What We Have Learned from the SWCC Roads-Sediment Monitoring

SWCC Aquatics Working Group (2016)

Background:

The SWCC Aquatics Working Group started with a focus on roads and sediment because those were major justifications and restoration goals for the SWCC and CFLRP; and because there was intense disagreement among specialists, districts, and forests about the relevance of road derived sediment in streams. We set out to inform that debate with new information that should help guide management. We note that sediment being delivered from roads is not the only ecological issue associated with roads; it was just the first we investigated.

We also started with the intention of developing a landscape perspective. That is, we wanted to draw inferences about watershed and/or native fish population scale processes. Can restoration actually create a measureable and ecologically relevant response at these scales? The CFLRP was intended to be "landscape" restoration rather than a disconnected collection of projects and this is a critical element of any relevant monitoring design. There were four key components to our approach:

1st Component: We concluded early on it was unlikely we could measure effects of individual restoration projects in stream channels directly because of natural variability, long temporal lags, confounding effects of other disturbances, and the relatively small effects of individual or even collective projects. As a first approach to the problem, we chose to validate the underlying conceptual model: roads -> sediment -> stream habitat, by linking the best possible estimates of road sediment delivery (GRAIP) for entire watersheds to existing in-channel conditions (PIBO). If the model holds and can be quantified empirically, it could be used to inform the question of how much restoration is needed to have a meaningful effect at a watershed scale.

2nd Component: Because of the anticipated difficulty of detecting in-channel effects of individual or even multiple projects we concluded that monitoring site-level process (i.e., road segment erosion and sediment delivery) rather than stream channel response should be used to monitor restoration effects directly. If a complete inventory of road conditions in the watershed were available (i.e., using GRAIP), those effects could be put into a landscape perspective (i.e. how much have we reduced total sediment delivery in the watershed).

3rd Component: Because the full GRAIP inventory is expensive and time consuming, it is unlikely that it can be used across the entire Southwest Crown landscape. GRAIP-Lite has been developed as an alternative set of GIS based models that can be used to estimate the GRAIP results for un-sampled watersheds. GRAIP-Lite depends on calibration from representative watersheds and sediment plots that are part of the normal GRAIP process. Conceivably, GRAIP-Lite could be used to identify potentially important road related sediment sources.

4th Component: In other work with local schools, we learned that stream turbidity is associated with significant nutrient export that may influence water quality of downstream lakes and streams. We questioned whether the relative concentrations and export of suspended sediment (measured as turbidity), and major nutrients (total N and total P) varied across streams in the Southwest Crown and whether those characteristics might be used for water quality monitoring in response to road, forest, and watershed restoration actions. We were particularly interested in simple metrics and procedures that could be implemented through citizen science with the local community and students. We implemented a one year pilot study to explore these questions. We used both GRAIP and GRAIP-Lite results to correlate estimates of road sediment delivery with in-stream measures of water quality.

What we have learned:

- The data indicate that the conceptual model linking road related sediment delivery and channel substrate is right, but we have very few samples with high sediment delivery. The results indicate that fine sediments in stream channel substrate vary substantially, but are present in higher levels in watersheds with the highest sediment delivery (*Figure 1*).

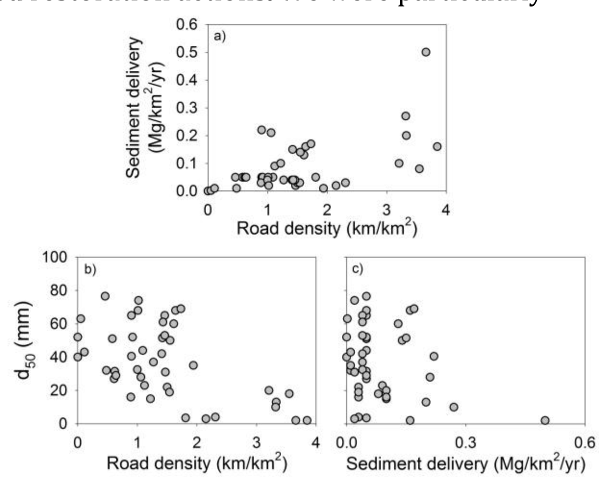


Figure 1. Relationship of fine sediment in-stream with road density and sediment delivery from roads.

