

Nutrient and Sediment Loading Predictions for Prescribed Fire Using Optimized WEPP Model

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Background and Problem

- Limited knowledge about impacts from pile burning on water quality
- Limited knowledge about impacts of spatial and temporal variability of soil hydrophobicity
- Filling these knowledge gaps has been identified as a priority research need
- And of course, the TMDL

Objectives

- Optimize WEPP's most sensitive soil parameters
- Predict sediment and nutrient loads from burn piles
- Volcanics and granitics
- Spring and Fall (investigate seasonal hydrophobicity)

Why WEPP?

- Hillslope-scale
- Runoff, erosion, sediment yield, and particle size sorting predictions
- Average annual, return period, and event predictions
- Particle size sorting allows for VFS (<16um) calcs
- Runoff predictions allow for nutrient load calcs

Optimizing WEPP

■ Rainfall simulations

- Hydraulic conductivity (infiltration rate)
- Interrill erodibility (overland flow and rain splash)
- Runoff and sediment nutrient quality*
- Soil Texture

■ Rill runoff simulations

- Rill erodibility (concentrated flow)

* Used to calculate nutrient loads

Rainfall and Rill Runoff Simulations

- 4 Sites
 - 2 Volcanic
 - 1 Mixed Colluvium
 - 1 Mixed Glacial Outwash

- 2 Seasons
 - Spring and Fall
 - 2 Forest + 4 Burn Piles per site per season

Volcanic Colluvium Optimization Results

| | Ki (10^6 kg s m^{-4}) | Kr (10^{-3} s m^{-1}) | K sat (mm hr $^{-1}$) | ortho-P (mg L $^{-1}$) | Ads P (mg L $^{-1}$) | Ammonia (mg L $^{-1}$) | Nitrate (mg L $^{-1}$) |
|---------------|--------------------------------------|--------------------------------------|---------------------------|----------------------------|--------------------------|----------------------------|----------------------------|
| Fall Forest | 1.28 | 0.019 | 3.2 | 0.65 | 379 | 0.04 | 0.09 |
| Fall Burn | 2.55 | 0.291 | 12.4 | 1.04 | 37 | 2.79 | 1.58 |
| Spring Forest | 2.20 | 0.019 | 48.0 | 0.16 | 303 | 0.13 | 0.10 |
| Spring Burn | 1.70 | 0.291 | 29.0 | 0.35 | 513 | 0.81 | 0.32 |

Mixed Glacial Outwash Optimization Results

| | Ki (10^6 kg s m^{-4}) | Kr (10^{-3} s m^{-1}) | K sat (mm hr $^{-1}$) | ortho-P (mg L $^{-1}$) | Ads P (mg L $^{-1}$) | Ammonia (mg L $^{-1}$) | Nitrate (mg L $^{-1}$) |
|---------------|--------------------------------------|--------------------------------------|---------------------------|----------------------------|--------------------------|----------------------------|----------------------------|
| Fall Forest | 49.00 | 0.039 | 3.5 | 0.08 | 738 | 0.13 | 0.59 |
| Fall Burn | 3.50 | 1.985 | 13.8 | 0.36 | 110 | 0.25 | 0.24 |
| Spring Forest | 49.00 | 0.039 | 50.0 | 0.18 | 64 | 0.15 | 0.29 |
| Spring Burn | 3.50 | 1.985 | 32.0 | 0.35 | 85 | 0.25 | 0.25 |

Mixed Colluvium

Optimization Results

| | K _i (10 ⁶ kg s m ⁻⁴) | K _r (10 ⁻³ s m ⁻¹) | K _{sat} (mm hr ⁻¹) | ortho-P (mg L ⁻¹) | Ads P (mg L ⁻¹) | Ammonia (mg L ⁻¹) | Nitrate (mg L ⁻¹) |
|---------------|---|---|--|----------------------------------|--------------------------------|----------------------------------|----------------------------------|
| Fall Forest | 0.65 | 0.036 | 3.5 | 1.03 | 112 | 0.04 | 0.33 |
| Fall Burn | 1.40 | 0.527 | 13.8 | 0.86 | 217 | 3.00 | 0.57 |
| Spring Forest | 0.65 | 0.036 | 50.0 | 0.30 | 837 | 0.24 | 0.45 |
| Spring Burn | 1.40 | 0.527 | 32.0 | 1.22 | 118 | 0.52 | 0.44 |

