Sediment Transport Prototypes

Novel Methods to Disconnect Forest Roads from Streams

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Sediment Originating from Unpaved Forest Roads

Why is it important?

Sediment from forest roads is a concern for aquatic habitats, regulated by EPA

Endangered Species Act

Threatened salmonid species in Willamette and Lower Columbia Basins (NMFS 2015)

• Chinook Salmon
• Chum Salmon
• Coho Salmon
• Steelhead
Research Objective

For a small, field scale, test track with sediment control treatments

Observe and Quantify

1) Sediment transport leaving surface aggregate
2) Physics of sediment generation in surface aggregate
3) Treatment efficacy – benefit, service life, construction

During wet-weather hauling conditions
Hypotheses

- Filtration devices will provide a sediment sequestration benefit.
- Geogrid reinforcement will improve aggregate performance (reduce rutting).
Dunn Research Forest

Reconstructed 120 ft section of road

- 6 treatments
- 12 ft x 20 ft sections
- Insloped towards ditch
- 2 aggregate varieties
Runoff Collection Trench

- **Direction of Truck Traffic**
- **Simulated Rainfall**
- **Flexible PVC water bar with buried wood support**
- **Impermeable channel liner to provide confinement**
- **12” layer of aggregate, unbound at road surface**
- **Geogrid reinforcement beneath channel liner (Geo-treatments only)**
- **Runoff collected for laboratory analysis**
Methods

Field Testing

Runoff Collection Flume

ISCO Pump Sampler

Sprinklers ~ 0.60 in/hr
Analytical Methods

- Turbidity
- Suspended Solids
- Screening/Sieving
- Data Logger
- Permeability
- Rutting
Turbidity and Suspended Solids Concentration

Turbidity
- ISCO pump samplers
- Turbidimeter
- Drying ovens

Sample Stats
- 220,000 NTU
- 160,000 mg/L

Suspended Solids
## Aggregate Degradation

### Methods

- Mechanical Screen
- Wet Sieve

### Table: Pre-Test vs. Post-Test

<table>
<thead>
<tr>
<th>Size</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>d &gt; 2&quot;</td>
<td>d &gt; 2&quot;</td>
<td></td>
</tr>
<tr>
<td>2&quot;</td>
<td>2&quot;</td>
<td></td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>1 1/2&quot;</td>
<td></td>
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<tr>
<td>1&quot;</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>1/2&quot;</td>
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<tr>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
<td></td>
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<tr>
<td>1/4&quot;</td>
<td>1/4&quot;</td>
<td></td>
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<tr>
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<tr>
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<tr>
<td>No. 40</td>
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<tr>
<td>No. 100</td>
<td>No. 100</td>
<td></td>
</tr>
<tr>
<td>No. 200</td>
<td>No. 200</td>
<td></td>
</tr>
</tbody>
</table>

Modified from Coop et al. 2004
Subgrade Pressure

WG* – well-graded
PG* – poorly graded
**C – Control
**B – Biomass
**G – Geotextile

Data Logger

Truck 1
Truck 2

WG* – well-graded
PG* – poorly graded
**C – Control
**B – Biomass
**G – Geotextile

PGC  PGB  PGG
WGG  WGB  WGC

Photo: Ben Leshchinsky
Test Track After 600 Truck Passes

Photo: Ben Leshchinsky
Turbidity and Suspended Solids Concentration (SSC)
Turbidity and SSC Time Series

**Turbidity**

- **Well-Graded Aggregate**
  - Control
  - Geotextile

- **Poorly-Graded Aggregate**

**Suspended Solids Concentration**

- **Well-Graded Aggregate**

- **Poorly-Graded Aggregate**
Permeameter Testing

<table>
<thead>
<tr>
<th>Filtration Treatment</th>
<th>Filter Sand Only</th>
<th>Filter Sand and Geotextile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent treatment</td>
<td>2 % SSC</td>
<td>2 % SSC</td>
</tr>
<tr>
<td>Influent turbidity (NTU)</td>
<td>6,600</td>
<td>6,600</td>
</tr>
<tr>
<td>Max. effluent turbidity (NTU)</td>
<td>2,200</td>
<td>1,200</td>
</tr>
<tr>
<td>Min. turbidity reduction</td>
<td>67 %</td>
<td>82 %</td>
</tr>
<tr>
<td>Time to peak concentration (min)</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

