Introduction: Dry Ravel

Dry Ravel is the movement (rolling, bouncing, and sliding) of soils and rock particles due to gravity. It is a dominant process in steep, dry environments (Gabet, 2003). Wildfire frees ravel stored by vegetation roots and stems. Ravel accumulates at the bases of steep slopes effectively pre-loading channels with sediment and material that can be transported during the next storm.

• The model uses DEM data, soil parameters, pre-fire plant parameters and fire severity. The model assumes ravel moves by sliding.

• Modeled ravel is generated by two sources:
  1. Ravel held by plant stems, modeled as tetrahedrons.
  2. Soil particles held on slopes by roots.

Basic Equations:

\[ a = (g \sin \alpha - g \tan \beta \cos \alpha) \]

\[ a_x = a \frac{\tan \alpha_x}{\tan^2 \alpha_x + \tan^2 \alpha_y} \]

\[ v_{out} = v_{sin} + a_x t \]

\[ t = \frac{v_{sin}^2 + a_x X - v_{sin}}{a_y} \]

\[ g = 9.8 \text{ m/s}^2; \text{ gravity} \]

\[ a = \text{acceleration} (\text{m/s}^2) \]

\[ t = \text{time} (\text{s}) \]

\[ X, Y = \text{distance} (\text{m}) \]

\[ v = \text{velocity} (\text{m/s}) \]

\[ \alpha = \text{slope angle (deg)} \]

\[ \beta = \text{kinetic friction angle (deg)} \]

\[ \gamma = \text{static friction angle (deg)} \]

Code:
The model works by looping through all potential source cells. If ravel is mobilized in a source cell, it travels through down slope cells until coming to rest. Movement is entirely controlled by slope and friction angles. Ravel moves in two dimensions and can turn to follow the steepest slope.

Field Data

• Observations are from four small watersheds in the San Dimas Experimental Forest. Each watershed contains 25 production and 50 deposition traps.

• Traps have a 0.3 m opening. Production traps are scaled by source area (m²) and deposition traps are scaled by trap opening.

• Observations greater than the mean plus two standard deviations were removed from the dataset.

• Post fire ravel measurements were taken after the Williams Fire (2002) and a prescribed fire (2001).

Dry Ravel Inputs:

• DEM
- 10 Meter Digital Elevation Map.
• Burn Severity Map
- Resampled to 10 Meter grid to match the DEM
- Each Burn Severity was optimized to a burn depth
• Parameter file
- Mean stem diameter of vegetation (0.05 m)
- Vegetation density (1 plant/m²)
- Burn Depths (m)
- Bulk density of soil (1300 kg/m³)
- Static friction angle (34°)
- Kinetic friction angle (31.1°)

Dry Ravel Outputs:

• Dry Ravel Outputs
- Burn Depths were optimized using a particle swarm algorithm. The optimized burn depths were reasonable in that the low burn severity burn depth was the smallest and the medium burn depth was slightly larger and the high burn severity was the largest.

Model Development

Calibration

• Optimize burn depth for each watershed and burn severity in order to match modeled production to observed production values for each trap.

• Calculate Nash-Sutcliffe efficiencies (NSeff) with observed (O) and modeled (P) production values for each watershed.

Results

• Burn depths were optimized using a particle swarm algorithm. The optimized burn depths were reasonable in that the low burn severity burn depth was the smallest and the medium burn depth was slightly larger and the high burn severity was the largest.

Future Plans

• Integrate vegetation density maps into the input to replace the highly sensitive burn depth.