Attachment 2

Deposition of Fine Sediment in the Salmon River Watershed, Payette and Boise National Forests, Idaho. Statistical Summary of Interstitial and Surface Sediment Monitoring: 1983-2006.
(report without appendices)

DEPOSITION OF FINE SEDIMENT IN THE SALMON RIVER WATERSHED, PAYETTE AND BOISE NATIONAL FORESTS, IDAHO

STATISTICAL SUMMARY OF INTERSTITIAL AND SURFACE SEDIMENT MONITORING, 1983-2006

Steelhead Redds, East Fork South Fork Salmon River near Yellow Pine, Idaho,
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Abstract

This report updates analyses of interstitial sediment monitoring on the Payette National Forest, and incorporates up to 24 years of monitoring. It is mainly a statistical summary with minimal interpretation, though we have discussed obvious inferences that appeared, and we have provided classification of most sites according to sediment-related WCIs as modified for the SFSR and reference sites in the Chamberlain Basin, and we have identified approximate sediment-related WCIs for the non-granitic portions of the SFSR and Big Creek watersheds. In general, reference sites were characterized by more interstitial space than sites in developed watersheds and reference sites were most often classified as “functioning appropriately” (FA); however, there were many exceptions. The sites in non-granitic watersheds were also typically higher in interstitial space than those in granitic watersheds, which reflects mainly inherent differences due to bedrock characteristics.

A new feature in this report was an effort to develop a method for identifying which sites in what we’ve labeled “bad” years actually had substandard data by identifying statistical outliers that should be omitted from regressions of cobble embeddedness on free matrix. The approach appears to be reasonable as demonstrated with applying it to the 2006 data, and may be useful in upcoming analyses.

We also made some technical corrections to our database that involved reassigning data to site E077 from E142 upon investigation of site characteristics and raw data records. These types of corrections are ongoing as anomalies resulting from these annual analyses are revealed.

As always, this report supersedes previous reports where results overlap. We are continually upgrading and correcting errors in production data, analytic routines, and previous reports. This report represents the epitome of this process at the time it was released.

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Introduction

The genesis and development of sediment monitoring on the Payette National Forest (PNF) is thoroughly described in previous reports (Burns 1984 *et seq.*; Nelson *et al.* 1996 *et seq*.; Ries and Burns 1989; Ries *et al.* 1991). The purpose of this report is to summarize the interstitial and surface sediment monitoring data, exclusive of monitoring specific to grazing allotment management, which is reported elsewhere (Nelson 2007a), collected on the Payette National Forest since 1983. These data can be used to evaluate conditions relative to so-called “Watershed Condition Indicators” (WCIs) promulgated by our revised LRMP (USFS 2003), and as revised by Nelson and Burns (2005) for the South Fork Salmon River (SFSR) pursuant to Endangered Species Act consultation with NOAA Fisheries Service (NMFS 2003); analyses and graphics are displayed to facilitate comparison to the appropriate WCIs.

We also need a method to help determine which cobble embeddedness data from certain years that we have identified as probably containing invalid measurements are most likely to be incorrect, and which are likely to be correct. We have explored this question in a very preliminary sense with this report using analysis of influence statistics in the regression analysis, and believe that it has potential for wider application to our production data to produce more robust comparisons and trend analyses in the future.

This report is also the third[1] in the series for 2007 and completes the first part of the reporting needs for the updated South Fork Salmon River Interactive Report available on CD-ROM[2]. It is also a report that summarizes data from the 11 years since we instituted a rigorous annual pre-season training program that includes classroom instruction in sediment and fish issues and data collection methods as well as field practice; the Microsoft® PowerPoint® training package is also included on the CD-ROM and development of a web-based training module is in development.

[1] The annual Fisheries — Range Monitoring Report has been added to this series this year; it includes temperature monitoring information as well as sediment analyses at some of the same sites included in this report.

[2] Contact Rodger L. Nelson for the interactive report on CD-ROM.

Methods

Study Areas

Study areas are organized here as they were in Nelson *et al*. (2004a), with monitoring sites described as "Primary," "Supplemental" (Appendix 1, Table 4) or "Miscellaneous" (Table 5) depending upon the extent of their records and whether they receive regular monitoring. This classification excludes sites that were specifically created to monitor effects of grazing management on salmonid habitat, but the primary sites and some supplemental sites in the Secesh River watershed are used for that monitoring as well; fuller analysis of grazing management monitoring can be found in Nelson (2007a). We have updated the descriptions of these sites with GPS coordinates where available.

The monitoring sites in the EFSFSR and Monumental Creek were established primarily to monitor the effects of large mines (at Stibnite and Thunder Mountain, respectively), but mining operations in those areas have been discontinued; consequently, except for the reference site on Tamarack Creek in the Frank Church River Of No Return Wilderness (FCRONRW) monitoring at these sites has been discontinued.