Geotextile sequestered sediment but did not clog system.
Permeability Testing

What does a geotextile cost

Fabric $1.25 per sq. yrd
Geogrid $1.50 per sq yrd

Results

Conclusion
Aggregate Degradation

Aggregate degradation is a function of truck traffic.
Rutting – Inside Wheel Track

Results

**48 Passes**

- WG
- WGG
- PGG
- PG

**100 Passes**

**200 Passes**

**300 Passes**
Subgrade Pressure

Geotextile reinforcement $\equiv$ Lower subgrade pressure
**Results**

**Sediment Delivery**

Sediment lost per road section by mass (mg) and by percent of available moveable material.

<table>
<thead>
<tr>
<th>Passes</th>
<th>WGC1</th>
<th>WGC2</th>
<th>WGG</th>
<th>PGG</th>
<th>PGC2</th>
<th>PGC1</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>406,563</td>
<td>618,534</td>
<td>727,012</td>
<td>454,275</td>
<td>881,358</td>
<td>784,976</td>
</tr>
<tr>
<td>300</td>
<td>1,246,993</td>
<td>4,530,937</td>
<td>3,301,831</td>
<td>3,476,684</td>
<td>3,945,009</td>
<td>4,214,700</td>
</tr>
<tr>
<td>600</td>
<td>4,265,394</td>
<td>10,996,594</td>
<td>7,031,671</td>
<td>N/A</td>
<td>7,233,863</td>
<td>7,313,456</td>
</tr>
</tbody>
</table>

- **100 Passes**: 406,563, 618,534, 727,012, 454,275, 881,358, 784,976
- **300 Passes**: 1,246,993, 4,530,937, 3,301,831, 3,476,684, 3,945,009, 4,214,700
- **600 Passes**: 4,265,394, 10,996,594, 7,031,671, N/A, 7,233,863, 7,313,456

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**Graphs**

- **WGC1, WGC2, WGG**
  - 100 Passes: 0%, 1%, 2%
  - 300 Passes: 1%, 1%, 1%
  - 600 Passes: 1%, 1%, 1%

- **PGC1, PGC2, PGG**
  - 100 Passes: 0%, 0%, 0%
  - 300 Passes: 0%, 0%, 0%
  - 600 Passes: 0%, 0%, 0%
Findings – Sediment Transport

- Sand filter berm system:
  - Can provide a > 70% reduction in turbidity under appropriate service conditions (no road failure)
  - Recovered to base turbidity within 20 minutes
  - Can extend time to peak concentration
  - Poorly-graded rock transports a greater percentage of available moveable material
Findings – Sediment Generation

• Geogrid reinforcement:
  • Decreased rutting for well-graded rock
  • Reduced relative breakage in poorly-graded rock
• Lower subgrade pressure for both aggregate varieties
• Aggregate degraded in proportion to truck traffic
Application

- Log truck traffic roads
  - Reduce peak turbidities and SSCs from traffic
  - Extend time to maximum concentration
- Non-roadside installation
  - In-ditch construction
- Road-stream crossings
Filter Berm Specification

- Geotextile AOS: 0.2 mm (No. 80 sieve)
- Ensure adequate anchoring
- Ensure anchoring is flush with native subgrade
- Min. height of 6”
- Min. 3” taller than adjacent prism
- Replace when berm is visibly punctured or failing
Conclusion

Outputs

• MS Degree in Water Resources Engineering
  • Two poster presentations (won award from WFGRS)
  • Two oral presentations (won award from WRS)
• Undergraduate mentorship
• Manuscript under review
• Performed research in College Forests
  • Site used for teaching and outreach field trips
Questions?

References

