Sediment Transport Prototypes: Novel Methods to Disconnect Roads from Streams

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Project duration
Project was completed June 2015 with successful defense of M.S. thesis. Investigators are in the process of submitting a publication for peer-review to International Journal of Forest Engineering.

Objectives
Project objectives remained consistent with those outlined in the original proposal. This investigation sought to determine if there is a difference in sediment produced and transported away from six different road prism configurations in order to reduce real and potential sediment delivery to adjacent streams and other aquatic habitat. Specific goals within this framework include:

- Determine if a relationship exists, and quantify such a relationship if it exists, between road materials/configuration and sediment production within road prism under wet weather hauling conditions.
- Determine if a relationship exists, and quantify such a relationship if it exists, between road materials/configuration and sediment transport to adjacent roadside ditch under wet weather hauling conditions.
- Evaluate the efficacy of each road configuration design considering both the cost and constructability of the road design with potential sediment sequestration benefit over the useful lifetime of the road.
- Report findings for peer review and publish results.

Summary of accomplishments toward objectives over past year
Over the past year the project has completed all laboratory sample processing of field data from six different road configurations, all laboratory tests of treatment methods, and all analysis of data and results. These milestones have included:

- Electronic compilation of raw field data including:
  - Clegg impact values
  - Undrained shear strength of soil
  - Simulated rainfall measurements
- Truck traffic start and stop times
- Road rutting depth
- Lateral spreading of wheel tracks

- Processing and tabulation of field data including:
  - Soil moisture from subgrade core samples
  - Turbidity and suspended sediment concentration from road runoff samples
  - Subsurface pressure from traffic loading
  - Particle size distribution of aggregate sample bags

- Data manipulation and compilation including:
  - Subgrade pressure time series and maximum pressure per load
  - Hardin relative breakage values for each aggregate sample bag

- Follow-up laboratory testing of sand filtration berm using permeameter
- Sediment budget comparing loss of available mobile material from each road section

All data analysis and conclusions have been made after repeated review and discussion with principal and co-investigators. This led to additional milestones in the completion of Erica Kemp’s master’s degree including:
- Oral presentations at scientific symposia
- Completion of master’s thesis
- Presentation of thesis and successful defense of work

After graduation from Oregon State University, Erica Kemp has drafted a publication currently under review in *International Journal of Forest Engineering*.

**Problems, barriers, proposed changes to objectives**

Feedback from successful and unanimous approval of thesis defense included suggestions for additional analysis and work. This discussion prompted the addition of a sediment budget into the proposed publication article.

**Comprehensive summary of project results and impacts over life of project**

Field testing evaluated the efficacy of two treatment methods intended to both filter road runoff by sequestering sediment and reduce sediment generated in the road prism by reinforcing the native subgrade material. Effluent material from each road section showed strong periodicity corresponding with the onset and termination of truck traffic. The strong signal from the truck traffic eclipsed any would-be field indicators of filtration treatment efficacy, therefore laboratory tests were performed to determine the filtration benefit of the geotextile and filter sand berm road treatment. This periodicity suggests that treatments for road systems are most critical during periods of heavy traffic only.

Filtration tests run in a permeameter revealed a substantial reduction in effluent turbidity when treated with the filtration sand and geotextile. If implemented correctly, this treatment can reduce turbidity by over 70 percent of influent loading levels. When turbid influent was followed by clean influent, the permeameter effluent recovered to base turbidity levels within 20 minutes. While this treatment was labor intensive to construct, the benefits may outweigh the extra cost of implementation in stream-adjacent road segments or in targeted in-ditch construction. Baseline specifications for implementation are provided.

The geogrid reinforcement laid over the native subgrade material improved load distribution for both well-graded and poorly-graded aggregate material. Geogrid reinforcement reduced
rutting in well-graded aggregate but increased rutting poorly-graded aggregate. Additionally, the geogrid reinforcement reduced relative breakage in poorly-graded aggregate but provided no discernable benefit in well-graded aggregate. While this treatment was easy to install and could easily be placed over large areas, applications should be targeted based on aggregate variety and the benefit desired as rutting and breakage improvements were not universal among aggregate types tested. Such a system may reduce the effects of pumping on very weak subgrades.

Finally, the test road section remains as a demonstration area for research in the College Forest.
All aggregates degraded in proportion to truck traffic. While both aggregate varieties produced fine materials as a result of degradation, the poorly-graded aggregate lost a greater percentage of available mobile material than the well-graded aggregate. While this seems counter-intuitive considering the well-graded aggregate contained much more fine material, it lends itself to agreement with similar studies finding an ideal fines concentration among aggregates to minimize sediment transport. Thus, use of well-graded aggregate can result in less leaching of fine-grained material during hauling. However, if poorly-graded aggregate is used, it is best to have some sort of diversion or filtration structure when stream-adjacent or stream-crossing.

Study results show a substantial benefit to the use of filter sand and non-woven geotextile material to sequester fine sediments and filter turbid runoff. The use of geogrid reinforcement universally lowered subgrade pressures among two aggregate varieties, but improvements in rutting and relative breakage of aggregate material was dependent on aggregate variety. A sediment budget showed that the percent of fine material present in a road aggregate influences the amount of sediment transport possible via road runoff. Combined data sets resulted in specifications for a filter berm system for reducing sediment loading from hauling (see below). This system is intended for the shoulders of roads, but could be effective for ditch treatments as well.

**List of names and brief overview of graduate and/or undergraduate engagement in project**

Over the past year, Erica Kemp completed laboratory sample processing and testing with the help of undergraduates Chris Hale and Hunter Goguen. She also completed her master’s thesis entitled *Sediment Transport Prototypes: Novel Methods to Disconnect Forest Roads from Streams* which was successfully defended and electronically uploaded to the OSU Scholars Archive.

**List of presentations, posters, etc.**

- Western Forestry Graduate Research Symposium at Oregon State University
  - 2014 Poster Presentation  Won 2nd Place Overall Poster Presentation
  - 2015 Oral Presentation
- Hydrophiles Water Research Symposium at Oregon State University
  - 2014 Poster Presentation
  - 2015 Oral Presentation  Won Hydrophiles Best Master’s Oral Presentation
- April 2015: Presentation to Civil Engineering Class of 2015 at George Fox University
- On June 1st, 2015, Erica presented and successfully defended this research to complete her Masters of Science degree in Water Resources Engineering.

**List of publications, thesis citations**
