n is the number of miles of road constructed, p is steepness of the sideslope in degrees, Oc is angle of cut and Of is angle of fill. (C)

308. Lehre, A.K. 1981. Sediment budget of a small California Coast Range drainage basin near San Francisco. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 123-139.

"Three years of detailed measurements of erosion and sediment discharge in the 1.74 km^2 drainage basin of Lone Tree Creek, a small stream 14 km northwest of San Francisco, showed that debris slides and flows from colluvium-filled swales are the most important erosional agent and account for most of the current sediment yield from the basin. The bare scars are loci for sheetwash and gully development; they refill by backwearing of slide scarps and by soil creep. During the study period, only 53 percent (2068 t/km^2) of all sediment mobilized was discharged from the basin; the remainder was stored in slide scars, on footslopes, and in gully and channel banks and beds. Sediment is removed from storage by storms with recurrence intervals greater than 10 years. Comparison of present rates of sliding and refilling suggests that slide frequency has increased approximately tenfold in the past 50-150 years, and that slides are currently mining relict colluvium." (A)

309. Lenvain, J.; De Boodt, M.; Suwardjo. 1976. An effective way in fighting soil erosion: promoting growth of young trees through plantpit treatment with soil conditioners. Mededelingen van de Faculteit Landbouwwetenshappen Rijksuniversiteit Gent. 41(4): 141-157.

"Soil conditioning to fight erosion can be applied in different ways. One of the possibilities is that the soil conditioner treatment is concentrated to the plantpit of the young trees in order to start vegetation in eroded areas.

"The advantages of the plantpit technique are: (1) the reforestation of a strongly eroded area becomes technically possible, (2) soils which are not suitable for agriculture can yield a reasonable amount of wood for paper industry or other purposes, (3) the application of fertilizers is rationalized and its efficiency is highly increased because leachages are prevented, (4) the percentage of surviving trees is increased, which means a lower number of young trees to be planted in order to cover the soil, and eventually less intermittent cuttings afterwards; replanting which is so often needed in difficult areas is thus avoided, (5) the soil cover and thus the microclimate to develop low by the ground growing vegetation (including litter) is established faster; finally a bigger production per ha can be expected." (A)

310. Li, R.M.; Simons, D.B.; Carder, D.R. 1977. Mathematical modeling of soil erosion by overland flow. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 210-216.

"An unsteady overland flow soil erosion model was developed to simulate sediment outflow hydrographs and land-form evaluation processes. Because the model was developed assuming an overland flow surface of sandy soil, the soil detaching and transporting capacity of raindrop input was ignored. However, the effect of raindrop impact on flow resistance was included.

"This rainfall-erosion model simulates both water and sediment flow routing and produces time-dependent erosion rates. The simulated results agree reasonably well with the available experimental data from soil plots. The model can generate time-dependent landforms, and the generated landforms tend to be concave in shape,which is common in nature. Also, we found that the soil erosion rates were very sensitive to surface slope and shape. The general practice of assuming a uniform slope shape may result in serious errors.

"The applicability of the proposed simple model is limited to the following conditions: (a) the overland flow erosion is mainly due to sheet erosion; (b) the kinematic-wave approximation for flow routing is valid, and the surface slope is less than 25 percent; (c) the detaching and transporting capacities caused by raindrop impact are negligible." (A)

311. Li, R.M.; Stevens, M.A.; Simons, D.B. 1976. Water and sediment routing from small watersheds. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-193 to 1-204.

"In many past studies, a statistical interpretation of observed data has been utilized to solve sediment-yield and related problems. The unit hydrograph method for water routing and the Universal Soil Loss Equation for estimating erosion are examples of these types of studies. It is difficult to predict the response of a watershed to various land developments or treatments using these methods because they are based on the assumption of homogeneity in time and space. Numerical modelling using equations describing the physical processes is a viable way to study the effects of various watershed treatments or land developments on water and sediment yields from watersheds.

"The numerical model presented in this paper simulates the physical processes by which water and sediment are moved overland to and down creeks and rivers in watersheds. Some of the processes modeled are interception and infiltration from rainfall, overland flow from excess rainfall, sediment production due to raindrop impact, sheet erosion by overland flow, channel erosion, and the water and sediment routing through the channel system. A nonlinear kinematic-wave approximation for flow routing has been used to route water and sediment overland and in channels.

"For the watershed simulated, the computed water and sediment yields agree with the measured water and sediment yields. In addition, this model has the capability to predict watershed treatment effects on individual water and sediment hydrographs and long-term yields, and to identify the sediment sources in watersheds." (A)

312. Livesey, R.H. 1975. Corps of Engineers methods for predicting sediment yields. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 16-32.

Because the nature of various projects is diverse, both in magnitude of design and geographic location, methods used by the U.S. Army Corps of Engineers vary with individual district offices. Although a variety of procedures have been developed by the Corps to predict sediment yields, they all relate closely to one of three basic empirical approaches: (1) direct measurement of the yield rate sampling sediment or surveying reservoir, (2) extrapolation of such data to unmeasured watersheds, or (3) establishment of identifiable physiographic characteristics of watersheds or streamflow that permit development of predictive equations. Each method is discussed in detail. (C)

313. Loughran, R.J.; Campbell, B.L.; Elliott, G.L. 1981. Sediment erosion, storage and transport in a small steep drainage basin at Pokolbin, N.S.W., Australia. In: Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 252-269.

"Within Maluna Creek basin (1.74 km^2) near Newcastle, Australia, soil surveys and the results of runoff-erosion plot experiments indicate that soil loss is greatest from cultivated land under vines (10 percent basin area), compared with forest (60 percent) and grassland (30 percent). Alluvial fans and flood plains are the chief sediment storages. Caesium-137 techniques reveal a greater sedimentation rate on one fan at the base of a cultivated slope than on the flood plain of Maluna Creek. Loss of sediment from the basin occurs mainly during high-intensity rainstorms. In one event, suspended-sediment concentrations reached a peak of 12 600 mg 1^{-1}." (A)

314. Lull, H.W.; Reinhart, K.G. 1965. Logging and erosion on rough terrain in the East. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 43-47.

Research into the effects of logging practices on erosion was conducted in the Fernow Experimental Forest in West Virginia. Maximum stream turbidities occurred during logging; sources of sediment were improperly constructed skidroads and skidroads located too close to the streams. Water quality measurements taken after logging indicated rapid reduction in erosion. (C)

315. Lusby, G.C. 1965. Causes of variations in runoff and sediment yield from small drainage basins in western Colorado. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 94-98.

"During a study of the effects of grazing on runoff, sediment yield, vegetation, and infiltration rates in paired, grazed and ungrazed, drainage basins in the Badger Wash area, it was determined that runoff and sediment yield were considerably less in the ungrazed basin of each pair, although no large changes in composition or density of plant cover were recorded." (A)

Study of erosion on hillslopes revealed a seasonal cycle of soil loosening by frost action and compaction of the soil by rainbeat in the spring and summer. In the grazed basin, trampling by livestock caused earlier and more pronounced compaction of loose soil and thereby produced higher rates of runoff and sediment yield. Exclusion of grazing decreased runoff and sediment yield, without major changes in vegetative cover. (C)

316. Lusby, G.C. 1977. Determination of runoff and sediment yield by rainfall simulation. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 19-30.

"The need exists for a tool to produce realistic data on the hydrologic effect of rainstorms on different soil-vegetation complexes. With this in mind, a portable rainfall simulator was developed that covered natural drainage basins of several thousand square feet. In order to test the feasibility of the simulator, measurements of runoff and sediment yield resulting from rainfall applied to two virtually identical basins were compared and similar results were obtained. Sediment yield was found to be related to runoff by the power curve $Y = 4.56X^{1.25}$, where Y = sediment yield in tons per acre and X runoff in inches. Results indicate that the rainfall simulator will be of value in determining hydrologic effects of different land treatment practices." (A)

317. Maner, S.B. 1958. Factors affecting sediment delivery rates in the Red Hills physiographic area. Transactions of the American Geophysical Union. 39(4): 669-675.

"Twenty-five records of watershed sediment delivery rates and factors affecting sediment-delivery rates are analyzed. Relief and maximum length of watershed expressed as relief-length ratio in a simple curvilinear correlation or as individual variables in a multiple curvilinear correlation are found to offer a much closer correlation with sediment delivery rates than size of sediment contributing area or several other factors tested.

"The basic trend of thought in this study is that rates of sediment yield of watersheds are immediately comparable only if their gross erosion rates per unit area are the same. Otherwise, it is their delivery rates that must be compared, and once causal factors of the sediment delivery rate have been evaluated for a soil and climatic region, it is possible to predict sediment yields closely from gross erosion data and the delivery rate characteristics of individual watersheds within that region." (A)

318. Maner, S.B. 1965. Geology in sediment delivery ratios. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 108-110.

"The link between drainage basin geology and sediment delivery ratio is the drainage-network elements. The initial scale, shape, and distribution of these elements are a function of geologic structure and lithology. The current shape, scale, and distribution of these elements are conditioned by the kinds of geomorphic processes active in a given area and the length of time the processes have been active. The fact that inter-relation betweeen geomorphic characteristics of drainage basins does exist indicates the current stage of the geomorphic cycle to be a prime factor in determining which of the drainage basin characteristics are best related, quantitatively, to sediment delivery ratio." (A)

319. Marston, R.A. 1977. A synoptic approach to assessing non-point sources of sediment from forested watersheds. In: Aubertin, G.M., ed. "208" symposium, non-point sources of pollution from forested land; 1977 October 19-20; Carbondale, IL. Carbondale, IL: Southern Illinois University: 351-370.

"Considerable attention has been accorded to modeling efforts which attempt to quantify total basinwide sediment yield. Such a number provides little insight to the spacial distribution of non-point source contributing areas of the watershed. Meanwhile, other efforts to model surface erosion, channel erosion, or mass movement associated with silvicultural activity are often found to be useless as a 208 planning tool because they do not acknowledge the importance of hydrologic processes operating in forested watersheds. A synoptic approach to assessing non-point sources of sediment from forested watersheds is described which provides a framework for translating stability ratings for stream channels contiguous to classified hillslope segments into Best Management Practices for these hillslope-channel systems." (A)

320. Marston, R.A. 1978. Morphometric indices of streamflow and sediment yield from mountain watersheds in western Oregon. Corvallis, OR: U.S. Department of Agriculture, Forest Service, Siuslaw National Forest. 74 p.

"Systems analysis of fluvial form and process is used as a basis for determining significant statistical correlation between morphometric variables and streamflow and sediment yield. Seventy-two basin and stream network morphometric variables are measured for fifteen small, instrumented watersheds in mountain regions of western Oregon. A comprehensive review of the literature reveals eleven morphometric variables which have been used with some success to estimate annual runoff, base flows, peak flows, and sediment production on an area-yield basis. The most useful estimate of mean annual runoff is provided by drainage density (r^2 = .735). Relief ratio is the single most useful estimate of base flow (r^2 = .471). The most useful estimate of mean annual peak flow is provided by stream frequency (r^2 = .487). Drainage density is the single most useful estimate of mean annual sediment yield (r^2 = .425). Significant correlations are graphically displayed for additional variables. Some correlations are restricted to specific physiographic land types. Interpretation of the derived relationships is discussed relative to their usefulness as a tool in land management planning for the Siuslaw National Forest." (A)

321. Martz, L.W.; Campbell, I.A. 1980. Effects of a pipeline right-of-way on sediment yields in the Spring Creek watershed, Alberta. Canadian Geotechnical Journal. 17: 361-368.

"Very few data are available on the sediment yield of Alberta watersheds especially in the northern portion of the province. In the 175 000 km^2 Peace River basin, which covers about 25% of Alberta, sediment data are collected regularly at only four stations. One of these is the 112.7 km^2 Spring Creek watershed. In 1977 a pipeline was installed near the mouth of Spring Creek, disturbing an area of about 5000 m^2 near the stream channel. The effects of this were to increase local sediment yields by over 1600 Mg in a 4 month period. This compares with regional averages for the Peace River basin of 18-88 Mg $km^{-2}year^{-1}$. The study indicates the magnitude of spatial variation of sediment production and shows some effects of geotechnical activities on sediment yields." (A)

322. Mattice, C.R. 1977. Forest road erosion in northern Ontario: a preliminary analysis. Rep. O-X-254. Sault Ste. Marie, ON: Canadian Forestry Service, Great Lakes Forest Research Centre. 27 p.

"To determine if forest roads caused significant erosion problems in northern Ontario a preliminary study was conducted in 1972 and 1973. Areas that were potentially more erodible when disturbed were investigated. A crude measure of the severity of erosion was made, based on the accumulation of cross-sectional areas intersected by offset lines. These areas provided an index of the size and distribution of features in relation to slope position and road centerline.

"The study suggests that most erosional effects are restricted to the road right-of-way. It also suggests that the problem areas were restricted to only 6 percent of the length of road sampled and generally occurred only where the maximum slope exceeded 10 percent. Problems encountered were due partly to a lack of proper management and partly to a lack of knowledge." (A)

323. Mattison, J.L.; Buckhouse, J.C. 1977. Ecological land units of Bear Creek Watershed and their relationship to water quality. WRRI-53. Corvallis, OR: Water Resources Research Institute, Oregon State University. 122 p.

Ten habitat types representing varying stages of ecological condition and management treatment were sampled for sediment production, using an artifical rainfall simulator. (C)

"Tractor logging in the mixed forest unit caused a significant increase in soil loss. Non-forest units exhibited a high natural variability in sediment production within the site, which tended to override any differences that may have resulted from a management treatment. Significant differences that did occur appeared to be closely related to differences in soils or ecological condition." (A)

324. McCammon, B.P.; Hughes, D. 1980. Fire rehab in the Bend municipal watershed. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 252-259.

"The Bridge Creek Fire burned 450 acres of the Bend Municipal Watershed in July, 1979. The area burned included the intake facilities and both sides of the stream for a distance of approximately 0.6 mile upstream from the intake. Ground cover on the 30 to 70 percent slopes was completely consumed and hydrophobic conditions existed throughout the area. In order to protect the water quality of the municipal supply, rehabilitation measures consisting of grass seeding, fertilization, snag terracing, and channel debris clearing were implemented. An intense thunderstorm on September 1, 1979 resulted in shutting off the water supply to Bend due to excessive turbidity caused by ash washing off the sideslopes. The snag terraces stored approximately 1,600 cubic yards of sediment on the hillside. While several direct entries of sediment into Bridge Creek were noted, less than 2 cubic yards were deposited in the intake's weir pond." (A)

325. McClimans, R.J. 1980. Best management practices for forestry activities. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 694-705.

"Small headwater streams are especially vulnerable to intensive timber harvesting. A practical guide was sought for silvicultural best management practices (BMP) for the field practitioner. This report defines critical combinations of site conditions for which BMP are needed to minimize adverse impacts on soil and water resources when undertaking certain forestry activities. BMP are also outlined. The report includes assessment methodologies, definitions, charts and graphs for the selection and effective application of BMP for forestry." (A)

326. McClimans, R.J.; Taylor, G.F., II; Huggins, A.; Bowen, A.F. 1978. Annotated bibliography of forest practices in relation to water quality. AFRI Res. Rep. 37. Syracuse, NY: Applied Forest Research Institute, College of Environmental Science and Forestry, State University of New York. 146 p.

"The recent surge of interest in forest practices as they relate to water quality stems, in part, from Section 208 of the Federal Water Pollution Control Act Amendments of 1972. As a result, so-called Best Management Practices (BMP) are being developed to minimize adverse impacts on water quality while maintaining the economic viability of commercial forest operations. A study of the pertinent published literature is important to any informed statement about the economic, environmental, and social impacts that could result from application of BMP. In conducting such a study, four particular questions begged answer, namely: (1) What is the extent of hydrologic and water quality information systems? (2) What is the state-of-knowledge of the impacts of forest activities on water quality? (3) What is known regarding the economic feasibility of various management techniques and practices? (4) What are the legal and social constraints and incentives on implementation of management practices?" (A)

327. McColl, J.G.; Grigal, D.F. 1979. Nutrient losses in leaching and erosion by intensive forest harvesting. In: Impact of intensive harvesting on forest nutrient cycling. Syracuse, NY: College of Environmental Sciences and Forestry, State University of New York: 231-248.

"Deep leaching and erosion are both pathways of nutrient loss from sites following intensive harvesting. Temporary increases in leaching losses may degrade surface-water quality, but generally will not be great enough to measurably decrease site quality under well-managed harvest and post-harvest conditions. Amounts of nutrientslost in erosion can be very great, especially from associated road construction. Mechanisms of leaching are understood, and leaching rates are relatively easily measured and may even be predictable in some cases. In contrast, erosional losses are difficult to measure, and often difficult to predict or control. Good engineering in both road placement and harvesting method can greatly minimize losses. Future work should concentrate on combined watershed/small-plot studies over a wide range of site conditions, with realistic treatments. More attention should be given to soil properties, microbiological processes, and atmospheric inputs, and their interactions with intensive harvesting, especially 'whole tree' techniques. Emphasis in assessing the importance of leaching and erosion should be directed at determining loss of productivity, and not simply the amount of nutrient movement." (A)

328. McCool, D.K.; Papendick, R.I.; Brooks, F.L. 1976. The universal soil loss equation as adapted to the Pacific Northwest. In: Proceedings, 3d Federal interagency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resource Council: 2-35 to 2-147.

"Use of the universal soil loss equation for soil loss prediction in the Pacific Northwest has been limited by inapplicable relationships for the factors of the equation. A first-generation adaptation of the equation was made by developing new relationships to fit Pacific Northwest conditions. These included (a) a slope length-steepness relationship to account for steeper slopes (greater than 20 percent) and runoff-induced erosion; (b) a runoff-rainfall erosion factor that accounts for effects on soil loss of climatic phenomena peculiar to the region, i.e., low intensity rainfall, snowmelt, and rain or snowmelt on frozen ground; and (c) first-approximation crop management factors to fit the region." (A)

329. McGuinness, J.L.; Harrold, L.L.; Edwards, W.M. 1971. Relation of rainfall energy streamflow to sediment yield from small and larger watersheds. Journal of Soil and Water Conservation. 26(6): 233-235.

"Sediment yield measured from 1 and 2 acre agricultural watersheds largely was a function of rainfall energy, rainfall intensity, and crop cover characteristics. Suspended-sediment yield from a 6,000 square mile watershed primarily was a function of the transport capacity of streamflow. The temporal patterns of sediment yield and suspended-sediment yield are distinctly different on the different sized areas. The energy-intensity parameter devised by Wischmeier from plot data seems valid for calculating the sediment yield from small watersheds." (A)

330. McKenzie, G.D.; Studlick, J.R.J. 1979. Erodibility of surface-mine spoil banks in southeastern Ohio: an approximation. Journal of Soil and Water Conservation. 34(4): 187-190.

"Measurements of accumulated sediment in interbank basins of unreclaimed strip mines determined the average annual soil loss from unvegetated, 18-year-old spoil banks. Assuming the universal soil loss equation (USLE) can be used to estimate sediment yield from strip-mine slopes, the topographic factor in the USLE was determined in two ways, and values for erodibility (K) were calculated. The technique is applicable to unreclaimed mines where interbank basins trap all slope-derived sediment." (A)

331. McPherson, H.J. 1971. Dissolved, suspended and bed load movement patterns in Two O'Clock Creek, Rocky Mountains, Canada, Summer, 1969. Journal of Hydrology. 12: 221-233.

"During the summer of 1969, 12850 tons of material were removed as suspended sediment load, 440 tons as dissolved load and 65 tons as bed load from Two O'Clock Creek Basin in the Canadian Rockies. This is equivalent to a surface lowering of the basin by 0.0195 inches per year, a figure which agrees very well with rates of denudation reported by researchers for other mountain areas. During the peak snow melt generated flood in early June, 87 percent of the total sediment load was exported. Most of the remainder was transported out of the basin by a secondary high flow resulting from rainfall and snow melt in early July. The single most intense rainstorm of the season on August 5 and 6 resulted in a minor increase in stream flow but no increase in sediment discharge." (A)

332. Meade, R.H. 1969. Errors in using modern stream-load data to estimate natural rates of denudation. Geological Society of America Bulletin. 80: 1265-1274.

"The practice of calculating natural rates of denudation from routinely collected data on the loads of suspended and dissolved matter in modern rivers is subject to several significant errors. The sources of these errors are demonstrated by examples from the Atlantic drainage of the United States, where their total effect has apparently doubled the natural rate of erosion.

"The largest error is caused by assuming that modern sediment loads in populated areas represent natural erosion, whereas in fact they mainly reflect the influence of man. Conversion of forests to croplands in the middle Atlantic states causes about a tenfold increase in sediment yield. Coal mining, urbanization, and highway construction have added extra loads of sediment to the streams. Modern sediment loads in the Atlantic-draining rivers are probably 4 to 5 times greater than they would be if the area had remained undisturbed by man.

"Errors in calculating the chemical denudation are caused by atmospheric contributions to the dissolved loads of streams and by pollutants that are added directly to stream waters. About one-quarter of the salts in the Atlantic-draining streams were contributed from the atmosphere, either as recycled sea salts or as pollutants and soil dust that originally became airborne as a result of the activities of man. Perhaps another one-tenth of the dissolved load consists of industrial and agricultural wastes or acid mine waters that have been added directly to the streams." (A)

333. Meeuwig, R.O. 1969. Infiltration and soil erosion on Coolwater Ridge, Idaho. Res. Note INT-103. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 5 p.

"The infiltration and erosion caused by simulated rainfall were measured on a granitic subalpine ridge in northcentral Idaho. Erosion was closely correlated with the amount of exposed soil. Infiltration was not highly correlated with any single factor." (A)

334. Meeuwig, R.O. 1970a. Infiltration and soil erosion as influenced by vegetation and soil in northern Utah. Journal of Range Management. 23(3): 185-188.

"The influences of vegetation, soil properties, and slope gradient on infiltration capacity and soil stability of high-elevation herbland on the Wasatch Front in northern Utah were investigated under simulated rainfall conditions. Results emphasize the importance of vegetation and litter cover in maintaining infiltration capacity and soil stability. Infiltration is also affected significantly by soil properties, notably bulk density, aggregation, and moisture content." (A)

335. Meeuwig, R.O. 1970b. Sheet erosion on Intermountain summer ranges. Res. Pap. INT-85. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 25 p.

"Simulated rain was applied to small plots on seven mountain rangeland sites in Utah, Idaho, and Montana. The magnitude of soil erosion was found to depend primarily on the proportion of the soil surface protected from direct raindrop impact by plants, litter, and (in some cases) stone. Soil organic matter favored stability of fine-textured soils, but apparently increased erodibility of sandy soils." (A)

336. Meeuwig, R.O. 1971. Soil stability on high-elevation rangeland in the Intermountain area. Res. Pap. INT-94. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 10 p.

"Measurements were taken of the amount of soil eroded from small plots under the impact of a fixed amount of simulated rain. Under these conditions, erosion is more closely related to amount of cover than to any other site characteristic. However, the relation between erosion is about the same on a 5-percent slope with 40-percent cover as it is on a 35-percent slope with 80-percent cover. Organic matter is the most important soil parameter affecting erodibility, but the direction and magnitude of its effects depend on soil texture. Organic matter decreases erosion of clay soils, but tends to increase erosion of sandy soils." (A)

337. Meeuwig, R.O.; Packer, P.E. 1976. Erosion and runoff on forest and range lands. In: Heady, H.F.; Falkenborg, D.H.; Riley, J.P., eds. Watershed management on range and forest lands: Proceedings, 5th workshop of the U.S./Australia Rangeland Panel; 1975 June 15-22; Boise, ID. Logan UT: Utah Water Research Laboratories, College of Engineering, Utah State University: 105-116.

"The principles and consequences of common forest and range practices—logging, roads, grazing, surface mining, recreation, and fire—on erosion and runoff are summarized and discussed in light of recent North American research results." (A)

338. Megahan, W.F. 1972. Logging, erosion, sedimentation—are they dirty words? Journal of Forestry. 70(7): 403-407.

Three factors that control the rate of surface erosion (detachability, forces applied, and surface cover) are discussed in terms of how each is affected by logging. Applicability of erosion data collected in Idaho to other areas and means of controlling erosion are explained. (C)

339. Megahan, W.F. 1974a. Deep-rooted plants for erosion control on granitic road fills in the Idaho Batholith. Res. Pap. INT-161. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 18 p.

"The study was installed in 1968 and continued through 1972. Tree survival averaged about 97 percent after four growing seasons. Fertilizer increased planted tree growth an average of 95 percent during the year of peak effect. Tree planting, coupled with straw mulch and erosion netting, reduced erosion an average of about 95% over 3 years. Planted trees alone provided surprisingly large reductions in erosion, ranging from 32 to 51 percent. Planting ponderosa pine at a spacing of 3 by 3 to 4 by 4 feet is recommended as an erosion-control measure for granitic road fills in the Idaho Batholith." (A)

340. Megahan, W.F. 1974b. Erosion over time on severely disturbed granitic soils: a model. Res. Pap. INT-156. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

"A negative exponential equation containing three parameters was derived to describe time trends in surface erosion on severely disturbed soils. Data from four different studies of surface erosion on roads constructed from the granitic materials found in the Idaho Batholith were used to develop equation parameters. Rainfall-intensity data were used to illustrate that variations in erosion forces, as indexed by rainfall kinetic energy times the maximum 30-minute rainfall intensity (the erodibility index), were not the cause of the time trend in surface erosion. In addition, although vegetation growth can be an important factor in reducing accelerated erosion, it did not cause the rapid erosion decreases found in the cases studied. The evidence suggests that surface 'armoring' was the dominant factor causing the time trends in surface erosion." (A)

The equation is: $E = Ent - So(e^{-kt}-l)$; where E is the cumulative onsite erosion at time t after disturbance, En is an estimate of the long-term "normal" erosion rate on the disturbed area, So is an index of the total amount of soil available for erosion due to disturbance, and k is an index of the rate of decline of erosion following a disturbance. (C)

341. Megahan, W.F. 1975. Sedimentation in relation to logging activities in the mountains of central Idaho. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 74-82.

Past research on the effects of logging on sedimentation in the Idaho Batholith has suggested that: (1) undisturbed forested watersheds yield sediment in quantities from 4.5 to 26.9 cubic yards per square mile per year; (2) organic sediments may account for a substantial loss of water storage capacity in reservoirs—the average organic content of 90 samples of reservoir-deposited sediments was 5.1 percent and ranged from 1 to 60 percent; (3) logged areas in which skidding had occurred produced 1.6 times as much sediment as undisturbed forested areas, and roads produced 220 times as much sediment; and (4) about 84 percent of the surface erosion occurred by the end of the 1st year, rising to 93 percent by the end of the 2d year. (C)

342. Megahan, W.F. 1976. Sediment storage in channels draining small forested watersheds in the mountains of central Idaho. In: Proceedings, 3d Federal interagency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Denver, CO: U.S. Water Resources Council: 4-115 to 4-126.

"The role of sediment storage was studied in channels draining seven small forested watersheds in central Idaho. Data collection included an inventory of sediment deposited behind channel obstructions, detailed surveys of channel cross sections, and measurements of annual sediment yields in sediment detention reservoirs.

"Extremely large volumes of sediment were trapped behind channel obstructions in the 1973 and 1974 sample years; only about 10 percent of the sediment stored appeared as sediment yield. Most obstructions shifted from one year to the next; so the stability of the remaining sediment stored in the channels was questionable.

"The series of detailed channel cross sections was used in evaluating annual changes in the total volume of sediment stored on channel bottoms. Considerable aggregation occurred during the low flow year (1972-73), whereas degradation occurred during the high flow year (1973-74). Annual watershed erosion was determined by entering the annual sediment yields and the annual change in stored sediment into a continuity equation." (A)

343. Megahan, W.F. 1977. Reducing erosional impacts of roads. In: Kunkle, S.H.; Thames, J.L., eds. Guidelines for watershed management. FAO Conserv. Guide 1. Rome, Italy: Food and Agricultural Organization of the United Nations: 237-260.

All aspects of erosion control associated with road design, construction, and maintenance are discussed. Although most of the information is taken from experience in the U.S. Rocky Mountain States, it is presented for use by an international audience. Sections discuss erosion processes, basic erosion principles, guidelines for reducing erosional inpacts of roads, land use planning, route reconnaissance and location, road design, slope stabilization measures, construction, road maintenance, and road closure. (C)

344. Megahan, W.F. 1978. Erosion processes on steep granitic road fills in central Idaho. Soil Science Society of America Journal. 42(2): 350-357.

