Erosion and Physical Ecosystem Services in Chaparral

Peter M. Wohlgemuth

USDA Forest Service
Research and Development

Second Southern California Chaparral Symposium
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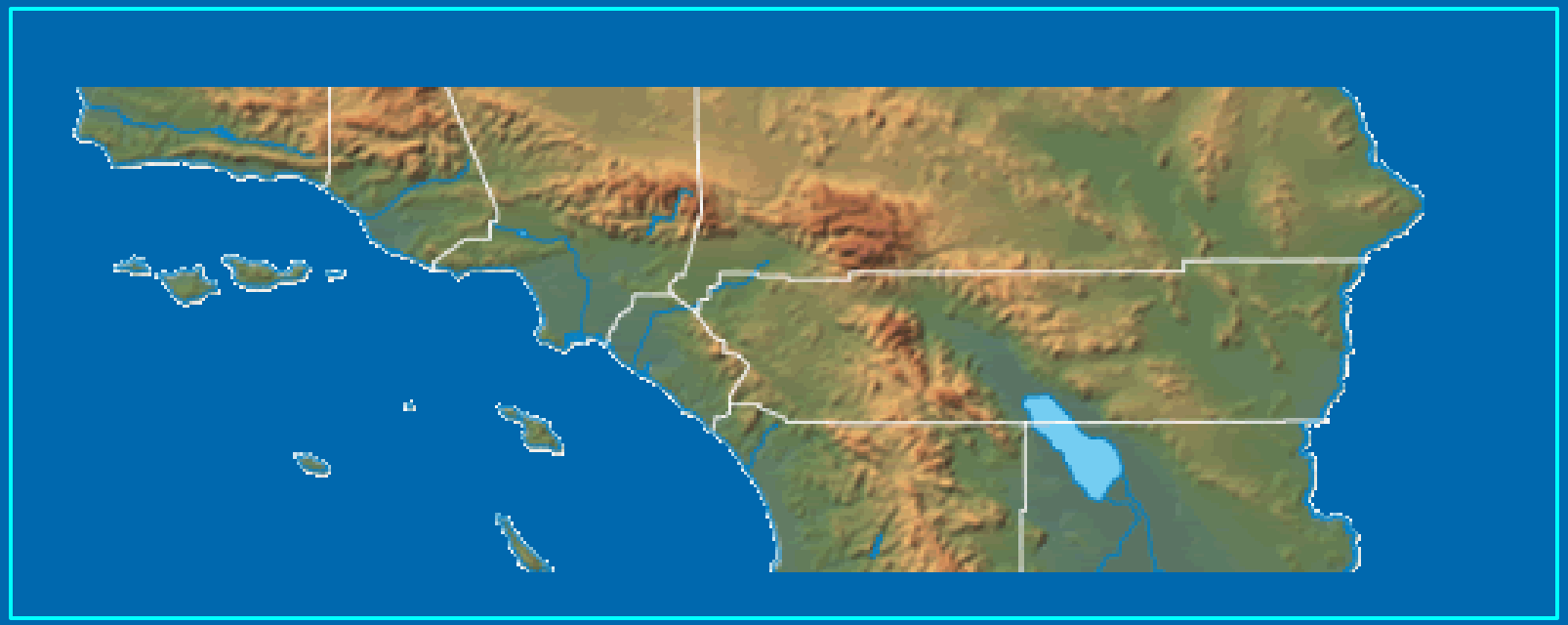
Outline

