Forest Soil Erosion Processes and Prediction

Thanks to Bill Elliot, Research Leader U.S. Department of Agriculture Forest Service
Objective of Presentation

- To present an overview Forest Soil Erosion Processes
Surface Runoff

Precipitation or melting snow

Infiltration

Deep Seepage

Surface Runoff

Groundwater

Evapotranspiration

Snow Interception & Sublimation

Shading

Lateral Flow
Disturbances add Complexity

- Climate
- Vegetation
- Geology/Soils
- Topography
- Human and Natural Disturbances
- Runoff
- Erosion
- Sustainability
- Water Quality
Elliot’s Principles of Erosion

- If it doesn’t rain, it doesn’t erode [by water]
- If it rains and doesn’t run off, it still doesn’t erode!
- Undisturbed forests erode very little.
- Most people are not concerned about forest erosion… unless that eroded sediment reaches a channel!
Forest Disturbances

- Wildfire
  - Wildfire Fire lines
Forest Disturbances

- Wildfire
- Forest roads and trails
Forest Disturbances

- Wildfire
- Forest roads and trails
- Timber Harvest
Forest Disturbances

- Wildfire
- Forest roads and trails
- Timber Harvest
  - Site preparation
    - Prescribed Fire
    - Tillage
Forest Disturbances

- Wildfire
- Forest roads and trails
- Timber Harvest
  - Site preparation
    - Prescribed Fire
    - Tillage
- Biomass Utilization
Onsite impacts of Timber or Biomass harvest

- Loss of ground cover
  - Increases runoff
  - Increases surface and channel erosion
Onsite impacts of Timber or Biomass harvest

- Loss of ground cover
- Compaction
  - Increases runoff
  - Increases surface and channel erosion
Onsite impacts of Timber or Biomass harvest

- Loss of ground cover
- Compaction
- Concentration of runoff
  - Increases runoff
  - Increases surface and channel erosion
- Increases road soil erodibility by 4 to 5 times
Historically, erosion research was on *agricultural* lands
- Frequently disturbed from tillage
- Methods to predict average annual erosion rates were developed
- Little concern about sediment delivery to streams
The Universal Soil Loss Equation:

- Developed from agricultural plots
- Predicts average annual erosion
The Universal Soil Loss Equation:

- Developed from agricultural plots
- Predicts **average annual erosion**
- Depends on climate, soil, topography, crop, and conservation practices
  - $A = R K L S C P$
- Sediment delivery prediction is not well developed
Problem with Average Annual Erosion

- In forests, only the road network erodes every year.
- Undisturbed forests have minimal or no erosion.
- Forests erode when disturbed every 10 to 100 years (or longer) by:
  - Harvesting & Site Preparation
  - Wildfire
Problem with Average Annual Erosion

- Forests erode when disturbed every 20 to 100 years (or longer) by
  - Harvesting and Site Preparation
  - Wildfire
- Erosion rate in year of disturbance depends on the weather for that year, NOT the average weather
  - Most erosion occurs in years with severe weather
Problem with Average Annual Erosion

- Forests erode when disturbed every 20 to 100 years (or longer) by
  - Harvesting
  - Wildfire

- Erosion rate in year of disturbance depends on the weather for that year, NOT the average weather

- Forests recover very quickly following fire or harvest
Forest Erosion Modeling Needs: Science

- Estimation of upland erosion
- Estimation of sediment delivery
- Ability to consider **variability** in weather the year of a disturbance
- Ability to consider **cumulative affects**, where only a part of a watershed is disturbed each year.
WEPP Improvements for forests

- Expanded WEPP Model for Forests
  - The Water Erosion Prediction Project
    - Models erosion processes
      - Infiltration, Runoff and Soil Water Balance
      - Erosion, Deposition & Delivery of Sediment
      - Plant growth and residue accumulation and decomposition
  - Improved the winter processes
  - Improved the hydrology to include lateral flow on steep slopes
  - Collected field data to determine the input variables for soil
US Forest Service WEPP Modeling

- We expanded the WEPP Model for Forests
  - The Water Erosion Prediction Project
- We collected field data to determine the input variables for soil
- We developed a U.S. climate database for remote climates
- We developed online interfaces to make WEPP easy to use
Forest Service WEPP Interfaces for Roads

- **WEPP:Road** – Describes road templates with greater detail, including road travel way runoff and sediment yield
- **WEPP:Road Batch** for multiple segments

http://forest.moscowfsl.wsu.edu/fswepp/
Forest Service WEPP Interfaces for Disturbed Forested Hillsides

- Disturbed WEPP – For forest management, fire effects, and rangeland predictions
Other Forest Service WEPP Interfaces for Disturbed Forested Hillsides

- **Disturbed WEPP** – For forest harvesting, fire effects, and rangeland predictions
- **ERMiT** – For wildfire single storm and mitigation analysis
- **WEPP FuMe** – For Fuel Management Synthesis

Output summary based on 50 years of possible weather

<table>
<thead>
<tr>
<th>Line</th>
<th>Source of sediment</th>
<th>Sediment delivery in year of disturbance (ton mi(^{-2}))</th>
<th>Return period of disturbance (y)</th>
<th>&quot;Average&quot; annual hillslope sedimentation (ton mi(^{-2}) y(^{-1}))</th>
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<tr>
<td>1</td>
<td>Undisturbed forest</td>
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<td>1</td>
<td>0</td>
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<td>2</td>
<td>Wildfire</td>
<td>780.8</td>
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<td>Prescribed fire</td>
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<td>20</td>
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<tr>
<td>4</td>
<td>Thinning</td>
<td>0</td>
<td>20</td>
<td>0.0</td>
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<td>5</td>
<td>Low access roads</td>
<td>0.5 to 2.6</td>
<td>1</td>
<td>0.5 to 2.6</td>
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<tr>
<td>6</td>
<td>High access roads</td>
<td>1.7 to 4.2</td>
<td>1</td>
<td>1.7 to 4.2</td>
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</tbody>
</table>
Limitations to WEPP

- Scale may be too small
  - WEPP hillslope good for up to 100 acres
  - WEPP Watersheds up to 5 sq km
  - Users frequently want 10 sq mi + watersheds
- Work still needed on snow interception, flood routing, and sediment transport
Summary

- Forest soil erosion is caused by disturbances like roads, fire, and timber harvest.
- Biomass removal may increase erosion if not carefully managed.
- Modeling tools have been developed for forests which may be useful to international forest managers.