"A set of thirty 20.2-m^2 (1/200-acre) erosion plots was used to study erosion occurring on steep road fills constructed with granitic soil materials in the Idaho Batholith. Erosion data were collected for a 3-1/2-year period from 1969 through 1972. Erosion on bare control plots averaged 3.4 metric tons/km^2 per day for water years 1970 through 1972. Erosion was reduced an average of 44% and 95% by tree planting and straw mulching, respectively. Daily erosion rates were consistently higher during summer periods than during snowfree winter periods, presumably because of greater rainfall energy during the summer. Dry creep accounted for at least 15% of the total annual erosion for the years sampled and was as high as 40% in 1971. The erodibility index was a poor predictor of erosion for rain periods. Observations in the area suggest that wind was an important erosion factor on the steep slope studied. The median particle size of eroded materials (D_{50}) tended to decrease throughout the summer and fall until mid-October when it abruptly increased. Soil crusting during the summer and soil freezing and thawing in the fall may have caused these seasonal trends." (A)

345. Megahan, W.F. 1981. Effects of silvicultural practices on erosion and sedimentation in the interior west—a case for sediment budgeting. In: Baumgartner, D.M., comp., ed. Interior west watershed management: Proceedings of a symposium; 1980 April 8-10; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 169-181.

"Accelerated surface and mass erosion are often caused by silvicultural practices in the interior western United States. Onsite erosional impacts may also be manifested at downstream locations as increased sedimentation. Expressed per unit area of soil disturbing practice, roads are the primary cause of accelerated erosion and sedimentation. Logging activities can also increase erosion and effects can be magnified by slash burning and wildfire. Increased surface erosion from logging tends to be greatest on south aspects and lowest on north aspects. An understanding of erosional processes is important to efficiently reduce surface and mass erosion. Sediment budgeting is an important consideration for evaluating the amount and effects of erosion and the resulting downstream sedimentation." (A)

346. Megahan, W.F.; Kidd, W.J. 1972. Effect of logging roads on sediment production rates in the Idaho Batholith. Res. Pap. INT-123. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

"Results suggest three guides to use in the control of surface erosion on roads and subsequent downslope sediment movement in the Idaho Batholith: (a) apply erosion control measures immediately after road construction for maximum effectiveness; (b) ensure that treatments protect the soil surface until vegetation becomes established; (c) take advantage of downslope barriers (logs, branches, etc.) to effectively delay and reduce the downslope movement of sediment." (A)

347. Megahan, W.F.; Molitor, D.C. 1975. Erosional effects of wildfire and logging in Idaho. In: Watershed management: Proceedings of a symposium; 1975 August 11-12; Logan, UT. New York: American Society of Civil Engineers: 423-444.

Soil erosion following clearcut logging of coniferous forest and subsequent wildfire was studied adjacent to a tributary of the Payette River in the Idaho Batholith. "Considerable" accelerated rill and splash erosion was observed on the clearcut and burned site, whereas only slight splash erosion and no rill erosion was observed on a burned but uncut site. All erosion observed occurred after fire; "...pre-fire clearcutting is the most probable factor causing increased erosion following forest fire." (C)

348. Megahan, W.F.; Nowlin, R.A. 1976. Sediment storage in channels draining small forested watersheds in the mountains of central Idaho. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 4-115 to 4-126.

"The role of sediment storage was studied in channels draining seven small forested watersheds in central Idaho. Data collection included an inventory of sediment deposited behind channel obstructions, detailed surveys of channel cross sections, and measurements of annual sediment yields in sediment detention reservoirs.

"Extremely large volumes of sediment were trapped behind channel obstructions in the 1973 and 1974 sample years; only about 10 percent of the sediment stored appeared as sediment yield. Most obstructions shifted from one year to the next, so the stability of the remaining sediment stored in the channels was questionable.

"The series of detailed channel cross sections was used in evaluating annual changes in the total volume of sediment stored on channel bottoms. Considerable aggregation occurred during the low flow year (1972-73), whereas degradation occurred during the high flow year (1973-74). Annual watershed erosion was determined by entering the annual sediment yields and the annual change in stored sediment into a continuity equation." (A)

349. Megahan, W.F.; Platts, W.S.; Kulesza, B. 1980. Riverbed improves over time: South Fork Salmon. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 380-395.

"The South Fork of the Salmon River historically supported one of Idaho's largest chinook salmon runs as well as a large run of steelhead trout. During the period from 1950 to 1965, considerable logging and attendant road construction activities took place in the South Fork watershed. A combination of highly erodible soils, steep slopes, widespread soil disturbances from logging and road construction, and some large storms in 1955, 1962, 1964, and 1965 caused severe sedimentation in the river that literally buried many of the prime salmon spawning and rearing areas with sand. The USDA Forest Service responded to the problem by developing a restoration program that included a moratorium on all road construction and logging activities and a variety of watershed rehabilitation practices. River responses were monitored by photographic documentation, surveys of channel cross sections to document changes in bottom elevation, a series of transects to evaluate the particle-size distribution on the surface of the riverbed in both chinook salmon spawning and rearing areas, and core samples of the channel bottom to determine changes in the particle-size distribution of the channel substrate in spawning areas. Data collected over the years from 1966-1979 show statistically significant decreases in bottom elevation and increases in the particle size of bottom materials indicating an improvement in fish habitat conditions. Improvement was dramatic enough to provide the basis for a cautious reentry into the South Fork watershed for timber harvest purposes beginning in 1978. A second paper describes how this is to be accomplished." (A)

350. Meiman, J.R. 1974. Water and erosion control in relation to revegetation of high-altitude disturbed lands. In: Berg, W.A.; Brown, J.A.; Cuany, R.L., eds. Revegetation of high-altitude disturbed lands: Proceedings of a workshop; 1974 July; Fort Collins, CO. Inf. Ser. 10. Fort Collins, CO: Environmental Resources Center, Colorado State University: 24-30.

"This review has concentrated on soil and water control directly related to revegetation problems and the associated land treatment measures. Problems of mass failure of slopes, roads, stream stabilization, and wind erosion were not included.

"The objective of this review was to identify some general principles and literature sources. As in all field problems, field observation and experience are paramount. Each site has its own peculiar set of requirements within a geomorphic-soil-vegetation-climatic setting. Careful observation of where and how snow drifts, whether iceing [sic] of diversions and culverts is a problem, where erosion begins on a slope down from the crest, whether rill erosion is occurring between diversions, the amount of sediment delivered by diversion ditches, and the effectiveness of different kinds and rates of mulch on rill and sheet erosion are examples of the valuable information that can be gained by careful observation. In this context, it is very important to observe soil erosion and runoff during times of storms and snowmelt. The planner should do some of the routine maintenance inspection so he can learn from his mistakes.

"Because of the potentially high risks from failure, soil and water control systems should be thought of in terms of a coordinated approach of planning, careful supervision during installation, regular inspection, and thorough maintenance. Anything less can result not only in loss of investment but could bring about greater damages or costs than if no action were taken." (A)

351. Meyer, L.D. 1971. Soil erosion by water on upland areas. In: Shen, H.W., ed. River mechanics, Vol. 2. Fort Collins, CO: H.W. Shen: 27-1 to 27-25.

An overview of the soil erosion process, a mathematical model describing the proccess, and the Universal Soil Loss Equation are presented and discussed. (C)

352. Meyer, L.D.; DeCoursey, D.D.; Romkens, M.J.M. 1976. Soil erosion concepts and misconceptions. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-1 to 2-12.

"Current concepts of the process of soil erosion by water are presented. Their implications as a basis for continued improvements in erosion prediction and control are discussed. Research deficiencies are indicated, and promising new approaches are explored." (A)

353. Meyer, L.D.; Foster, G.R.; Romkens, M.J.M. 1975. Source of soil eroded by water from upland slopes. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 177-189.

Recent research has helped define the differences between interrill and rill erosion; some results are presented. In the past, these sources of erosion have been combined to consider sheet and rill erosion on a unit-area basis. The differing effects of slope length, slope steepness, slope shape, and surface canopy cover on the separate processes of rill and interrill erosion are examined. Value of the concept's design is discussed. (C)

354. Meyer, L.D.; Johnson, C.B.; Foster, G.R. 1972. Stone and woodchip mulches for erosion control on construction sites. Journal of Soil and Water Conservation. 22: 264-269.

"Mulches of crushed stone, gravel, and woodchips showed great potential for erosion control on construction slopes. Soils covered with 1 inch of stone mulch were much less erodible than those with more than 2 tons/acre per-acre of straw. Heavier rates of stone or 1.5 inches of woodchips were even more effective. Good to excellent stands of grass were obtained on many of the stone and woodchip treatments following erosion tests. The study was conducted on a 20 percent borrow pit side-slope with slope lengths up to 150 feet." (A)

355. Meyer, L.D.; Monke, E.J. 1965. Mechanics of soil erosion by rainfall and overland flow. Transactions American Society of Agricultural Engineers. 8(4): 572-577, 580.

"The mechanics of soil erosion by rainfall and shallow depths of runoff as affected by slope steepness, slope length and particle size were studied in the laboratory. Erosion from a bed of simulated soil was measured by sampling the runoff for sediment content. Runoff erosion increased rapidly with increasing slope steepness and length, except at small steepnesses and lengths where essentially no erosion occurred. Smaller particle sizes were more erosive at most slope steepnesses and lengths, but the larger sizes were more erosive at small steepnesses and lengths. Rainfall plus runoff, as compared with runoff alone, increased the erosion of the smaller particle sizes but decreased erosion of the larger sizes." (A)

356. Meyer, L.D.; Romkens, M.J.M. 1976. Erosion and sediment control on reshaped land. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-65 to 2-76.

"Recent research concerning soil erosion and sediment control on land reshaped for nonagricultural purposes is discussed. Included are: adaptation of the Universal Soil Loss Equation, variability of rainfall erosiveness, evaluations of soil erodibility and topographic effects, influence of mulch rates and types, and enhancement of rapid revegetation. Implications of this knowledge and areas of research needed are indicated." (A)

357. Meyer, L.D.; Wischmeier, W.H. 1969. Mathematical simulation of the process of soil erosion by water. Transactions American Society of Agricultural Engineers. 12(6): 754-758, 762.

The framework for a mathematical model was developed to describe soil erosion by water. The approach considered soil detachment by rainfall, transport by rainfall, detachment by runoff, and transport by runoff as separate but interrelated parts of the soil erosion process. The study was concerned primarily with investigating the feasibility of separating the soil erosion process into several component processes rather than with obtaining quantitative results. A model was developed, however, that describes the movement of soil particles along successive increments of slope. The model, as presented, is not ready for universal application. (C)

358. Meyer, L.D.; Wischmeier, W.H.; Daniel, W.H. 1971. Erosion, runoff and revegetation of denuded construction sites. Transactions American Society of Agricultural Engineers. 14(1): 138-141.

"Erosion and runoff rates were measured for six treatments representing typical construction-site conditions that result from major land reshaping. Subsequently, reestablishment of vegetation on these conditions was studied in relation to various methods of reshaping, mulching, fertilizing, and seeding. "This research has strongly indicated that a layer of good soil over a denuded area plus surface mulch is the best combination of those treatments tested for minimizing soil erosion and enhancing rapid revegetation on reshaped land. Additional benefits may be expected from minimizing compaction of such areas, shallow surface tillage before seeding, use of a seed mixture containing fast-growing grasses, and application of supplemental irrigation as needed." (A)

359. Meyer, L.D.; Wischmeier, W.H.; Foster, G.R. 1970. Mulch rates required for erosion control on steep slopes. Soil Science Society of America Proceedings. 34(6): 928-931.

"The erosion-reducing effectiveness of six rates of straw mulch was tested on slopes averaging 15 percent. Mulch rates of only 0.56 and 1.12 metric tons per hectare reduced soil losses to less than one-third of those from unmulched areas during a series of intense simulated rainstorms. A 2.24-metric tons per hectare rate decreased soil loss to only 18 percent of that from no mulch, and the 4.48– and 8.96-metric tons per hectare rates reduced it to less than 5 percent.

"Runoff velocity for the 0.56-metric tons per hectare rate was one-half that for no mulch, but heavier rates decreased velocity only slightly more. The reduced velocity due to mulching accounted for much of the resulting decrease in soil erosion.

"Although the small mulch rates greatly reduced erosion, more mulch was required to fully control erosion than was required on the less-steep, more permeable soil conditions tested in earlier studies." (A)

360. Miller, C.R. 1965. Advances in sedimentation relevant to watershed programs. Transactions American Society of Agricultural Engineers. 8(1): 146-152.

Progress during the past few decades in the field of sedimentation is reviewed within three general categories: sediment source, yield, and delivery; reservoir sedimentation; and sediment transport and stream channel stability. (C)

361. Miner, N.H. 1968. Natural filtering of suspended soil by a stream at low flow. Res. Note PNW-88. Portland OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 4 p.

"During road construction, soil that is added to a stream by tractors crossing during low flow is temporarily 'filtered' out before it travels far. Five-gallon samples were taken at 150, 300, 600, and 1,200 feet downstream from a road crossing, with sodium flourescein dye used as a tracer. Suspended particle concentration was reduced from 1,055 p.p.m. at 150 feet below the road to 108 p.p.m. at 1,200 feet. The 'filtering' action is a combination of settling of larger particles and dilution of sediment-laden water. This filtration is temporary and deposited soil will tend to be flushed downstream during high flows and may cause channel erosion or other damage." (A)

362. Molnau, M.; Chacho, E. 1980. Snow-erosion relationships on mine waste dumps. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 877-887.

"The spatial distribution of snow on mine waste dump faces and the melt pattern have a large influence on the amount of erosion resulting from snowmelt water. A dump with an even melt pattern experienced little erosion while for other dumps, the melt pattern appeared to determine the erosion. On two of four dumps, high erosion occurred in the first year after dump construction but a consistent pattern could not be found because of the irregular melt patterns." (A)

363. Moore, W.R.; Smith, C.E. 1968. Erosion control in relation to watershed management. Journal of the Irrigation and Drainage Division, American Society of Civil Engineers. 94(IR3): 321-331.

This report describes the significance of erosion and sediment problems, the types of erosion and their relative importance, erosion control measures, and benefits from erosion control in small watersheds. (C)

364. Morgan, R.P.C. 1979. Topics in applied geography: soil erosion. London: Longman Group Limited. 113 p.

"Soil erosion is a hazard traditionally associated with agriculture in tropical and semi-arid areas. In recent years, however, its importance has become apparent in areas devoted to forestry, transport and recreation. Moreover, erosion is increasingly being recognized as a hazard in temperate countries such as Britain, Belgium and Germany. Conservation measures depend upon a thorough understanding of the mechanics of the erosion processes. This book is the first text to concentrate on soil erosion, a subject which is usually covered only briefly in books on soil conservation.

"The mechanics of erosion are reviewed in the first part of the book with emphasis on the extent of and deficiencies in current knowledge. Techniques of classifying land with respect to erosion risk are also examined and a simple working method is presented. A discussion of various approaches to modelling soil erosion focuses on the value of models for predicting rates of soil loss and planning conservation work. Strategies for erosion control are related to the changes that man can make to the soil, plant cover and slope of the land and the effect that these have on the mechanics of erosion. The themes developed in the first part of the book are integrated in a case study of erosion risk evaluation and conservation planning in Peninsular Malaysia. Here the application of erosion mapping, land classification, erosion modelling and conservation systems is described in practice. Attention is given to working with scarce data using remote sensing and detailed field survey." (A)

365. Mosley, M.P. 1980. The impact of forest road erosion in the Dart Valley, Nelson. New Zealand Journal of Forestry. 25(2): 184-198.

"A survey of erosion on a road system constructed in granitic terrain in the Dart Valley, Nelson, for production forest development has been carried out. Rates of sediment input into the stream system in 1978-9 averaged 255 m^3/km/yr over the 25 km road system, but figures for individual roads varied widely, from 14 m^3/km/yr for a 10-year-old valley bottom road to 1270 m^3/km/yr for a 1-year-old mid-slope road which had suffered a number of large culvert or fill slope failures. Total rates of erosion on the road system were three times greater, but much sediment is fed on to vegetated slopes beneath the roads, and is stored there. Total sediment input from the road system into the stream system in 1978-9 was estimated as 12 000 t/yr, in comparison with an estimate for natural sediment yield from the catchment of 9600 t/yr. Much of the sediment has been stored in headwater channels (which are, however, probably subject to periodic flushing by major storm events), deposited upon point bars above the low-flow water level in the main river, or flushed out to sea in suspension. The impact of the road-derived sediment upon the Dart River is therefore probably limited. The estimated natural sediment yield of the Wangapeka is an order of magnitude greater than that from the Dart; sediment from the Dart Valley road is therefore unlikely to have had any significant impact upon the Wangapeka, or the Motueka downstream." (A)

366. Musgrave, G.W. 1947. The quantitative evaluation of factors in water erosion—a first approximation. Journal of Soil and Water Conservation. 2(3): 133-138.

The primary relationships important in predicting sheet and rill erosion are explained: (1) erosion is proportional to the maximum 30-minute rainfall raised to the 1.75 power, (2) erosion is proportional to slope steepness raised to the 1.35 power, and (3) erosion is proportional to the slope length raised to the 0.35 power. An example demonstrates the use of these relationships, and two tables provide empirically derived numerical ratings of cropping system and inherent soil erodibility for predicting soil erosion. (C)

367. Mussallem, K.E.; Lynch, J.A. 1980. Controlling nonpoint source pollution from commercial clearcuts. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 669-681.

"Under the provisions of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), the State of Pennsylvania has developed "Best Management Practices" (BMP) for controlling nonpoint source pollution from silvicultural activities. An evaluation of the effectiveness of the BMP as they apply to commercial clearcutting was conducted on The Pennsylvania State University's Leading Ridge Experimental Watersheds. The control, paired watershed approach was used to evaluate the impact of a 110-acre commercial clearcut on a 257-acre watershed on water quality. Harvesting commenced October, 1976 and ended May, 1977. Three years of precutting stream chemistry data have been compared with 2 years of post-cutting data. Concentration data following clearcutting were significantly altered, but most of these changes were caused by dilution from increased water yield. Mass flux changes for potassium and nitrate-nitrogen were significantly increased during the post-treatment period. Overall, the BMP were very effective in controlling non-point source pollution." (A)

368. Mutchler, C.K.; Bowie, A.J. 1976. Effect of land use on sediment delivery ratios. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-11 to 1-21.

"Data from two subwatersheds in northern Mississippi were used to compute sediment delivery ratios for each during a 15-year period. Land use changes resulted in greatly decreasing land and gully erosion estimates in one watershed and slightly increasing estimates for the other. Computed annual sediment delivery ratios did not seem to change due to changing land use on either watershed. However, annual values of delivery ratios changed directly with annual runoff." (A)

369. Mutchler, C.K.; Young, R.A. 1975. Soil detachment by raindrops. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 113-117.

"Raindrop impact is the primary source of energy for detaching soil from any land area not protected by cover of some sort. Raindrop impact also plays an important part in sediment transport by very thin waterflow. The direct role of raindrops in the mechanics of erosion is the subject of this paper." (A)

370. Namba, S. 1972. Control of floods and erosion by vegetative and mechanical means in extensively-eroded forest lands. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 5; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 286-292.

"Methods of restoring stability to eroding forest lands are described. Vegetation is a primary aid for control of runoff and erosion and costs less than mechanical means. Both vegetation and mechanical measures are needed in most situations. Vegetative measures call for more elaborate planning than mechanical installations. Both herbaceous and woody vegetation should be used, the former for quick control and the latter for permanent cover. Modern methods have reduced the labour costs but have increased overall costs. Criteria are needed to better evaluate the economics of restoration work." (A)

371. National Association of Counties Research Foundation. 1970. Urban soil erosion and sediment control. Water Pollut. Control Res. Ser. 15030 DTL 05/70. Washington, DC: U.S. Department of the Interior, Federal Water Quality Administration. 97 p.

"This study was conducted to determine the causes and the extent of urban and suburban soil erosion and sediment problems, and to describe ways in which local communities can organize and implement effective sedimentation control programs. An evaluation is provided on the state-of-the-art of urban sedimentation control, and a series of research needs in the sedimentation field is cited.

"In addition, this report includes the 'Community Action Guidebook for Soil Erosion and Sediment Control,' which describes methods by which local governments can organize, plan, finance, staff, and implement urban sedimentation control programs. Aspects of areawide approaches, legal authority, and public support for sedimentation control are discussed, and an action plan is outlined." (A)

372. Negev, M. 1967. A sediment model on a digital computer. Tech. Rep. 76. Stanford, CA: Stanford University, Department of Civil Engineering. 109 p.

"This study presents a method for the simulation of suspended sediment records from rainfall and total flow data, and from the simulated overland flow produced by the Stanford Watershed Model. The sediment simulation is achieved by modeling the sediment production and transport processes on a digital computer. The model distinguishes between two main sources of sediment, the land surface where rainfall and overland flow play the major role in sediment production, and the stream system where the total flow is the most significant parameter." (A)

373. Nikolaenko, V.T. 1972. Antiabrasive role of tree-shrub vegetation. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 6; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 293-295.

"The benefits of planting tree-shrubs along the abrading shore line of reservoirs are described. Brush-willow, shrubby-alder, birdcherry and tamarisk have demonstrated their usefulness in providing bank protection against the abrasive energy of waves. These species can tolerate prolonged flooding and can act as silt traps. When undermined they are not uprooted as are larger trees but continue to grow in the collapsed bank. Plantings have been known to protect banks which would otherwise retreat 100 to 300 meters because of shoreline reworking. Such losses can add up to 10 to 30 hectares of land per kilometer of shoreline." (A)

374. Noble, E.L. 1965. Sediment reduction through watershed rehabilitation. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 114-123.

"Several methods of obtaining soil stabilization on high mountain watersheds are available to the land administrator. These are (1) intensive management practices, (2) revegetation coupled with intensive management practice, and (3) contour trenching. Each method recognizes the fundamental relation existing between land cover and hydrologic behavior and reflects the importance of maintaining the productivity of the site for the production of forage, fiber, wildlife, and recreation. The application of each method requires a careful analysis of the (1) geologic norm, (2) type of flooding, (3) watershed protection requirements, and (4) adaptability of the site for treatment. Of the methods described, contour trenching has proved most effective in controlling flooding, and sedimentation occurring from badly deteriorated mountain watersheds. The application of this method is not a panacea for all flood-source areas but has proved effective in controlling flooding from badly deteriorated lands occasioned by high intensity summer rainstorms." (A)

375. Noble, E.L.; Lundeen, L.J. 1971. Analysis of rehabilitation treatment alternatives for sediment control. In: Morris, J., ed. Forest land uses and stream environment: Proceedings of a symposium; 1970 October 19-21; Corvallis, OR. Corvallis, OR: Oregon State University: 86-96.

"The aquatic environment of the South Fork Salmon River has been severely damaged in recent years by excessive rates of sediment production. A special study was conducted to determine the source and extent of the damage and measures required to reduce future sediment production to a 'tolerable' level. Linear programming was used as an aid to select from 190 possible treatment alternatives and minimize treatment costs at various levels of sediment reduction. The desired level of sediment could be reached at a cost of $5 million. Debris basins to trap sediment moving in the channel proved to be the most effective and economical type of treatment while control of sediment production from roads and timber harvest on steep, fragile lands would have a very high cost." (A)

376. Nolan, K.M.; Janda, R.J. 1981. Use of short-term water and suspended-sediment discharge observations to assess impacts of logging on stream-sediment discharge in the Redwood Creek basin, northwestern California, U.S.A. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 415-437.

"Sediment-transport data resulting from periodic and synoptic sampling of water and suspended-sediment discharge have been used to estimate the degree to which extensive, tractor-yarded, clear-cut timber harvesting has accelerated naturally high erosion in the Redwood Creek basin, northwestern California. Suspended-sediment transport curves (SSTCs) of eight streams draining basins of diverse geology and landuse were compared using analysis of covariance. Adjusted mean values of suspended-sediment discharge per unit area (SSD/A) for streams draining recently harvested terrane were at least twice as great as adjusted means for streams draining physically comparable, nearly uncut basins. Relationships between SSTCs of higher-order streams and those of lower-order tributary streams draining areas with contrasting amounts of timber harvest further indicated that timber harvest caused tributary streams to become major sediment sources at times of high water discharge. Synoptic sampling conducted during nine storms indicated that water discharge per unit area (WD/A) from streams draining harvested terrane was roughly twice that from unharvested terrane under similar hydrologic conditions. Synoptically measured values of suspended-sediment discharge were roughly 10 times greater from harvested terrane than from unharvested terrane." (A)

377. Office of Water Resources Research. 1971. Urbanization and sedimentation: a bibliography. WRSIC 71-203. Washington, DC: U.S. Department of the Interior, Water Resources Scientific Information Center, Office of Water Resources Research. 116 p.

"URBANIZATION AND SEDIMENTATION is another in a series of planned bibliographies in water resources to be produced wholly from the information base comprising only SELECTED WATER RESOURCES ABSTRACTS (SWRA). At the time of search for this bibliography, the data base has 31,244 abstracts covering SWRA through September 1, 1971 (Volume 4, Number 17)." (A)

The bibliography contains 102 citations with abstracts. (C)

378. Ohlander, C.A. 1976. Defining the sediment trapping characteristics of a vegetative buffer, special case: road erosion. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-77 to 2-82.

"This paper discusses the amount of sediment trapped by a vegetative buffer that may exist below a road drainage outlet. The buffer characteristics are defined in relation to slope percent, soil erodibility, and a soil-cover complex index called the Runoff Curve Number (RCN). A Standard Buffer is defined as a particular length of site capable of trapping 953 kilograms of sediment per year:

$$\text{Standard Buffer, meters} = (16.16 + 17.69 \text{ Soil K} + 1.34 \text{ Slope percent}) \times (31\text{RCN})/(6900 - 69 \text{ RCN} .$$

Where: Standard Buffer is the slope distance needed for filtering out the sediment, soil "K" is the soil erodibility index from the universal soil loss equation, and RCN is the Runoff Curve Number from the Soil Conservation Service Engineering Handbook.

"The ratio of actual buffer distance to the Standard Buffer distance times 953 kilograms equals the yearly sediment trapped.

"The relationship of Road Erosion minus Sediment Trapped has implications that can be used as a first approximation of some land use effects on water quality." (A)

379. O'Loughlin, C.L.; Rowe, L.K.; Pearce, A.J. 1980. Sediment yield and water quality responses to clearfelling of evergreen mixed forests in western New Zealand. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 285-292.

"Clearfelling and removal of logs followed by burning on two steep basins in north Westland, New Zealand, caused marked stream water quality changes. In a basin which was tracked, harvested by rubber-tyred skidders and burnt, sediment yield rates increased to eight times the yield rate from a nearby forested control basin. Most sediment derived from the track. In a basin which was clearfelled and harvested by a downhill cable system with no tracking, sediment yields were not significantly different from the control basin. Harvesting and burning increased nutrient outflows in stream water, particularly NO_3—N and K, Mg and Ca. The retention of a streamside protection strip in the skidder-logged basin prevented intrusion of logging debris into the stream and subdued nutrient concentration increases after harvesting and burning but did not prevent large quantities of sediment entering the stream." (A)

380. Omernik, J.M. 1977. Nonpoint source-stream nutrient level relationships: a nationwide study. Ecol. Res. Ser. EPA-600/3-77-105. Corvallis, OR: U.S. Environmental Protection Agency, Environmental Research Laboratory. 151 p., plus plates.

"National Eutrophication Survey (NES) data collected from a nationwide network of 928 nonpoint-source watersheds were studied for relationships between macro-drainage area characteristics (particularly land use) and nutrient levels in streams. Both the total and inorganic forms of phosphorus and nitrogen concentrations and loads in streams were considered.

"For both nationwide and regional data sets, good correlations were found between general land use and nutrient concentrations in streams. Mean concentrations were considerably higher in streams draining agricultural watersheds than in streams draining forested watersheds. The overall relationships and regionalities of the relationships and interrelationships with other characteristics are illustrated cartographically and by regression techniques....Two methods are provided for predicting nonpoint source nutrient levels in streams; one utilizing mapped interpretations of NES nonpoint source data and the other, regional regression equations and mapped residuals of these regressions. Both methods afford a limited accountability for regional characteristics." (A)

381. Onstad, C.A. 1976. Watershed erosion model validation for southwest Iowa. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-22 to 1-34.

"Watershed erosion data from two ARS watersheds near Treynor, Iowa are used to test a modification of the Universal Soil Loss Equation developed by Onstad and Foster (1975). This model utilizes a distributed set of input variables and includes a detachment and a transport phase. Depending on the magnitude of each phase, soil is either eroded or deposited. Predicted sediment yields from sheet-rill sources were compared with measured yields from single events and with predictions by the Universal Soil Loss Equation and another erosion prediction equation. A sensitivity analysis was performed for the fitted parameter in the Onstad-Foster model. Confidence intervals were also calculated for a wide range of single-event sediment yields." (A)

382. Onstad, C.A.; Foster, G.R. 1975. Erosion modeling on a watershed. Transactions of the American Society of Agricultural Engineers. 18(2): 288-292.