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

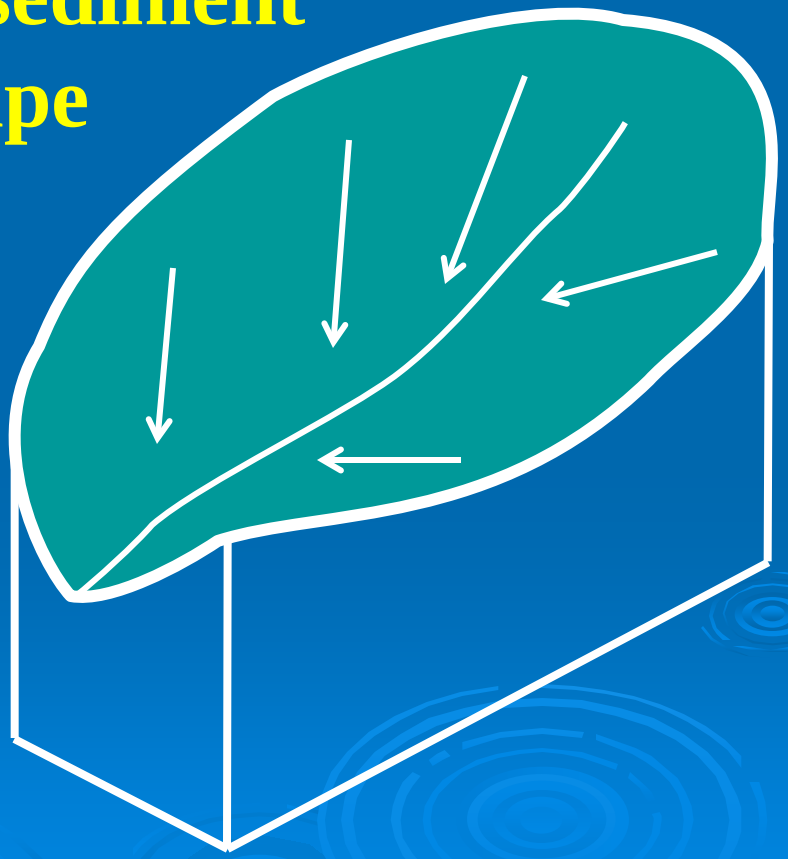
- Occurs when the available forces overcome the soil resistances (ground cover, soil characteristics, inertia)

