# Table of Contents

Chapter 1: Fires, Floods and Mitigation ......................................... 1
  1.1 The global importance of fire ............................................ 1
  1.2 A redefinition of “flow” processes for fire areas ....................... 1
  1.3 Fires and the urban/wildland interface in California .................. 2
  1.4 The Southern California "fire-flood" model ............................ 2
  1.5 Runoff and erosion after fires in Southern California ................ 3
  1.6 Runoff and erosion after fires in the Western United States ......... 12
  1.7 Runoff and erosion after fires in other Mediterranean climates .... 15
  1.8 Erosion and sediment yield after fire .................................. 20
  1.9 History of post-fire mitigation ....................................... 20

Chapter 2: The Oakland Firestorm ............................................... 24
  2.1 The fire ........................................................................ 24
  2.2 Oakland: erosion hazard potential ....................................... 25
  2.3 Mitigation efforts after the firestorm .................................. 26
  2.4 Perception of the post-fire erosion hazard in the Oakland Hills .......... 27
  2.5 General observations from October, 1991, to April, 1992 ............ 28
  2.6 Plot monitoring program: methods .................................... 30
  2.7 Channel response ...................................................... 32
  2.8 Surface runoff response at monitoring plot sites ...................... 33
  2.9 Flow paths .................................................................... 34
  2.10 Erosion by splash and overland flow .................................. 36
  2.11 Bioturbation .................................................................. 37
  2.12 Soil moisture and post-fire landslide potential ....................... 38
  2.13 Artificial rainfall experiments ........................................ 39
  2.14 Sprinkler experiments: the apparatus ................................ 40
  2.15 Sprinkler experiments: the plot ....................................... 43
  2.16 Sprinkler experiments: runoff rates and processes ................... 43
  2.17 Sprinkler experiments: erosion rates and processes .................. 45
  2.18 Summary of the Oakland Hills response to fire ..................... 47

Chapter 3: Additional Field Studies .............................................. 50
  3.1 Introduction .................................................................. 50
  3.2 Field methods ............................................................ 50
  3.3 Australia: the Sydney fires of 1994 .................................. 51
  3.3a Previous field studies - Royal National Park ....................... 52
  3.3b Observations following the January 1994 fires in Sydney ........... 52
  3.4 Laguna Beach Fire: 1993 - 1995 ...................................... 54
  3.4a Rill development ...................................................... 56
  3.4b Erosion rates and flooding .......................................... 57
  3.5 Old Topanga Fire: 1993 - 1995 ...................................... 59
  3.5a Post fire runoff and erosion process .................................. 60
  3.5b Rill development ...................................................... 61
  3.6 Highway 41 Fire: San Luis Obispo, 1994-1996 ...................... 62
Table 2.6b  Particle size fraction and soil textures for Oakland Hills burn area sites
Table 2.7  Watershed parameters for monitored drainage basins.
Table 2.8  Rainfall & Runoff for fire area monitoring sites January - April, 1992
Table 2.9  Sediment loss at winter monitoring sites
Table 2.10  Sediment loss due to bioturbation on winter erosion plots in the Oakland fire area.
Table 2.11  Sediment loss due to bioturbation on summer sprinkler plots in the Oakland Hills.
Table 2.12  Summer sprinkler runoff and erosion plots
Table 2.13  Summer sprinkler runoff and erosion plots
Table 2.14  Sprinkler experiment nozzle characteristics.
Table 2.15  Percent frequency distribution of natural and simulated raindrops
Table 2.16  Regression analysis of the mean of natural raindrop size frequencies
Table 2.17  Oakland hills runoff and erosion sprinkler experiment parameters
Table 2.18  Runoff comparisons for sites monitored both for winter storms and summer sprinkler experiments.
Table 2.19a  Discharge by overland flow and through-flow during sprinkler experiments
Table 2.19b  Percent runoff for sprinkler experiment sites
Table 2.20  Thickness of the wettable layer overlying a hydrophobic horizon
Table 2.21a  Sediment loss during sprinkler experiments on Oakland erosion plots.
Table 2.21b  Sediment yield during sprinkler experiments on Oakland erosion plots.
Table 2.22  Sprinkler experiment suspended sediment concentrations
Table 2.23  Plot response to overland flow
Table 2.24  Plot response to overland flow
Table 3.1  Particle size fraction and soil textures for Laguna Beach burn area
Table 3.2  Rill depths at Laguna Beach fire area monitoring sites
Table 3.3a  Rainfall records for the Laguna Beach fire area
Table 3.3b  Rainfall recorded by the City of Laguna Beach
Table 3.4  Estimated erosion rates for Laguna Beach fire area
Table 3.5a  Runoff and rainfall for Laguna Canyon between 1974 and 1995
Table 3.5b  Laguna Beach monthly rainfall totals (mm), runoff (mm) and the runoff to rainfall ratio for the five wettest years
Table 3.6  Rainfall for January, 1995, which resulted in flooding in Laguna Beach
Table 3.7  Correlation between peak flow runoff and rainfall totals
Table 3.8  Previous fires that have occurred within portions of the area burned by the 1995, Old Topanga Fire
Table 3.9  Particle size fraction and soil textures for Old Topanga burn area mud torrents.
Table 3.10  Rill network parameters for the Old Topanga fire area (Malibu).
Table 3.11a  Rainfall at the Tassajera Creek Raingage.
Table 3.11b  Chorro Creek Rainfall Records 1994 - 1995 (Mahlin, 1995)
Table 3.12  Highway 41 fire sediment sources and volumes for four catchments, October, 1994.
Table 3.13a.  Rill Density for Tassajera Creek Catchments, Highway 41 Fire area.
Table 3.13b  Rill Density for Tassajera Creek Catchments, Highway 41 Fire area, December 8, 1997
Table 3.14 Shear Strength for the Vision and Calabasas Fire Areas

Table 3.15 Los Angeles County debris basin data (Los Angeles County, 1997)

Table 4.1 Fire areas visited (1993 - 1996).