"A mathamatical procedure is described to estimate soil detachment and transport, and consequently, sediment yield from single storms on a watershed basis. Also presented is a method for estimating interrill and rill sediment in the total yield. Limited results are shown in detail for two watersheds, one in Ohio and one in Iowa." (A)

383. Onstad, C.A.; Larson, C.L.; Hermsmeier, L.F.; Young, R.A. 1967. A method of computing soil movement throughout a field. Transactions of the American Society of Agricultural Engineers. 10(6): 742-745.

A relationship was developed for the slope and length factors of the Universal Soil Loss Equation to allow for complex slopes: $LSi = (L0.5/100)(0.76 + 0.53\ si + 0.076\ si^2)$; where L is slope length and si is the slope of the last increment of slope length. Testing with limited field data indicated that the equation provides slightly better predictions of mean soil loss from concave and convex slopes than the assumption of uniform slope. (C)

384. Onstad, C.A.; Mutchler, C.K.; Bowie, A.J. 1977. Predicting sediment yields. In: Soil erosion and sedimentation: Proceedings, national symposium on soil erosion and sedimentation by water; 1977 December 12-13; Chicago, IL. ASAE Publ. 477. St. Joseph, MI: American Society of Agricultural Engineers: 43-58.

"Sediment yield is the amount of soil transported from a drainage basin. The studies for predictions of sediment yield have general uses, which include the following. Simulations are used to extend a short-term sampling program to an adequate data base to predict future watershed response to various land-use alternatives and as an ordered sequence of steps in time and space so that information gaps can be identified. The specific needs for sediment yield prediction are so varied that no single model could meet them without a great loss efficiency. These needs generally fall into the categories of length of model event time, area to be simulated, and sediment sources. At present, many sediment yield models are available for use or have been used for various purposes. In general, these models can be grouped into two categories. The first group of models are those derived from statistical analyses. These are usually equations relating sediment yield to one or more watershed or climatic factors. The second group of models are called parametric models. These models introduce numeric values to quantify the factors affecting erosion, transport, and deposition. Also included in this group are models using time variant interactions of physical processes. These types of models start with a structure of hydrologic or hydraulic processes that are basic to the modeling objective. The successful field testing of most techniques for predicting sediment yields depends almost entirely upon the availability of a reliable watershed data-base, consisting of indepth measurements of many watershed parameters." (A)

385. Oomi, S.; Tsunamoto, K. 1974. Studies of the soil erosion on the slope at the mountainside—about the accelerated precipitation index for the soil erosion at the variation of forest species and soil structure. Journal of Japanese Forestry Society. 56(11): 379-385.

"The writers had already proposed the fundamental formula of soil erosion...on the clayey soil land in the Fifu Prefecture. Based on the study of erosion on a mountain slope in the Nagano Prefecture it was confirmed that the formula would also be applicable to sandy soil. Furthermore, the correlation ratio of 'Accelerated Precipitation Index' Pli to 'Amount of Soil erosion E' provides the means to determine the amount of the spontaneous soil slide without rainfall." (A)

386. Orr, H.K. 1970. Runoff and erosion control by seeded and native vegetation on a forest burn: Black Hills, South Dakota. Res. Pap. RM-60. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

"Growth of seeded species in combination with reestablishment of native vegetation reduced overland runoff and soil erosion to tolerable levels within one to four growing seasons. Gross rainfall was a poor indicator of runoff and soil erosion from small plots. Trends were best defined by declining rates of runoff and sediment production per unit of excess rainfall. Sixty percent ground cover density (live vegetation plus litter) is postulated as the minimum necessary for soil stabilization. This cover density almost certainly could not have been reached within the 4-year study period without seeding." (A)

387. Orwin, J., ed. 1978. Revegetation in the rehabilitation of mountain lands: Proceedings of a symposium arranged by the Protection Forestry Division; 1974 December 3-5; Rotorua, New Zealand. F.R.I. Symp. 16. Rotorua, New Zealand: New Zealand Forest Service, Forest Research Institute. 244 p.

"Symposium No. 16...has been organized to allow the dissemination of information dealing with the revegetation of eroded mountain land. Most of the Forest Service work covers trials carried out over approximately 15 years in the Craigieburn Range, Canterbury and in the Kaweka Range, Hawkes Bay.

"In view of the different disciplines involved the Symposium has been organized into sessions dealing with grasses and legumes, soils, climate and tree growth, tree selection, and practical revegetation methods." (A)

388. Osterkamp, W.R. 1976. Variation and causative factors of sediment yields in the Arkansas River Basin, Kansas. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-59 to 1-70.

"Measured sediment yields in the Arkansas River basin of Kansas range from 10 to 500 tonnes per year per square kilometre (30 to 1,430 tons per year per square mile); highest yields in various parts of the western two-thirds. Yields predicted from general curves based on climate agree poorly with measured yields. To improve the correlation between calculated (predicted) and measured yields, the climate-dependent curves are converted to a single curve dependent on runoff that is more directly applicable to sediment yield. The yields predicted by this curve for specific areas are adjusted by applying a power function of average slope. Where other determinants of sediment discharge do not increase or decrease yields significantly, adjusted yields show rough agreement with those measured. Discrepancies between the calculated and measured yields generally are inferred to be a result of geologic influences. Calculation of the adjusted yields permits a refined delineation of areal variations in sediment yields based on sample data, and provides a means of estimating yields from unsampled basins." (A)

389. Ottens, J.; Rudd, J. 1977. Environmental protection costs in logging road design and construction to prevent increased sedimentation in the Carnation Creek Watershed [Vancouver Island]. Rep. BL-X-155, Pac. For. Res. Center. Ottawa, ON: Canadian Forestry Service, Fisheries and Environment Canada. 28 p.

"The Ritherdon Road extension project on the west coast of Vancouver Island was used in 1975 to study the relationship between logging road design and construction tasks, and stream sedimentation. A method of determining least cost logging road design and construction prescriptions to meet stream sedimentation standards is described using sample data.

"Although the data gathered for that study were insufficient to derive definite relationships between sedimentation from logging road construction and damage prevention costs, the information and experience gained may serve to illustrate a possible approach to achieving least cost sedimentation prevention and the critical data gaps. The possibility that the road was designed and constructed so that very little sedimentation occurred during the study period should not be ignored in developing guidelines.

"The insufficient number of significant observations indicate that either long-term study in a single watershed or a study encompassing more than one study area, or both, are required to gain sufficient information to develop biologically significant sedimentation standards, and least cost and effective road design and construction remedies. It is not enough to study sedimentation only during the construction phase. It is important to determine the sedimentation caused by the degree of completion that the road is left in after completion of construction. This will yield a two-part analysis that should contribute toward linking road design and construction effects on stream habitat quality during complete years or the life cycle of salmon. It is well recognized that much hydrological and biological information remains to be acquired. There is also a need to conduct more work to determine efficient measures of preventing sedimentation from roads and their costs. More detailed cost accounting on road projects using special categories for environmental design and practices will, if supplemented with sedimentation monitoring, aid in determining effective and least cost remedies for meeting sediment standards." (A)

390. Packer, P.E. 1967. Criteria for designing and locating logging roads to control sediment. Forest Science. 13(1): 1-18.

"A recently completed study developed criteria for the design, location, and construction of logging roads in the northern Rocky Mountains to prevent damage to the water resources and to conserve soil. Results reveal which characteristics of watersheds and of secondary logging roads influence erosion of road surfaces and movement of sediment downslope from roads. They define the manner and degree in which these characteristics affect road-surface erosion and sediment movement, and they indicate which characteristics are controllable or alterable by design, management, or choice. They also provide the quantitative criteria needed to develop road design and location requirements that should be considered in planning and executing timber harvest operations, so that soil and water resources will be protected." (A)

391. Packer, P.E.; Aldon, E.F. 1978. Revegetation techniques for dry regions. In: Reclamation of drastically disturbed lands. Madison, WI: American Society of Agronomy: 425-450.

"Revegetating surface-mined lands involves shaping spoil piles to desirable configurations, application of available surface soil, and planting of suitable vegetation. Major factors influencing success of surface-mine revegetation programs are (i) the chemical, hydrologic, and physical characteristics of reshaped spoil materials as they influence productivity; (ii) the climatic characteristics of the site reflected by amounts and distribution of precipitation and the potential for evapotranspiration; and (iii) the availability of seeds and propogated plant parts of both native and suitable introduced plant species." (A)

392. Packer, P.E.; Christensen, G.F. 1970. Guides for controlling sediment from secondary logging roads. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 42 p.

This handbook was developed from research and experience in the Northern Region of the USDA Forest Service. It is a practical guide in convenient size and shape to use in the field as well as in the office. Chapters address: (1) factors that affect erosion of logging road surfaces and movement of sediment, (2) guides for spacing cross drains and determining widths of protective strips, (3) how to apply these guides for controlling erosion and sediment flow, (4) how to install devices to control erosion and sediment flow, and (5) 15 key rules for reducing erosion on logging roads. (C)

393. Packer, P.E.; Williams, B.D. 1980. Logging residue disposal effects on surface hydrology and soil stability of lodgepole pine forests. In: Environmental consequences of timber harvesting in Rocky Mountain Coniferous Forests. Gen. Tech. Rep. INT-90. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 111-122.

"In the high-elevation lodgepole pine forests of western Wyoming, the most effective logging residue disposal treatment in terms of surface runoff and erosion control is chipping the residue and respreading it as a protective mulch. This treatment has serious disadvantages—almost complete suppression of vegetation and elimination of natural lodgepole pine reproduction. The most adverse soil and vegetative characteristics, the poorest surface runoff and erosion control, and the slowest watershed recovery occur where logging residue has been dozer piled and burned. Chipping and removing the chips is a superior treatment for watershed protection, but its practicality is contingent upon a market for chips or small timber products. Broadcast burning remains the most effective residue treatment in terms of protection of soil and vegetal characteristics, control of surface runoff and soil erosion, and rapidity of watershed recovery following logging." (A)

394. Painter, D.J. 1981. Steeplands erosion processes and their assessment. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 2-20.

"It is emphasised that the three aspects: assessing, understanding and controlling regolith erosion processes, are interrelated. Erosion assessment in New Zealand is reviewed, showing that it is well developed. Control techniques have been a mixture of successes and failures. Understanding of erosion processes, which must link assessment and control, has sometimes been inadequate. A diagram of simplified erosion proccesses is presented, to show their interrelationships and to define terminology. Recent developments in particle and fluid mechanics relevant to erosion proccesses are described and the future application of the most significant of these developments is briefly suggested." (A)

395. Painter, R.B.; Blyth, K.; Mosedale, J.C.; Kelly, M. 1974. The effect of afforestation on erosion processes and sediment yield. In: Effects of man on the interface of the hydrological cycle with the physical environment. IASH-AISH Publ. 113. Paris: International Association of Hydrological Sciences: 62-67.

"The effect of coniferous afforestation on erosion processes and sediment yield in upland areas of the United Kingdom, is being studied in three experimental basins; one is rough pasture and used for sheep grazing, the second has recently been deep ploughed and planted with mixed conifers, while the third is under mature coniferous forest. A proposed model of sediment processes is given, and the measurements made of sediment yield, both suspended and bedload, and of erosion from source areas, notably streambanks, gullies, forest roads, forest ditches, and local slips, are described. Forest ditching has had an immediate effect on sedimentation giving 1000 fold increases in both suspended sediment concentrations and total yield, compared with the pre-ditching situation. Bedload measurements suggest that even after ditches mature, erosion on steeper slopes produces substantial changes in the supply of material." (A)

396. Parsons, D.A. 1965. Vegetative control of streambank erosion. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 130-136.

"Vegetation may protect a streambank in at least three ways. Perhaps the most important of these is the reduction of water speeds and tractive forces at the soil surface to a value below that required to cause erosion. Second in importance is, perhaps, the protection given to the bank material as a buffer against ice, logs, and other transported materials. The stalwart barrier of trees standing along the edge of a stream prevents the impact of the transported materials with the soft material of the bank. Or, in another way, the tough but pliant shrub-type materials, bending with the forces involved, act as skid surfaces for the transported materials as they are deflected by the banks of streams of all sizes. Third, close-growing vegetation will contribute to bank stability, within a narrow range of conditions, by inducing deposition. Subsequent to a rare flood that has caused damage but not complete destruction to the vegetative cover, the deposition that occurs in minor floods helps to maintain the bank." (A)

397. Patric, J.H. 1976. Soil erosion in the eastern forest. Journal of Forestry. 74(10): 671-677.

"This paper provides an overview of what is known about forest soil erosion in eastern United States. By most accounts, erosion from undisturbed as well as carefully managed forest land is 0.05 to 0.10 ton/acre/year; that is less than the geologic norm (0.18 to 0.30) and far less than maximum tolerable rates for agricultural land (1 to 5 tons/acre/year). Eroded material is about equal parts of particulate and dissolved matter. Responsibly managed timber harvest causes only minor increases in forest soil erosion, usually from channels and logging roads, but irresponsible timber harvest can increase erosion of particulate matter to unacceptable levels." (A)

398. Patric, J.H. 1977. Soil erosion and its control in eastern woodlands. Northern Logger and Timber Processor. 25: 4-5, 22-23, 31, 51.

"Because overland flow rarely occurs in the eastern hardwood forest, there is no mechanism to transport particulate matter across the forest floor. Eroded material, consisting equally of particulate matter and dissolved solids, originates primarily in stream channels. This material averages about 0.05 to 0.10 ton per acre per year.

"Tree cutting does not cause overland flow so it has only a negligible and temporary effect on soil erosion rates and on stream pollution.

"Logging, especially in streams, can cause erosion rates to increase greatly, but logging roads more frequently are sites of accelerated erosion.

"Erosion rates will not be materially accelerated if loggers stay out of stream channels and apply to logging roads what is known about controlling overland flow." (A)

399. Patric, J.H. 1980a. Effects of wood products harvest on forest soil and water relations. Journal of Environmental Quality. 9(1): 73-80.

"The effects of silvicultural treatments on streamflow have been evaluated for 20 years on a 34.7-ha forested catchment on the Fernow Experimental Forest, near Parsons, in north-central West Virginia. Selection harvest of 13, 8, and 6% of the basal area in 1958, 1963, and 1968, respectively, had negligible effect on any measured property of water. In 1969-1970, 31.7 ha were harvested by clearcutting, leaving a 3.0-ha protective strip of lightly cut forest extending about 20 m along both sides of the stream channel. This treatment had no effect on stormflow or stream temperature, but water yield increased 253 mm (38%) during the first year after cutting. Concentrations of sediment, nitrate, calcium, magnesium, potassium, and sodium in streamflow increased slightly. These effects on water quality were held to low levels by the protective strip and prudent management of logging roads. Subsequent cutting of the protective strip and clearing the stream channel in 1972 increased water yield 40 mm (9%) and raised stream temperature as much as 7.8°C. Luxuriant regrowth over the entire watershed reduced all effects on water within 2 years after each treatment, and no effect from any treatment was measurable after 1977." (A)

400. Patric, J.H. 1980b. Some environmental effects of cable logging in Appalachian forest. Gen. Tech. Rep. NE-55. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

"The forestry literature, especially from the Eastern United States, was reviewed for reports concerning effects of wood products harvest on forest soil, water, residual stands, wildlife, and visual appeal. In all cases, cable logging caused less unwanted effects on these resources than did other harvest systems. Even though the concept of cable logging is well established, logging machinery built according to this principle, and fully suited to harvesting the eastern hardwood forest, has not been developed." (A)

401. Patric, J.H.; Aubertin, G.M. 1977. Long-term effects of repeated logging on an Appalachian stream. Journal of Forestry. 75(8): 492-494.

"Watershed 2 on the Fernow Experimental Forest has been logged four times since the turn of the century. While little is known of how streams were affected by logging after 1901 or during World War II, the effects of diameter-limit cutting in 1958 and 1972 are well documented. Both cuts caused small increases in streamflow but had little effect on water quality by any criterion except turbidity, which was increased by poorly located and ill-managed logging roads. The evidence suggests that if responsible road practices are followed, continued diameter-limit cutting will not harm forest streams." (A)

402. Patric, J.H.; Brink, L.K. 1977. Soil erosion and its control in the eastern forest. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 362-368.

"It can be argued that several decades of research have done little more than refine Major Chittenden's...concept of soil erosion in the forest: 'Soil erosion does not result from forest cutting in itself, but from cultivation, using that term in a broad sense. The question of preventing such erosion or soil wash is altogether one of dispensing with cultivation or properly controlling it. The natural growth which follows the destruction of a forest is fully as effective in preventing erosion, and even in retaining run-off as the natural forest.'

"Although the thread of this concept is descernable [sic] through the fabric of forestry literature since 1909, several counterthreads sometimes obscure the forests' presently conceived role in the control of soil erosion. For example, many people had—and continue to have—difficulty in distinguishing Chittenden's 'forest cutting' from 'cultivation.' We feel that a clear distinction between these terms is essential for people who are deeply concerned about predicting soil losses from erosion....

"Given that flowing water is the only cause of significant soil erosion in the eastern forest, we need to understand the disposition of water in an uncut forest, how its disposition is changed by tree cutting, and the potential for soil erosion in both situations." (A)

403. Patric, J.H.; Gorman, J.L. 1978. Soil disturbance caused by skyline cable logging on steep slopes in West Virginia. Journal of Soil and Water Conservation. 33(1): 32-35.

"A URUS mobile skyline system removed an average volume of 32.6 cubic meters (4,500 board measure) per hectare of hardwood logs from 16 hectares (40 acres) of steep forest land in West Virginia. Six months after logging, we evaluated the area's hydrologic performance. There was no evidence of reduced infiltration, increased bulk density, overland flow, or accelerated erosion, except on heavily used skid trails. The soil was severely disturbed (B horizon exposed) on less than 3 percent of the logged land; more than 90 percent was undisturbed." (A)

404. Paustian, S.J.; Beschta, R.L. 1979. The suspended sediment regime of an Oregon coast stream. Water Resources Bulletin. 15(1): 144-154.

"Armored stream segments may affect the suspended sediment regime of small mountain streams in western Oregon by the release of fine sediments stored in the bed gravels. Sieve analysis of bed materials indicated that at least 30 percent of the suspended sediment yield for the 1975-76 winter had been stored in the streambed. Suspended sediment concentrations during storm-generated runoff were influenced by stream discharge and hydrograph characteristics. Sediment-discharge relations for individual storms were characterized by hysteresis loops. A seasonal flushing of fines was shown by a progressive decrease in the ratio of suspended sediment to stream discharge during the winter runoff period." (A)

405. Pearce, A.J. 1976a. Geomorphic and hydrologic consequences of vegetation destruction, Sudbury, Ontario. Canadian Journal of Earth Sciences. 13: 1358-1373.

"Near-complete destruction of vegetation over 125 km^2 near Sudbury, Ontario has increased denudation rates by two orders of magnitude and caused substantial changes in hydrologic regime. Denudation by channeled and unchanneled flow, measured with erosion pins on small plots (2-1000 m^2) and a small drainage basin (0.09 km^2), averaged 6000 m^3/km^2 (maximum 24,700 m^3/km^2) during summer and fall in 1971 and 1972. Maximum denudation occurred during late August to October. Snowmelt runoff in 1972 yielded 1000 m^3/km^2 of sediment. The weighted average denudation rate, including rates of bedrock disintegration (60-170 $m^3/km^2/y$; mean 120 $m^3/km^2/y$) is 3700 $m^3/km^2/y$.

"Runoff coefficients average 0.88 for events with return periods between 2 and 10 years; 25% of the May-October rainfall runs off as Hortonian overland flow. Estimated sedimentation rates for three flood-control structures indicate 25% storage depletion over a 50 year period: the return period of floods then able to be retained is reduced to 50 years, compared to the design parameters of 100 year 6 h rainfall (smaller structures) and 100-200 year 12 h rainfall, 6 h P.M.P. (largest structure)." (A)

406. Pearce, A.J. 1976b. Magnitude and frequency of erosion by Hortonian overland flow. Journal of Geology. 84: 65-80.

"Erosion of Hortonian overload flow on unvegetated small plots (2 m^2) underlain by fine sandy silts averaged 2.45 kg sediment loss and 3.5 mm surface lowering during summer and fall, 1972. Total loss and mean surface lowering during seven measurement periods in 1972 were highly correlated with total rainfall kinetic energy in runoff-producing storms and with total runoff kinetic energy. Correlations with other energy and precipitation variables were not significant. Intensity-duration-frequency relationships for Hortonian overland flow combined with linear regression equations of erosion amounts on runoff kinetic energy indicate that erosion by Hortonian overland flow is dominated by runoff events of long duration (1-6 hours) and moderate intensity (5-15 mm/hour), with return periods of 1-2 years." (A)

407. Pickup, G. 1981. Stream channel dynamics and morphology. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 142-165.

"The paper describes recent developments in fluvial geomorphology including work on sediment yields and delivery ratios, flow resistance, hydraulics and sediment transport, river morphology and process, applied studies, and modelling. Recent work on sediment yield has shifted away from plot studies to small catchments and includes direct measurement of sediment delivery from different sources, tracer studies, and runoff and sediment dynamics over the short term. Recent developments in channel hydraulics include revived interest in gravel bed rivers but little progress has been made in developing new methods for estimating sediment load, although there is now great potential for improving the accuracy of traditional methods. In river morphology, the search for a unified theory linking stable channel form, flow resistance and sediment transport continues, but with little success. Process studies involving field measurement are becoming more popular and are casting doubt on many previously accepted ideas of the relationship between process and form. Applied studies relating to the problems of sediment in the environment are becoming important and growth areas include the behaviour of sediment as a pollutant and its role in river and estuarine nutrient balances and ecology. Applied studies increase the need for prediction and complex models of sedimentation processes are reaching the stage where they can be used as operational tools." (A)

408. Piest, R.F. 1965. The role of the large storm as a sediment contributor. In: Proceedings, Federal inter-agency sedimentation conference: 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 98-108.

"A knowledge of the sediment contribution of large rainstorms, relative to the total quantity of sediment removed from a watershed over a long period of time, is a prerequisite to the planning of an efficient soil conservation program. Because the large storm has especially high flow rates and other erosive features...its role as a sediment contributor is not always seen in proper perspective....For most watersheds more than one-half of the soil losses are attributable to the smaller storms that occur more often than once a year, on the average. We can therefore expect that recommended land use and land treatment practices in upland areas...would result in significant reduction in downstream sedimentation." (A)

409. Piest, R.F. 1970. Sediment sources and sediment yields. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 96(HY6): 1283-1329.

"A few of the more commonly used methods for determining sediment production are examined and references are made to publications that provide more detail on the subject." (A)

Methods presented and discussed for predicting sheet and rill erosion include the Musgrave equation and the Universal Soil Loss Equation. A number of methods are also presented and discussed for predicting gully erosion, sediment yield, and sediment delivery ratios. (C)

410. Piest, R.F.; Bradford, J.M.; Spomer, R.G. 1975. Mechanisms of erosion and sediment movement from gullies. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 162-176.

Data are presented concerning sediment movement from four gullies in northern Missouri. Mechanisms that seem to affect gully erosion rates are explored. The gullies discussed are of the valley head type, draining field-sized areas in a deep loess region. (C)

411. Piest, R.F.; Kramer, L.A.; Heinemann, H.G. 1975. Sediment movement from loessial watersheds. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 130-141.

"The purpose of this study is to review what is known about the movement of soils from loessial watersheds and to extend this knowledge by applying experiences from instrumented watersheds near Treynor, Iowa. We examine inaccuracies resulting from the use of the sediment-delivery method to predict sediment yields in the loess region. Then, using previously defined relationships between soil erosion and sediment yield, and insights gained from the intense measurements on the Treynor watersheds, we identify factors that will improve soil loss predictions and propose an independent function to represent sediment conveyance/retardance properties of a soil surface. The end result, when fully developed, should improve sediment-yield prediction procedures." (A)

412. Poeschl, H.J. 1977. Application of the Universal Soil Loss Equation on forested land. In: Aubertin, G.M., ed. "208" symposium, non-point sources of pollution from forested land; 1977 October 19-20; Carbondale, IL. Carbondale, IL: Southern Illinois University: 83-100.

Soil loss research began over 60 years ago in the United States; the first soil loss prediction equation was formulated about 1940. The Universal Soil Loss Equation (USLE) now in use was developed about 20 years later. The USLE is A = RKLSCP; where A = average annual soil loss in tons per acre, R = rainfall index, K = soil erodability, L = length of slope, S = steepness of slope, C = cover management factor, and P = practice factor. The cover management factor (C for forested lands) accounts for the tree canopy, forest litter, and size and type of undergrowth. Forested lands as defined in the 1970 Conservation Needs Inventory is land at least 10 percent stocked by forest trees of any size. There are 3.6 million acres of forested land in Illinois, of which 1.3 million acres are grazed. Application of the USLE on forested lands is demonstrated in two examples. (C)

413. Rakoczi, L. 1975. Effects of man on sedimentation and erosion in rural environments. Hydrological Sciences Bulletin. 20(13): 103-112.

Papers on erosion and sedimentation presented at the Paris symposium "Effects of Man on the Interface of the Hydrological Cycle with the Physical Environment" are reviewed. Concluding remarks of the reviewer follow: (C)

"It is very interesting, indeed, to see how hydrologists and other scientists are tackling erosion problems in different countries. These problems can be equally serious in countries where the establishment of an effective data collection network is a task for the future, and e.g. in the USA where such a network has been operating for a long time.

"It is also remarkable that in the papers dealing with experimental basins only traditional methods of sediment sampling are mentioned. I would like to draw your attention to the fact that different tracer methods (both radioactive and inactive) are known and successfully used in the field study of sheet erosion. The sudden changes in suspended sediment concentration in streams can be followed or even recorded by nuclear instruments which indicate the required concentration data directly, on the spot. These techniques are especially suitable for experimental areas, and can significantly deepen our knowledge about the erosion-sedimentation processes....

"Finally, I would like to emphasize that erosion research is a typical field for team work. Successful investigations can only be carried out by the united efforts of hydrologists, engineers, physicists, agricultural scientists, etc. The results of research, i.e. the recommended soil conservation measures can be effectively carried out only by coordinated technical, economical, social and legal interventions.

"The whole set of questions should be viewed in the light of world-wide protection of the human environment. It has to be borne in mind that soil erosion and sedimentation is a substantial part of the overall deterioration of our environment. In this light sediment is a pollutant which can be most effectively controlled if the sources of it are under proper and rational human control." (A)

414. Reed, L.A. 1976. Sediment control during highway construction in central Pennsylvania. In: Environmental aspects of irrigation and drainage. New York: American Society of Civil Engineers: 497-507.

"Offstream and onstream detention ponds were studied to determine their effectiveness in reducing sediment and turbidity in streams below construction projects in a study area in central Pennsylvania. The offstream ponds designed to intercept the runoff from the construction area before it can enter the stream seem to be the most efficient method to reduce both sediment and turbidity. The onstream pond was an effective sediment trap but it prolonged high stream turbidity well beyond the normal turbidity period after a storm. The reason the onstream pond was not very effective in controlling turbidity was that sediment in the runoff water from the construction area was composed of 70 percent clay, even though clay made up only 26 percent of the subsoil." (A)

415. Reed, L.A. 1977. Effectiveness of sediment-control techniques used during highway construction in central Pennsylvania. Water-Supply Pap. 2054. Washington, DC: U.S Department of the Interior, Geological Survey. 57 p.

"A different method for controlling erosion and sediment transport during highway construction was used in each of four adjacent drainage basins in central Pennsylvania. The basins ranged in size from 240 to 490 acres (97 to 198 hectares), and the area disturbed by highway construction in each basin ranged from 20 to 48 acres (8 to 19 hectares). Sediment discharge was measured from each basin for 3 years before construction began and for 2 years during construction. In one of the basins affected by the construction, three offstream ponds were constructed to intercept runoff from the construction area before it reached the stream. In another basin, a large onstream pond was constructed to trap runoff from the construction area after it reached the stream. In a third area, seeding, mulching, and rock dams were used to halt erosion. In the fourth area, no sediment controls were used.

"The effectiveness of the various sediment-control measures were determined by comparing the sediment loads transported from the basins with sediment controls to those without controls. For most storms the offstream ponds trapped about 60 percent of the sediment that reached them. The large onstream pond had a trap efficiency of about 80 percent, however it remained turbid and kept the stream flow turbid for long periods following storm periods. Samples of runoff water from the construction area were collected above and below pond dams to determine the reduction in sediment as the flow passed through the device. Rock dams in streams had a trap efficiency of about 5 percent. Seeding and mulching may reduce sediment discharge by 20 percent during construction, and straw bales placed to trap runoff water may reduce sediment loads downstream by 5 percent." (A)

416. Reid, L.M.; Dunne, T.; Cedarholm, C.J. 1981. Application of sediment budget studies to the evaluation of logging road impact. Journal of Hydrology (NZ). 20(1): 49-62.