- Measured sediment delivery from roads in our watersheds is low relative to expected background levels and other geologies (*Table 1*); it tends to be concentrated in a small proportion of road segments and delivery points (*Figure 2*). The low levels can be attributed to low base-erosion rates (geology); low road-stream connectivity (geomorphology and glacial history); and low traffic/road use. The latter may be particularly important since it can change with management.

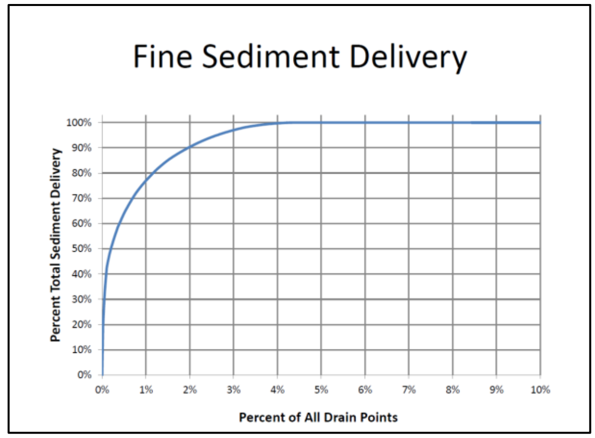


Figure 2: Cumulative sediment delivery as % road drain points.

Table 1. Comparison of sediment delivery rates of differing background geologies surveyed with GRAIP.

	Seeley Lake RD, Lolo NF, MT	Bear Valley, ID	Payette NF, ID	Umatilla NF, OR	Siuslaw NF, OR
Connected Road length (%)	4	13	17	27	4
Road Sediment Delivery (%)	4	10	20	26	3
Specific Sediment Delivery (Mg/km^2)	0.15	0.46	5.50	0.045	0.20
Base Erosion	7	18	18	2	79
Rate (kg/m)	3.2 (non-jammer)	0.9	1.7	3.2	2.1

- GRAIP estimates showed a positive association with the GRAIP-Lite estimates for available samples, though GRAIP-Lite tends to overestimate the GRAIP results. There were no associations between GRAIP-Lite estimated sediment delivery and water quality parameters.