Statistical Analyses

Information about sampling methods, statistical procedures, and database quality control/quality assurance is presented in Nelson *et al.* (1997 *et seq.*) and are not reiterated here. Information from discontinued sites that had data collected after production of Nelson *et al*. (1997) was updated in Nelson *et al.* (2004a) and is not included in this report unless additional data have been collected. Thorough discussion of statistical methods was presented in the previous interstitial monitoring report (Nelson *et al*. [2006]) and is not reiterated here; however, we have decided to use the SAS® general linear models procedure (PROC GLM) for all means comparisons, which facilitates standardizing analytical outputs and creating summaries that can be pasted into tables in this report. The results from PROC GLM with only two classes are equivalent to results provided by PROC TTEST (the t-test procedure; SAS® Institute 1989), except that we cannot adjust for unequal variances, an adjustment that has not seemed to be very helpful in any case.

To date, we have simply rejected the entire cobble embeddedness data set for the years in which the regression of cobble embeddedness on free matrix was not significant or otherwise appeared to be incorrect (*i.e.*, where $P>|t|<0.10$ and the coefficients appear to be very different from the usual models; see below)[3]. The rationale for this has been that the cobble embeddedness sampling is more technical and therefore more likely than the free matrix data to be collected incorrectly (Nelson *et al.* 1997). We remain comfortable with this reasoning, but have been dissatisfied with rejecting entire sets of annual data when it seems likely that only a subset of the annual data were actually incorrectly collected. To begin resolving this issue, we ran some simple influence diagnostics on the 2006 data set, which had a marginally significant model ($P=0.0778$) and model parameters that we judged to indicate a poor model (see below). We looked at both Studentized residuals (RSTUDENT) and the DFFITS statistic, a measure of the standard influence of an observation on the predicted value (SAS® Institute 1990). We considered the absolute value of RSTUDENT larger than 2 and values of DFFITS larger than $2 \bullet (p / n)^{½}$ as suggesting outliers or other highly influential points that might

[3] We admit that this includes some professional judgment on our part in the range of $P>0.05$ and $P<0.10$ that is based on experience and a desire to only eliminate data that we are confident are flawed.

indicate improperly collected data[4]. We then refit the regression model without suggested outliers to investigate whether the model was improved without the suspect point.

Surface fines statistics are presented in the statistical tables in Appendix 3 (primary time series analyses) Appendix 4 (statistical summaries), and Appendix 5 (other time series analyses) and time series graphs are presented in Appendix 6, but surface fines are not specifically discussed in the report. We have argued elsewhere that surface fines represent poor salmonid habitat condition indicators (Nelson *et al.* 2004b), and display them here for completeness; however, we continue to caution that visually determining the frequency of fine particles is problematic.

Changes for this Report

The analyses of East Fork South Fork Salmon River (EFSFSR) sites, except for the Tamarack Creek site (E076), have been eliminated, though the statistical summary tables are provided in Appendix 4 and the graphics are provided in Appendix 6; the analyses for the Big Creek sites have been discontinued for the same reason. In addition, the multiple comparisons of embeddedness for the Lower South Fork Salmon River (Lower SFSR) have also been eliminated, in this case because there are no very recent data for two of the sites (Pony Creek [E030] and Elk Creek [E054]); similarly, the embeddedness comparisons for Chamberlain Creek area were eliminated because of the lack of recent measurements on the Chamberlain Creek site (E032).

In the past, the modeling of cobble embeddedness on free matrix has used all available data. Changes to the underlying database have provided an efficient means of restricting the analysis to only the sites that this series of reports has covered (i.e., The SFSR, Chamberlain Basin, and Big Creek); we have done that for this report, which may cause Table 2 to display different results than in past reports, as may ongoing corrections to the production database when errors are discovered.

Display Issues

In Nelson *et al*. (2006) we added visual cues to highlight important information in the statistical summary tables, and we have continued that in this report. The statistical tables display a five-year mean for 30-hoop free matrix and cobble embeddedness, where possible, from the most recent five annual means with colored shading; these means are referred to as "recent," though for some sites with discontinuous records, the data may not have been collected very recently. The color-coding used was: light green for "Functioning Appropriately" (*e.g.*, FA), light blue for "Functioning at Risk" (*e.g.*, FR), and light pink for "Functioning at Unacceptable Risk" (*e.g.*, FUR)[5]; means were rounded to the nearest full percentage for determining the rating. With cobble embeddedness, the data record is somewhat more erratic because we now favor 30-hoop free matrix monitoring over embeddedness, except for maintaining enough embeddedness samples each year for determining the linear relationship between the two indices (*i.e.*, for double sampling). Data used for determining five-year means for comparisons among or between sites are highlighted in the tables by dark shading with light text. Treatment sites are separated from control sites in tables by double lines (═══), and an additional separation is identified in the SFSR Road Reconstruction monitoring site tables between

[4] These diagnostic cutoff values are presented in SAS® Institute (1990); however, the DFFITS value is referenced to another publication that we do not have; p represents the number of model parameters and n represents the number of observations.

