Erosion and Physical Ecosystem Services in Chaparral

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Outline

1. Background

2. Erosion on Chaparral Hillslopes

3. Erosion in Chaparral Watersheds

4. Physical Ecosystem Services in Chaparral
1. Background

- Setting
- Erosion
- Fire Effects
- Ecosystem Services
Setting

- Foothills and lower mountain slopes of southern California, Coast Range, and Sierra Nevada
- Mediterranean climate; coarse upland soils; tectonic uplift
Erosion

- The movement of soil and sediment by the forces of gravity, wind, and water
- Occurs when the available forces overcome the soil resistances (ground cover, soil characteristics, inertia)
Erosion in Chaparral Watersheds

Movement of water and sediment through the landscape

Hillsides

Streams
The Hydrologic Cycle

From Dunne and Leopold, 1978
Infiltration/Overland Flow

Precipitation

Overland Flow

Infiltration

Soil Column

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Infiltration

- The movement of water into the soil
- Measured as a depth per unit time (1.5 cm/hr)
- Governed by rain intensity, ground cover, and soil characteristics
- Becomes percolation and groundwater flow
Overland Flow

- Movement of water over the ground surface
- Caused by rainfall exceeding infiltration
- Caused by saturating the ground
- Results in sheetflow and rill flow
Fire Effects

- Loss of vegetation and litter
- Changes in soil properties
Water Repellent Soils
Water Repellent Soils

(A) Unburned
Litter
Water repellent layer
Wettable soil

(B) Fire
Water repellent zone
Decreasing temperature
Wettable soil

(C) Burned
Wettable layer
Water repellent layer
Wettable soil

after DeBano, 1981
The Hydrologic Cycle

- More rain reaches the ground (loss of canopy and litter layer)
- Soil water repellency reduces infiltration
- Less transpiration with plant mortality
- Overland flow greatly increases
- Stream flow greatly increases
Post-fire Erosion

- Erosion increases both on hillsides and in stream channels
- All mechanisms of erosion are enhanced (wind, water, gravity) as resistances are removed
- Water-driven erosion is particularly enhanced because of the extra runoff
Ecosystem Services

- How do we value chaparral?
- Culturally determined
Ecosystem Services

- How do we value chaparral?
- Culturally determined

What do we lose if it’s missing?
2. Erosion on Chaparral Hillslopes

- Processes and Mechanisms
- Erosion Rates
- Fire Effects
Hillslope Erosion Processes

Gravity
- Dry ravel

Wind
- Mass movement

Water
- Rainsplash
- Sheetwash
- Rilling
Rates of Hillslope Erosion in Chaparral

- **Dry Season** – 1 to 65 Kg/m/year (~2)

- **Wet Season** – 2 to 56 Kg/m/year (~3)

- For a 1000 m stream, that’s a delivery of 10,000 Kg/year!
Fire Effects on Hillslopes

- Loss of vegetation and litter
- Changes in soil properties
Post-fire Erosion

Dry Ravel

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Post-fire Erosion

Rilling
Rates of Post-fire Hillslope Erosion

- **Dry Season** – 2 to 600 Kg/m/year (~15)
- **Wet Season** – 3 to 750 Kg/m/year (~50)

- For a 1000 m stream, that’s a delivery of 130,000 Kg/year!

- Return to baseline conditions in 1 to 2 years
3. Erosion in Chaparral Watersheds

- Processes and Mechanisms
- Erosion Rates
- Fire Effects
Processes of Stream Erosion

- Delivery of sediment from the hillsides and water from the soil mantle
- Concentrated power of turbulent flow
- Vertical erosion of the stream bed
- Horizontal erosion of the stream banks
- Episodic transport and temporary storage
Mechanisms of Stream Transport

- **Dissolved load** – solutes
- **Suspended load** – fine particles
- **Saltation load** – bounce along the stream bed
- **Bed load** – rolled along the stream bed
Sediment Yield

- Discharge of sediment at a watershed outlet
- Combination of hillslope and stream erosion
- An integrated average across all sections of the watershed
Rates of Sediment Yield in Chaparral

- Extremely variable
- Watershed size matters
- Dry Years – Zero
- Wet Years – 3 to 150 m³/ha/year
Fire Effects on Watersheds

- Loss of vegetation and litter
- Changes in soil properties
- Extra delivery of water and sediment from the hillsides
Post-fire Erosion

Headwater Stream Scour

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Post-fire Erosion

Small Stream Erosion

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Post-fire Erosion

Debris Flows
Post-fire Erosion

Debris Flows

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Rates of Post-fire Sediment Yield

- Smaller Watersheds – 30 to 40 m³/ha/year
- Larger Watersheds – 300 to 600 m³/ha/year
- Return to baseline conditions – it depends!
Post-fire Sediment Yield

From Rowe et al, 1949

Years Since Burning

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Long-term Sediment Yield

Source: L.A. County
4. Physical Ecosystem Services

What do we lose if chaparral is missing?

- Water Supply and Purification
- Soil Productivity
- T&E Species and Habitat Protection
- Sediment/Flood Retention
Runoff increases . . . but it is heavily bulked with solids and potential contaminants.
Soil Productivity

- Poor soil quality
- Loss of topsoil
- Loss of nutrients
T&E Species and Habitat Protection

- Riparian species especially at risk
- Adapted to a dynamic environment
- Watershed fragmentation
Sediment/Flood Retention

Flood control structures, debris basins, and reservoirs . . .

costly to construct and costly to maintain
Sediment/Flood Retention

Threats to life, property, and infrastructure . . .

to downstream human communities
Summary

- Background
- Erosion on chaparral hillslopes
- Erosion in chaparral watersheds
- Physical ecosystem services in chaparral