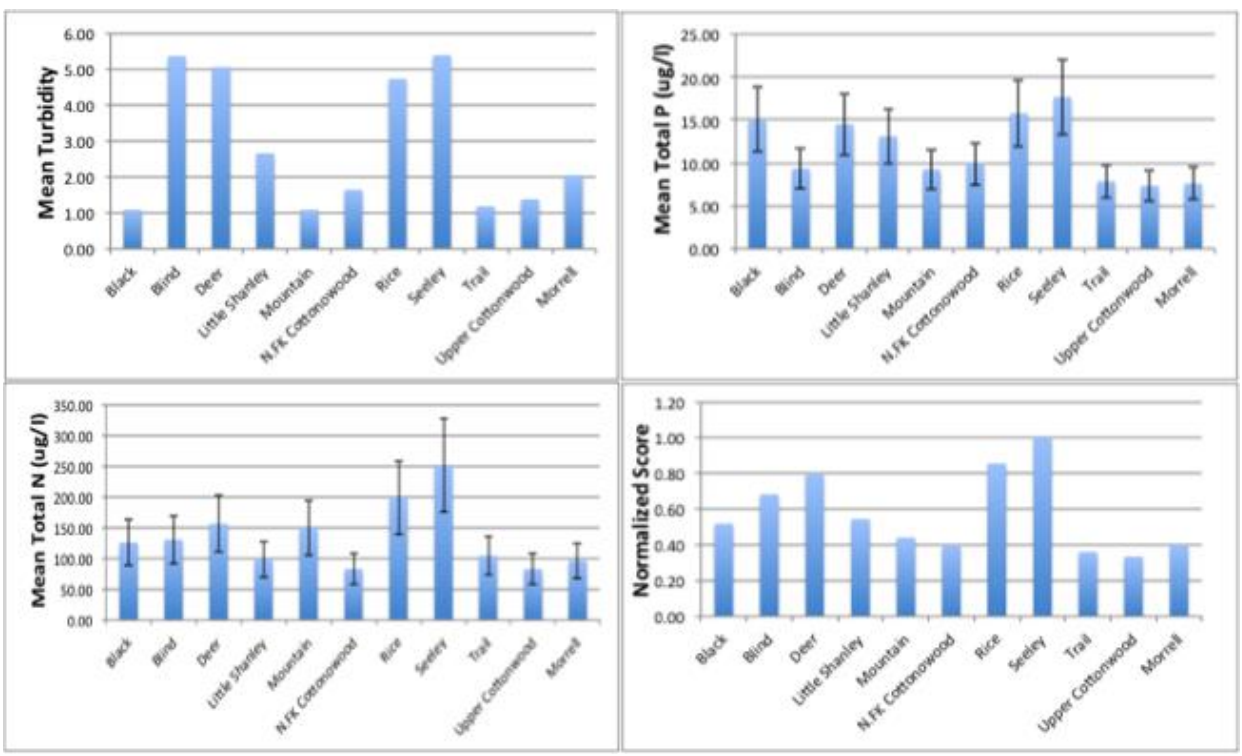
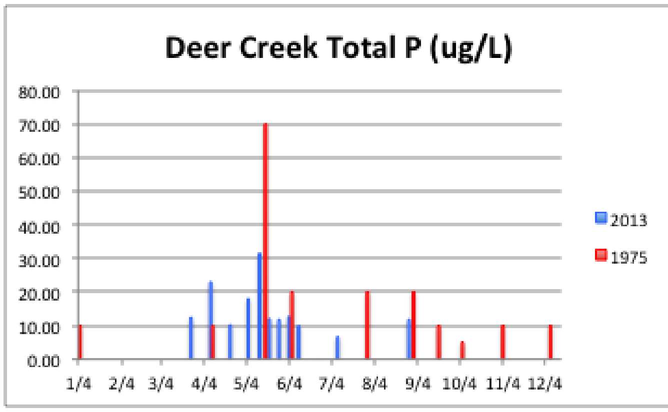


Figure 3. Mean turbidity (NTU), total P (µg/l), total N (µg/l), and the normalized mean score for all three metrics for 11 intensively sampled streams in 2013. The approximate 95% CI are shown as vertical bars for P and N.

- Water quality measured by turbidity, total nitrogen and total phosphorous ranged widely among and within the intensively sampled streams (*Figure 3*). Total phosphorous was strongly associated with turbidity and suspended sediment. Although estimates of road-derived sediment were not associated with water quality, roads in some small tightly connected watersheds clearly did influence turbidity. It may be that roads have a more important influence on very fine suspended sediment, turbidity and nutrient loading than can be measured in the current GRAIP sediment plots and erosion models.
- Poor water quality in several streams in the 1970s was associated with intensive logging. At least one of those watersheds appears to have recovered substantially in the last 40 years (*Figure 4*). The results suggest that intensive management may have an effect that we do not see under current conditions, and that recovery can occur with time.



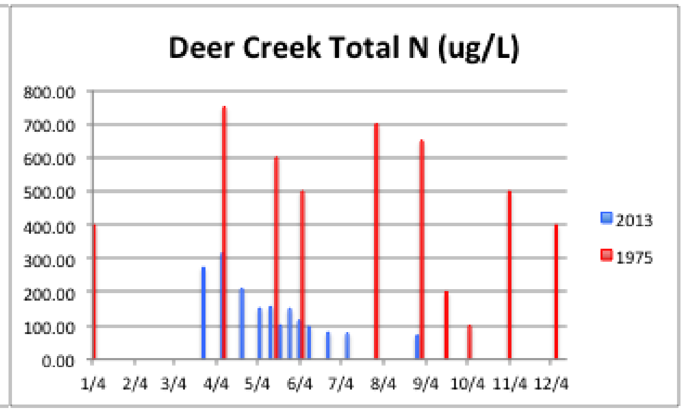


Figure 4. Concentrations of total P and and total N in Deer Creek sampled in 1975 and 2013.

- Students and volunteers collected important water quality information that would not have been possible with a limited budget. The intensive sampling produced consistent, high quality information and provided the foundation for comparisons among streams and through time at a fraction of the cost anticipated through more traditional staffing. The work with schools has provided wider recognition of the CFLR and leveraged work in additional sites and communities.