Erosion in Chaparral Watersheds

Movement of water and sediment through the landscape

Hillsides

Streams



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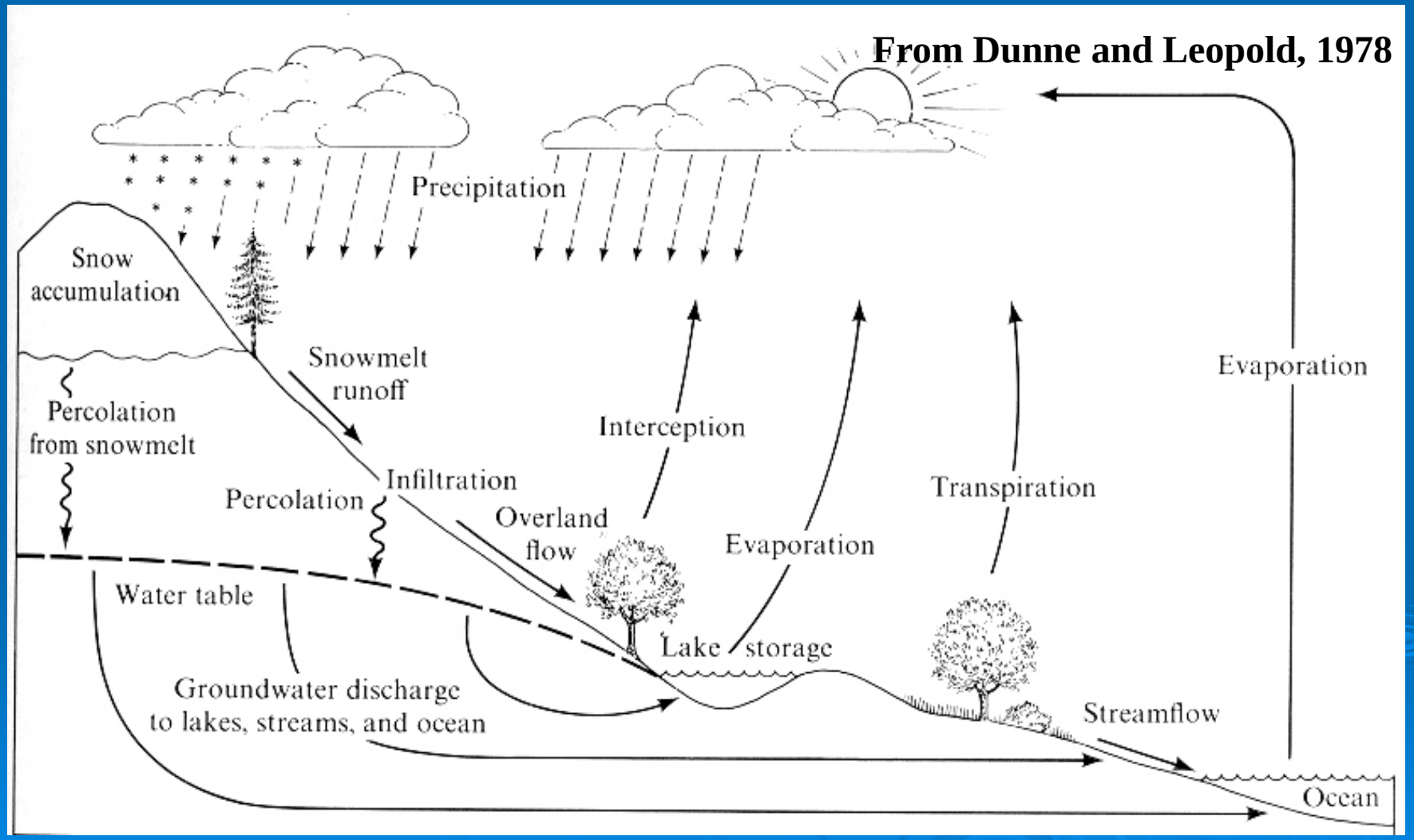
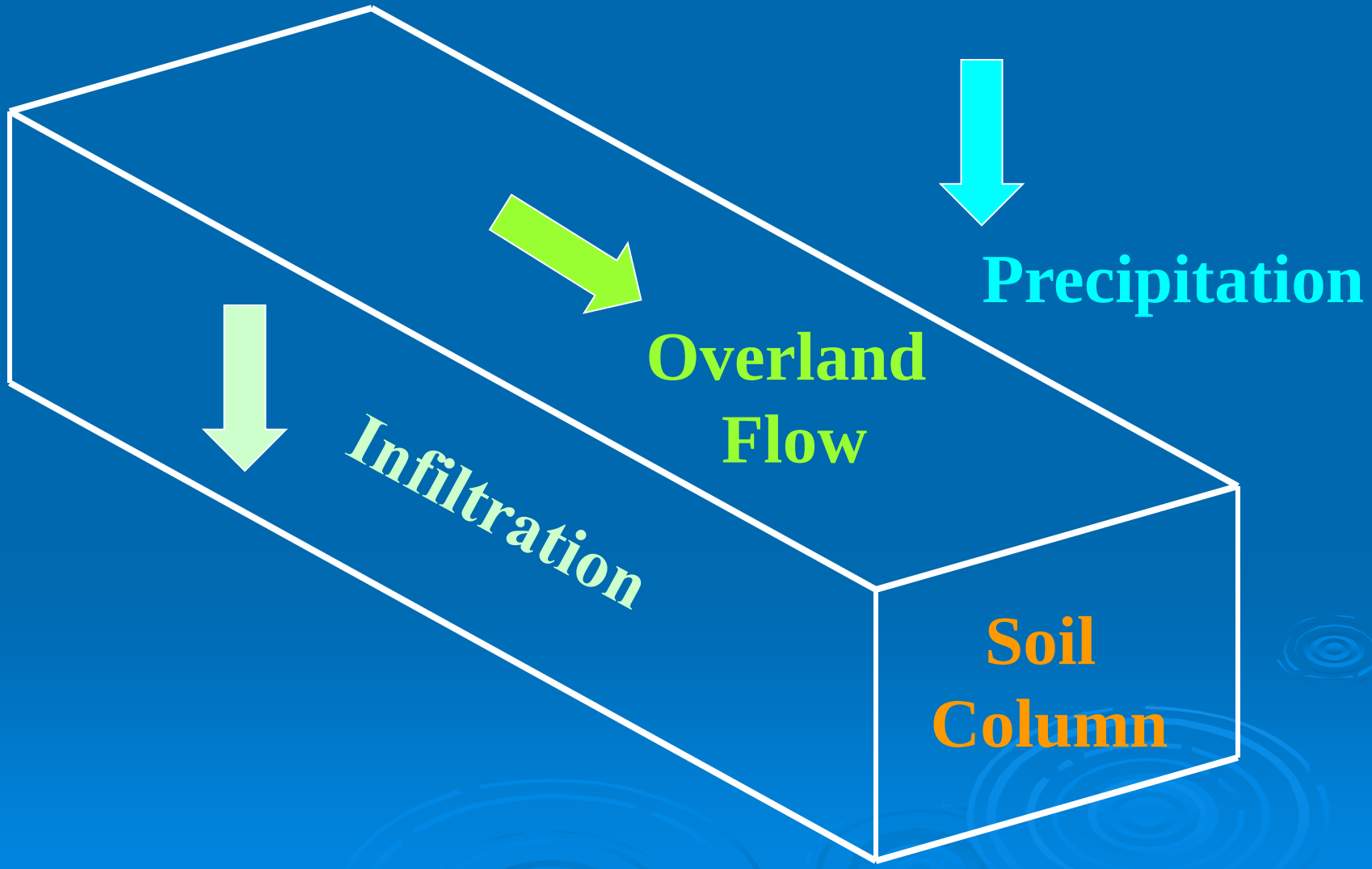
The Hydrologic Cycle