[5] In Nelson *et al.* (2006), some of these were inadvertently shaded in light orange.

1994 and 1995 with a solid line (   ) to identify the periods before and after major reconstruction work, respectively.

The overall and recent means shown in the summary tables may not be the same as the means shown in the comparisons tables. This may occur if the period of record differs (*i.e.*, SFSR Road sites are compared for a different period than in the context of the SFSR watershed) but will mainly occur because of a decision to display means in the summary tables based on averaging the data column in the table as opposed to displaying the means from the comparison test in the comparison tables. The comparison test means are based on raw data rather than being computed from annual means.

We have also added visual cues to the time series analysis tables: parameters for statistically significant trends that suggest improving conditions (*i.e.*, toward increased interstitial space) are highlighted in light green (*e.g.*, r^2, whereas significant deteriorating trends are highlighted with light pink (*e.g.*, r^2; non-significant trends have not been highlighted. Furthermore, in the time series graphics, the WCI limits are shown as horizontal reference lines. These lines correspond to the revised free matrix and cobble embeddedness WCI five-year mean values in the upper SFSR, Secesh River, lower SFSR, and Chamberlain Creek. Nelson and Burns (2005) did not propose revised sediment WCIs for the predominantly non-granitic EFSFSR watershed, but they did investigate reference conditions. Using the same mechanism that was used to determine the revised WCIs for the granitic portions of the SFSR, estimated values for WCIs, corresponding to the median and 25th percentile free matrix means from non-granitic reference sites presented in Nelson and Burns (2005) could be derived (Table 1). For the EFSFSR[6]. The horizontal reference lines in the free matrix and surface fines graphics for the EFSFSR reflect these estimated WCI values (*i.e.*, the breaks between the functional groups); however, we have represented the default WCI limits from the LRMP for embeddedness in the EFSFSR. For surface fines, which we have not measured with respect to the LRMP definition as being smaller than 0.85mm, the median and 75th percentiles were plotted as reference lines and approximate functional ratings in Table 1 were indicated in the statistical summary tables. We generally discourage use of surface fines as an indicator of salmonid habitat condition (Nelson *et al.* 2004b), but have included the information here using this approach for consistency with the LRMP but using the WCI derivation method used in Nelson and Burns (2005).

Table 1.—Functional ratings for cobble embeddedness and free matrix WCIs defined in Nelson and Burns 2005) for the granitic portion of the SFSR and approximate ratings for surface fines with approximate ratings for all indicators for non-granitic watersheds (based on 5-year means).

Watershed Type	Watershed Condition Indicator	Functional Category		
		FA	FR	FUR
Granitic	Free Matrix	≥17%	11-17%	<11%
	Cobble Embeddedness	≤32%	32-42%	>42%
	Surface Fines	≤12%	12-18%	>18%
Other	Free Matrix	≥43%	33-43%	<33%
	Cobble Embeddedness	≤19%	19-25%	>25%
	Surface Fines	≤3%	3-6%	<6%

[6] These limits have not been proposed as WCIs, but represent the equivalent limits from the non-granitic reference component of the data analyzed by Nelson and Burns (2005) to define revised WCIs for the granitic portions of the SFSR watershed.

Data Quality Assurance and Quality Control

Previous reports (Nelson *et al*. [1997 *et seq*.]) contain detailed information on database development and data quality control; these documents, and particularly Nelson *et al*. (2006) should be consulted for this information. We continue to examine data in our database and make corrections as needed. For example, we discovered that data collected at site E077 was incorrectly assigned to site E142 from 1996 through 2006[7], which we've corrected (Nelson 2007b)[8]; this investigation also led to incorporation of some data from 1990 that had not yet been integrated with the production database. We also continue to inspect statistical analysis command programs and make corrections as needed; any discrepancies between summary results displayed in this report and that in previous reports should be regarded as corrections. Note that calculated embeddedness values shown should be different because the regression relationship changed. However, it appears that not all of the data from the identified "bad" years for cobble embeddedness data (see below) were removed from the time series analyses; these are corrected here even for sites that have been discontinued.

During preparation of this report, we investigated the cobble embeddedness data collected from 1996 to 2006, inclusive, for instances wherein the embedded diameter exceeded the rock diameter. This situation can only occur if data were incorrectly recorded in the field or incorrectly entered into the database. We encountered 14 instances of this error in 48,462 records (0.03%). While not a comprehensive estimate of the error rate in the database, it does suggest that quality control efforts during data are succeeding. These errors have not been corrected at this time, but are unlikely to have any substantive effect on the reported results; they will be corrected as time permits.