Table 4.2 Effectiveness of in-channel straw bale and sand bag check dams within the Laguna Beach fire area.

Table 4.3 Summary of check dam effectiveness for three fire area locations.

Table 4.4 Survey of Laguna Canyon debris fences in the Laguna Beach fire area.

Table 4.5 Basal cover provided by seeding and natural revegetation in the Tassajera Watershed (Hwy 41 fire).

Table 4.6 Ground cover provided by seeded grasses following fires in 1993 and 1994.

Table 4.7a Landslides within the Highway 41 burn area in San Luis Obispo County following rains in March, 1995.

Table 4.7b Landslides on unburned slopes adjacent to the Highway 41 burn area in San Luis Obispo County following rains in March, 1995.

Table 4.8 Frequency of landslides in burned and unburned areas of San Luis Obispo County following heavy rains in March, 1995.

Appendix II. Figures

Figure 1.1 The global fire regime

Figure 1.2 California fire history and costs

Figure 1.3 Development of a rill network due to hydrophobicity

Figure 1.4 Southern California storm zones

Figure 1.5 Mean monthly soil loss for erosion plots in South Africa

Figure 1.6 Rainfall and sediment yield in afforested catchments in Israel

Figure 1.8 Soil Loss and rainfall for Royal National Park, Australia

Figure 1.9 Soil loss and rainfall for adjacent canyons, San Gabriel Mountains

Figure 2.1a General location map of Oakland fire area

Figure 2.1b Location map of fire area winter monitoring sites

Figure 2.1c Oakland fire area and distribution of burn intensity

Figure 2.2 Oakland fire area raingage network

Figure 2.3 Oakland fire area - runoff and rainfall relationships

Figure 2.4 Wettable horizons and generation of overland flow

Figure 2.5 Sediment loss for winter monitoring sites

Figure 2.6 Sediment loss for winter monitoring sites

Figure 2.7 Mean runoff and sediment loss

Figure 2.8 Cumulative sediment loss

Figure 2.9 Soil moisture for treated and untreated sites

Figure 2.10a Diagram of sprinkler apparatus

Figure 2.10b Diagram of sprinkler apparatus

Figure 2.11a Raindrop size frequency distribution

Figure 2.11b Raindrop size frequency distribution

Figure 2.12 Flow for a single nozzle at different working pressures

Figure 2.13.a.1 Runoff hydrograph and isohyetal map for CK1 run 1

Figure 2.13.a.2 Runoff hydrograph and isohyetal map for CK1 run 2

Figure 2.13.b.1 Runoff hydrograph and isohyetal map for CK2 run 1
Figure 3.17a General Location map of Rabbit Creek fire
Figure 3.17b Rabbit Creek fire area
Figure 3.18 Wren Creek tributary cross sections
Figure 3.19 Shear strength of rilled and unrilled soils for five fire areas
Figure 3.20a Location map of the Mt. Vision fire
Figure 3.20b Shear strength of soils at nine sites within the Mt. Vision fire area
Figure 3.21a Location map of the Calabasas fire
Figure 3.21b Shear vane sites within the Calabasas fire area
Figure 3.21c Shear strength of soils at three sites within the Calabasas fire area
Figure 3.22 Mean sediment yield for 108 debris basins in Los Angeles County
Figure 3.23 Sediment yield for debris basins with slopes greater than 35 degrees
Figure 3.24 Sediment yield as a function of geology for slopes greater than 35 degrees
Figure 3.25 Sediment yield as a function of fire history
Figure 3.26a Distribution of storm types in the Western United States
Figure 3.26b Time distribution of rainfall within storm types
Figure 3.27a Model of hydrologic and erosional response to intense rainfall
Figure 3.27b Model of hydrologic and erosional response to moderate rainfall
Figure 4.1a Two year event rainfall intensities for California fire areas
Figure 4.1b Two year event rainfall intensities for California fire areas
Figure 4.2 Laguna Beach channel mitigation
Figure 4.3 Laguna Beach check dam sites
Figure 4.4 Excavation of check dams leads to failure
Figure 4.5 Area - failure relationship for in-channel check dams
Figure 4.6 Debris fences, a design for failure
Figure 4.7 K-rail structures as used in Laguna Beach
Figure 4.8a Laguna Beach, Vet Canyon cross section, station 107 meters
Figure 4.8b Laguna Beach, Vet Canyon cross section, station 148 meters
Figure 4.9 Laguna Beach, Vet Canyon cross section, station 306 meters
Figure 4.10 Laguna Beach, location of hydromulch treatment
Figure 4.11a Erosion as a function of ground cover in the West
Figure 4.11b Erosion as a function of ground cover in Utah
Figure 4.11c Erosion as a function of ground cover in Montana
Figure 4.11d Erosion as a function of ground cover in subalpine Montana
Figure 4.11e Erosion as a function of ground cover in New South Wales, Australia
Figure 4.11f Erosion as a function of ground cover for three California forest Districts
Figure 4.12 Highway 41 fire area and raingage network
Figure 4.13a Landslide map of San Luis Obispo Quad
Figure 4.13b Landslide map of Morro Bay South Quad
Figure 4.13c Landslide map of Morro Bay North Quad
Figure 4.13d Landslide map of Atascadero Quad
Figure 4.14 Typical landslide morphology
Figure 4.15 Percent cover provided by seeded grasses, 1956-1972