Infiltration/Overland Flow



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

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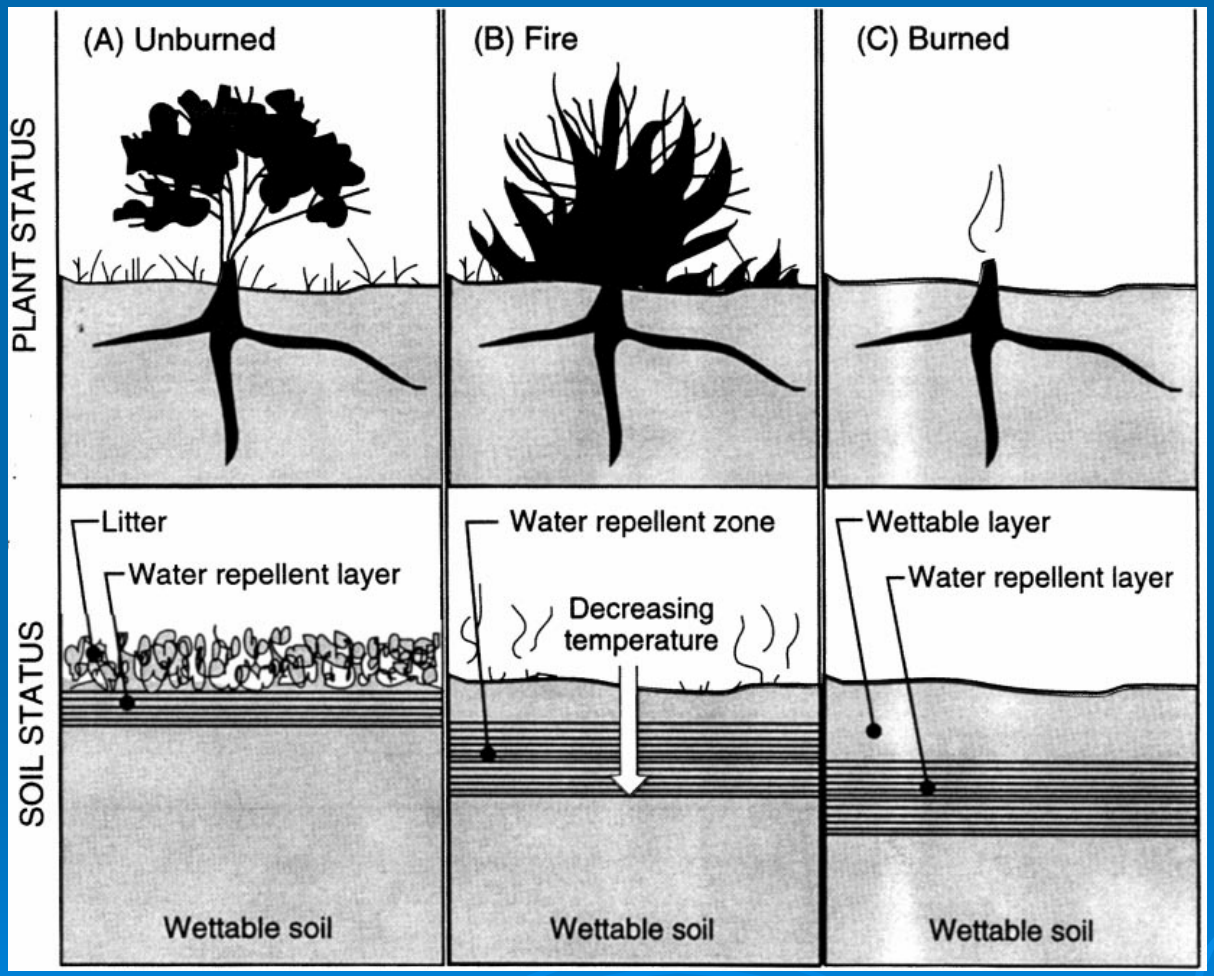
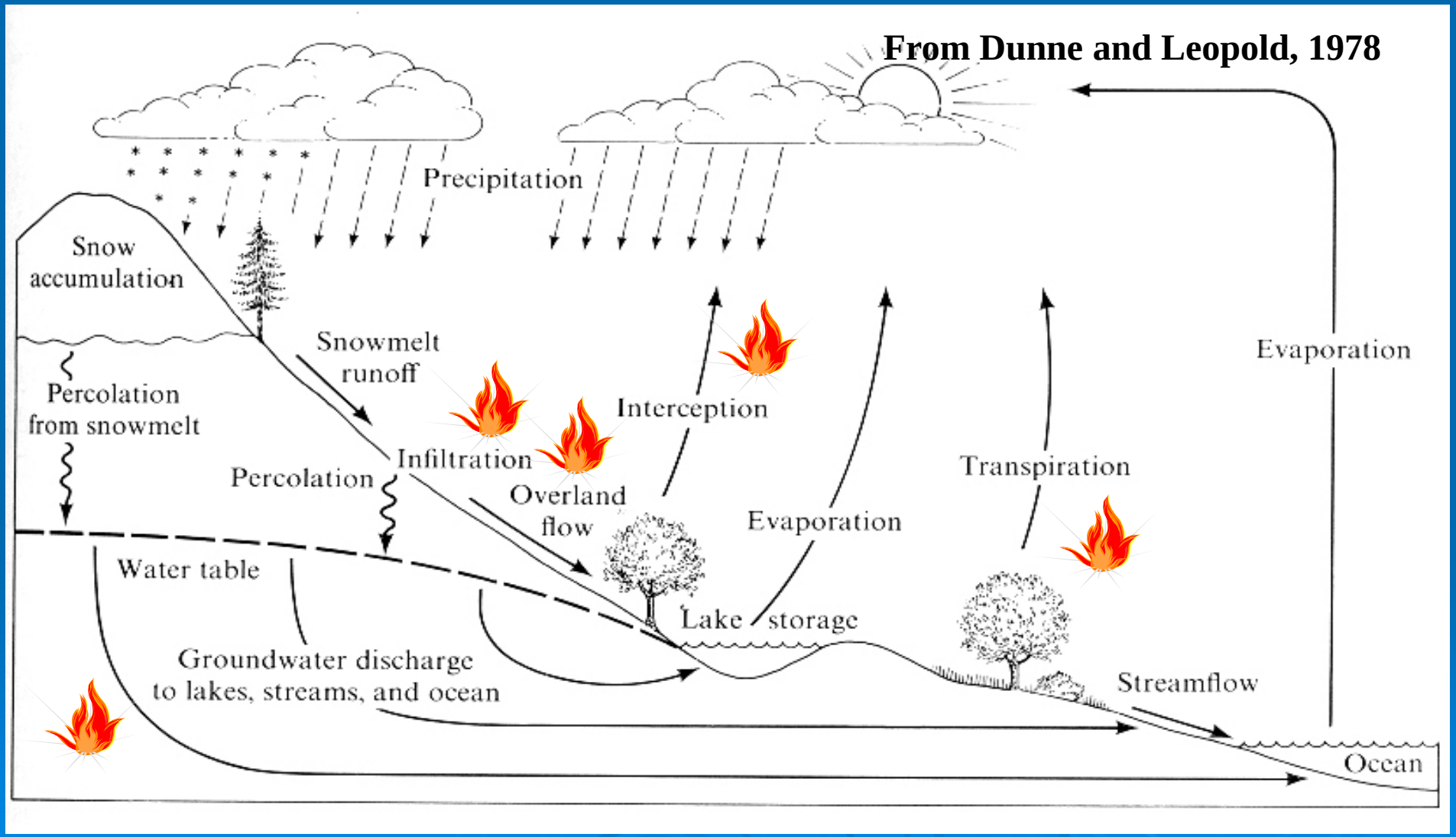
Water Repellent Soils