"The construction of a partial sediment budget provides a flexible, efficient, and economical means of evaluating changes in sediment production rates generated by changes in land use. Application of the method to a 40% clear-felled area of the northwestern United States demonstrates that landslides are responsible for about 60% of the road-related sediment production. An additional 20% is produced by surface erosion on gravel roads, and about 80% of this value is derived from roads along which logs are being transported. In the terms of the production rate of sediment smaller than 2 mm in diameter, however, the sources are of near-equal importance, and paving the haul roads will result in a 30% decrease in the production rate of fine-grained material." (A)

417. Renard, K.G. 1977. Erosion research and mathematical modeling. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 31-44.

"Recent water quality legislation has accelerated the need for erosion control. Although past efforts have not directly recognized the relationship between hydrologic processes and erosion, future work will undoubtedly combine the hydrologic and erosion models. Because water is the major transporting agent (excluding wind erosion), estimating erosion requires knowing the rates and amounts of water available within a watershed. The availability of watershed models and large storage computers facilitates such efforts.

"The Universal Soil Loss Equation, an empirical model developed from extensive data, is used widely for estimating erosion in the Unites States. It is being modified to extend its applicability and to improve its accuracy in producing estimates. The modifications and combinations of this erosion equation with a hydrologic model are illustrated.

"Other available techniques for estimating erosion, like physical component and stochastic models, are discussed with an example of each to illustrate some advantages and disadvantages. The physically-based schemes undoubtedly have the most potential for predicting erosion differences caused by changes in land use. As demands for land intensify, erosion must be minimized, since it often irreversibly reduces the productive capacity of our soil resources.

"An example of a model incorporating several of the analytical schemes is presented and is illustrated with some data from the Walnut Gulch Experimental Watershed. A stochastic runoff generating model was used along with an analytical component model of the stream water-sediment transport and a mystery black box model to describe the properties of stream width, depth, and slope, using a stream-order concept." (A)

418. Renard, K.G. 1980. Estimating erosion and sediment yield from rangeland. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 164-175.

"Sediment yields in many rangeland areas of the western United States are larger than might be expected with the low rainfall generally characteristic of the area. These high yields result from: (1) the general low vegetal density inadequately protects the soil against the erosion forces of raindrops and runoff; (2) land slopes are often steep and infiltration is generally low, which results in high shear from the water moving over the land surface; (3) high intensity thunderstorms and their associated high kinetic energy are relatively common, which leads to excessive splash erosion and overland runoff; and (4) channel slopes are generally steep and contain large amounts of alluvium for transport in the runoff.

"The problems associated with erosion/sediment yield for downstream areas are well documented. The problems are important not only because of deposition in reservoirs (loss of storage) and channels (decreased conveyance capacity) but also because the sediments often contain appreciable quantities of absorbed chemicals, which can severely degrade water quality. Recent water quality legislation and the mandates to correct pollution problems in the waters of the United States have created a new emphasis on this problem with water quality.

"Another problem is that erosion in upland areas often reduces soil productivity. In western rangeland areas, the problem is often acute because the soil profile in such areas is already insufficient for adequate forage production. Soil erosion reduces a soil's potential for production of forage by: (1) loss of soil water storage capacity; (2) decreased infiltration rate (surface sealing) and increased opportunity for runoff and evaporation; (3) loss of soil nutrients; and to a lesser extent (4) increased weed production; (5) reduced seed germination; and (6) decreased root development.

"Methods for estimating erosion and sediment yield from rangelands are based primarily upon the principles developed in parts of the U.S., where cultivated agricultural activities are prevalent. Techniques incorporating disturbance of the soil by tillage are not generally applicable to rangelands, so the erosion estimating techniques must be appropriately adjusted to reflect such differences. Typical problems unique to rangelands are those associated with the different soils of range, the existence of erosion pavements and the protection from raindrop impact and shear of surface runoff this affords, grazing and trampling by cattle, and the importance of channel erosion processes. In this paper, some sediment yield formulae are tested against sediment accumulation data from nine small watersheds in the Walnut Gulch Experimental Watershed." (A)

419. Renfro, G.W. 1976. Use of erosion equations and sediment-delivery ratios for predicting sediment yield. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 33-45.

This article discusses computation of gross erosion resulting from sheet and channel erosion, computation of sediment delivery ratios, and the use of gross erosion estimates and sediment delivery ratios in predicting sediment yield. (C)

420. Rhoades, E.D.; Welch, N.H.; Coleman, G.A. 1975. Sediment-yield characteristics from unit source watersheds. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 125-129.

Preliminary data are presented on sediment yield from several small watersheds subjected to different land-use patterns. The data show many features of sediment yield including the relative yield of good-to-excellent rangeland versus poor-to-fair rangeland, sheet and rill erosion from poor-to-fair rangeland versus gully erosion from poor-to-fair rangeland, and the magnitude and seasonal distribution of different cropping patterns. (C)

421. Rice, R.M.; Crouse, R.P.; Corbett, E.S. 1965. Emergency measures to control erosion after a fire on the San Dimas Experimental Forest. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 123-130.

"In 1960 a wildfire swept most of the 17,000-acre [San Dimas] Experimental Forest. It destroyed much valuable research underway, but it also presented an opportunity to study flood flows and erosion rates from completely burned watersheds....This paper reports on a continuing study begun during the dry winter of 1960-61, and covers data collected during the four major storms of the 1961-62 season." (A)

422. Rice, R.M.; Datzman, P.A. 1981. Erosion associated with cable and tractor logging in northwestern California. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 362-385.

"Erosion and site conditions were measured at 102 logged plots in northwestern California. Erosion averaged 26.8 m^3/ha. A log-normal distribution was a better fit to the data. The antilog of the mean of the logarithms of erosion was 3.2 m^3/ha. The Coast District Erosion Hazard Rating was a poor predictor of erosion related to logging.' In a new equation that 'explained' about 40 percent of the variability in erosion, yarding method was associated with a 3.7-fold difference in erosion, aspect with a 4.3-fold difference, geologic type with a 13.5-fold difference, and slope with a 16-fold difference. The analysis suggests that an additional source of variation was operative that may be related to how the logging was done. Future investigations, therefore, should focus more on the conduct of logging operations than descriptions of the site logged." (A)

423. Rice, R.M.; Sherbin, S.A. 1977. Estimating sedimentation from an erosion hazard rating. Res. Note PSW-323. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 4 p.

"Data from two watersheds in northern California were used to develop an interpretation of the erosion-hazard rating (EHR) of the Coast Forest District as amount of sedimentation. For the Caspar Creek Experimental Watershed, each EHR unit was estimated as equivalent to 0.0543 cubic yards/acre/year on undisturbed forest. Experience within the District provided estimates of average excess sediment produced by logging: 17.5 cubic yards/acre for tractor yarding, and 6.3 cubic yards/acre for cable yarding. These estimates based on limited data should be supplemented by additional research to cover wide variations in condition." (A)

424. Rice, R.M.; Tilley, F.B.; Datzman, P.A. 1979. A watershed's response to logging and roads: South Fork of Casper Creek, 1967-76. Res. Pap. PSW-146. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 12 p.

"The effect of logging and roadbuilding on erosion and sedimentation are analyzed by comparing the North Fork and South Fork of Caspar Creek, in northern California. Increased sediment production during the 4 years after road construction was 326 cu yd/sq mi/yr—80 percent greater than the predicted by the predisturbance regression analysis. The average sediment load during the 3 years of logging increased by 957 cu yd/sq mi/yr—275 percent greater than the predicted values. Although the erosion or sediment increases do not appear to be degrading site quality, average turbidity levels in the South Fork exceeded water quality standards." (A)

425. Rich, L.R. 1961. Surface runoff and erosion in the lower chaparral zone—Arizona. Stn. Pap. 66. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 35 p.

"Observations and measurements to date permit the following conclusions relative to the management of granitic watersheds in the lower chaparral zone:

1. Intense summer thunderstorms are characteristic of Arizona. Where the plant cover is sparse, and infiltration capacity low, surface runoff may be high. Surface flows carry considerable sediment, deepen channels and generally increase erosion. To control erosion, management must be directed toward reduction of surface runoff.

2. Surface runoff and erosion were reduced, and a perennial grass cover was established by cutting woody vegetation and grubbing its roots, sloping steep gully sides, placing cut brush in gully channels, and then seeding to Boer and Lehmann lovegrasses.

3. Hardware-cloth checks placed on the contour also reduced erosion, but did not produce additional vegetation. Most surface runoff was produced during summer." (A)

426. Rickert, D.A.; Beach, G.L.; Jackson, J.E. [and others]. 1978. Oregon's procedure for assessing the impacts of land management activities on erosion related nonpoint source problems. Portland, OR: Water Quality Program, Department of Environmental Quality, State of Oregon. 219 p.

"A procedure is presented for relating stream quality conditions to regional terrain characteristics and to land management activities. The procedure has been developed as part of the Oregon 208 Assessment of nonpoint source problems and is intended to provide informational guidelines for aiding the control of erosion related problems. This report describes the procedure and its application to the Evans Creek Basin in the Rogue River Drainage of Southwest Oregon.

"The procedure is based on the mapping of the erosion potential of different terrains in a basin from the analysis of slope, geology, and soils. Maps of these factors are prepared and collated with information on: (1) the distribution of land management activities; and (2) a rating of stream quality as defined by surveys of stream channel stability and fish habitat conditions. An additional feature of the approach is the use of high altitude, color infrared imagery for mapping the erosional-depositional features of the land and streams. The distribution and severity of the mapped features are coordinated with the stream quality rating as a basis for identifying the relative impacts of different management activities on different types of terrain.

"The combined information is presented as interpretive maps and formatted into a ready-to-use regional management tool through the development of erosional impact matrices. The matrices are designed to show at a glance the relative severity of land and stream impacts that can be expected from applying various land management activities to identified types of terrain. Together, the maps and matrices can be used to: (1) determine the suitability of land management activities on identified types of terrain as an aid to the development of land management guidelines and regulations (county level planning); (2) provide resource managers and decision makers with an understanding of erosional processes and resultant stream quality problems; (3) identify where existing problems occur; (4) prioritize the need for future site specific studies; and (5) enable data and technology to be transferred from small study areas to larger areas of similar terrain and climate." (A)

427. Ripkin, J.F.; Killen, J.M.; Gulliver, J.S. 1977. Methods for separation of sediment from storm water at construction sites. EPA-6OO/2-77-033. Cincinnati, OH: U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Office of Research and Development. 91 p.

"Large construction sites, when exposed to rainfall, yield runoff which may transport an objectionable load of mineral solids from the site. This report discusses the nature and amount of solids which may be transported and reviews the primary and secondary methods which may be employed to remove the transported solids from the effluent water. Limited consideration is given to the settling basin as a primary treatment device but the principal focus is on the use and characteristics of modern, available, commercial equipment for the secondary treatment process necessary to remove fine mineral solid suspensions. Specific recommendations are made for equipment selection and for additional studies to more clearly characterize these selections for construction site use. The study is based on a review of published technical literature and from trade literature obtained from a wide solicitation of American manufacturers." (A)

428. Ripley, P.O.; Kalbfleisch, W.; Bourget, S.J.; Cooper, D.J. 1961. Soil erosion by water. Publ. 1083. Ottawa, ON: Canadian Department of Agriculture. 35 p.

"It is true that there is little or no danger of erosion in many parts of Canada during five or more winter months; frozen soil is not susceptible to the ravages of flowing water. Furthermore, neither monthly nor yearly precipitation totals are as great in Canada as in some other countries. It must not be taken for granted, however, that water erosion cannot be extremely damaging in this country.

"Rapidly melting snow or short heavy rainfalls are likely to occur almost anywhere in Canada, and there has been water erosion with flooding in every province within the memory of the present generation." (A)

This report provides a soil erosion map of Canada and specifically discusses factors affecting soil erosion, effects and control of soil erosion, and management of eroded or erodible land. (C)

429. Ritter, D.F. 1977. Forest hydrology and stream dynamics. In: Aubertin, G.M., ed. "208" symposium, non-point sources of pollution from forested land; 1977 October 19-20; Carbondale, IL. Carbondale, IL: Southern Illinois University: 71-81.

"Rivers are geomorphic agents that behave according to constraints exerted on them by variables that are external to the channel. Vegetation plays an important role in fluvial processes. It follows that any climatic variation or human activity that alters the vegetal composition requires a change in the runoff and sediment characteristics, an ultimately, a response in the river dynamics. Rivers draining forests normally have low average discharges and low sediment loads. When a forest canopy is replaced by pasture or cropland, the streams usually respond with (1) an increase in total discharge, (2) higher flood peaks of shorter duration, (3) greater sediment loads and (4) an increase in the size of the sediment. The major fluvial responses can be categorized as (1) those involving prolonged downcutting or fillingof the channel, (2) those in which the local channel morphology is adjusted and (3) major changes over large segments of the river system." (A)

430. Roehl, J.W. 1962. Sediment source areas, delivery ratios and influencing morphological factors. In: Publication 59, Association Internationale Hydrologie Scientifique: 202-213.

"Sediment being a product of erosion, is discussed in terms of erosion sources. The various sediment sources, components of both sheet and channel type erosion, are analyzed as to their relative importance as producers of sediment in several physiographic areas of the southeastern United States. Sheet erosion is, in most instances, the prime contributor of sediment. The sediment delivery ratios, the percentage relationships between annual gross erosion above that point, are analyzed and discussed in terms of several morphological factors that apparently have measurable influences on them. These morphological features include size of drainage area, drainage density, stream order, relief/length ratio and others. In some areas it appears that the relief/length ratio is the best indicator of sediment delivery ratios, although size of drainage area will give reasonable estimates." (A)

431. Roehl, J.W. 1965. Erosion and its control on agricultural lands. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970; Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 18-22.

"Erosion is the wearing away of the land surface by detachment and transport of soil and rock materials through the action of moving water, wind, or other geological agent. Normal, or geologic, erosion pertains to this wearing away of the land under natural environmental conditions. Accelerated erosion, brought about by man, is conceived to be the erosion occurring at a rate greater than normal for the site, usually through a reduction of a vegetal cover. While both wind and water are the principal agents producing accelerated erosion, this discussion will be confined to the water-caused process." (A)

432. Roehl, J.W. 1969. Sediment control methods: introduction and watershed area. Journal of the Hydraulics Division, American Society of Civil Engineers. 95(HY2): 649-676.

Land and structural types of watershed treatment that may be used to reduce erosion, floodwater, and sedimentation damages are described. (C)

433. Rogers, W.F. 1971. Hydrograph analysis and some related geomorphic variables. In: Morisawa, M., ed. Quantitative geomorphology: some aspects and applications. Binghamton, NY: Publications in Geomorphology, State University of New York: 245-257.

"First order drainage channels originate when the tractive force exerted by flowing water is sufficient to move surface sediment. The amount of runoff available to move sediment is a function of the geology and climate. Soils derived from fine grained rocks have lower infiltration rates and higher runoff volume than soils derived from coarser grained rocks in a semi-arid climate. Root density and penetration increases in a more humid climate and increases infiltration rates. The number of first order channels is inversely proportional to the infiltration capacity of the soil.

"Each first order channel acts as a source area for surface runoff. The distribution of first order channel distances from the gage determines the timing of the delivery of water to the gage. A comparison of the frequency histogram of first order channel distances for drainage basins in Pennsylvania and their hydrographs of runoff from general storms show marked similarity. This close correspondence indicates the shape of the surface runoff hydrograph and is largely controlled by the distribution of first order channel distances." (A)

434. Rogoff, M.J. 1978. Use of the Universal Soil Loss Equation in water quality assessment: an annotated bibliography. Exch. Bibliogr. 1498. Monticello, IL: Council of Planning Libraries. 16 p.

This annotated bibliography "...focuses on the applications of the USLE (Universal Soil Loss Equation) in areawide water quality management. References are included that point out the specific hazards and limitations in water quality assessment." (A)

The bibliography contains 19 references. (C)

435. Rohlf, R.; Meadows, M.E. 1980. Dynamic mathematical modeling of rill erosion. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 13-26.

"A dynamic mathematical model was developed for simulating rill formation during the overland runoff-erosion process. The model couples the water-sediment continuity equation, sediment continuity equation and the kinematic approximation to the water-sediment momentum equation with sediment transport, erosion and channel boundary shear relationships for the prediction of sediment discharge and channel geometry variation during rill formation. A simple power equation was used to define lines of zero shear within the channel cross-section. The flow area between adjacent zero shear lines was determined by integration and used to calculate the shear distribution on the channel boundary. The shear distribution determined by this method was reasonably close to measured data collected by Replogle for a semi-circular channel with a depth equal to 1/3 the diameter. An excess shear equation developed by Foster for cohesive soil was used to predict the rate of soil detachment from the rill channel boundary.

"Preliminary testing of the model was performed using data from a 1974 rill erosion study conducted by Foster. The model under predicted the sediment discharge from the rill and eroded rill area." (A)

436. Romkens, M.J.M.; Johnson, C.B.; Nelson, D.W. 1978. Soil erosion control on construction sites with portland cement. Journal of Soil and Water Conservation. 33(5): 232-235.

"We used simulated rainfall to determine the erosion control effects of portland cement on upland soils. Our treatments included four rates of cement application and two methods of cement incorporation on two medium-textured soils. The application of 2.50 metric tons of portland cement per hectare (1.1 tons/acre), applied as a suspension on a tilled slope of moderate steepness and length, nearly eliminated soil erosion. Lower rates of cement application proved ineffective in controlling soil erosion, while higher application rates resulted in adverse effects on the establishment of vegetative cover. Incorporation of cement into the top 2.5 centimeters (1 inch) of soil at the 2.50-metric-ton-per-hectare rate proved ineffective for soil erosion control." (A)

437. Rosgen, D.L. 1976. The use of color infrared photography for the determination of suspended sediment concentrations and source areas. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 7-30 to 7-42.

"The concepts and special techniques for applying color infrared photography in sediment studies are presented. These techniques were developed and evaluated through a low elevation color infrared photography flight and concurrent water quality sampling conducted on 164 km (100 miles) of stream over the West Fork of the Madison River in southwestern Montana. The concentrations and sources of sediment produced during peak snowmelt runoff were determined by photo densitometric analysis coupled with specifically located ground control stations.

"Excellent correlations were established by regression analysis of the ground truth variables including stream width to discharge and suspended sediment to turbidity. Photo density was correlated with suspended sediment and turbidity, both produced strong correlations which were significant at the 99% confidence level. These correlations made it possible to determine reliable estimates of sediment concentrations from the aerial photography where stream measurements were not obtained." (A)

438. Ross, B.B.; Shanholtz, V.O.; Contractor, D.N. 1980. A spatially responsive hydrologic model to predict erosion and sediment transport. Water Resources Bulletin. 16(3): 538-545.

"A finite element numerical model has been developed by the authors which routes overland and channel flows in a watershed, given soils, land use, topographic descriptors, and rainfall as input. Such processes as infiltration, canopy interception, seasonal growth of vegetation, and depression storage are described in the hydrologic context of the model. These capabilities, along with the spatial detail and responsiveness of the model, allow a ready adaptation of the model to provide for the prediction of sediment transport and yield.

"It is assumed that the best results can be obtained by a technique which utilizes the following procedures. Sediment yield to the channel is described by functions describing soil detachment by rainfall and overland flow and transport by overland flow. Since the model description of the channel flow processes involves a more realistic representation of the physical drainage system, an attempt was made to define sediment transport in the channel by erosion and sedimentation mechanics.

"A conceptual framework is provided whereby the integrated effects of various land use activities on sediment transport and yield can be evaluated. Inherent in this provision of the model is the capability of determining the effects of any control measures to be implemented on a watershed." (A)

439. Rothacher, J. 1972. Managing forest land for water quality. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 6; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 232-244.

"Water quality management relates to problems of ultimate social importance. The technology is available to control large-scale changes in sediment, temperature, and chemical and bacteriological quality of water from forest land. In many cases, water quality considerations are also economic in terms of maintaining site quality, minimizing road mileage and maintenance, and reducing treatment costs." (A)

440. Rothacher, J.; Glazebrook, T.B. 1968. Flood damage in the National Forests of Region 6. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 20 p.

Large-scale flooding occurred in National Forests of the Pacific Northwest during December 1964 and January 1965. Subsequent damage and its relation to management practices was studied. The landscape, storm, and storm damage are described. Recommendations are made on the transportation and timber harvesting systems, location of recreation areas, and protection of the fisheries resource. (C)

441. Rothacher, J.; Lopushinsky, W. 1974. Soil stability and water yield and quality. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 23 p.

"Forest residue activities influences soil and water resources in proportion to the amount they increase soil disturbance. Drastic disturbance of litter and surface soil can lead to surface erosion and stream sedimentation. Residues and residue treatment would not normally increase mass soil erosion nor would water yields change significantly. The quantity of chemicals in streams increases when rate of decomposition of residues exceeds uptake by vegetation. Burning of forest residues increases the quantity of chemicals that may reach streams roughly in proportion to the quantity of fuel burned. Broadcast burning after logging of old-growth Douglas-fir increased loss of nutrient cations 1.6 to 3.0 times that from an unburned area." A)

442. Rothwell, R.L. 1977. Suspended sediment and soil disturbance in a small mountain watershed after road construction and logging. In: Swanson, R.H.; Logan, P.A., eds. Proceedings, Alberta Watershed Research Program symposium; 1977 August 31-September 2; Edmonton, AB. Inf. Rep. NOR-X-176. Edmonton, AB: Northern Forest Research Centre, Canadian Forestry Service, Fisheries and Environment Canada: 286-300.

"The effects of road construction and logging on water quality in Marmot Creek Experimental Watershed were studied in terms of suspended sediment and soil disturbance. The objective of the study was to demonstrate that water quality deterioration associated with forest harvesting can be prevented by careful planning of road construction and logging. Roads were constructed in Cabin subbasin 2 years before logging. Logging was done by clear-cut blocks, with logs skidded by rubber-tired skidders and crawler tractors. Suspended sediment record was obtained on a daily basis during the summer flow season, 4 years before roads and logging and 3 years afterward. Soil disturbance and erosion caused by roads and logging were evaluated by mapping and reconnaissance of disturbed areas.

"Soil exposure from roads and logging affected 25% of the total area of Cabin subbasin. Soil exposure on cut blocks averaged 32%, with most of it caused by skidroads. Mapping and reconnaissances of disturbed areas showed very little erosion and no sediment transport towards streams. Analysis of sediment data showed no increases in sediment concentrations or discharges that could be associated with roads or logging." (A)

443. Rothwell, R.L. 1978a. Erosion control on forest roads. Agriculture and Forestry Bulletin. 1(4): 29-32.

"...a brush mulch can be very effective in controlling erosion and reducing sediment movement from roads into streams. Maximum benefits usually occur immediately after application when soils are bare and unprotected from the erosive forces of raindrop splash and flowing water. Logging debris placed on the ground helps control erosion by decreasing the energy of flowing water, reduces sediment movement into streams by trapping and holding it on the ground, and provides small microclimatic sites favorable to grass germination and growth. The benefits of a brush mulch decrease when the sediment trapping capacity of debris is exceeded, which usually occurs one to two years after application...." (A)

444. Rothwell, R.L. 1978b. Watershed management guidelines for logging and road construction in Alberta. Inf. Rep. NOR-X-208. Edmonton, AB: Fisheries and Environment Canada, Canadian Forestry Service, Northern Forest Research Centre. 43 p.

"Most serious erosion and sedimentation problems on forested lands originate from logging operations and road construction....Main causes are logging on steep slopes, skidding straight up and down slopes, constructing roads that change or disturb the natural flow of drainage channels, roads with steep gradients, and drainage systems inadequate to divert water from road surfaces. The prospect of increased timber harvesting in most forest regions of Alberta makes necessary more specific criteria governing logging operations and road construction to ensure adequate protection of our water resources.

"The basic tenet of these guidelines is that serious erosion and sedimentation can be prevented only by minimizing soil disturbance and controlling surface runoff. This requires an understanding of soil erosion processes and the implementation of well-planned logging operations and road construction. The guidelines and examples cited in this report illustrate what can be done and the benefits that result. If implemented, these guidelines should reduce erosion, sedimentation, and deterioration of **water quality.**

"The first section of this report briefly discusses erosion and **watershed damage.** The second and third sections present watershed management guidelines for logging and road construction, including road maintenance. Italicized technical terms appearing in the text are defined in Glossary...." (A)

445. Rowlison, D.L.; Martin, G.L. 1971. Rational model describing slope erosion. Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers. 97(IR1): 39-50.

The relative effects of rainfall intensity and soil unit weight on erosion are evaluated in a laboratory study. (C)

"The results indicate that there exists a surface of maximum erosion rate which is a function of slope, unit weight, and depth of water flow over the soil." (A)

446. Rutter, N.W. 1968. A method for predicting soil erosion in the Rocky Mountain Forest Reserve, Alberta. Pap. 67-67. Ottawa, ON: Department of Energy, Mines, and Resources, Geological Survey of Canada. 32 p.

"A method of soil erosion prediction was formulated for the non-geologist in order to forecast water erosion hazards in potential logging areas of the Rocky Mountain Forest Reserve, Alberta. By using the material presented, a worker should be able to establish qualitatively the gross erosion hazard of exposed soil through airphoto interpretation and field reconnaissance. The steps involve determining the type and lithology of soils, and their erosion hazard based upon internal and external factors.

"Infiltration rate, grain size characteristics, carbonate cement content, and the binding strength of silt and clay are the important inherent soil properties to evaluate. On the basis of these properties the least erodible soils include glacial outwash, alluvial fan and floodplain deposits, talus, and carbonate-cemented till with a high percentage of gravel-sized material. The most erodible soils are lake, pond, and muskeg deposits, and soil derived from the underlying bedrock and till containing a high percentage of silt and clay." (A)

447. Sarles, R.L.; Emanuel, D.M. 1977. Hardwood bark mulch for revegetation and erosion control on drastically disturbed sites. Journal of Soil and Water Conservation. 32(5): 209-214.

"Experiments at five locations in southern West Virginia showed that bark compares favorably with straw and wood-fiber mulches for stabilizing soils on disturbed sites. Based on findings from the five experiments, bark applications of 30 and 50 cubic yards per acre are recommended. Slopes steeper than 2:1 and those facing south and west need the heavier application, as do sites exposed over winter. The experiments also demonstrated that improved equipment is needed to apply bark mulch efficiently." (A)

448. Sartz, R.S. 1976. Sediment yield from steep lands in the driftless area. In: Proceedings, Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-123 to 1-131.

"Suspended sediment in runoff water was measured on natural runoff plots and small watersheds in different land uses on southwestern Wisconsin's ridge and valley lands. Substantial amounts of sediment were discharged only from cultivated or heavily grazed catchments. The greatest amounts, sometimes exceeding 200,000 ppm., came from tilled cropland in early stages of development.

"Ungrazed forest and prairie yielded no significant amounts of runoff or sediment, regardless of slope steepness, unless they intercept water from overlying fields. However, field runoff can carve huge gullies on forested slopes that lie below cultivated uplands." (A)

449. Saxton, K.E.; Spomer, R.G.; Kramer, L.A. 1971. Hydrology and erosion of loessial watersheds. Journal of the Hydraulics Division, American Society of Civil Engineers. 97(HY11): 1835-1851.

"Results are reported which relate vegetation and conservation treatment to the hydrology and erosion of agricultural watersheds that have deep loessial soils. Six years of streamflow and erosion data from five small research watersheds in western Iowa are presented and analyzed." (A)

Analysis includes water yield, peak runoff rates, sheet-rill erosion, and gully erosion. (C)

450. Schumm, S.A.; Hadley, R.F. 1961. Progress in the application of landform analysis in studies of semiarid erosion. Circ. 437. Washington, DC: U.S Department of the Interior, Geological Survey. 14 p.

"The analysis of topographic and hydrologic data gathered during studies of erosion in semiarid areas of Western United States show the following relations: (a) Mean annual sediment yield from small drainage basins is related to a ratio of basin relief to length; (b) mean annual runoff from small drainage basins is related to drainage density; (c) mean annual sediment yield per unit area decreases with increase in drainage area; (d) the form of some convex hill slopes is related to surficial creep; (e) asymmetry of drainage basins, including differences in hill-slope erosion and drainage density, is related to microclimatic variations on slopes of diverse exposure; (f) the cutting of discontinuous gullies is closely related to steepening by deposition of the semiarid valley floor, (g) aggradation in ephemeral streams seems to be most prevalent in reaches where the ratio of contributing drainage area to channel length is relatively small; and (h) stream-channel shape, expressed as a width-depth ratio, is related to the percentage of silt-clay in bed and bank alluvium.