Management Implications:

- In-channel fine sediments varied widely among streams even with low road densities. Watersheds with high road densities were more likely to have high levels of fine sediment, but GRAIP results show that not all road segments are equally important. **Take home point:** *Not all roads are equal.*
- With the data collected to date, much of what can be done to reduce sediment delivery to stream channels can be addressed by focusing on some critical points in the road network, especially at or near stream crossings. **Take home point:** *The existing road generated sediment risks identified by full GRAIP assessments may be mitigated to a substantial degree through strategic replacement/ up-grade of problem crossings, and relocation of some tightly connected road segments. Application of geospatial tools like GRAIP/GRAIP-Lite can help managers focus attention on the critical places in the road network.*

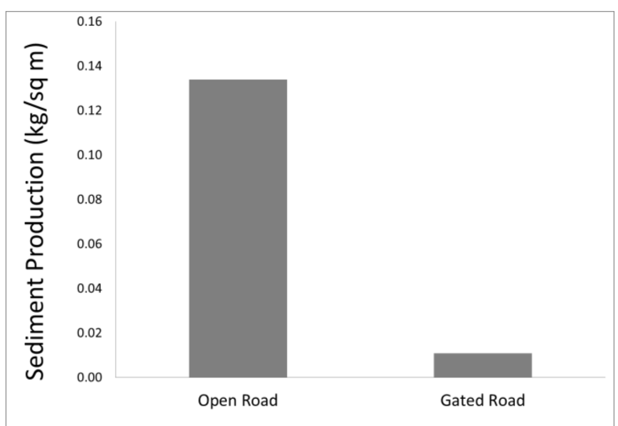


Figure 5: Sediment from open and gated roads 2012-2014.

- Increased traffic associated with intensive management could result in increases in erosion and sediment delivery (*Figure 5*). **Take home point:** *For some roads, managing road use and road closures could provide important benefits without complete road obliteration.*

- The effects of some road segments on streams are likely to be amplified with hydrologic events, such as fire, large thunderstorms, and rain-on-snow events that have not been observed in the period of our work. **Take home point**: *Episodic events are likely to occur and should be monitored afterwards to understand their effect on stream channels in the SW Crown.*
- Very fine sediment that influences turbidity and the export of phosphorous may not be reflected in the GRAIP sediment plots, or in the PIBO measures of channel substrate. **Take home point**: *Relatively simple and inexpensive water quality sampling using citizen volunteers may be an effective approach to monitoring watershed conditions.*
- **Final Take home point**: *Roads can have important hydrologic and ecologic effects other than the disruption of channel substrates. The focus of SWCC CFLR on roads and sediment influencing fish habitat should be broadened to consider other effects.*

Findings published in:

Al-Chokhachy, R., Black, T.A., Thomas, C., Luce, C.H., Rieman, B., Cissel, R., Carlson, A.A., Hendrickson, S., Archer, E.K., and Kershner, J.L. 2016. Linkages between unpaved forest roads and streambed sediment: why context matters in directing road restoration. Restoration Ecology doi: 10.1111/rec.12365.

Rieman, B. and Wallenburn, J. 2014. Water quality monitoring to determine the influence of roads and road restoration on turbidity and downstream nutrients: a pilot study with citizen science. Final Report for the Southwest Crown CFLRP, Project agreement #12-PA-11011600-039. Available online: http://www.swcrown.org/monitoring/aquatics-monitoring/

Next steps:

- Maintain 12 existing GRAIP sediment plots and traffic counters.
- Monitor sediment delivery on high traffic roads by placing sediment plots on haul roads that will see major increases in use with planned restoration projects.
- Post-treatment GRAIP work on sites in Cold Creek on Swan Lake District and Cottonwood-Shanley watershed on Seeley Lake District.
- Re-monitor road segments that were adjacent to the Morrell fire or used during suppression.
- Expand water quality monitoring on Clearwater with community citizen scientists. Use high resolution sampling with automated samplers in one or a few sites to help understand the frequency of sampling required for relatively precise estimates.
- Continue water monitoring at Morrell Creek, Elk Creek, and Poorman Creek with local students.

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