after DeBano, 1981

The Hydrologic Cycle



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	Wind	Water
Dry ravel		Rainsplash
Mass movement		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 m^3/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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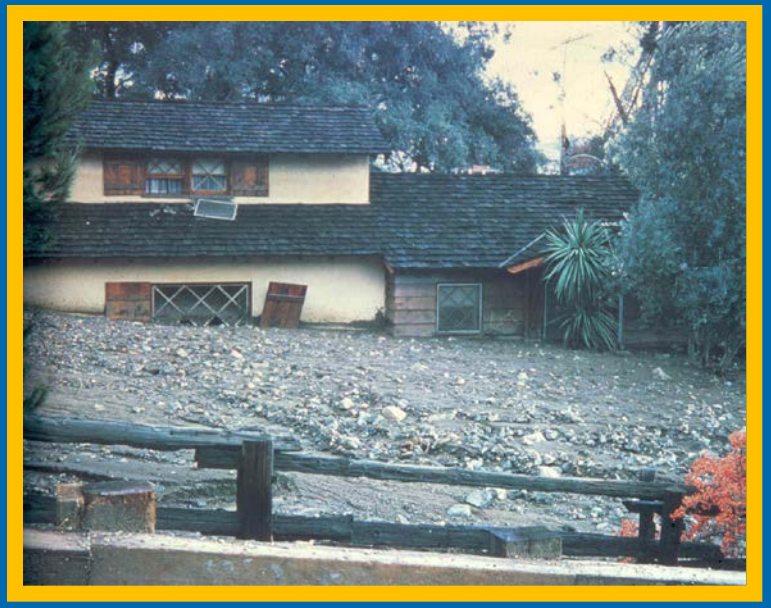
Post-fire Erosion