"The above relations cannot be detected without measurement of terrain characteristics. They further indicate the importance of quantitative terrain analysis in studies of erosion." (A)

451. Scott, R.G., Jr.; Buer, K.Y.; James, S.M. 1980. South Fork Trinity River watershed study. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 406-417.

"This paper discusses the results of a 3-year study by the California Department of Water Resources of erosion and turbidity in the 2460 square kilometres (km^2) South Fork Trinity Basin, Trinity County, California....A data base for the basin was developed which includes geology, landslides, timber harvest and burns, roads, stream cross sections, turbidity, and erosion hazards. This study used a novel method of analysis and presentation of turbidity data.

"The results of this investigation indicate that human management activities, coupled with nature on very sensitive terrain, are the major causes of the severely damaged tributaries on South Fork Mountain and high turbidity which occurs for most of the winter in the South Fork Trinity River. Serious cumulative effects are related to many timber-harvested areas on South Fork Mountain. This study also found that human management activities **did not** contribute to excessive turbidity over most of the basin where geologically sensitive conditions do not exist. Prevention of further watershed degradation by changing land use ordinances and forest practice rules is recommended.

"This study demonstrates that by developing a comprehensive data base, watershed management can be effective. Areas with poor regeneration, erodible soils,and unstable bedrock, can be delineated and avoided, and cumulative effects predicted, resulting in an environmentally sound, more productive forest." (A)

452. Selby, M.J. 1970. Slopes and slope processes. Publ. 1. Hamilton, New Zealand: Waikatu Branch, New Zealand Geographical Society. 59 p.

"Slopes are the fundamental units of the landscape and hence the primary concern of the geomorphologist. They are produced by a wide range of processes....For the purposes of this paper only hillslopes comprising the surface between a drainage divide and a valley floor and between upper and lower erosion surfaces are considered." (A)

This monograph summarizes information on hillslopes (theories of slope development, modern slope studies, factors of erosion); slope processes (climatic, topographic, vegetation, soil factors); types of erosion, causes and processes of mass movement; wind erosion; and accelerated erosion in New Zealand. (C)

453. Shirley, E.D.; Lane, L.J. 1978. A sediment yield equation from an erosion simulation model. Hydrology and Water Resources in Arizona and the Southwest. 8: 90-96.

"Sediment is widely recognized as a significant pollutant affecting water quality. To assess the impact of land use and management practices upon sediment yield from upland areas, it is necessary to predict erosion and sediment yield as functions of runoff, soil characteristics such as erodibility, and watershed characteristics. The combined runoff-erosion process on upland areas was modeled as overland flow on a plane, with rill and interill erosion. Solutions to the model were previously obtained for sediment concentration in overland flow, and the combined runoff-erosion model was tested using observed runoff and sediment data. In this paper, the equations are integrated to produce a relationship between volume of runoff and total sediment yield for a given storm. The sediment yield equation is linear in runoff volume, but nonlinear in distance and, thus, watershed area. Parameters of the sediment yield equation include the hydraulic resistance parameter, rill and interill erodibility terms, and flow depth-detachment coefficient and exponent." (A)

454. Shown, L.M. 1970. Evaluation of a method for estimating sediment yield. In: Geological Survey research 1970. Prof. Pap. 700-B. Washington, DC: U.S. Department of the Interior, Geological Survey: B245-B249.

"A method for estimating annual sediment yield, developed by the Pacific Southwest Inter-Agency Committee, was tested in 28 small watersheds ranging in size from 0.02 to 37 square miles. These watersheds for which hydrologic records exist are in arid and semiarid areas of western Colorado, north-central New Mexico, and east-central Wyoming, and represent a variety of geologic, climatic, ecologic, and topographic conditions. Estimates of sediment yield correlated closely with sediment yields measured in reservoirs, but the estimates were usually lower than the measured yields. The method was designed to make general sediment classifications for areas greater than 10 square miles, but it also appears to work nearly as well for watersheds that are as small as 0.1 square mile." (A)

455. Simons, D.B.; Li, R.M.; Stevens, M.A. 1975. Development of models for predicting water and sediment routing and yield from storms on small watersheds. CER 74-75 DBS-RML-MAS 24. Fort Collins, CO: Civil Engineering Department, Engineering Research Center, Colorado State University. 123 p.

"A mathematical model simulating water and sediment hydrographs from small watersheds has been developed. This model is designed to simulate the response of the basin to individual storms. The model includes a water balance on the single storm basis, loose soil detachment by raindrop impact and by moving water, and water and sediment routing features for both overland flow and channel systems. The flow routing is accomplished by employing the nonlinear kinematic-wave approximation developed in this study.

"Unlike the conventional approach to parametric modeling of watershed response, this model is based on the physical processes governing the mechanics of water and sediment flow and requires less calibration than any existing water or sediment models known to the writers.

"The model has been validated with data from Watershed 1 and Watershed 17 in the Beaver Creek drainage of north-central Arizona. With the model, the shape, peak flow and time to peak flow of water and sediment hydrographs along with the total water yield and sediment yield were simulated. In addition, this model has the capability to predict the effects on water and sediment yields of various land and resource management practices and can be used to estimate the water and sediment yields from ungaged watersheds.

"In view of the mathematical approximations made in formulating this water and sediment routing model, the applicability of the model at present is limited to the following situations:

1. The streams within the watershed are ephemeral, and the movement of subsurface flow and ground water flow are negligible.

2. The kinematic-wave approximation for flow routing is valid; i.e., the gradients due to local and convective accelerations are negligible and the water surface slope is nearly equal to the bed slope.

3. The water yield simulation is on the single storm basis.

4. The stream channel geometry is stable; that is, erosion and deposition of channel bank material is negligible.

"When a water balance model for simulating the water budget during interstorm periods is incorporated, long-term water and sediment yields can be estimated with this model.

"Test results show that there are satisfactory agreements between the simulated and the measured peak water flow; time to peak water flow, water yield and sediment yield for different size storms in two watersheds using only one set of model parameters. This verifies that the model can be used to synthesize missing data and to predict the response of watersheds to various types of watershed management practices. Also, it has been demonstrated that the model could be used to estimate flood flows from ungaged watersheds." (A)

456. Simons, D.B.; Reese, A.J.; Li, R.; Ward, T.J. 1977. A simple method for estimating sediment yield. In: Foster, G.R., ed. Soil erosion: prediction and control: Proceedings, national conference on soil erosion; 1976 May 24-26; West Lafayette, IN. Spec. Publ. 21. Ankeny, IA: Soil Conservation Society of America: 234-241.

"We present here a simple method for quickly estimating the sediment yield in small watersheds. The method employs an integral procedure developed from available information. It includes the estimation of sediment yield using a modified soil loss equation, a method for estimating storm occurrence frequency, and an equation for bed load estimation. The method is useful to determine guidelines for sediment control in land use planning." (A)

457. Singer, M.J.; Blackard, J. 1978. Effect of mulching on sediment in runoff from simulated rainfall. Soil Science Society of America Journal. 42(3): 481-486.

"Simulated rainfall was used to test the relationship between sediment in runoff and percent of the soil that was mulch covered. Oak leaves (*Quercus douglasii* H.A.), redwood litter (*Sequoia sempervirens* (D. Don) Endl.) and oat straw (*Avena barbata* Brot.) were used as mulches on a $0.37 m^2$ plot of Auburn (loamy, mixed, thermic, Ruptic-Lithic Xerochrepts) surface soil at a 9% slope. Cover percentage was related to sediment in surface runoff by a parabolic relationship. The relationship between redwood and oak covers and sediment in runoff was not significantly different, but both were significantly different from oat straw. Cover shape or distribution of intercover space appears to be important in affecting sediment loss. Runoff volume was significantly reduced by high cover levels which protected the soil from sealing and helped maintain a high infiltration rate." (A)

458. Singer, M.J.; Blackard, J.; Gillogley, E.; Arulanandan, K. 1978. Engineering and pedological properties of soils as they affect soil erodibility. Contrib. 166. Davis, CA: California Water Resources Center, University of California. 32 p.

A study evaluated the erodibility of three major range soils through field study and eight major California soils through use of a small laboratory rainfall simulator. A persistent drought during the study prevented collection of meaningful data from the field plots. Of the eight soils studied in the laboratory, critical shear stress, sodium adsorption ratio, and dithinoite iron content were three measurable soil properties found to be important in determining their relative erodibility. In studying the relationships between percent mulch cover and four types of mulch, it was found that a single model was insufficient to accurately show the relationship between percent soil cover and soil loss. (C)

459. Singh, T. 1976. Yields of dissolved solids from aspen-grassland and spruce-fir watersheds in southwestern Alberta. Journal of Range Management. 29(5): 401-405.

"Water quality samples representing various flow conditions were collected from the main creeks of Streeter and Marmot experimental watersheds in southwestern Alberta. Total dissolved solids were determined gravimetrically after evaporating aliquots of filtered samples. An excellent correlation between stream discharge and yield of dissolved solids was found in the two watersheds. The regression models thus established were used to estimate the yields of total dissolved solids from the stream flow data on a daily, monthly, and annual basis. The highest yield occurred in the month of June and the lowest during the low-flow months of winter. The yield of total dissolved solids transported annually amounted to 27 metric tons per square kilometer for aspen-grassland vegetation, compared to 69 metric tons per square kilometer for spruce-fir forest." (A)

460. Singh, T.; Kalra, Y.P. 1977. Impact of pulpwood clearcutting on stream water quality in west central Alberta. In: Swanson, R.H.; Logan, P.A., eds. Alberta Watershed Research Program symposium proceedings, 1977; 1977 August 31-September 2; Edmonton, AB. Inf. Rep. NOR-X-176. Edmonton, AB: Northern Forest Research Centre, Canadian Forestry Service, Fisheries and Environment Canada: 272-284.

"Water quality samples collected from logged catchments in the North Western Pulp and Power Company lease area showed increased concentrations and yields of most of the inorganic constituents. The samples were collected during the spring snowmelt and early summer period (May 21 to August 7, 1975) when high flows in streams result in maximum export of nutrients. The constituents determined were Ca, Mg,Ma, K, HCO_3, SO_4-S, Cl, NH_4-N, NO_3-N and NO_2-N, and PO_4-P.

"The increased concentrations of many constituents in the logged catchments are noteworthy, especially since dilution resulting from increased streamflow from the clearcuts should have lowered the concentrations. Higher export of nutrients from the clearcuts as a result of increased solute yields in stream waters has management implications for sites where soil mantle is thin." (A)

461. Skau, C.M.; Brown, J.C.; Nadolski, J.A. 1980. Snowmelt sediment from Sierra Nevada headwaters. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 418-429.

"Bedload and suspended sediments were sampled during snowmelt runoff from fourteen, first to third order watersheds in the headwaters of the east-central Sierra Nevada. Data were collected in 1978 and 1979. Combined bedload and suspended load are the first known estimates of total sediment load for this area. Concurrent studies indicate sediment loads during summer and winter low flow are minimal. Suspended sediment loads ranged from 35% to 99% of total load.

"Empirical equations were developed for predicting bedload, suspended load and total load on both a watershed and unit area basis. Independent variables used were: (1) mean channel slope, (2) geology, (3) area of active perennial and ephemeral channels, (4) drainage density from (3), (5) particle size, (6) maximum discharge + minimum discharge and (7) stream width + stream depth at maximum discharge.

"Measured bedload was compared with bedload predicted from Meyer-Peter and Muller and Einstein equations. Formula estimates were several orders of magnitude larger than measured loads." (A)

462. Skopp, J.; Daniel, T.C. 1978. A review of sediment predictive techniques as viewed from the perspective of nonpoint pollution management. Journal of Environmental Management. 2(1): 39-53.

"User-oriented criteria for the evaluation of physically based management models are presented. These criteria emphasize the utility rather than the elegance of the model. The standards are then applied to efforts at predicting non-point pollution loadings. In particular a critical review of sediment pollution is used as the basis for the evaluation of sediment yield models as management tools. A wide range of sediment yield models are rated and recommendations for their use are made." (A)

463. Skorodumov, A.S. 1972. Control over water erosion of soils in the forest-steppe zone. In: Proceedings of the joint FAO/U.S.S.R. international symposium on forest influences and watershed management; 1970 August 17-September 6; Moscow, U.S.S.R. Rome: Food and Agriculture Organization of the United Nations: 309-314.

"Cultural practices for preventing and controlling erosion in the forest-steppe zone are described. Soils of this area are greatly affected by water erosion. On croplands, measures to control erosion call for reduced row crop-black fallow rotations and the introduction of mixed grasses and intermediate and winter crops. Cultivation should be oriented along contour lines. Plowing should be done in the fall to conserve spring snow melt and use of subsoiling and dibbling techniques is recommended. The added cost of these measures can be balanced against better yields and conservation of soil. The system of agriculture on slopes includes forest shelterbelts around fields and pastures as well as on lands unfit for cultivation. Plantations at heads of ravines and on their slopes and bottoms are very important for erosion control. Their establishment and survival depend on the correct combination of cultural measures such as plowing and cultivation coupled with engineering measures to retain and spread surface runoff." (A)

464. Slaymaker, O. 1978. Sediment yield in unglacierised alpine and tropical low to moderate relief rainforest environments. Geo-Eco-Trop. 1: 113-129.

"Rates of sediment yield in tropical rainforest and unglacierised alpine environments have been overestimated in the past....This means, inter al, that the disparity between denudation and orogenesis...is even greater than...suggested....Humid unglacierised alpine and tropical rainforest environments show comparable suspended sediment and solute yields. If sediment yield data for two such contrasted environments show no significant difference, their use as a quantitative tool in discriminating morphoclimatic zones should be discouraged. Attempts to predict sediment yield on a zonal basis are likely to be unsuccessful....

"Unglacierised alpine environments show a scale effect whereby the smallest basins have lowest yields; intermediate basins show highest yields and largest basins have intermediate yields....For tropical rainforests, data are inadequate to confirm such a scale effect. Both environments show the effect of Pleistocene and recent history on sediment availability and hence on bed and bank erosion yields. In the case of the tropical rainforest environment, frequent changes of river course during the Pleistocene and Recent have increased sediment availability in some stream systems. In unglacierised alpine environments the distribution of glacial depositional materials from the Pleistocene influences sediment yield (cf. Whirlpool and Central Creeks).

"The tropical rainforests are particularly vulnerable to the impact of land use. Any land use change which alters the continuous vegetation cover generates a perturbation which is rapidly reflected in suspended sediment (surface erosion) yield and solute (biosphere) yield....Deep weathering profiles in tropical rainforests must be a result of length of time available under similar climatic conditions rather than rate of weathering.

"Measurable differences in rates of operation of individual processes which also give contemporary yield contrasts can be identified in (i) creep, solifluction, rockfall and surface wash, which are greater in unglacierised alpine environments, and (ii) debris slides and mudflows, which are probably greater in tropical rainforests." (A)

465. Smith, D.D.; Wischmeier, W.H. 1957. Factors affecting sheet and rill erosion. Transactions of the American Geophysical Union. 33(6): 889-896.

"This paper discusses the two principal processes by which sheet erosion occurs and the six factors which affect the magnitude of the losses. The processes are raindrop impact and transportation of soil particles by flowing water. The factors are length and percent slope, cropping, soil management, and rainfall. The relative effectiveness of each of the three main conservation practices in control of erosion, contour farming, strip cropping, and terracing is presented. The factors and practices are combined in a rational erosion equation for calculating field soil loss for use in application of conservation practices and in assessing land program benefits." (A)

"The model used is a scientific, rather than an engineering, tool. Although conceptually more sophisticated than parametric engineering models, the small number f descriptive parameters employed is perhaps comparable with some engineering models. The universal soil loss equation was developed and has been proven as an engineering tool for predicting long-term average sediment yields, primarily from cropland. However, when the universal loss equation has been used to predict sediment yield on an event basis large errors have resulted. For such detailed event or event series simulation, I propose the present model, whose ultimate purpose is to provide a hydrologic model framework with which to evaluate alternate detachment and transport equations in unsteady flow. Expressions for detachment rates other than those used here may prove more accurate, but should be compared using better quality experimental data than presented here." (A)

467. Smith, R.B.; Wass, E.F. 1976. Soil disturbance, vegetative cover and regeneration on clearcuts in the Nelson Forest District, British Columbia. Rep. BC-X-151. Victoria, BC: Pacific Forest Research Centre. 37 p.

"...data were collected in the summers of 1974 and 1975 from 9,361 mil-acre plot and point samples along 78 transects distributed widely throughout the Nelson Forest District to describe soil and vegetative conditions on steep-slope clearcuts. The most soil disturbance was caused by ground skidding operations on bare ground (average 45% of the clearcut area) and the least by skyline logging. Ground skidding on snow and high-lead cable systems reduced soil disturbance by about one-half compared with summer ground skidding. Soil disturbance on ground between haul roads and skidroads was much less extensive than that related to roads but was increased by two to four times by broadcast slash burning. Vegetative cover increased steadily with time following logging on both burned and unburned surfaces between roads, but was higher after 11 years on the latter as a result of a greater initial cover of residual vegetation. Excluding planting, areas between roads in unburned clearcuts and road surfaces in both burned and unburned clearcuts were satisfactorily restocked with new and advance regeneration after about 9 years. Surfaces between roads in burned clearcuts were not satisfactorily restocked up to 10.5 years, the average age of the oldest burned clearcuts examined. Differences in vegetative cover and stocking of regeneration were noted among biogeoclimatic zones. Examples of soil erosion were recorded and described. Recommendations for further surveys and research are made." (A)

468. Snyder, C.T.; Frickel, D.G.; Hadley, R.F.; Miller, R.F. 1976. Effects of off-road vehicle use on the hydrology and landscape of arid environments in central and southern California. Water Resour. Invest. 76-99. Denver, CO: U.S. Department of the Interior, Geological Survey, Resources Division. 45 p.

"Two widely separated sites in California used for motorcycle hill-climbing were studied to evaluate the impact on the landscape and hydrology. At Panoche Hills in central California, an area formerly used by motorcycles together with an adjacent unused area were monitored from 1971 to 1975. Observations in both areas included measurements of precipitation, runoff, soil moisture, soil bulk density, plant cover, and erosion surveys. At Dove Spring Canyon in southern California erosion was measured on a site that is currently being used for motorcycle hill climbing. At the Panoche Hills site, the area used by motorcycles produced about eight times as much runoff as the unused area. Similarly, sediment yield from the used area was 857 m^3/km^2, while the quantity of sediment from the unused area was not measurable by standard survey methods. At the Dove Spring Canyon site, which is still being used for hill climbing, erosion surveys show that degradation in trails has been as much as 0.3 m in the period 1973-75. Compaction of soils and reduction of permeability appears to be the most serious hydrologic impact of motorcycle use at Panoche Hills. Increased bulk density of soils reduces depth of moisture penetration which deprives plants of moisture needed for growth." (A)

469. Snyder, G. 1980. Evaluating silvicultural impacts on water resources. In: Symposium on watershed management 1980; 1980 July 21-23; Boise, ID. New York: American Society of Civil Engineers: 682-693.

"Recently, the USDA Forest Service, under an interagency agreement with USEPA [U.S. Environmental Protection Agency], compiled a set of watershed analyses and prediction procedures. These state-of-the-art techniques are collectively referred to as WRENSS (Water Resources Evaluation of Nonpoint Sources—Silvicultural).

"The purpose of WRENSS is to provide a systematic, procedural, and analytical methodology for identifying and assessing alternative technical solutions to existing or potential non-point source water quality problems associated with site specific silvicultural activities. The techniques are regionalized so as to be applicable to the continental United States.

"This paper presents an overview of the techniques used in WRENSS. The procedures discussed are hydrology, surface erosion, soil mass movement, total potential sediment, temperature, dissolved oxygen and organic matter, nutrients and introduced chemicals." (A)

470. Snyder, G.G.; Haupt, H.F.; Belt, G.H., Jr. 1975. Clearcutting and burning slash alter quality of stream water in northern Idaho. Res. Pap. INT-168. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 34 p.

"Three cutting units of varying size, soil, and aspect located along streams in the Priest River Experimental Forest in northern Idaho were chosen for evaluation of changes in water quality caused by clearcutting and subsequent burning of slash. Water sampling stations were established on each creek—upstream, downstream, and on the site of clearcut-burned areas. Except for on-site stations, buffer strips of natural vegetation were left along channels to minimize the effects of treatment. Physical and nutrient comparisons between the upstream and downstream stations showed slight increases in electrical conductivity, bicarbonate, sulfate, calcium, and magnesium. Similar comparisons between upstream and the on-site stations revealed significant increases in pH, electrical conductivity, turbidity, suspended solids, bicarbonate, sulfate, potassium, calcium, and magnesium. Nutrients that did not indicate increases for buffer strip comparisons were chloride and sodium. In general, larger increases were observed at the on-site stations, except for one station with a different drainage pattern." (A)

471. Soil Science Society of America. 1979. Universal Soil Loss Equation: past, present, and future. SSSA Spec. Publ. 8. Madison, WI. 53 p.

"Soil erosion has been a serious problem for agriculture back through the centuries. When man started to cultivate the soil and plant and husband crops, soil erosion was accelerated. Prevention or reduction of soil erosion keeps the most fertile layer, the top soil, in the field, avoiding losses of plant nutrient elements and organic matter. Erosion control reduces the amounts of sediments that are transported into streams, lakes and estuaries, and coastal waters. Because the sediment load is the most serious water quality problem in the United States, control of erosion is a big factor in water quality as well as soil quality.

"One of the needs in the area of soil erosion control, as in all areas of science, has been to develop quantitative relationships between the many factors, such as slope, rainfall characteristics, soil physical properties, and crop cover, that influence erosion and the final effects measured in soil losses from land areas. The function of the symposium leading to this publication was to explore these quantitative relationships as expressed in the Universal Soil Loss Equation (USLE) and to test the utility of the equation in various situations....This publication presents the facts, underlying principles, and interpretations applicable to the processes and the control of soil erosion." (A)

472. Soons, J.M. 1968. Erosion by needle ice in the Southern Alps, New Zealand. In: Wright, H.E., Jr.; Osburn, W.H., eds. Arctic and alpine environments. Bloomington, IN: Indiana University Press: 217-227.

"Runoff plots were established in a representative valley of the Southern Alps at localities with different aspects and contrasting vegetation. At a number of these plots, and particularly on one with an unvegetated surface, an inverse relationship between sediment yield and precipitation was noted. In winter, sediment yields are frequently high when rainfall is low. This apparent anomaly is attributed to the action of needle ice, and support for this view is offered by the reduction in runoff during the winter, associated with frost lifting of the surface soil." (A)

473. Sopper, W.E. 1975. Effects of timber harvesting and related management practices on water quality in forested watersheds. Journal of Environmental Quality. 4(1): 24-29.

"Undisturbed forested watersheds are generally recognized as a primary source of high-quality water. The physical and chemical nature of these waters fluctuate constantly in response to natural stresses but are most influenced by man's activities. Three major forest land management activities—timber harvesting, fertilization, and herbiciding—which may have an adverse affect on water quality are reviewed. In general, research results indicate that nutrient losses, particularly nitrogen, following forest clearcutting are small to negligible. Similarly, forest fertilization studies indicate that nitrogen concentrations in streams are not drastically increased. Large aerial applications of selected herbicides in the West have demonstrated that, if carefully applied they can be used without impairment of water quality." (A)

474. Spraberry, J.A.; Bowie, A.J. 1969. Predicting sediment yields from complex watersheds. Transactions American Society of Agricultural Engineers. 12(2): 199201.

"The experimental watersheds established on the Pigeon Roost Creek basin in northern Mississippi provided the necessary conditions for computing gross erosion for (a) total land use, (b) cultivated land on slopes of 2 percent and greater, and (c) bare gully areas. This paper presents a relationship of the measured sediment yield at each of 13 stream gaging stations with the gross erosion values computed for these watersheds.

"The computed gross erosion from the two major sediment source areas, cultivated land 2 percent slope and above and bare gullies only, correlated better with the total measured sediment yield than the erosion computed from the entire contributing area. The procedure of using only the two major source areas simplifies and greatly reduces the work involved in the computation of gross watershed erosion." (A)

475. State of California, Department of Forestry, Resources Agency. 1977. Soil erosion definitions. State For. Note 67. Sacramento, CA. 3 p.

"These terms are used frequently to describe soil erosion. A definition for each of the terms is printed here to establish a common understanding and to provide a means of accurate communication between persons dealing with soil erosion and soil erosion control measures." (A)

Definitions are provided for 23 terms. (C)

476. State of California, Water Resources Control Board. 1973. A method for regulating timber harvest and road construction activity for water quality protection in northern California. Volume 2: Review of problem and annotated bibliography. Publ. 50. Sacramento, CA. 96 p., plus appendix.

"The report develops a systematic method for assessing, regulating, and controlling the impact on water quality by logging, road building and similar land disturbing practices in northern coastal California....Volume II includes a review of the problem and an annotated bibliography." (A)

The problem review covers legal aspects; erosion and effects, and causes and control of erosion. The annotated bibliography contains 416 references. (C)

477. Stone, E. 1974. The impact of timber harvest on soils and water. In: Report of the President's advisory panel on timber and environment. Washington, DC: The President's Advisory Panel on Timber and Environment: 427-467.

"This paper considers how cutting and removal of wood products affect the stability of forest land, its capacity for sustained productivity, and the characteristics of its streams. It considers only lands that are intended to remain as productive forests, excluding clearings for other purposes—agriculture, powerlines, recreational developments, housing—and their consequences." (A)

The paper includes a comprehensive literature review covering several topics: water flow and flood protection, soil loss and erosion, water quality, nutrient loss and recovery, and other supposed impacts. (C)

478. Strand, R.L. 1975. Bureau of Reclamation procedures for predicting sediment yield. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 10-15.

The paper describes procedures used for predicting sediment yield by the Bureau of Reclamation in the design and operation of water supply projects. The most frequently used are the flow duration, sediment-rating curve procedure; and the preparation of sediment-yield rate curves. (C)

479. Striffler, W.D. 1965. Suspended sediment concentrations in a Michigan trout stream as related to watershed characteristics. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 144-150.

"The purpose of the study reported here was to examine the suspended sediment concentration in a representative northern Michigan watershed and evaluate the sediment load with respect to geology, soils, land use, and other watershed characteristics....The study demonstrates that watershed characteristics can successfully be evaluated with respect to their influence upon stream sediment concentrations or sediment discharge rates by using individual suspended sediment observations from the sample watersheds rather than total sediment yields as the dependent variables....Of all sediment sources [in this study], eroding banks, which yield about 28 percent of the suspended sediment load, represent a source that the land manager can effectively control." (A)

480. Striffler, W.D.; Mogren, E.W. 1971. Erosion, soil properties, and revegetation following a severe burn in the Colorado Rockies. In: Slaughter, C.W.; Barney, R.J.; Hansen, G.M., eds. Fire in the northern environment—a symposium: Proceedings of a symposium; 1971 April 13-14; Fairbanks, AK. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 25-36.

"During the summer of 1967, 20 erosion plots, 42 soil sampling points, and 50 vegetation plots were established in the Comanche Burn area, a 470-acre burn in the Central Rocky Mountains. Observations indicate that erosion during the first summer after the burn was not a serious problem but that some erosion was occurring. The amount of rock exposed on the soil surface is more important than slope in initiating particle movement during low intensity storms but slope is the controlling factor during high intensity storms. Analysis of soil physical factors show that the burn had very little effect in spite of a complete destruction of litter and surface vegetation. This was attributed to the coarse textured soils.

"Revegetation after the burn showed a steady increase with an average of 3.5 spruce-fir seedings the first year and 22.4 seedlings per acre the third year. Lodgepole pine seedlings increased from 1,185 to 1,385 seedlings per acre over the 3-year period. Subordinate vegetation also increased in number and species composition." (A)

481. Swanson, F.J. 1980. Geomorphology and ecosystems. In: Waring, R.W., ed. Forests: fresh perspectives from ecosystem analysis: Proceedings, 40th annual biology colloquim; 1979 [Dates of meeting unknown]; Corvallis, OR. Corvallis, OR: Oregon State University Press: 159-170.

"Geomorphic factors, both processes and landforms, play important active and passive roles in forest ecosystems. Many influences of geomorphic processes and landforms on vegetation are mediated by physical, nutritional, and hydrologic properties of soils. Landforms principally determine the geographic distributions of fauna and flora. Landform effects on terrestrial fauna are mainly the result of landform—flora interactions. Geomorphic processes and flora interact strongly in steep terrain and along streams and rivers. Live and dead vegetation regulates rates of geomorphic processes, which, in turn, destroy vegetation, create new development of plant communities.