[7] Nelson et al. (1997), in fact, suggested that there might be some variation in the location of sampling assigned to E142; the situation has now been resolved.

[8] This is also reflected in Table 4 where E077 is now identified as a supplemental monitoring site in the Secesh River with E142 reclassified as a miscellaneous site.

Results and Discussion

Relationships Between Free Matrix and Cobble Embeddedness

Basic Double-Sampling Analysis

We have consistently shown that, when properly collected, there is a significant linear relationship between cobble embeddedness and free matrix; we have interpreted a failure to achieve such a relationship as likely indicative of improperly collected embeddedness data Nelson *et al*. (1997, *et seq.*) This rationale supports use of free matrix in those years where the relationship does not exist (Table 2), highlighted in orange) to estimate (predict) the corresponding cobble embeddedness from the 30-hoop free matrix counts, and for estimating cobble embeddedness at those sites where annual embeddedness sampling has been discontinued. Restricting the data set to just the geographic area typically considered in these reports resulted in slightly different relationships that have been reported previously, and also led to repatriation of the 1999 data set as correct data for this area; apparently data from other watersheds were degrading that relationship previously. There were 389 paired samples available for this regression analysis, which resulted in the following linear relationship:

Table 2.—Regressions of cobble embeddedness on relative frequency of free particles from 30-hoop free matrix samples, 1988-2006 (linear equations of the form y = bx + a).

Year	Sample Size (n)	Linear Regression Model: Parameters		Statistics	
		a	b	r^2	Prob>|t|[a]
1988	21	45.83	-0.49**	0.64	<0.0001
1989	73	44.35	-0.45**	0.35	<0.0001
1990	80	46.40	-0.51**	0.37	<0.0001
1991	23	38.03	-0.26†	0.08	0.0990
1992	22	29.96	-0.23	0.06	0.1503
1993	28	32.87	-0.19*	0.12	0.0419
1994	96	27.53	-0.09	0.02	0.1179
1995	27	20.49	0.01	-0.04	0.9655
1996	29	49.58	-0.55**	0.28	0.0017
1997	28	41.55	-0.45**	0.39	0.0002
1998	22	41.98	-0.44**	0.34	0.0028
1999	22	39.48	-0.40*	0.21	0.0189
2000	21	30.27	-0.17	0.02	0.2542
2001	22	41.25	-0.37**	0.28	0.0064
2002	8	37.80	-0.41**	0.66	0.0091
2003	25	39.59	-0.46**	0.39	0.0005
2004	33	46.71	-0.66**	0.41	<0.0001
2005	26	40.85	-0.45**	0.26	0.0049
2006	18	39.81	-0.25†	0.13	0.0806
Accepted[b]	389	44.25	-0.49**	0.41	<0.0001
Overall	624	39.81	-0.38**	0.27	<0.0001

[a] H_o: b=0.
[b] Accepted = Data from years not shown in colored shading.

$$CE = 44.24506 - 0.48520 \bullet FMX \quad (1)$$

where "CE" was predicted cobble embeddedness and "FMX" was percent free matrix particles. This relationship had a coefficient of determination (r^2) of 0.33 and a P-value (probability of a greater absolute value of t based on H_o: b = 0) of less than 0.0001.

Residual Analysis of 2006 Data

The initial regression of cobble embeddedness on free matrix counts using the 2006 data produced a only a marginally significant inverse relationship with a slope that was unexpectedly high (Table 2). Investigation of the residuals (Table 3, next page) indicated that the data for site E077[9] was highly influential and potentially an outlier, and

[9] Initially, the data for this site were encoded as belonging to site E142. Because of this outlier analysis, we visited the site and noticed that it had some peculiarities that could lead to problems with cobble embeddedness data collection, which are described in more detail in Nelson (2007c). Upon further inspection of the monitoring record, it was subsequently discovered that the site visited was E077 and not E142, so the database was corrected as described in Nelson (2007b). Corrected data summaries and graphics for E142 are included in this report.

that this was probably the only data that did not conform to the expected model. The absolute value of the Studentized residual for site E077 exceeded the suggested critical value of 2 and the absolute value of the DFFITS statistic exceeded the critical (absolute) value of 0.667. Thus, we refit the model with the data from site E077 omitted, and derived a more robust model similar to what we would expect:

$$CE = 44.23 - 0.35 \bullet FMX \quad (2)$$

This model had an R^2 of 0.41 and P = 0.0058. One point retained in the corrected model (for site E006) slightly exceeded the critical (absolute) DFITS value but not the critical value for Studentized residuals. The corrected relationship with the outlier shown is displayed in Figure 1. That this point deviated considerably from the value predicted by equation 1 above is clearly seen by the embeddedness trend graphic in Figure 94.