Ksat Results

- Fall volcanic forest < burned (75% less) with forest and burned soil saturations at 65% and 18%, respectively
- Volcanic forest and burned increased from fall to spring (1400% and 134%, respectively)
- Within first year, volcanic burned increased to ~ 60% of forest (spring values)
- Little difference between volcanic and mixed glacial outwash spring values: function of texture?

Modeling Methods and Assumptions

- Burn pile length 12 ft
- Spacing between piles 12 ft
- Forest length 12 ft
- Width 12 ft
- 50% cover (rock, ash, char)
- Seasonal hydraulic conductivities held constant
- 100-yr climate : annual and summer /fall (Oct – Nov)
- No vegetation growth or senescence

Sediment Loads (lbs/yr)

| | | Summer/Fall | | Annual | |
|-----------------------|-----------|-------------|--------------------|--------|-----------------|
| | Slope (%) | Forest | Burn Pile | Forest | Burn Pile |
| Volcanic Colluvium | 10 - 50 | 0 | 0.01 - 0.65 | 0 | 0 - 0.02 |
| Mixed Colluvium | 10 - 50 | 0 | 0 - 0.02 | 0 | 0 |
| Mixed Glacial Outwash | 10 - 25 | 0 | 0 | 0 | 0 |

Adsorbed P Loads (mg/yr)

| | | Summer/Fall | | Annual | |
|-----------------------|-----------|-------------|-------------------|--------|----------------|
| | Slope (%) | Forest | Burn Pile | Forest | Burn Pile |
| Volcanic Colluvium | 10 - 50 | 0 | 0.1 – 10.8 | 0 | 0 – 3.8 |
| Mixed Colluvium | 10 - 50 | 0 | 0 – 2.4 | 0 | 0 |
| Mixed Glacial Outwash | 10 - 25 | 0 | 0 | 0 | 0 |

ortho-P Loads(mg/yr)

| | | Summer/Fall | | Annual | |
|-----------------------|-----------|-----------------|-----------------|------------------|----------------|
| | Slope (%) | Forest | Burn Pile | Forest | Burn Pile |
| Volcanic Colluvium | 10 - 50 | 11 - 97 | 51 - 196 | 0.2 – 0.9 | 6 - 8 |
| Mixed Colluvium | 10 - 50 | 16 - 144 | 36 - 146 | 0 | 16 - 21 |
| Mixed Glacial Outwash | 10 - 25 | 0 | 0 | 0 | 0 |

Ammonia Loads (mg/yr)

| | | Summer/Fall | Annual | | |
|-----------------------|-----------|---------------|------------------|--------|----------------|
| | Slope (%) | Forest | Burn Pile | Forest | Burn Pile |
| Volcanic Colluvium | 10 - 50 | 1 - 6 | 137 - 526 | 0 - 1 | 13 - 18 |
| Mixed Colluvium | 10 - 50 | 1 - 6 | 125 - 508 | 0 | 7 - 9 |
| Mixed Glacial Outwash | 10 - 25 | 2 - 12 | 10 - 32 | 0 | 3 - 5 |

Nitrate Loads(mg/yr)

| | | Summer/Fall | | Annual | |
|-----------------------|-----------|---------------|-----------------|--------------|--------------|
| | Slope (%) | Forest | Burn Pile | Forest | Burn Pile |
| Volcanic Colluvium | 10 - 50 | 1 - 13 | 78 - 298 | 0 - 1 | 5 - 7 |
| Mixed Colluvium | 10 - 50 | 5 - 46 | 24 - 97 | 0 | 6 - 8 |
| Mixed Glacial Outwash | 10 - 25 | 9 - 53 | 10 - 31 | 0 | 3 - 5 |

Questions or Comments?

Thank you!

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