"...forest ecosystem development on many time scales involves the interplay of physical and biological factors, particularly in mountainous regions. The physical sciences should be well represented in any major ecosystems study." (A)

482. Swanson, F.J.; Dyrness, C.T. 1975. Impact of clear-cutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. Geology. 3: 393-396.

"The H.J. Andrews Experimental Forest can be divided into two zones of approximately equal area, each with strikingly different susceptibilities to erosion by rapid soil movements. A stable zone occurs at elevations above 900 to 1,000 m in terrain underlain by lava-flow bed rock. Since logging and road cutting began in 1950, only two small road-related slides have taken place in the stable zone. In contrast, the unstable zone, located at elevations below 1,000 m and underlain by altered volcaniclastic rock, has been the site of 139 slides during the same period.

"Slide erosion from clear-cut areas in the unstable zone has totaled 6,030 m^3/km^2, or 2.8 times the level of activity in forested areas of the unstable zone. Along road rights-of-way, slide erosion has been 30 times greater than on forested sites in the unstable zone; however, only about 8 percent of a typical area of deforested land in the unstable zone is in road right-of-way. At comparable levels of development (8 percent roads, 92 percent clear-cut), road right-of-way and clear-cut areas contribute about equally to the total impact of management activity on erosion by landslides in the unstable zone. The combined management impacts in the unstable zone (assuming 8 percent road right-of-way and 92 percent clear-cut) appear to have increased slide activity on road and clear-cut sites by about 5 times relative to forested areas over a period of about 20 yr." (A)

483. Swanson, F.J.; Swanson, M.M.; Woods, C. 1981. Analysis of debris-avalanche erosion in steep forest lands: an example from Mapleton, Oregon, USA. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 67-75.

"Inventories of shallow, rapid soil mass movements (debris avalanches) are useful for assessing impacts of forestry practices such as clearcutting and road construction. Analysis of inventory data from steep Pacific Rim forest land indicates a several-fold increase in debris-avalanche erosion from clearcutting relative to the rate in forested areas and even greater increases from roads. Some of the limitations of interpretation of inventory data can be overcome with improved data analysis." (A)

484. Swanston, D.N. 1967. Debris avalanching in thin soils derived from bedrock. Res. Note PNW-64. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p.

"In southeast Alaska, many valley slopes that are greatly over-steepened by glacial erosion support mature forest rooted in shallow soil over bedrock. Debris avalanches on these slopes are one of the most frequent types of mass wastage in the region. They are especially common along the mainland and interior islands of the Alexander Archipelago where glacial till deposits are often thin or absent due to the resistance of local bedrock to glacial erosion.

"At present, the forest land manager does not consider large-scale debris avalanching of this type an important erosion hazard in existing sale areas. Because of the poorer quality of timber of these soils and the steep and difficult terrain, slopes with shallow soils are often excluded from logging. As the logging industry expands to these sites in southeast Alaska, however, an understanding of this type of debris avalanching will become important in land management.

"On slopes steeper than the internal angle of friction and in the absence of a well-developed, cohesive soil, landslides must be considered a natural erosion process responding to the basic laws of physics. They are an inevitable result of any occurrence which tends to reduce the resistance of a slope to sliding.

"Many of these slopes remain stable for years despite the action of external forces tending to reduce their resistance to sliding. The slope soils, therefore, must possess a slide resistancer which is not directly related to the physical properties of the soil. Present indications are that this force is produced by tree rooting through the soil and into cracks in the underlying bedrock. Destruction of this rooting system would greatly increase susceptibility of the slope soil to slides." (A)

485. Swanston, D.N. 1970. Mechanics of debris avalanching in shallow till soils southeast Alaska. Res. Pap. PNW-103. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 17 p.

"Three areas with recent debris avalanches in a shallow, permeable till soil common to southeast Alaska were instrumented and analyzed using established methods of soil mechanics. These studies indicated that a combination of complete saturation during periods of excessive rainfall, naturally unstable slopes ($>34^{\circ}$), and the loss of the anchoring effect of tree roots in an otherwise cohesionless soil were the principal causes of the debris avalanching.

"Practical methods of delineating potential debris avalanche areas in the till soils are discussed." (A)

486. Swanston, D.N. 1971. Principal mass movement processes influenced by logging, road building, and fire. In: Krygier, J.T.; Hall, J.D., eds. Forest land uses and stream environment: Proceedings of a symposium; 1970 October 19-21; Corvallis, OR. Corvallis, OR: Oregon State University: 29-39.

"Dominant natural soil mass movement processes active on watersheds of the western United States include (1) debris avalanches, debris torrents; (2) slumps and earth flows; (3) deep-seated soil creep; and (4) dry creep and sliding. A dominant characteristic of each is steep slope occurrence, frequently in excess of the angle of stability of the soil. All but dry creep and sliding occur under high soil moisture conditions and usually develop or are accelerated during periods of abnormally high rainfall. Further, all are encouraged or accelerated by destruction of natural mechanical support on the slopes. Logging, road building, and fire play an important part in initiation and acceleration of these soil mass movements. Road building stands out at the present time as the most damaging activity, with soil failures resulting largely from slope loading, back-slope cutting, and inadequate slope drainage. Logging and fire affect stability primarily through destruction of natural mechanical support for the soils, removal of surface cover, and obstruction of main drainage channels by debris." (A)

487. Swanston, D.N. 1976. Erosion processes and control methods in North America. In: Proceedings, 16th world congress of IUFRO, Div. I; 1976 June 24; Oslo, Norway. Oslo, Norway: Norwegian IUFRO Congress Committee: 251-275.

"Creep, slump-earthflows, debris avalanches, and debris torrents are the major erosion processes on mountainous forest land; they function as primary links in the natural transport of soil material to streams.

"In deeply weathered, clay-rich mantle materials, creep movement may range as high as 15 mm per year. Where discrete failure occurs, transport rates of material by slump-earthflow may increase by several orders of magnitude. On steep slopes characterized by shallow, coarse-grained mantle materials and steep, incised drainages, debris avalanches and debris torrents transport large volumes of material to the stream at rates as high as 20 m per second.

"Clearcutting and road construction accelerate these processes, the former by destroying the stabilizing influence of vegetation cover and altering the hydrologic regime of the site. The latter exposes bare mineral soil and interrupts the balanced strength-stress relationships existing under natural conditions by cut and fill activities, poor construction of fills, and alteration of surface and subsurface water movement.

"Once unstable areas are identified and characterized, the forest land manager has several techniques available for minimizing erosion damage. These include various types of stand manipulation—ranging from no logging to clearcutting and replanting, selection of logging methods which can help to minimize surface disturbance and destruction of stabilizing vegetation, and judicious location and design of forest roads." (A)

488. Swanston, D.N. 1981a. Creep and earthflow erosion from undisturbed and management impacted slopes in the Coast and Cascade Ranges of the Pacific Northwest, U.S.A. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 76-94.

"Soil creep, slumping, and earthflows are major processes of natural slope erosion and sediment transport on slopes underlain by deeply weathered parent material in the Cascade and Coast Ranges of Oregon, Washington, and northern California, USA. Creep movement is quasi-viscous, occurring under shear stresses too small to produce discrete failure. The soil mass is primarily mobilised (sic) by breakdown of included clay structures. Remolding transforms the clay fraction into a slurry which lubricates the remaining soil mass. Where shear stresses are great enough, slumps and earthflows develop and enlarge by progressive failure of the mantle materials. Substantial sections of drainage basins in the region are affected by these processes and are highly sensitive to any manipulations or impacts that change the stress distribution in the soil mass.

"Creep and earthflow rates in various geologic terrains have been monitored since 1972 by bore-hole inclinometer methods. Depth of movement varies from near-surface to more than 17 meters. Undisturbed rates of movement are variable within all parent material types but are within the range of 0.5 to 104 mm/year. The highest rates occur above zones of incipient shear or extension flow marking changes in parent material type, degree of alteration, or structural weakness. Slope exerts little control over variations in movement rate. Rates are most sensitive to water content of the parent materials. Monitored sites show clear relationships between seasonal rainfall and total yearly movement, and movement predominantly occurs during the fall and winter rainy season or during the spring snowmelt. Movement on a storm by storm basis was not detectable. Preliminary analysis of one harvested slope indicates a marked increase in movement beginning the second year after disturbance with post-impact rates more than twice undisturbed rates." (A)

489. Swanston, D.N. 1981b. Watershed classification based on soil stability criteria. In: Baumgartner, D.M., comp., ed. Interior west watershed management: Proceedings of a symposium; 1980 April 8-10; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 43-58.

"Judging the natural stability of a watershed and assessing soil mass movement hazards related to harvest activities is possible by combining subjective evaluation of factors controlling stability of an area and a limited strength-stress analysis based on available or easily generated field data.

"The resulting analysis indexes the watershed in terms of relative hazard, identifies problem areas, defines failure mechanisms, and pin-points factors which may be amenable to specific control or correction procedures." (A)

490. Swanston, D.N.; Dyrness, C.T. 1973. Stability of steep land. Journal of Forestry. 71(5): 264-269.

Processes and principles of controlling surface and mass movement erosion are summarized. (C)

491. Swanston, D.N.; Swanson, F.J. 1976. Timber harvesting, mass erosion, and steepland forest geomorphology in the Pacific Northwest. In: Coates, D.R., ed. Geomorphology in engineering. Stroudsburg, PA: Dowden, Hutchinson & Ross, Inc.: 199-221.

"Creep, slump-earthflows, debris avalanches, and debris torrents function as primary links in the natural transport of soil material to streams in the Pacific Northwest.

"In areas characterized by deeply weathered, clay-rich mantle materials, creep movement may range as high as 15 mm/yr. Locally, where strain buildup causes discrete failure and the development of progressive slump-earthflows, transport rates of material to the stream may increase by several orders of magnitude. In areas characterized by steep slopes, shallow, coarse-grained mantle materials and steep, incised drainages, discrete failures producing debris avalanches and debris torrents transport large volumes of material to the stream at rates as high as 20 m/s.

"Timber-harvesting operations, particularly clearcutting and road construction, accelerate these processes, the former by destroying the stabilizing influence of vegetation cover and altering the hydrologic rigime of the site, the latter by interrupting the balanced strength-stress relationships existing under natural conditions by cut and fill activities, poor construction of fills, and alteration of surface and subsurface water movement." (A)

492. Task Committee on Erosion of Cohesive Materials. 1968. Erosion of cohesive sediments. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 94(HY4): 1017-1049.

"This is the final report prepared by the Task Committee on Erosion of Cohesive Materials, Sedimentation Committee, Hydraulics Division, ASCE. The report describes laboratory research, field observations, design criteria, and agricultural land and channel problems as related to cohesive sediments. Much of the literature currently available is reviewed and recommendations are made for practical application to design and for further research. An extensive bibliography, a compilation of design equations and charts, and some design information not now available in the literature are included." (A)

493. Task Committee on Preparation of Sedimentation Manual. 1969a. Sediment control methods: introduction and watershed area. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 95(HY2): 649-675.

"The varying implications regarding the control of sediments to individuals working in different fields is discussed. The subject is considered in two general areas, the land surface and the fluvial channels and associated water bodies. Sediment control on land is discussed in terms of watershed areas, and includes considerations of sheet erosion and the rills gullies or other fluvial channels included wholly therein. Larger channels are discussed separately in terms of natural and artificial channels, since control of the former is restricted generally by its existing form and the design of the latter is permitted many more degrees of freedom. Controls in reservoirs and harbors are treated separately, since the concepts or purposes differ measurably. The prevention of the erosion of sediment particles from the land or from fluvial channels and the controls applicable in fluvial channels or in the lakes, reservoirs, estuaries, or bays into which they flow are also explored." (A)

494. Task Committee on Preparation of Sedimentation Manual. 1969b. Sediment measurement techniques: A. Fluvial sediment. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 95(HY5): 1477-1514.

"Sediment movement in a natural stream [is] an extremely complex phenomenon.... It must be reemphasized that the development of adequate measurement equipment and techniques is dependent on a thorough understanding of the erosion, transportation, and deposition phenomena. The accuracy of sediment discharge determinations is dependent not only upon the field methods and equipment utilized in the collection of data, but upon knowledge of the distribution of the sediment in the flow. Particularly valuable is an understanding of the vertical and horizontal distribution of the sediment in a stream cross section, together with information on the size of the bed material and on the bed form.

"In alluvial streams, the concentration of coarse material transported in suspension depends mainly upon velocity, concentration of fine sediment, bed configuration, and the shape of the measuring section. Therefore, the concentration of the coarse material in suspension may increase or decrease from section to section even though the water and total sediment discharge remain uniform." (A)

495. Task Committee on Preparation of Sedimentation Manual. 1970. Sediment sources and sediment yields. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers. 96(HY6): 1283-1329.

"Most individuals have observed soil erosion and deposition phenomena in nature and could ascribe general reasons for these occurrences with some degree of confidence. The interplay of the forces causing erosion is less obvious, however. As with other natural occurrences, erosion and deposition rates could be accurately predicted if all causes were known and could be taken into account. In nature, and often in the laboratory, it is seldom possible, or practical, to measure all these variables in isolation so that a completely deterministic model can be developed. Therefore, probabilistic values based on measurements must be assigned to the major causative variables to obtain quantitative estimates of erosion and deposition for a given situation.

"The adequacy of measurement records and the success in analyzing them determine the degree to which deterministic methods rather than probabilistic (stochastic) methods have been utilized for estimating rates of erosion, sediment transport, and deposition.

"In this chapter, a few of the more commonly used methods for determining sediment production are examined, and references are made to publications that provide more detail on the subject." (A)

496. Thronson, R.E. 1971. Control of erosion and sediment deposition from construction of highways and land development. PB-258 418. Washington, DC: U.S. Environmental Protection Agency, Office of Water Programs. 56 p.

"Sedimentation involves three basic processes: erosion, transportation, and deposition. Costs of correcting erosion and sediment deposition problems resulting from highway construction and land development activities often are unjustifiably transferred to the taxpayer. They result when consequences of the construction operations on downstream areas are not properly considered. The report discusses deposition and control methods." (A)

497. Tiedemann, A.R.; Conrad, C.E.; Dieterich, J.H. [and others]. 1979. Effects of fire on water: a state-of-knowledge review. Gen. Tech. Rep. WO-10. Washington, DC: U.S. Department of Agriculture, Forest Service. 28 p.

"Although effects of fire on water resources vary widely across the United States, there were some common responses among studies that are worthy of emphasis:

(1) "Fire exerts pronounced effects on basic hydrologic processes, leading to increased sensitivity of the landscape to eroding forces and to reduced land stability. This is manifested primarily as increased overland flow, and greater peak and total discharge. These provide the transport force for sediment from the landscape."

(2) "Erosion responses to burning are a function of several factors including: degree of elmination of protective cover; steepness of slopes; degree of soil nonwettability; climatic characteristics; and rapidity of vegetation recovery."

(3) "Sedimentation, increased turbidity levels, and mass erosion appear to be the most serious threats to water resources following fire (especially wildfire). Elimination of protective streambank cover has been shown to cause temperature increases that might pose a threat to aquatic life."

(4) "Despite the lack of documentation of fire size and intensity, large fires of high intensity appear to have the greatest potential for causing damage to water resources."

(5) "Fire causes rapid mineralization and mobilization of nutrient elements that are manifested in increased levels of nutrients in overland flow and in soil solution. Watershed studies, however, indicate that these additional nutrients do not significantly impair the quality of surface waters for municipal purposes. Effects of nutrient losses via sediment and solution have not been related directly to site productivity but in general do not appear to represent a significant proportion of total site nutrient capitals."

(6) "Fire-caused water quality changes were not shown to adversely affect composition or productivity of benthic macroinvertebrates but this is a poorly documented research area." (A)

498. Tiedemann, A.R.; Klock, G.O.; Mason, L.L.; Sears, D.E. 1976. Shrub plantings for erosion control in eastern Washington...progress and research needs. Res. Note PNW-279. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p.

"In August 1975, survival measurements and vigor estimates were made on 14 species of shrubs planted on road cut and fill slopes between 1971 and 1973 on the Wenatchee, Okanogan, and Colville National Forests. Their average survival ranged from 37 to 53 percent and was better at low than high elevations and greater on fill slopes than cut slopes.

"Of species planted on enough sites to enable a good assessment of survival, blue elderberry, bush penstemon, wild rose, and serviceberry had the highest survival. Vigor of blue elderberry and penstemon was good, but vigor of wild rose and serviceberry was only fair to poor.

"Survival rate of bitterbrush, squaw carpet ceanothus, and snowbrush ceanothus was reduced on cut slopes because plants were covered by ravelling soil material. However, good survival and growth of these plants on fill slopes indicate they can probably be used successfully on many sites of this type." (A)

499. Tollner, E.W.; Barfield, B.J.; Haan, C.T.; Kao, T.Y. 1976. Suspended sediment filtration capacity of simulated vegetation. Transactions American Society of Agricultural Engineers. 19(4): 678-682.

"An exponential power function relating the fraction of sediment in a simulated rigid vegetal media to pertinent physical variables was developed using linear regression techniques and various transformations. Homogeneous sediments and non-submerging flows were studied. The mean velocity was found to be the most influential parameter on sediment trapping followed by the flow depth, particle fall velocity, section length, and spacing hydraulic radius." (A)

500. Tollner, E.W.; Hayes, J.; Barfield, B.J. 1978. The use of grass filters for sediment control in strip mine drainage. Volume I: Theoretical studies on artificial media. IMMR-35-RRR2-78; NTIS Rep. PB-281 712. Lexington, KY: Institute of Mining and Minerals Research, University of Kentucky. 56 p.

"The results of studies conducted with shallow flows in a simulated, erect vegetation are given and discussed. A spacing hydraulic radius was proposed to define the characteristic length applicable to the computation of a Reynold's number. This term was in turn used in relationships to predict mean velocity and channel bottom drag. Data are presented which show that these relationships are good approximations to actual conditions in the experimental media.

"Results are presented showing that sediment deposition in an erect media can be predicted rather well, assuming a knowledge of flow rate, sediment characteristics, media density, and channel slope. Homogeneous sediment and steady flows are assumed in this model. Analytical results are summarized in tabular form. Research needed to apply the model to an actual field situation is outlined briefly." (A)

501. Toy, T.J., ed. 1977. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd. 86 p.

"The papers included in this volume were presented at a Special Session of the 1975 annual meeting of the Association of American Geographers. The purpose of this symposium was to promote the involvement of physical geographers in erosion research. Since the intensity of erosion is affected by a variety of environmental elements, the broad scope of the physical geographer's training seems to equip him well to undertake investigations in this area. It seemed appropriate to assemble papers, authored by eminent researchers and reflecting the current 'state of the art,' to serve as a catalyst for their involvement....The contents of these papers summarizes the progress achieved by earth scientists toward an understanding of the erosion process." (A)

502. Toy, T.J. 1977. Introduction to the erosion process. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 7-18.

"A basic understanding of erosion processes is a necessary prerequisite to the comprehension of the following papers. It is the purpose of this chapter to provide the required foundation. Definitions for terms frequently encountered in the remainder of the text and throughout the soil erosion literature are included. Discussion centers around the factors which affect the intensity of soil erosion and the various expressions of soil loss. References cited in this chapter offer direction to readers seeking supplemental sources and greater depth of coverage for the various topics." (A)

503. Trimble, G.R., Jr.; Sartz, R.S. 1957. How far from a stream should a logging road be located? Journal of Forestry. 55(5): 339-341.

Observations are presented on sediment-discharge distance made at 36 open-topped culverts in a road on the Hubbard Brook Experimental Forest, New Hampshire. Percent slope of land between road and stream versus distance to filter out sediment is presented in a graph; the graph can be used as a guide for determining the buffer strip width needed. The width of buffer strip suggested for a given percent slope is 25 feet on 0 percent, 45 feet on 10 percent, 65 feet on 20 percent, 85 feet on 30 percent, 105 feet on 40 percent, and 125 feet on 50 percent. The authors suggest doubling the width of the recommended buffer strip in the case of a municipal watershed. (C)

504. ULI [Urban Land Institute]; ASCE [American Society of Civil Engineers]; NAHB [National Association of Home Builders]. 1978. Residential erosion and sediment control: objectives, principles, and design considerations. Washington, DC: Urban Land Institute; New York: American Society of Civil Engineers; Washington, DC: National Association of Home Builders. 63 p.

This report covers some basic concepts for protecting land and water resources against detrimental impacts of erosion and sedimentation during residential construction. The objectives, principles, and design are complex individually and collectively on a variety of levels; many detailed considerations have of necessity been omitted. Concepts generally found to be useful follow: (C)

"Erosion and sediment movement and deposition have both beneficial and detrimental effects.

"Sediment movements should not be permitted at rates or in quantities which will cause significant residual damage. Under ideal conditions any change in the nature or amount of sediment leaving a site as a result of construction should maintain or improve environmental quality when compared to pre-construction conditions. While these ideal conditions cannot always be achieved the importance of environmental quality to man's long-term welfare and survival means that sound judgment must be exercised in establishing allowable rates of change from those expected in the natural cycle.

"Strong emphasis needs to be placed on 'natural' engineering and land planning techniques, which will not only preserve and enhance natural features of the land, both on and off the site, but protect them. There are techniques which use and improve the natural processes taking place at a construction site, during and after the actual construction period, rather than ignoring or replacing them with artificial systems.

"There must be increasing recognition that each site has its own set of natural resources, land use limitations, environmental conditions, and occupancy requirements. These factors and their interrelationships vary from site to site within a community, and variations in design standards will be required for achievement of optimum off-site protection.

"There must be continuing recognition of a balance of responsibilities and obligations between individual land owners and the public for the protection of the environment from the adverse impacts of excessive erosion and sedimentation. It must be understood that significant immediate and long-term expenditures for the construction and maintenance of this protection will be incurred by individual home owners and the community. A balance must be struck in determining the acceptable ranges of damage, in order to avoid restricting housing availability and choice." (A)

505. Ursic, S.J. 1977. Water quality impacts of harvesting and regeneration practices. In: Aubertin, G.M., ed. "208" symposium, non-point sources of pollution from forested land; 1977 October 19-20; Carbondale, IL. Carbondale, IL: Southern Illinois University: 223-232.

"Information on water quality from undisturbed southern forest lands is summarized and the impacts of harvesting and regeneration practices on non-point source pollution discussed. An urgent need is to obtain data upon which equitable water quality standards for forest lands can be based and to formulate feasible practices to help meet water quality goals. Sediment is the major pollutant of concern. Base levels of sediment concentrations for important southern forest-land cover types are suggested. Sediment contributions from channels must be evaluated apart from those caused by forestry activities to prevent placing needless restrictions on forest lands. Short-lived changes in water quality after properly planned and executed harvesting, including clearfelling, can meet reasonable standards for sediment and chemical water quality. Sufficient information is not available to evaluate activities creating greater soil disturbances than harvesting." (A)

506. Ursic, S.J.; Dendy, F.E. 1965. Sediment yields from small watersheds under various land uses and forest covers. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 47-52.

The results of 3 years of studies on small upland watersheds in northern Mississippi suggest that: (1) runoff was greatest on corn and pasture, lesser on abandoned fields and depleted hardwoods, and least on pine plantations; (2) annual sediment yields and average concentrations of sediment per unit runoff were greatest from corn, less from pasture, still less from abandoned fields and depleted hardwoods, and least from pine plantations and mature pine hardwoods; (3) runoff was greater from watersheds with loessial soils than from watersheds with loess and coastal plain soils; (4) the effect of soil on sediment yield was not constant for all cover types; and (5) annual sediment production ranged from 43 tons per acre from a cultivated watershed to a few pounds per acre from a pine plantation; and sediment yields from abandoned fields with a dense cover of mature grass, and from forest cover, did not exceed 0.5 tons per acre annually. (C)

507. U.S. Department of Agriculture, Agricultural Research Service. 1961. A universal equation for predicting rainfall-erosion losses—an aid to conservation farming in humid regions. ARS 22-66. Washington, DC. 11 p.

Various aspects of the universal soil loss equation are discussed: historical, equation development, its factors, soil loss tolerances, and application of the equation. (C)

508. U.S. Department of Agriculture, Agricultural Research Service. 1965. Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC. 933 p.

"This publication contains the papers and discussions presented at the Federal Inter-Agency Sedimentation Conference, held at Jackson, Miss., on January 28-February 1, 1963. The conference was organized and sponsored by the Federal agencies represented on the Subcommittee on Sedimentation of the Federal Inter-Agency Committee on Water Resources....A total of 310 engineers, geologists and others from 41 States and one foreign country attended the conference...." (A)

The proceedings include 93 technical papers, organized under the symposia categories of (1) land erosion and control, (2) sediment in streams, (3) sedimentation in estuaries, harbors, and coastal areas, and (4) sedimentation in reservoirs. (C)

509. U.S. Department of Agriculture, Forest Service. 1977. An analysis of research and development needs on nonpoint source water pollution on forest and range lands. Interagency Agreement EPA-1AG-D6-0060. Athens, GA: U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development. 149 p.

This document identifies problems to be solved relating to nonpoint source water pollution and provides a basis for determining responsibilities and approaches and for estimating costs. It is intended to be used by those concerned with water quality from forest and rangelands and will hopefully result in improved coordination and effectiveness of related Federal, State, and university programs.

The overall objective of the proposed research and development is to provide improved methods for predicting, evaluating, and controlling nonpoint source water pollution. Initial emphasis is on a thorough review of existing information and a synthesis of that information in a format suitable for application to the nonpoint source control program. New knowledge and procedures developed will be used for determining best management practices for controlling nonpoint source pollution of forest and rangelands, within the constraints of multiple use management. The research considers all major pollutants and forest activities, with particular emphasis given to sediment and nutrients resulting from timber harvest, mechanical site preparation, roads and trails, and grazing. (C)

510. U.S. Department of Agriculture, Forest Service. 1980. An approach to water resources evaluation of non-point silvicultural sources (a procedural handbook). EPA-600/8-80-012. Athens, GA: U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development. 861 p.

"This handbook provides an analysis methodology that can be used to describe and evaluate changes to the water resource resulting from non-point silvicultural activities. It covers only the pollutant generation and transport processes and does not consider the economic, social and political aspects of pollution control.

"This state-of-the-art approach for analysis and prediction of pollution from nonpoint silvicultural activities is a rational estimation procedure that is useful in making comparative analyses of management alternatives. These comparisons are used in selecting preventive and mitigative controls and require site-specific data for the analysis.

"This handbook also provides quantitative techniques for estimating potential changes in streamflow, surface erosion, soil mass movement, total potential sediment discharge, and temperature. Qualitative discussions of the impacts of silvicultural activities on dissolved oxygen, organic matter, nutrients, and introduced chemicals are included.

"A control section provides a list of control practices that have been used effectively and a methodology for selecting mixtures of these controls for the prevention and mitigation of water resource impacts. Such mixtures are the technical basis for formulating Best Management Practices." (A)

511. U.S. Department of Agriculture, Soil Conservation Service. 1970. Controlling erosion on construction sites. Agric. Inf. Bull. 347. Washington, DC. 32 p.

"Each year more than a million acres of land in the United States are converted from agricultural use to urban use....Erosion on land going into use for highways, houses or shopping centers is about 10 times greater than on land in cultivated row crops, 200 times greater than on land in pasture, and 2000 times greater than on land in timber." (A)

This bulletin provides examples of accelerated erosion, and of approaches to controlling erosion and sediment production. (C)

512. U.S. Department of Agriculture, Soil Conservation Service. 1977a. Procedure for computing sheet and rill erosion on project areas. Tech. Release 51, rev. 2. Washington, DC. 17 p.

Use of the universal soil loss equation in predicting sheet and rill erosion from upland slopes is described. Each variable is explained, with particular attention given to the cropping factor as it pertains to forests, rangelands, and pasture lands. A map exhibits average annual values of the rainfall factor over the 48 contiguous States. Examples of the equation's use are presented. (C)

513. U.S. Department of Agriculture, Soil Conservation Service. 1977b. Procedure for determining rates of land damage, land depreciation and volume of sediment produced by gully erosion. In: Kunkle, S.H.; Thames, J.L., eds. Guidelines for watershed management. FAO Conserv. Guide 1. Rome: Food and Agriculture Organization of the United Nations: 125-141.

"This technical release provides a guide to the determination of future rates of potential land damage, land depreciation and sediment produced by gully erosion." (A)

514. U.S. Environmental Protection Agency. 1976a. Erosion and sediment control, surface mining in the eastern United States, design. Vol. 1. EPA 625/3-76-006. Washington, DC. 102 p.