Table 3.—Residual analysis of regression of cobble embeddedness on free matrix using 2006 data (linear model: CE = 39.81 - 0.25 • FMX, P = 0.0806, R^2 = 0.18)[a].

Site Code	Cobble Embeddedness		Influence Statistics	
	Measured	Predicted	RSTUDENT	DFFITS
E134	28.86	35.35	-0.8158	-0.2679
E136	30.17	32.71	-0.3073	-0.0753
E076	18.73	27.26	-1.1313	-0.4896
E054	29.91	30.47	-0.0685	-0.0185
E034	25.58	27.55	-0.2509	-0.1036
E035	30.09	29.11	0.1204	0.0391
E057	33.45	29.43	0.4964	0.1537
E062	29.54	26.21	0.4395	0.2235
E071	27.00	25.85	0.1532	0.0823
E077	16.35	36.44	-3.3153	-1.2871
E081	38.07	33.71	0.5326	0.1406
E116	31.89	36.20	-0.5438	-0.2036
E117	35.19	32.75	0.2941	0.0722
E006	49.12	35.62	1.8482	0.6323
E016	41.11	35.85	0.6618	0.2346
E023	25.33	34.12	-1.1091	-0.3069
E067	48.91	35.21	1.8680	0.6003
E068	40.17	35.63	0.5675	0.1944

[a] CE — Cobble Embeddedness; FMX — 30-Hoop Free Matrix counts.

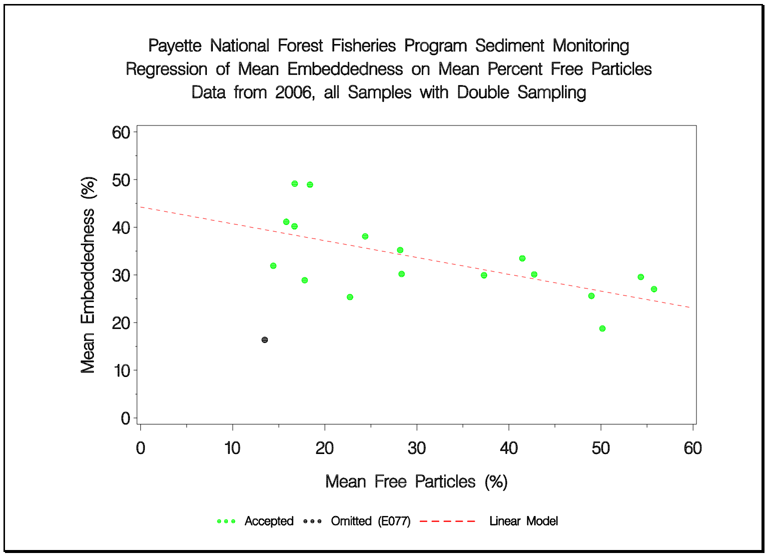

Figure 1.—Relationship of cobble embeddedness on free matrix for 2006 showing identified outlier that was omitted.

This method appears to be a potentially useful tool for identifying incorrect data in the database and restoring some data that we currently reject simply because they were collected during years we have determined to be problematic.

Upper South Fork Salmon River

30-Hoop Free Matrix

Previously, Nelson *et al.* (2006) reported that the site on Blackmare Creek (E006), an undeveloped watershed, had the highest proportion of free particles in the streambed in the period, but not significantly more than either the other control site (E068) or the Fitsum Creek site (E023). Although there are still no statistically detectable differences among these three sites, the statement is no longer true because free particle counts were higher for the latter two sites in 2006 and the Blackmare Creek site had a lower count (Table 6). As seen previously, time series analysis identified significant decreasing trends in free particles at E068, but that was the only identified trend (Table 16).

The Buckhorn Creek watershed is the most extensively developed of these four watersheds, and was the setting for considerable timber harvest in the past and extensive rehabilitation work more recently. The primary Buckhorn Creek site (E016) had the fewest streambed free particles on average and the 5-year mean placed it in the "Functioning at Unacceptable Risk" (FUR) category according to the revised SFSR WCIs (< 11%) in last year's report (Nelson *et al.* 2006). However, most of the low free particle measurements were made prior to 2001, and the site would now rate a better "Functioning at Risk" (FR) classification. Only the Fitsum Creek site could be classified as "Functioning Appropriately" (FA), with the undeveloped Fourmile Creek and Blackmare Creek sites being similar but "Functioning at Risk" (FR) for sediment according to the revised sediment WCIs. Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figures 2 to 5.