Debris Flows

Post-fire Erosion



Debris Flows

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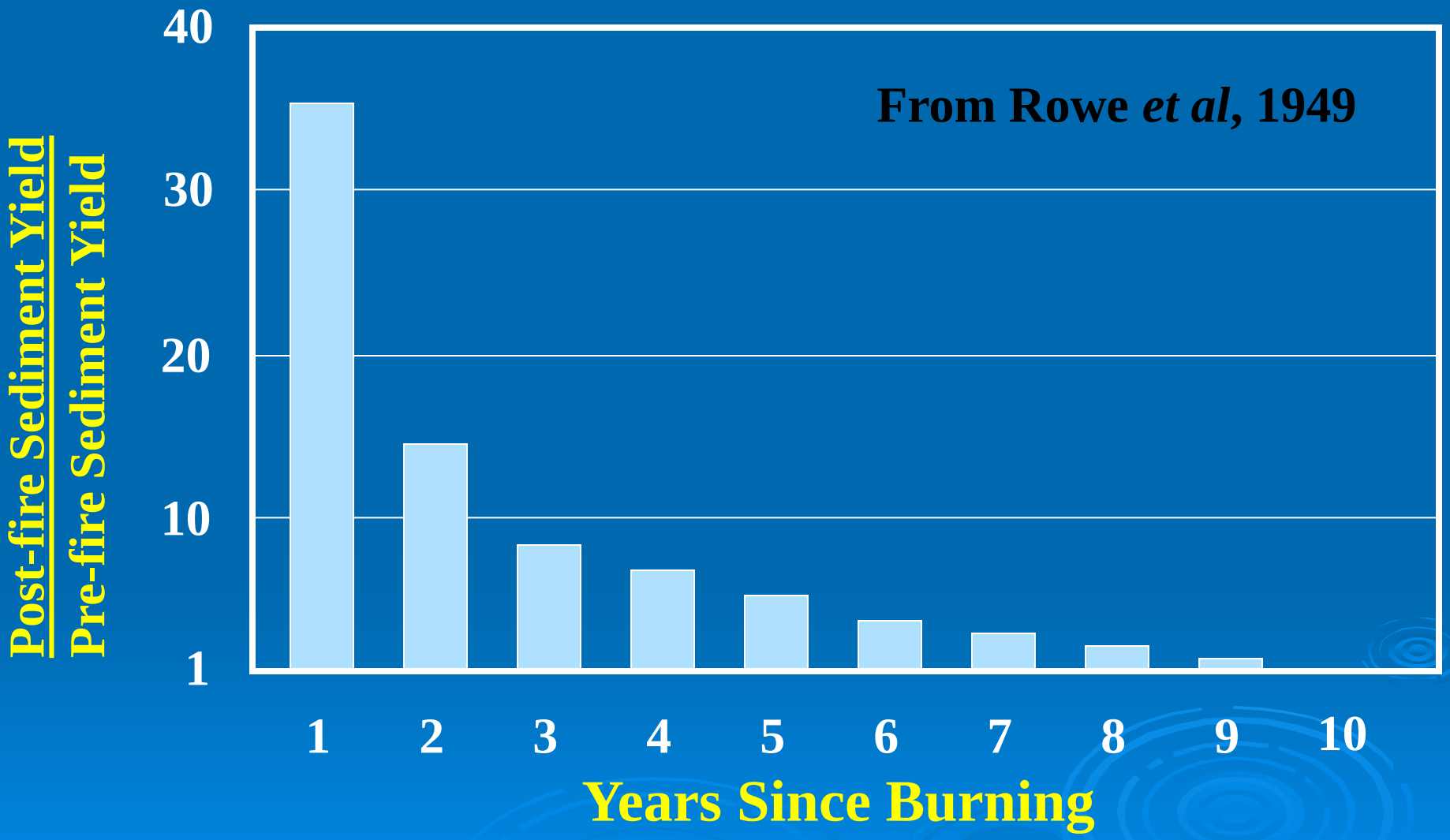
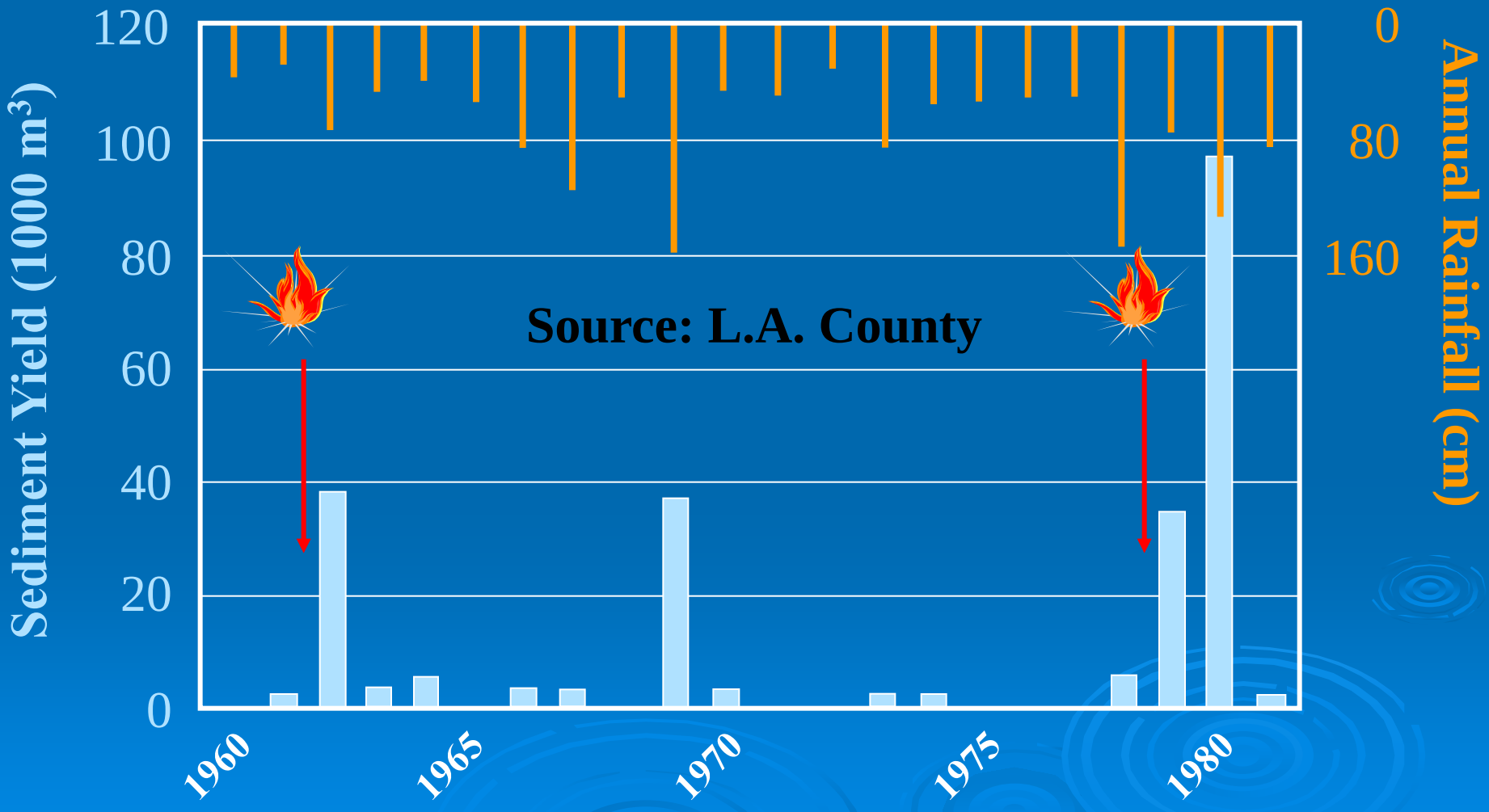
Rates of Post-fire Sediment Yield

- **Smaller Watersheds – 30 to 40 m^3/ha/year**
- **Larger Watersheds – 300 to 600 m^3/ha/year**
- **Return to baseline conditions – it depends!**

Post-fire Sediment Yield



Long-term Sediment Yield



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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**

Water Supply and Purification

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