"The six sections in volume I cover all the basic concepts of erosion and sediment control. The text has been designed to provide the technician and the layman with a thorough explanation of the need for control, basic control principles, available technology for erosion and sediment control, and procedures for preparing and implementing a control plan." (A)

515. U.S. Environmental Protection Agency. 1976b. Erosion and sediment control, surface mining in the eastern United States, design. Vol. 2. EPA 625/3-76-006. Washington, DC. 136 p.

"The four sections in volume II cover the basic design concepts of erosion and sediment control. The text provides general design and construction considerations for a number of selected control structures, a description of available erosion control products and materials, a sample erosion and sediment control plan, and information on selected state mining laws and reclamation information." (A)

516. U.S. Environmental Protection Agency, Office of Air and Water Programs. 1973. Processes, procedures, and methods to control pollution resulting from silvicultural activities. EPA 430/9-73-010. Washington, DC. 91 p.

"This report provides information of a general nature regarding processes, procedures, and methods for controlling pollution caused by sediment runoff from logging roads, skid trails, and other areas of disturbed soils in forest areas; pesticides and fertilizers used in forest regeneration activities; chemicals and other materials applied for forest fire prevention; and temperature increases in small streams exposed to solar radiation by logging of bordering timber stands. It is intended to act as a state-of-the-art document useful for the development of effective programs to control nonpoint sources of pollution." (A)

517. U.S. Environmental Protection Agency, Region 10. 1976. Forest harvest, residue treatment, reforestation and protection of water quality. EPA 910/9-76-020. Seattle, WA. 273 p.

"This report is a state-of-the-art reference on the protection of water quality in planning and conducting forest harvest, residue treatment, and regeneration operations.... It is intended to be an aid for dealing with pollution from nonpoint sources; and is designed to inform and assist state, federal and local agencies; industry; and the general public. The report is specifically intended to assist in the (1) identification of potential hazards to water quality, and (2) selection of procedures, practices, or methods suitable for preventing, minimizing, or correcting water pollution problems. It is also a reference source to other publications, information, and materials." (A)

518. U.S. Environmental Protection Agency, Region 10; Arnold, Arnold and Associates; Dames and Moore. 1975. Logging roads and protection of water quality. EPA 910/9-75-007. Seattle, WA: U.S. Environmental Protection Agency. 312 p.

This report is a state-of-the-art reference of methods, procedures and practices for including water quality consideration in the planning, design, construction, reconstruction, use and maintenance of logging roads. The report is divided into two parts. The first part provides general perspective on physical features and conditions in the EPA Region X which are relevant to water quality protection and logging roads. The second part outlines specific methods, procedures, criteria and alternatives for reducing the degradation of water quality. Topic coverage in this part includes road planning, design, construction and maintenance including the use of chemicals on roads." (A)

519. Utzig, G.; Herring, L. 1975. Forest harvesting impacts at high elevations—five case studies. Res. Note 72. Victoria, BC: British Columbia Forest Service, Research Division. 85 p.

"This report represents the completion of...a preliminary study of high elevation ecosystems, with emphasis on the inter-related problems of soil stability, regeneration, and permanent productivity losses. The project was divided into two phases each of which involved two months of field work in 1973.

"Phase one consisted of a brief reconnaissance survey in each of the six Forest Districts, where the authors were directed to critical areas by foresters in industry and the Forest Service. This served to point out the distribution of soil stability and regeneration problems throughout the province. It was concluded that the problems were not restricted to only one site type, but were the result of a general lack of planning and an appreciation of the range of site characteristics and potential site responses....

"The second phase of the project has attempted to document the problems encountered, and determine their probable origin, both natural and man-caused, placing emphasis upon the interactions between forest management practices and natural site characteristics of high elevation mountainous terrain. This included an examination of the relationship between soil stability problems and harvesting practices, particularly road construction....A second consideration was specifically what combinations of climate, geology, soil, and topography had contributed to the erosion and regeneration problems in the areas studied.

"Five of the critical areas examined briefly in the first phase were selected to exemplify a wide range of site conditions, including variations of geologic material, climatic regime and management practice. Three of these areas were in the Vancouver Forest District and two in the Nelson Forest District (Map 1). Site characteristics and management impacts were inventoried in each of the areas, and interpreted for their cause and effect relationships. It is anticipated that further studies will attempt to quantify the habitat parameters involved, and to establish criteria for identifying and mapping those forest ecosystems which are susceptible to resource degradation by forest harvesting." (A)

520. Vice, R.B.; Guy, H.P.; Ferguson, G.E. 1969. Sediment movement in an area of suburban highway construction, Scott Run Basin, Fairfax County, Virginia, 1961-64. Water-Supply Pap. 1591-E. Washington, DC: U.S. Department of the Interior, Geological Survey. 41 p.

"Movement of sediment during a period of intensive highway construction was studied in the Scott Run basin, Fairfax County, Va., from 1961 to 1964. The 4.54-square-mile drainage basin, which empties into the Potomac River about 6 miles above the head of the Potomac Estuary, was the scene of highway construction covering 11 percent of the basin; other types of urban construction in the basin during this time were minor.

"Sediment that moved with the flow was measured at the gaging station by a system of representative samples. These samples made it possible to document the sediment yield for 88 storm events representing the overland runoff. Analysis of streamflow and sediment transport during the period showed that (1) the 88 events accounted for 37 percent of the runoff and 99 percent of the sediment movement in 3 percent of the time; (2) the highway construction areas, varying from less than 1 to more than 10 percent of the basin at a given time, contributed 85 percent of the sediment; (3) 38 percent of the sediment movement occurred during April, May, and June, and only 11 percent occurred during July, August, and September; and (4) on the basis of residual soil and stream-sediment particle sizes, the amount of sediment eroded from areas of construction was about twice that transported form the basin.

"Precipitation during the study was about 12 percent less than the long-term average. If normal precipitation had prevailed, the estimated gross erosion in the construction area would have been about 20 percent more than actually occurred, giving an average of 151 tons per acre per year, about 76 tons of which would be transported from the basin. This amount is about 10 times that normally expected from cultivated land, 200 times that expected from grassland, and 2,000 times that expected from forest land." (A)

521. Walling, D.E.; Peart, M.R. 1980. Some quality considerations in the study of human influence on sediment yields. In: The influence of man on the hydrological regime with special reference to representative and experimental basins. IAHS-AISH Publ. 130. Washington, DC: International Association of Hydrological Sciences: 293-302.

"Traditionally, studies of human influence on sediment yields have focused on magnitude considerations. However, quality considerations offer considerable potential for extending such studies by providing information on sediment-associated transport, the selectivity of the erosion and sediment delivery system and the processes and sources involved. Examples of these quality considerations are drawn from the authors' work in the basin of the River Exe, Devon, UK." (A)

522. Water Resources Council. 1970. Annotated bibliography on hydrology and sedimentation 1966-1968, United States and Canada. Jt. Hydrol.-Sediment. Bull. 10. Washington, DC. 613 p.

"The Hydrology and Sedimentation Committees, Water Resources Council, have sponsored this Bibliography as a guide to literature on hydrology and sedimentation for the use of Government agencies and the public. Every effort has been made to cover all such literature published in the United States and Canada during the period indicated in the title.

"Hydrology and sedimentation are broad fields, and it is difficult to draw sharp dividing lines between items to be included and those to be excluded from a bibliography. The compilation is largely the result of a shelf-by-shelf search of several large libraries, with the decision as to inclusion of articles resting with the compiler. Care has been taken to include all listing of significant technical value in these fields. Articles on construction and on methods of making chemical and biochemical water analyses, highly popularized articles, material of current or local news value only, and tabulations of data in annual series have been generally excluded. Federal agencies furnished listings and annotations for most of the Federal publications.

"In a few instances, annotations are not given for the listings either because the title is self-explanatory, respondents did not supply annotations, or publications containing the missing papers were not available in the libraries searched.

"The index of the bibliography covers both place and subject. In the United States and Canada, the smallest geographical subdivisions used are states and provinces. Elsewhere, geographical subdivision is by country. For papers applying to areas larger than the smallest subdivision, entries are listed under major river basins in the United States and by continents for the rest of the world.

"In general, listings in the index are primary. A paper describing the climate of an area is listed under that area only, unless it also contributes to the techniques of climatology, in which case it is listed under 'Climatology' or other suitable subject heading. Similarly, a paper on groundwater resources is listed under that heading although it may contain incidental information on geology, rainfall, streamflow, etc. Secondary listings have been used where a paper is of a scope clearly exceeding the one subject listing. Users of the index may therefore find it necessary to consult several allied headings to obtain references to all papers bearing directly or indirectly on any topic.

"While the bibliography is intended to cover only publications for the period 1966-1968, it lists some earlier papers inadvertently omitted from previous issues." (A)

523. Water Resources Council. 1976. Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-1 to 7-41.

The proceedings of this symposium comprises 82 papers under seven major headings: (1) sediment yield and sources, (2) erosion and sediment control, (3) physical and chemical properties of sediment, (4) sediment transport and deposition, (5) channel adjustments, (6) coastal zone sedimentation, and (7) instrumentation. (C)

524. Weaver, W.E.; Madej, M.A. 1981. Erosion control techniques used in Redwood National Park, northern California, 1978-1979. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 640-654.

"Redwood National Park has initiated a rehabilitation program to reduce erosion from lands impacted by timber harvest and road construction. Severity of damage to park lands varies with age and type of logging, underlying geology and hillslope gradient. For each rehabilitation site, detailed geomorphic maps delineated natural and disturbed drainages, slope instabilities, and other erosional problems. Next, heavy equipment disaggregated and outsloped logging roads, excavated road fill from stream channels, removed unstable road fill from road prisms, and restored altered drainages to their natural patterns. After heavy equipment work was completed, labor-intensive work crews constructed erosion control structures to stabilize gullies and stream channels, minimize rainsplash erosion and rilling, and promote revegetation of disturbed areas. Checkdams, water ladders and flumes, wattling, wooded terraces, mulches and vegetative techniques were used. Winter maintenance of these structures is essential to assure adequate protection of slopes and drainages through high rainfall periods. Costs and time involved for rehabilitation technique are included." (A)

525. Wells, W.G. 1981. Some effects of brushfires on erosion processes in coastal southern California. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 305-342.

"The effect of periodic brush fires in determining the sedimentation regime in the coastal mountains of southern California is outlined. Data is presented to illustrate the sediment discharge from experimental plots. The physical and chemical composition of soils subject to burning is examined, and linked to a hypothesis of rill formation." (A)

526. Wischmeier, W.H. 1974. New developments in estimating water erosion. In: Land use: persuasion or regulation: Proceedings, 29th annual meeting, Soil Conservation Society of America; 1974 August 11-14; Syracuse, NY. Ankeny, IA: Soil Conservation Society of America: 179-186.

"Soil losses in runoff from farm fields or construction areas are usually estimated by the universal soil loss equation. New developments have increased the utility of this equation by providing techniques for estimating site values of its factors for additional land use, management, and climatic conditions.

"By combining basic erosion principles and modeling concepts with existing plot data, methodological techniques were derived for estimating (a) topographic effect on irregular slopes; (b) the soil factor when soil type changes within a slope length; (c) the cover and management factor for undisturbed land, such as range, idle, or forested areas; and (d) the rainfall factor in the western states. Although estimates obtained by these techniques will be less accurate than values obtained directly from research measurements, they can provide very helpful guides for estimating erosion and planning control practices." (A)

527. Wischmeier, W.H. 1975. Estimating the soil loss equation's cover and management factor for undisturbed areas. In: Present and prospective technology for predicting sediment yields and sources: Proceedings, sediment-yield workshop; 1972 November 28-30; Oxford, MS. ARS-S-40. Oxford, MS: U.S. Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory: 118-124.

"A numerical evaluation of the effectiveness of various types and qualities of cover and management as protection against the erosive forces of rainfall and runoff is a very important factor in sediment prediction. This factor has been evaluated for cropland from more than 10,000 plot years of soil-loss data assembled from plot studies over the past 40 years. However, data are now available for its direct evaluation for various wooded, range, and idle lands—areas that also contribute to watershed sediment loads. Use of either the Musgrave equation or universal soil loss equation to estimate the sediment contribution from such sources has required reliance on highly generalized judgment values for the cover and management factor.

"This report presents a methodical routine and the necessary graphs for approximating the universal soil loss equation cover and management factor for situations that are not represented in previous research data. The technique is based upon a refined interpretation of the empirically derived factor." (A)

528. Wischmeier, W.H. 1976. Use and misuse of the Universal Soil Loss Equation. Journal of Soil and Water Conservation. 31(1): 5-9.

The widely-used Universal Soil Loss Equation was designed to predict soil loss from sheet and rill erosion. For other applications, several precautions must be observed. Each of the six erosion factors in the equation (R, erosive forces of rainfall and runoff; K, inherent erodibility of the soil; L and S, dimensionless factors adjusting for effects of slope length, steepness, and shape; C, cropping and management variables; P, supporting soil management practices) is a simplified function of many varying and interrelated factors, and soil loss estimates "...must be recognized as the best available estimates rather than as absolute data." Specific limitations in application of the equation are discussed for four areas: estimation of the soil erodibility factor, K; estimation of the cover and management factor, C; attempts to estimate total watershed sediment yield; and attempts to estimate soil loss for specific storm events. (C)

529. Wischmeier, W.H. 1977. Soil erodibility by rainfall and runoff. In: Toy, T.J., ed. Erosion: research techniques, erodibility and sediment delivery. Norwich, England: Geo Abstracts Ltd.: 45-56.

"The amount of soil that is eroded from a given land area depends on the particular combination of erosive and resistive forces. The erosive potential of rainfall and its associated runoff depends on the rainstorm characteristics as well as the amount of rain and is also influenced by the topographic features. The ability of a soil to resist action by the erosive forces depends on its physical and chemical properties and the influences of cover, management, and conservation practices.

"The Universal Soil Loss Equation (USLE) is designed to evaluate the net effect of the particular combination of all these factors on a given land area. It computes average annual soil loss in tons per acre as a product of numerical site values for: (1) the erosive forces of the rainfall and runoff, (2) the inherent susceptibility of the particular soil to erosion, (3) the length, steepness, and shape of the land slope, (4) vegetal cover, tillage, and the direct and residual effects of soil and crop management, and (5) the effectiveness of supplemental conservation practices. The numerical value of each of these major erosion factors is a function of many variables, but can be evaluated within reasonable accuracy limits for a given site from published tables and charts based on relationships that have been derived by the U.S. Department of Agriculture from nearly a half century of field and laboratory research. The product of appropriate values for the first three factors is a quantification of the inherent erosion potential of the site; the last two factors account for the reduction in this potential that can be affected by various alternative combinations of land use and management.

"The USLE was designed to predict average annual sheet and rill erosion from field-size areas, for use as a guide for soil-conservation planning. Its value for this purpose has been well established through more than a decade of successful use in the Soil and Water Conservation Districts of the 31 states east of the Rocky Mountains. The equation can also be helpful for estimating sediment yields from large watersheds, but additional factors must also be considered. Only a relatively small fraction of the soil eroded from field areas usually reaches a major stream. The USLE is not designed to predict deposition in depressional areas, field boundaries, and along the path of the runoff after it leaves the field. For watershed sediment load prediction, it must be used together with a deposition equation or a sediment delivery ratio. If it is applied to large heterogeneous watersheds, they should be subdivided into relatively homogeneous subareas for which representative values of the equation's factors can be determined. Sediment from streambank, channel, or gully erosion must be computed separately." (A)

530. Wischmeier, W.H.; Johnson, C.B.; Cross, B.V. 1971. A soil erodibility nomograph for farmland and construction sites. Journal of Soil and Water Conservation. 26(5): 189-193.

"A new soil particle-size parameter was found and used to derive a convenient erodibility equation that is valid for exposed subsoils as well as farmland. A simple nomograph provides quick solutions to the equation. Only five soil parameters need to be known: percent silt, percent sand, organic matter content, structure, and permeability. The new working tool opens the door to several new considerations in sediment-control planning." (A)

531. Wischmeier, W.H.; Mannering, J.V. 1969. Relation of soil properties to its erodibility. Soil Science Society of America Proceedings. 33(1): 131-137.

The inherent erodibility of 55 selected soils of the Corn Belt is related to the physical and chemical properties of each soil. (C)

"Properties that contributed significantly to soil-loss variance included percentages of sand, silt, clay and organic matter; pH; structure and bulk density of plow layer and subsoil; steepness and concavity or convexity of slope; pore space filled by air; residual effects of sod crops; aggregation; parent material; and various interactions of these variables. An empirical equation was derived for calculating the universal soil loss equation's erodibility factor K for specific soils. Tests of the equation against soils of the older erosion-research stations, for which the erodibility factor is known, substantiated its general applicability over a broad range of medium-textured soils." (A)

532. Wischmeier, W.H.; Meyer, L.D. 1973. Soil erodibility on construction areas. In: Soil erosion: causes and mechanisms; prevention and control. Spec. Rep. 135. Washington, DC: Highway Research Board, National Research Council: 20-29.

The Universal Soil Loss Equation (USLE) is introduced, and the soil erodibility factor (K) is discussed in detail. Results of extensive field, laboratory, and statistical analyses of the relationships of various soil properties and their influences on soil erodibility are summarized. The effect of various mulches and mulch rates on the amount of soil eroded is discussed. Use of the USLE is illustrated. (C)

533. Wischmeier, W.H.; Smith, D.D. 1958. Rainfall energy and its relationship to soil loss. Transactions of the American Geophysical Union. 39(2): 285-291.

"A relatively simple procedure is presented for computation of kinetic energy of a rainstorm from information on a recording-raingauge chart. An equation is developed describing rainfall energy as a function of rainfall intensity. The effects of rainfall energy and its interaction with other variables are evaluated in multiple regression analyses based on data representing four soil types. Application of this information to separate the effects of rainfall from those of physical and management characteristics in plot data is discussed briefly." (A)

534. Wischmeier, W.H.; Smith, D.D. 1965. Predicting rainfall-erosion losses from croplands east of the Rocky Mountains. Agric. Handb. 282. Washington, DC: U.S. Department of Agriculture. 47 p.

The basis for, and the use of the Universal Soil Loss Equation (USLE) is presented. A number of tables and graphs are simplified evaluations of factors in the USLE. The tables and graphs are explained and many examples of their use, along with use of the USLE, in solving problems of erosion and conservation planning are given. (C)

535. Wischmeier, W.H.; Smith, D.D. 1978. Predicting rainfall erosion losses: a guide to conservation planning. Agric. Handb. 537. Washington, DC: U.S. Department of Agriculture. 58 p.

"The Universal Soil Loss Equation (USLE) enables planners to predict the average rate of soil erosion for each feasible alternative combination of crop system and management practices in association with a specified soil type, rainfall pattern, and topography. When these predicted losses are compared with given soil loss tolerances, they provide specific guidelines for effecting erosion control within specified limits. The equation groups the numerous interrelated physical and management parameters that influence erosion rate under six major factors whose site-specific values can be expressed numerically. A half century of erosion research in many states has supplied information from which at least approximate values of the USLE factors can be obtained for specified farm fields or other small erosion prone areas throughout the United States. Tables and charts presented in this handbook make this information readily available for field use. Significant limitations in the available data are identified.

"The USLE is an erosion model designed to compute longtime average soil losses from sheet and rill erosion under specified conditions. It is also useful for construction sites and other non-agricultural conditions, but does not predict deposition and does not compute sediment yields from gully, streambank, and streambed erosion." (A)

This report supersedes Agriculture Handbook No. 282, "Predicting Rainfall-Erosion Losses From Cropland East of the Rocky Mountains." (C)

536. Wischmeier, W.H.; Smith, D.D.; Uhland, R.E. 1958. Evaluation of factors in the soil-loss equation. Agricultural Engineering. 39(8): 458-462, 474.

"Soil-loss estimation by means of empirical equations is a basic step in the now widely accepted slope-practice method of determining conservation practices to be applied to fields. This paper presents recent developments which add to the research information currently available to serve as a basis for factors comprising the soil-loss estimating equation." (A)

The authors suggest that soil loss is correlated to slope length most closely when slope length has an exponent of 0.5; however, the relationship can vary in time and space. The percent slope-soil loss data seem to exhibit a parabolic relationship for slopes under 20 percent. The paper also presents a family of curves to adjust soil loss data for differences in length and degree of slope, a rainfall parameter including kinetic energy of the storm and maximum 30-minute intensity, and a table to simplify calculation of this parameter. (C)

537. Witzigman, F.S. 1965. A summary of the work of the inter-agency sedimentation project. In: Proceedings, Federal inter-agency sedimentation conference; 1963 January 28-February 1; Jackson, MS. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 166-177.

"The Inter-Agency Sedimentation Project was initiated in 1939, mainly to develop improved sediment sampling instruments and techniques for measurement and analysis of sediment loads in streams. In 1956, the purpose of the project was expanded to include the solution of sedimentation problems that are of common concern to Federal agencies on the Subcommittee on Sedimentation of the Inter-Agency Committee on Water Resources, with special emphasis on methods of sampling automatically.

"Manually operated sediment samplers developed and currently recommended for field use include: (1) three depth-integrating suspended-sediment samplers that collect samples continuously from the stream as they are lowered from the surface to the bed and raised back to the surface; (2) two point-integrating suspended-sediment samplers with electrically operated valves; and (3) three bed-material samplers. Instruments have been developed, such as the single-stage sampler that is in widespread use and the pumping samplers that are in the field-testing stage, for obtaining samples or sediment information automatically from flashy streams when no observer is present. Two sediment-size analyzers have been developed. The bottom-withdrawal tube is a sedimentation device for size analysis of sediments finer than 0.7 mm. The visual-accumulation tube is a sedimentation device for the particle-size analysis of sand samples. Methods for determining concentration and particle size gradation which are being explored are electronic sensing, turbidity, ultrasonic sensing, and nuclear." (A)

538. Wolman, M.G; Gerson, R. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. Earth Surface Processes. 3: 189-208.

"Peak rainfalls and peak runoff rates per unit area are comparable over a world-wide spectrum of climates. However, while the magnitude of the external contribution of energy or force in diverse regions is similar, the impact on the landscape varies markedly between regions. Absolute magnitudes of climatic events and absolute time intervals between such events do not provide satisfactory measures of the geomorphic effectiveness of events of different magnitudes and recurrence intervals. Although geomorphic processes are driven by complex sets of interrelated climatic, topographic, lithologic, and biologic factors, the work done by individual extreme events can be scaled as a ratio to mean annual erosion and the effectiveness of such events in forming landscape features can be related to the rate of recovery of channel form or mass wasting scars following alteration by the extreme event. Thus, a time scale for effectiveness may relate the recurrence interval of an event to the time required for a landform to recover the form existing prior to the event.

"River channels in temperate regions widened by floods of recurrence intervals from 50 to more than 200 years may regain their original width in matters of months or years. In semi-arid regions, recovery of channel form depends not only upon flows but upon climatic determinants of the growth of bottomland vegetation resulting in variable rates of recovery, on the order of decades, depending upon coincidence of average flows and strengthened vegetation. In truly arid regions the absence of vegetation and flow precludes recovery and the width of channels increases as drainage areas up to 100 km^2 but remains relatively constant at larger drainage areas.

"Area as well as time controls the effectiveness of specific events inasmuch as the likelihood of simultaneous peak discharges or rainfalls and large areas is less, particularly in arid regions where events spanning areas of more than several thousand km^2 are extremely rare if experienced at all. To some extent a decrease in area in a humid region is comparable with a regional change from humid toward more arid climate reflected in the increase in importance of episodic as contrasted with more continuous processes. Exceedingly rare floods of extreme magnitudes, estimated recurrence intervals of 500 years or longer, may exceed thresholds of competence otherwise unattainable in the 'normal' record resulting in 'irreparable' transformations of valley landforms.

"Denudation of hillslopes by mass wasting during relatively rare events can also be related to mean rates of denudation and to recovery of hillslope surfaces after scarring by different kinds of landslides. Measured recovery times described in the literature vary from less than a decade for some tropical regions to decades or more in temperate regions. Recurrence intervals of high magnitude storms which trigger mass wasting range from 1 to 2 years in some tropical areas, to 3 or 4 per hundred years in some areas of seasonal rainfall and to 100 or more years in some temperate regions. The effectiveness of climatic events on both hillslopes and rivers is not separable from gradient, lithology, or other variables which control both thresholds of activity and recovery rate." (A)

539. Wolman, M.G.; Miller, J.P. 1960. Magnitude and frequency of forces in geomorphic processes. Journal of Geology. 68: 54-74.

"The relative importance in geomorphic processes of extreme or catastrophic events and more frequent events of smaller magnitude can be measured in terms of (1) the relative amounts of 'work' done on the landscape and (2) in terms of the formation of specific features of the landscape.

"For many processes, above the level of competence, the rate of movement of material can be expressed as a power function of some stress, as for example, shear stress. Because the frequency distributions of the magnitudes of many natural events, such as floods, rainfall, and wind speeds, approximate log-normal distributions, the product of frequency and rate, a measure of the work performed by events having different frequencies and magnitudes will attain a maximum. The frequency at which this maximum occurs provides a measure of the level at which the largest portion of the total work is accomplished. Analysis of records of sediment transported by rivers indicated that the largest portion of the total load is carried by flows which occur on the average once or twice each year. As the variability of the flow increases and hence as the size of the drainage basin decreases, a larger percentage of the total load is carried by less frequent flows. In many basins 90 per cent of the sediment is removed by storm discharges which recur at least once every five years.

"Transport of sand and dust by wind in general follows the same laws. The extreme velocities associated with infrequent events are compensated for by their rarity, and it is found that the greatest bulk of sediment is transported by more moderate events.

"Many rivers are competent to erode both bed and banks during moderate flows. Observations of natural channels suggest that the channel shape as well as the dimensions of meandering rivers appear to be associated with flows at or near the bankfull stage. The fact that the bankfull stage recurs on the average once every year or two years indicates that these features of many alluvial rivers are controlled by these more frequent flows rather than by the rarer events of catastrophic magnitude. Because the equilibrium form of wind-blown dunes and of wave-formed beaches is quite unstable, the frequency of the events responsible for their form is less clearly definable. However, dune form and orientation are determined by both wind velocity and frequency. Similarly, a hypothetical example suggests that beach slope oscillates about a mean value related in part to wave characteristics generated by winds of moderate speed.

"Where stresses generated by frequent events are incompetent to transport available materials, less frequent ones of greater magnitude are obviously required. Closer observation of many geomorphic processes is required before the relative importance of different processes and of events of differing magnitude and frequency in the formation of given features of the landscapes can be adequately evaluated." (A)

540. Wolman, M.G.; Schick, A.P. 1967. Effects of construction on fluvial sediment, urban and suburban areas of Maryland. Water Resources Research. 3(2): 451-464.

"The equivalent of many decades of natural or even agricultural erosion may take place during a single year from areas cleared for construction. Areas undergoing rapid development near Baltimore, Maryland, and Washington, D.C., lie on the Coastal Plain and Piedmont, with slopes generally of 1-10% but sometimes of 20% and more. Soil is deep, and the annual precipitation of 42 inches (1100 mm) is evenly distributed, with high summer intensities. Average sediment yield is 200-500 t/mi^2/yr (80-200 t/km^2/yr), with predominantly wooded watersheds supplying sometimes even less. Intensive farming 50-80 years ago caused yields up to 1000 t/mi^2/yr (400 t/km^2/yr), but such high yields are no longer present owing to the continuous decline of farm acreage in the metropolitan periphery. Sediment concentrations from areas undergoing construction ranged from 3000 to over 150,000 ppm, whereas in natural or agricultural catchments the highest comparative concentration was 2000 ppm. In terms of annual values, yields from construction areas range from several thousand to a maximum of 140,000 t/mi^2/yr (i.e., up to 55,000 t/km^2/yr) from a small area. Total yield declines with increasing drainage area as a result of dilution from waters draining urban and other land not actually under construction. Observations demonstrate that sediment storage occurs on construction sites as well as in valley bottomlands. Actual yields from a given unit surface may be even larger than those derived from measurements in streams. Data on erosion from roadcuts in Georgia, when converted to soil loss per area, result in sediment yields similar to those from building sites: 50,000-150,000 t/mi^2/yr (20,000-50,000 t/km^2/yr), and local measurements indicate depths of erosion on roadcuts of 0.1-0.2 ft (3-6 cm) over time intervals of generally less than one year. Imposition of large quantities of sediment on streams previously carrying relatively small quantities of primarily suspended material produced deposition of channel bars, erosion of channel banks as a result of deposition within the channel, obstruction of flow and increased flooding, shifting configuration of the channel bottom, blanketing of bottom-dwelling flora and fauna, alteration of the flora and fauna due to changes in light transmission and abrasive effects of sediment, and alteration of species of fish due to changes produced in the flora and fauna upon which fish depend. Analysis of building permit records showed that: (1) 50% of construction sites were open for eight months, 60% for nine, and 25% for more than one year; (2) contrary to expectations, construction activity is practically constant throughout the year, with about 84% of all sites being open in any one month; (3) the average size of a construction site for one permit-bearing building is 14,400 ft^2 (1340 m^2), a value that remained constant during the last decade. These findings, combined with statistics on highway construction, indicate that in four Maryland counties covering expanding metropolitan regions adjacent to Baltimore and Washington, at a minimum 7.2 mi^2 (19 km^2) of land are cleared at any one time for construction purposes. Housing and other buildings account for 5.7 mi^2 (15 km^2) and highways for 1.5 mi^2 (4 km^2). Sediment yield is roughly 700-1800 tons per 1000 increase in population. Progressive urbanization effects an initial rise in the total sediment, soon followed by a steady decline. The proportion of sediment from the construction source, however, will increase steadily and may overtake the total agricultural yield at a not very advanced stage of urbanization. Most economic evaluations of problems posed by urban sediment are subject to much uncertainty. The problem, however, is common to all conurbations, particularly where heavy earthmoving machinery is in use. Techniques for lessening sediment yield and delivery are available. Their widespread adoption presents complex issues of a local, legal, and social nature." (A)

541. Wood, H.B.; Merriam, R.A.; Schubert, T.H. 1969. Vegetation recovering—little erosion on Hanalei watershed after fire. Res. Note PSW-191. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 5 p.