Cobble Embeddedness

Cobble embeddedness measurements have been relatively stable at these sites over the monitoring record, though the Fourmile Creek and Fitsum Creek sites have a very irregular record with few measurements (Table 7). All of the sites would be classified as FR for the revised embeddedness WCIs because the five-year means exceed 32% but are less than 42%; this comports fairly well with the free matrix classification except at the Fitsum Creek site, an irregularity that may be explained by the large gap in the data from 1995 through 2002. On average, the mean embeddedness derived from either measurements or calculated from 30-hoop free matrix counts were similar. The revised WCIs made no provision for using calculated embeddedness for determining functional category, though these results suggest such use may be appropriate.

The overall and recent means were similar in all cases and no time trends were overtly suggested; however, one site (E068) showed moderately significant increasing embeddedness trend (Table 17). Nelson *et al.* (2006) erroneously stated that only two of the sites had a sufficient monitoring record for actually estimating time trends from embeddedness measurements. In fact, three sites had sufficient records and the Fourmile Creek site (E068) should have been discussed here and referenced in the "SFSR Road Sites" section; we have included it here this time. Illustrations of the variation in cobble embeddedness and apparent trends are provided in Appendix 6, Figures 6 to 9).

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 18, time series graphics are provided in Appendix 6, Figures 10-13, and statistical summaries are located in Appendix 4.

SFSR Road Sites

30-Hoop Free Matrix

In general, there were no significant differences in percent free particles between control and treatment means on these three streams (Table 8), though the control site on Cabin Creek (B126) had higher average free particles in the overall recent (2001-2006) means. Both of these sites were clearly in the FA range, and were the only sites that were; the Fourmile Creek sites were in the FR range while the Camp Creek sites had the lowest proportions of free particles, with the control site (E129) classified as FUR. In general, means from sites on an individual stream were significantly different than the means from sites on the other streams.

Time series analysis (Table 19) of the proportion of free particles over time supports the inference that most of the sites are generally losing interstitial space. Three sites showed pronounced, statistically significant downward trends with both the ordinary least squares and autoregressive models, and even the non-significant models suggested potential trends with negative slope. The non-significant result for the test site on Cabin Creek supports the idea of a renewal of the upward trend at that site reported in the 1997 report (Nelson *et al.* 1997), which we suggested in Nelson *et al*. (2002). Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figures 14 to 18, and most suggest a potential inflection point (*i.e.*, change in trend) around 1994, but we have not investigated this possibility.

Cobble Embeddedness

The SFSR Road sites have incomplete embeddedness records, and only the two sites on Fourmile Creek have sufficient measurements to evaluate functional condition based on embeddedness (Table 9). Both of these sites would be classified FR based on cobble embeddedness, just as they were using free matrix measurements. In general, the average calculated embeddedness values at all sites were similar to the measured means, though there were really too few measured values for the Camp Creek and Cabin Creek sites to make meaningful comparisons. Although no statistical comparisons between site pairs were made, the treatment and control sites did not appear to have different levels of embeddedness.

Only the Roadside site (E068) on Fourmile Creek had a sufficient record to evaluate embeddedness trend, which is discussed with the primary sites above. Illustrations of the variation in cobble embeddedness and apparent trends are provided in Appendix 6, Figures 19 to 23.

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 20, time series graphics are provided in Appendix 6, Figures 24-28, and statistical summaries are located in Appendix 4.

Secesh River

30-Hoop Free Matrix

Both of the Secesh River area primary sites could be categorized as FA based on recent mean free matrix counts (Table 10). There was little apparent difference between the overall and recent means at the Lick Creek site (E057), but free particles appeared to be more abundant at the Grouse Creek site (E062) recently. The Grouse Creek watershed burned extensively in the Burgdorf Junction Fire of 2000, and the highest free matrix counts have occurred since that fire; this is consistent with our belief that wildfire can result in coarsening of the streambed. Time series analysis (Table 21) confirmed that free particles have been increasing at the Grouse Creek site, and the trend of the autoregressive model was highly statistically significant ($P<0.01$). Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figures 83 to 84.

Cobble Embeddedness

Measured cobble embeddedness at both sites (Lick Creek [E057] and Grouse Creek [E062]) both had recent 5-year means that were clearly consistent with an FA assessment (Table 11). Nelson *et al.* (2006) reported that E062 was significantly less embedded than E057, but that situation no longer holds; there was no significant difference in embeddedness between the two sites. This suggests a decline in embeddedness at the Grouse Creek site, which was confirmed by time series analysis (Table 22); the analysis also revealed an increasing trend at the Lick Creek site. These results are consistent with the free matrix analysis for E062 but ambiguous for E057, where no trend in free particles was indicated. The declining trend in embeddedness at E062, together with the positive free matrix trend, support our contention that streambeds may coarsen after wildfire. Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figures 85 to 86.

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 23, time series graphics are provided in Appendix 6, Figures 87-88, and statistical summaries are located in Appendix 4.