"After a fire burned the Hanalei watershed on Kauai, Hawaii, transects and vegetation plots were established to record surface conditions and recovering vegetation. Four months after the fire, 86 percent of the transect length had a vegetation cover of less than 50 percent. Six months later, 94 percent of the transect length had a vegetation density of greater than 50 percent. Among the recovering herbaceous vegetation, fireweed was the dominant species. Uluhe regeneration has been low. Eight months after the fire, koa seedlings had a survival rate of 78 percent. Aerially seeded grasses and legumes were well established. No evidence of widespread erosion was found." (A)

542. Wooldridge, D.D. 1963. Soil properties related to erosion of wildland soils in central Washington. In: Forest-soil relationships in North America: Proceedings, 2d North American forest soils conference; 1963 August; Corvallis, OR. Corvallis, OR: Oregon State University: 141-152.

Soil properties related to soil erosion, and the use of mean soil aggregate size as an index of erosion hazard are discussed. (C)

"Mean aggregate size as determined and used in this investigation is a good guide in assessing the erosion hazard of a particular soil. It is sensitive to changes in vegetative cover and has strong association with soil organic-matter content, bulk density, and porosity—soil properties which are known to be related to soil tilth and structure." (A)

543. Wooldridge, D.D. 1964. Effects of parent material and vegetation on properties related to soil erosion in central Washington. Soil Science Society of America Proceedings. 28(3): 430-432.

"In a preliminary study of physical properties of wild land soils, three soil parent materials were sampled by horizons under forest and adjacent grass cover. Soil properties analyzed were mean water-stable aggregate, bulk density, organic matter, pH, total porosity, and percent clay, silt, and sand. Several of the measured soil properties were related significantly to parent material and horizon depth. Effects of vegetative cover were not reflected in overall averages of soil property values. However, these values, broken down by parent materials and horizons, indicated that forest and grass covers were associated with soil property differences, although the relation of these differences to changes in parent materials and horizons is not consistent. Over 40 percent of the variation in soil erosion hazard measured by mean size of water-stable aggregate is accounted for by multiple variation in soil organic-matter content, pH, total porosity, and bulk density." (A)

544. Wooldridge, D.D. 1979a. Suspended sediment from truck traffic on forest roads, Meadow and Coal Creeks. DOE 79-5a-3. Olympia, WA: State of Washington, Department of Ecology. 33 p.

"Objectives of this study were to identify the quantities and concentrations of suspended sediment generated by truck traffic in the use of haul roads adjacent to forest streams. Specifically, it measured sediment concentrations in milligrams per liter of suspended material transported by small forest streams and estimated the total quantities in relation to haul use." Conclusions follow:

1. "Increased suspended sediment concentrations and quantities of suspended sediment transported occurred in tributaries to small forest streams as a result of truck traffic during periods of light to moderate rainfall."

2. "Extended duration of light to moderate rainfalls (0.2 to 0.5 in/day) often produced increases in suspended sediment concentrations and transport in larger streams which drain main haul road systems."

3. "Actual quantities of sediment transported vary due to duration and quantity of antecedent rainfall and actual stream discharge rates. Streams tributary to Coal Creek, during 0.01 to 0.03 in/hr rainfall, will transport from 2 to 3 lbs. of sediment per hour. Coal Creek at similar low discharge rates will transport from 7 to 18 lbs. per hour. Increasing rainfall to 0.6 to 0.7 in/day increased sediment transport in Coal Creek during the work week to 70 lbs/hr. In the non-work week, this sediment rapidly flushed reducing to about 2 mg/1 or 3 to 5 lbs/hr."

4. "Intense rainfall rates of 0.3 to 0.4 in/hr cause rapidly increasing discharge, often obscuring impacts of road use activity, particularly during sustained periods of heavy rainfall. Concentrations increase to over 100 mg/l with a transport of 0.28 ton/hour...."

5. "Diurnal effects of truck traffic...can be identified during periods of light rainfall by increases in suspended sediment concentration downstream from main haul roads during the working hours. Suspended sediment concentrations remain near or at background levels during rainless periods or even with moderate to intense rain, but no road use."

6. "Road use studied in Meadow Creek drainage found no significant impacts of truck traffic on sediment concentration or transport processes. Sulfite liquor waste applied to control dust appears to also control production of mud during periods of rainfall. No sulfite liquor was found in the stream and turbidity occurring could not be traced to the road surfaces." (A)

545. Wooldridge, D.D. 1979b. Suspended sediment transport and forest road construction, Wildhorse Creek, Kalama River Basin. Seattle, WA: College of Forest Resources, University of Washington. 40 p., plus appendix.

"...sediment transport processes are extremely variable, dominated in particular by duration and intensity of rainfall but also affected by many random factors. Very significant increases in sediment transport are recorded when forest construction activities take place within the live stream channels. The impact and duration of increases in sediment transport are very dependent on pre- and post-construction rainfall rates and durations.

"Rainfall and increased streamflow were required to increase suspended sediment transport after road construction was completed. Sources of increased sediment included the road surface, ditch lines and exposed mineral soil, particularly near streams. Quantities of sediment from the above sources cannot be distinguished from natural sources." (A)

546. Wooldridge, D.D. 1980. Effects of forest harvest on sediment and water quality in the western Olympic Mountains, Washington. Seattle, WA: College of Forest Resources, University of Washington. 56 p.

"Study of the effects of clearcut forest harvest on water quality of Lindner Creek has demonstrated increased suspended sediment concentrations (to 16 mg/l) when yarding across the stream during periods of low summer flow. Total sediment transport ranged to 10 lbs/day. With fall rains, concentrations remained low; however, sediment transport increased to 92 lbs/day. Natural variations in suspended sediment concentrations, due to duration and intensity of rains and the ensuing magnitude of flood flow, mask sediment contributions from silvicultural activities as streamflow increases with winter storms. Suspended sediment concentrations were generally greater in Rock Creek for lesser winter storms than those measured in Lindner. Maximum suspended sediment concentrations reported for small forested watersheds frequently are highly variable between adjacent basins...." (A)

547. Wooldridge, D.D.; Larson, A.G. 1980. Suspended sediment from forest road construction. Seattle, WA: Forest Hydrology Laboratory, College of Forest Resources, University of Washington; Proj. Completion Rep., OWRT Proj. A-088-WASH. 72 p. Unpublished report on file with: College of Forest Resources University, University of Washington, Seattle, Washington.

"Suspended sediment in Fly Creek, a tributary of the Clearwater River on the Olympic Peninsula, increased during and after phase of construction of 2.5 miles of unpaved forest road. Construction practices conformed to the Washington State Forest Practices Rules and Regulations, considered at present Best Management Practices. Suspended sediment concentrations from road construction were related to the proximity of activities to streams and the occurrence of rainfall.

"Except for activities within the stream channel, suspended sediment increases were small uring construction in periods without rainfall. Rain was required before construction or log hauling significantly increased suspended sediment transport. Increases in suspended sediment concentrations generally coincided with rates of rainfall, independent of work hours or stream discharge. Although construction and log hauling made the sediment available, rain was required to transport to the stream. Usually, increased sediment concentrations in streams occurred days after construction or hauling terminated following rain. The rapidity with which rainfall caused increases in suspended sediment transport appears to be one of the major impacts of road construction." (A)

548. Woolhiser, D.A.; Miller, C.R. 1963. Case histories of gully control structures in southwestern Wisconsin. ARS 41-60. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service. 28 p.

"The construction of a gully control structure imposes an abrupt change in the conditions affecting sediment entrainment, transportation, and deposition. This change is superimposed upon a channel condition that is already unstable as evidenced by the existence of a gully. Because of the complex dynamic nature of the problem, design procedures for predicting stable channel gradients above and below these structures are highly subjective. Further complicating the possibility of predicting channel changes that will occur with structural control is the present limited knowledge of sediment transport phenomena in ephemeral streams.

"This report presents the results of the initial part of a study of channel thalweg profiles above and below gully control structures. The purpose of this initial phase is to document present and past conditions and experiences at a number of selected sites as an aid to the engineer in the design of this type installation. It will also illustrate certain items on which additional research is needed. Attention is primarily directed to the scour hole development at the principal spillway outlet and at channel thalweg development downstream." (A)

549. Wright, H.A.; Churchill, F.M.; Stevens, W.C. 1974. Effect of prescribed burning on sediment, water yield, and water quality from dozed juniper lands in central Texas. Lubbock, TX: Texas Tech University. 23 p.

"Prescribed burning was applied to six micro-watersheds that were each paired with an unburned watershed. Erosion losses, runoff, and water quality were unaffected on level areas, but effects last 9 to 15 months on moderate slopes and for 15 to 30 months on steep slopes. Erosion losses stabilized within 18 months on all slopes when vegetative cover reached 60 to 70 percent." (A)

550. Yamamoto, T.; Anderson, H.W. 1967. Erodibility indices for wildland soils of Oahu, Hawaii, as related to soil forming factors. Water Resources Research. 3(3): 785-798.

"Soil samples collected along 31 transects in the watersheds of the Koolau and Waianae ranges were analyzed in the laboratory for the size distribution of water-stable aggregates and suspension per cent. Indices of soil erodibility were related by principal component analyses with varimax rotation to these 7 soil-forming factors: parent material, rainfall, elevation, vegetation type, slope, aspects, and zone. Parent rock material was the most important factor in explaining variation of water-stable aggregates of soils in Hawaii. Nevertheless, differences in water-stable aggregates were also associated with differences in vegetation type and other soil-forming factors. Most of the soils studied were rated as slightly to moderately erodible under full vegetative cover. The loose condition plus the dispersive and slaking characteristics of volcanic ash soils suggest that they may be twice as erodible as soils of basaltic flow or of the colluvial origin. Among the soil characteristics that serve as indices of erodibility, the suspension per cent was found to be independent of other measures; hence, it may be expected to serve well as a part of an erodibility ratio, such as suspension-mean weight diameter or a surface-aggregation ratio. Conversion of the native koa-ohia scrubby forests by planting paper bark or silk-oak trees promises to result in development of less erodible soils as well as more useful forest products." (A)

551. Yamamoto, T.; Anderson, H.W. 1973. Splash erosion related to soil erodibility indexes and other forest soil properties in Hawaii. Water Resources Research. 9(2): 336-345.

"Soil losses under simulated rainfall were used to test indexes of erodibility based on soil aggregate size and Middleton's suspension percent. Soil samples were collected on the Koolau and Waianoe ranges on Oahu, Hawaii. Soil losses expressed as gross splash erosion and maximum splash erosion and maximum splash rate were related by regression on principal components to eight factors: soil erodibility index, bulk density, saturation soil moisture content, precipitation excess, organic matter content, geologic type, vegetation type, and climatic zone at the sampling site. Equations that included the percent of water stable aggregates 0.25-0.50 mm in size produced the highest explained variation: 81 percent in gross splash erosion and 66 percent in maximum splash rate. Gross splash was related to a soil erodibility index, bulk density, and infiltration and saturation moisture content. In contrast, maximum splash erosion variation was related to organic matter content as well as to an erodibility index and the bulk density of the soil. Ash and basalt colluvium soils required more careful management than basalt soil because of their higher maximum splash rates." (A)

552. Yoho, N.S. 1980. Forest management and sediment production in the south—a review. Southern Journal of Applied Forestry. 4(1): 27-36.

"The sediment yield from well-stocked forests is a minute fraction of that from more intensive land uses. Any activity that disturbs the vegetation and soil of a watershed can increase sediment yield. Forest practices commonly result in small short-term increases. Significant increases in sediment yields are essentially limited to practices conducted with heavy machinery. Sediment production from forestry operations can be diminished without appreciably altering current prescriptions. Yields from similar sites receiving the same type treatment vary by several hundred percent. Sediment yields are substantially reduced when channel disturbance is avoided during cultural operations and the minimum treatment consistent with achieving the desired cultural result is employed. Slope and soil erodibility should receive careful attention when prescribing cultural treatments. Greatest reductions of sediment yields from forest can be achieved by careful design, planning, construction, use and maintenance of forest roads and skid trails." (A)

553. Yoo, K.H.; Molnau, M. 1976. Modelling of runoff for erosion studies. Moscow, ID: Idaho Water Resources Research Institute, University of Idaho. 109 p.

"The overall objective of this project was to further the understanding of the hydrology of the Palouse. The specific objectives set forth for this part of the broader effort are:

1. Evaluate the overall applicability of the USDAHL-74 watershed model to Palouse conditions.

2. Evaluate the overland flow routing of this model.

3. Evaluate the channel routing portion of this model.

4. Determine the range of watershed size that can be represented by the model.

5. Devise a means of extracting the necessary parameters and data from the model for a soil erosion and transport model.

"...the following conclusions can be drawn:

1. The water year based simulation is very useful in obtaining the entire runoff season in one simulation and in defining the required initial parameters.

2. The free water separation revision improved the simulation during and after a long dry season. This is not completely satisfactory, however, since there were some poor simulations when the soil was wet before a rainfall.

3. The routing coefficients of the first and the second layers as calculated in the PARAMS subroutine seem to poorly estimate the time of storage.

4. The winter pan evaporation data needs to be improved. The method used in this report was the most direct available but does not appear to be proper during February and March. This controls the soil moisture and therefore the available water holding capacity which is probably the single most important factor in simulation.

5. Seasonal variation of groundwater recharge and infiltration rates are needed for a better simulation. Some of the higher predicted runoff in the warm season was caused by high overland flow possibly because of the low infiltration rate used in this study. If both infiltration and groundwater recharge were allowed to vary with season or with temperature, the simulation probably could be improved.

6. The snowmelt routine is inadequate. The other changes in the program cannot overcome the basic inability of the present equation to represent melt.

7. The model gives valuable information about overland flow. It gives depth and rate of overland flow. However, the results do not always seem to be reasonable, especially when a watershed is divided into more than two zones. Most overland flow occurs on alluvium and little or none on upper zones even when there is significant rainfall. A reasonable simulation was obtained on the Thompson watershed which consisted of only one zone.

8. Frozen ground effect on runoff does not seem to be properly simulated. The model uses antecedent temperature, but the freezing index...coupled with antecedent moisture...may be better for determining frozen ground conditions.

9. Subroutine POLLUT includes most of the parameters necessary for erosion modelling. Should any others prove necessary, it would be very easy to add them to that subroutine." (A)

554. Yorke, T.H.; Herb, W.J. 1976. Urban-area sediment yield—effects of construction-site conditions and sediment-control methods. In: Proceedings, 3d Federal inter-agency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 2-52 to 2-64.

"Suspended-sediment discharge and land use were monitored in eight small drainage basins in Montgomery County, Maryland, between 1963 and 1974. Five of these basins, located on the fringe of the rapidly expanding Washington, D.C., metropolitan area, were subjected to continuous construction activity as woodlots, pastures, and cultivated fields were replaced by houses, apartments, and shopping centers. Construction-site sediment yields ranged from 7 to 101 tons/acre/year. The degree of sediment control and the slope conditions on construction sites were the most significant factors affecting sediment yields; the proximity of construction to stream channels and the length of time that surface soils were unprotected affected yields to a lesser extent. As a result of improvements in grading practices and control measures, construction-site sediment yields were reduced 60 to 80 percent between 1966 and 1974." (A)

555. Young, K.K. 1976. Erosion potential of soils. In: Proceedings, 3d Federal interagency sedimentation conference; 1976 March 22-25; Denver, CO. SEDCOM-03. Washington, DC: U.S. Water Resources Council: 1-1 to 1-10.

"This paper describes the application of research to produce a practical field procedure for determining the erosion potential of soils. Special emphasis is given to the soil factors that influence erosion and to how soil survey are used to predict the areas of potential erosion." (A)

The universal soil loss equation is discussed and particular attention is given to estimating the inherent soil erodibility factor. (C)

556. Young, R.A.; Mutchler, C.K. 1969a. Effects of slope shape on erosion and runoff. Transactions American Society of Agricultural Engineers. 12(2): 231-233, 239.

This paper presents information that can be used to extend the applicability of principles developed for predicting erosion on uniform slopes to slopes of irregular shape. Analysis of the basic concepts of soil movement on land of various slope shapes revealed that: (1) erosion varies significantly from a given slope length with the same average degree of slope but with different slope configurations, (2) runoff also varies according to slope configuration but to a lesser degree, (3) these variations are essentially independent of type of ground cover, (4) the amount of lapse time since the last tillage operation before testing affected soil loss, and (5) maximum soil displaced on the concave slopes took place in the upper one-third of the plot and deposition occurred at the bottom of the plot, while on the convex and uniform slopes the maximum displacement occurred about three-fourths of the way down the slope. (C)

557. Young, R.A.; Mutchler, C.K. 1969b. Soil movement on irregular slopes. Water Resources Research. 5(5): 1084-1089.

"Soil loss and runoff were measured from concave, uniform, and convex slopes subjected to simulated rainfall. Fluorescent glass particles and microrelief measurements were used to determine soil movement patterns in the slopes. For slopes of equal average steepness, a concave shape greatly reduced the total sediment loss in comparison with that from either a uniform or convex slope. Average slope steepness was not a good indicator of soil delivery past a given point except for a uniform slope. In general, soil losses from irregular slopes depend on the steepness of a short section of that slope immediately above the point of measurement. Soil movement off the plots was primarily transported by raindrop splash to a rill system and then transported down the slope by runoff in the rill system. A breakdown of the rill system occurred on the bottom of the concave slopes because of decreasing local steepness, resulting in sheet flow and sediment deposition." (A)

558. Youngberg, C.T.; Harward, M.E.; Simonson, G.H.; Rai, D. 1975. Nature and causes of stream turbidity in a mountain watershed. In: Bernier, B.; Winget, C.H., eds. Forest soils and forest land management: Proceedings, 4th North American forest soils conference; 1973 August; Quebec, PQ. Quebec, PQ: Les Presses de l'Universite Laval: 267-282.

"In recent years, land management decisions have increasingly been influenced by environmental quality considerations. Proposed legislation in many areas, if passed, will impose stringent limits on the levels of allowable suspended sediments in streams and rivers. This has definite implications relative to timber harvest and related activities in forested watersheds, especially those in steep mountainous terrrain. The problem of stream turbidity is often compounded when water is impounded in reservoirs.

"A significant increase in reservoir and downstream turbidity was noted at the Hills Creek Reservoir following the large December, 1964, flood. A similar increase in turbidity in Cougar Reservoir was also observed at that time. The turbid conditions have persisted since 1965 at Hills Creek Reservoir but not at Cougar. The persistence of turbidity at the Hills Creek Reservoir became a cause for concern and a one-year-study was initiated in November, 1970.

"Water flowing into the reservoir was sampled during and between storm periods. Tributary streams which were found to be clear or only slightly turbid drained areas with stable soils. Watersheds which produced greater stream turbidities were those having soft pyroclastic bedrock with relatively unstable soils. Streams classed as very turbid or extremely turbid were associated with watersheds having massive landslides, cutbank slumps, or road failures.

"The results of the study indicate that most of the sediment load comes into the reservoir during major storm events, with some streams providing disproportionately high turbidities. Turbidity values for all streams decreased markedly between storms....

"Observations in the watershed of Hills Creek Reservoir indicate that 1) natural slumps are more prevalent in pyroclastic materials and in areas where high stream bed gradients exist; 2) cutbank slumps and road failures are also more frequent in pyroclastic materials; 3) poor road location in pyroclastic materials results in many cutbank slumps, road failures, and massive landslides; and 4) poor road maintenance practices result in increasing potential turbidity." (A)

559. Ziemer, R.R. 1981. Management of steepland erosion: an overview. Journal of Hydrology (NZ). 20(1): 8-16.

"Steepland erosion is a composite of surface, channel, and mass erosion. The relative importance of each process is determined by an interaction between climate, soil, geology, topography, and vegetation. A change in any of these components can increase or decrease the rate of erosion. The key to successful management of erosion is the ability to (1) identify potentially erodible sites, 2) correctly assess appropriate activities at those sites, and (3) have a political/regulatory system that allows for the exclusion of hazardous sites from land treatment. Steepland erosion is controlled most effectively—both in physical and economic terms—by preventative land-use practice rather than corrective action." (A)

560. Ziemer, R.R. 1981. Roots and the stability of forested slopes. In: Davies, T.R.H.; Pearce, A.J., eds. Erosion and sediment transport in Pacific Rim steeplands. IAHS-AISH Publ. 132. Washington, DC: International Association of Hydrological Sciences: 343-361.

"Root decay after timber cutting can lead to slope failure. **In situ** measurements of soil with tree roots showed that soil strength increased linearly as root biomass increased. Forests clear-felled 3 years earlier contained about one-third of the root biomass of old-growth forests. Nearly all of the roots 2 mm in diameter were gone from 7-year-old logged areas while about 30 percent of the 17 mm fraction was found. Extensive brushfields occupied areas logged 12 to 24 years earlier. The biomass of brushfield roots 2 mm in diameter was 80 percent of that in the uncut forest, and fewer large roots were found there than in the forest. Roots 17 mm in diameter in the brushfield accounted for 30 percent of that found in the forest, and for total root biomass, only 10 percent. Individual, live brush roots were twice as strong as conifer roots of the same size. This difference may partially compensate for reduced root biomass in brushfields. Net strength of the soil-root matrix in brushfields was about 70 percent of that in uncut forests. If soils are barely stable with a forest cover, the loss of root strength following clear-felling can seriously affect slope stability." (A)

561. Zingg, A.W. 1940. Degree and length of land slope as it affects soil loss in runoff. Agricultural Engineering. 21(2): 59-64.

"Available data on soil loss in runoff from degree and horizontal length of land slope experiments were studied by a system of coding. From an average of these coded data it was found that (1) doubling the degree of slope increased the total soil loss 2.80 times, and (2) doubling the horizontal length of slope increased the total soil loss 3.03 times.

"An experiment, in which a simulated 20-year frequency rainfall was simultaneously applied to various degrees of slope and horizontal lengths of land slope, was conducted on small plots. For an average of the tests conducted on these plots, the following occurred: (1) Doubling the degree of slope increased the total soil loss in runoff 2.61 times. (2) Doubling the horizontal length of slope increased the total soil loss in runoff 3.03 times. (3) Increasing the degree of slope increased the total runoff. (4) Increasing the length of slope decreased the total runoff. (5) The moisture content of the soil at the completion of the tests showed an inverse relationship to total runoff." (A)

Glossary

Accelerated erosion—Erosion which is more rapid than normal, natural, or geologic erosion, and which occurs primarily as a result of human activities (or, in some cases, from the activities of animals).

Active layer—The layer of soil or earth material above permafrost that thaws during summer and refreezes in winter.

Buffer strip—An undisturbed area between surface water and a potential source of erosion.

Channel erosion—Erosion of material from watercourse channels.

Check dam—A small dam constructed in a gully or other small water course to decrease the streamflow velocity, to minimize channel scour, and to promote deposition of sediment.

Corduroy—Trail or road surfacing constructed of logs (or sawn or split material), used for crossing swampy or unstable terrain. Same as puncheon.

Creep—Slow downslope movement of surficial soil and soil cover material.

Deposition—Settling out of material that had been transported in a fluid (air or water).

Dip—A reverse in the grade of a road or trail, accompanied by an angling outslope to divert water from the road or trail surface.

Dry ravel—Downslope movement of noncohesive soil or small rocks on steep slopes without flowing water.

Erosion—The process by which soil and rock are detached and transported by running water, wind, ice, and gravity.

Filter strip—Same as buffer strip.

Geologic erosion—The wearing away of Earth's surface by water, ice, wind, or other agents under natural environmental conditions.

Gully erosion—The removal of soil by intermittent concentrations of flowing water sufficient to cause the formation of channels that cannot be smoothed completely by normal cultivation methods.

Leave strip—Same as buffer strip.

Mass erosion—The movement of soil particles en masse (for example, landslides).

Mass wasting—Movement of soil or rock downslope by gravitational forces and not directly by running water; includes displacement such as creep, earthflows, and avalanches.

Mulch—A natural or artificial layer of plant residue or other material, such as stone or wood fiber, on the soil surface.

Natural erosion—Same as geologic erosion.

Normal erosion—The gradual erosion of land, when used by humans, that does not greatly exceed natural erosion.

Organic matter—The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population; commonly determined as the amount of organic material contained in a soil sample passed through a 2-millimeter sieve.

Permafrost—Earth materials remaining continuously below 0 ^{o}C for 2 years or longer.

Permeability—The quality of a soil horizon that enables water or air to move through it.

Puncheon—Trail or road surfacing constructed of logs (or sawn or split material), used for crossing swampy or unstable terrain. Same as corduroy.

Rehabilitation—The use of revegetation and techniques to control erosion.

Restoration—A long-term process by which a disturbed site returns to conditions that are similar to the original state.

Revegetation—Establishment of a vegetative cover on a disturbed surface.

Rill erosion—The removal of soil by small concentrations of flowing water in numerous channels small enough to be smoothed completely by normal cultivation methods.

Runoff—That portion of the precipitation that is discharged from the drainage area in stream channels, including surface runoff and groundwater runoff or seepage.

Sediment—Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on Earth's surface either above or below sea level.

Sediment delivery ratio—The percentage of eroded soil that is delivered to a specified point.

Sediment trap—A small dam, obstruction, or channel enlargement in a stream or watercourse that reduces sediment transport and induces deposition of entrained sediment.

Sediment yield—The total sediment outflow from a watershed or drainage basin, measurable at a point of reference in a specified period of time.

Sheet erosion—The removal of a fairly uniform layer of soil from the earth's surface by runoff.

Sheetflow—Water, usually storm runoff, flowing in a thin layer over the ground surface.

Sheet-rill erosion—The combination of sheet and rill erosion.

Soil erosion—The detachment and subsequent movement of soil particles in an entraining medium (rainfall, runoff, wind, ice).

Soil loss—The quantity of soil actually removed by erosion from test areas or small fields.

Soil piping—A form of erosion in which the soil is carried away by water running through holes in the ground. It has also been called pseudokarst, tunneling erosion, and pothole erosion.

Splash erosion—The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and separated particles may or may not be subsequently removed by surface runoff.

Subsidence—A lowering of terrain consequent to consolidation or removal of subsurface materials.

Surface erosion—The movement of individual soil particles along the surface of the ground.

Suspended sediment—Material transported in suspension in a fluid.

Thalweg—A line connecting points of maximum depth along a stream channel.

Thermal erosion—The thawing of frozen soils that results in settlement and degradation of a localized area; commonly associated with mechanical or hydraulic disturbance to the overlying insulating organic material.

Thermokarst—Uneven land subsidence resulting from melt of ice-rich permafrost and massive ground ice.

USLE—Universal Soil Loss Equation, a method for estimating soil loss by erosion: A = R K L S C P; where A = soil loss per unit area, R = rainfall factor, K = soil erodibility factor, L = slope length factor, S = slope gradient factor, C = cropping management factor, P = erosion control practice factor.

Water bar—An installation for diverting water from a road or trail; usually made of logs or soil.

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This annotated bibliography emphasizes the physical processes of upland soil erosion, prediction of soil erosion and sediment yield, and erosion control. The bibliography is divided into two sections: (1) references specific to Alaska, the Arctic and subarctic, and similar high-latitude settings; and (2) references relevant to understanding erosion, sediment production, and erosion control. Most of the cited works were published prior to 1981. Annotations generally consist of the author's abstract or summary

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