East Fork South Fork Salmon River

30-Hoop Free Matrix

Only the Tamarack creek site was monitored in 2006, so no comparisons among sites were made. The EFSFSR, which inherently has higher free matrix counts than most of the rest of the SFSR watershed, was included in the evaluation of sediment conditions for WCI revision, and the median and third quartile limits are reflected in Table 1 for "other" watersheds. Using those approximate indicator values, we would classify only the Tamarack Creek site as FA; previously, FR classifications applied to E050 and the two Sugar Creeks sites and FUR classifications for the two mainstem EFSFSR sites (Nelson *et al.* 2006).

Nelson *et al.* (2006) stated that the EFSFSR sites would no longer be monitored because mining has ceased at Stibnite; that was mostly true, but we do intend to continue monitoring the Tamarack Creek site to maintain a reference site in the cobble embeddedness to free matrix double sampling. No trend in free matrix particles was detected (Table 24). Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figure 101. Because mining at Stibnite has been discontinued and much of the mined area has been rehabilitated, these sites will no longer be monitored.

Cobble Embeddedness

We are no longer collecting sufficient data at these sites for comparisons to be meaningful. Cobble embeddedness measurements were collected at the Tamarack Creek site (E076) because it is a undeveloped reference site and is used in the double sampling procedure. The embeddedness result is provided in Appendix 4, and the time series analysis is shown in Table 25, which revealed no statistically detectable trend (Appendix 6, Figure 102).

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 26, time series graphics are provided in Appendix 6, Figure 103, and statistical summaries are located in Appendix 4.

Lower South Fork Salmon River

30-Hoop Free Matrix

Unsurprisingly, the control site on Porphyry Creek (E054), in an undeveloped remote watershed, had the highest proportion of free matrix particles, but it was significantly higher only than the site on Pony Creek (E056; Table 12). As its name suggests, the Porphyry Creek watershed is not typical of batholith watersheds, porphyry being larger grained and harder than most batholith granite, and actually seems to have inherently different streambed conditions than the sites in the two test watersheds; this is more fully discussed in Nelson and Burns (2005). Using the revised WCI values of Nelson and Burns (2005), both sites E056 and E054 would be classified FA, with the Elk Creek site (E030) classified as FR; this differs from last year's assessment (Nelson *et al.* 2006) because of the very high count at E054 in 2006. The Pony Creek site was the only site where we detected a trend in free particles, in this case, a declining trend (Table 27). Illustrations of the variation in free particles and apparent trends are provided in Appendix 6, Figures 104 to 106.

Cobble Embeddedness

Despite there being three primary sites in the Lower South Fork Salmon River watershed, direct comparisons of cobble embeddedness are difficult because only the Porphyry Creek site has a long-term record; data collection at the other two sites was suspended after 1994. Comparison among the sites based on what data exist (Table 13) suggests that all three would be classified as FA based on most recent five-year embeddedness means. While this appears to contradict the free matrix data, the fact that the comparison is based on much older data for sites E056 and E030 confounds interpretation. Similar caution should be used for the fact that the multiple comparison suggests that Elk Creek and Porphyry Creek embeddedness levels were statistically similar; no comparison covering just those years wherein all sites have data were made in this report. We believe that interpretations of habitat condition based on free matrix counts are likely to be more reliable than measured cobble embeddedness reported for these sites.

Only the Porphyry Creek site had sufficient data for time series analysis of embeddedness, and a moderately significant upward trend was detected (Table 28). This trend was not suggested by the tabular data for all embeddedness measurements, but was seen when data from suspect years were excluded from the analysis. Although this appears to contradict the free matrix data, it should be pointed out that there was a suggestion of a weak but non-significant declining trend in free particles as well. Illustrations of the variation in cobble embeddedness and apparent trends are provided in Appendix 6, Figures 107 to 109.

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 29, time series graphics are provided in Appendix 6, Figure 110-112, and statistical summaries are located in Appendix 4.

Chamberlain Creek

30-Hoop Free Matrix

While there were significant differences in free matrix counts between the two primary sites in the Chamberlain Basin (Table 14), they would both be classified as FA using the revised sediment WCIs (Nelson and Burns 2005), which are appropriate here because several Chamberlain Basin sites were used as reference sites in revising the WCIs. Nelson *et al.* (2006) reported a mild declining trend in free particles at the Chamberlain Creek site (E032), but this time series analysis revealed no statistically significant trends in free particles at the either primary site (Table 30). Illustrations of the variation in free particles, which appears to be greater at the West Fork Chamberlain Creek site (E136), and apparent trends are provided in Appendix 6, Figures 131 and 132.

Cobble Embeddedness

Cobble embeddedness measurements differed between the two primary Chamberlain Basin sites in a fashion consistent with the free matrix counts, with the West Fork Chamberlain Creek (E136) site having the lower embeddedness (Table 15); however, many fewer samples were obtained from E032, so the free matrix comparison should be considered more reliable. Time series analysis modeled a highly significant downward trend in embeddedness at E136 (Table 31). Illustrations of the variation in cobble embeddedness and apparent trends are provided in Appendix 6, Figures 133 and 134.

Surface Fines

Surface fines are not discussed here; time series analyses are shown in Appendix 2, Table 32, time series graphics are provided in Appendix 6, Figure 135 and 136, and statistical summaries are located in Appendix 4.

Conclusions

Interstitial sediment conditions and trends for up to 24 years of monitoring are reviewed in this report. We concentrated on the so-called “primary” sites, which typically had the longest and most complete records, though many of the “supplemental” sites (*i.e.*, sites that are also typically monitored annually) may have equally complete records that were not discussed; however, all data for sites with data collection after 1996 were included in the statistical summary tables (Appendix 4) and the time series graphics (Appendix 6). In addition, sites with long-term records and data collection since 1996 have time series analysis results displayed in Appendix 5, though the specifics of these analyses are not discussed.

This analysis shows that conditions at most sites are about what could be expected given management history (*i.e.*, undeveloped sites tended to be higher in interstitial space than developed sites), and that application of the revised interstitial WCIs for the SFSR produced reasonable outcomes: undeveloped sites were typically FA or at the upper end of FR, whereas sites in more developed areas or areas with exceptional disturbances were more often FR to FUR. In addition, these results were typically consistent regardless of whether the free matrix or cobble embeddedness indicator was used. Thus, our decision to increasingly rely on the simpler free matrix procedure for routine monitoring and assessment seems justified.

In the SFSR, most primary sites were “at risk” with respect to free particles and cobble embeddedness. Both the undeveloped primary sites (on Blackmare Creek and on Fourmile Creek) were rated FR for free particles, while one somewhat developed site (on Fitsum Creek) was not. The SFSR watershed is subject to fine sediment deposition, hence the need to limit disturbance and rehabilitate the problems caused by over development in the past, and there is no reason to assume that all systems naturally have optimum sediment conditions for all species at all times.

Further illustration of this can be seen in the analysis of the SFSR Road Reconstruction Project monitoring, where the sites on Cabin Creek, which is near Warm Lake and has had some development, were the only sites classified as FA (free matrix), while the Fourmile Creek sites were both FR (free matrix and cobble embeddedness). The Camp Creek sites, in a watershed that was among the first in the SFSR to be logged and roaded, were FR and FUR, one site having very low free matrix counts. Beneficial effects of paving the SFSR road were not detectable, except possibly in Cabin Creek, which has also seen more watershed stabilization work.

Generally, sites in the Secesh River watershed were “cleaner” than those in the upper SFSR despite considerable historical development; in fact, between the two primary sites, the more developed one had higher free matrix and correspondingly lower embeddedness with trends toward increasing interstitial space. This watershed, Grouse Creek, was historically heavily mined, mainly by dredging, but one major dredging operation was reclaimed in the early 1990s (Lund and Burns 1993); in addition, the watershed burned extensively in 2000, and increased water yield after the fire may be helping to coarsen the streambed.

Among the Lower SFSR primary sites, the reference site on Porphyry Creek probably had more interstitial space (as indicated by free matrix, embeddedness was less clear) than either developed site, which we would expect as a result of both inherent lithologic differences (Nelson and Burns 2005) and in past land management. Both of the developed sites were FR based on the free matrix WCI.

The Chamberlain Creek sites are all reference sites and were used in Nelson and Burns (2005) to develop sediment-related WCIs for the SFSR; consequently, it is unsurprising that they received FA classifications.

Overall, trends in interstitial space were roughly evenly distributed between decreasing and increasing trends, but trends were often toward decreasing interstitial space in reference sites. This phenomenon was first noted by Ries *et al.* (1991) for the SFSR, but seems to have some generality across the Forest. In contrast, many developed sites showed improving trends in one or both indicators, suggesting that rehabilitation efforts have been effective in ameliorating sediment deposition. Observed trends in cobble embeddedness and free matrix and functional classifications were typically complementary, but, though no rigorous analysis was made, surface fines did not seem to track the other indicators particularly well; we remain convinced that surface fines is not a robust indicator of habitat conditions.

A new investigation in this report involved outlier analysis in the double sample modeling of cobble embeddedness on free matrix counts. The initial modeling of 2006 data produced an unsatisfactory model, but we were able to successfully identify a statistical outlier with excessive influence on the model, remove it, and achieve a more appropriate model. We suggest that this may provide a suitable method for removing inaccurate samples from the data sets from the years we have traditionally excluded and use the remaining samples to better evaluate trends in measured embeddedness. We also found that restricting the analysis to the geographic area that contained the sites traditionally analyzed in these reports improved the model for 1999, and allowed us to use its data in this report's modeling.

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