UPPER TUOLUMNE RIVER ECOSYSTEM PROGRAM

2013 AND 2014 RIM FIRE MONITORING IN THE HETCH HETCHY REACH
Technical Memorandum

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1.0 INTRODUCTION

On August 17, 2013, a human-caused wildfire began near the confluence of the upper Tuolumne River and Jawbone Creek, downstream of the Hetch Hetchy Reach, but within the larger Upper Tuolumne River Ecosystem Program (UTREP) study area. Over the next two months, the Rim Fire burned (to varying degrees) over 257,000 acres within the Stanislaus National Forest and Yosemite National Park, becoming the third largest wildfire to date in California. While wildfire is a common and integral component of Sierra Nevada ecology, the Rim Fire stands out as a particularly large, hot, and destructive fire whose effects will be noted for decades to come.

The Rim Fire affected the entire UTREP study area, and resulted in a range of burn severities within the Hetch Hetchy Reach (O'Shaughnessy Dam to Early Intake). In some areas, the Rim Fire has dramatically affected vegetation characteristics, increased large wood loading, and increased fine sediment loading. Undoubtedly, the short and long-term effects of the fire will be mixed: it is likely the fire directly impacted wildlife populations, potentially including the small population of foothill yellow-legged frogs near Early Intake. Fish populations may potentially be negatively affected by fire-related fine sediment inputs, but positively affected by increased large wood and nutrient inputs. Overall productivity may initially increase with fire-related nutrient inputs, and then decline over time. Concurrent drought may delay some effects of the fire, but eventually rain and snowmelt will deliver fine sediment into and through the Hetch Hetchy Reach and upper Tuolumne River.

To provide a baseline for monitoring post-fire changes in physical habitat within the Hetch Hetchy Reach, pre-winter 2013 monitoring of cross sections, photopoints, and large wood storage documented conditions at many study sites. Although the winter of 2013/2014 was relatively dry, SFPUC staff observations suggested that fire-related fine sediment delivery to the mainstem Tuolumne River had already begun. These fine sediments will likely affect future fish and foothill yellow-legged frog habitat conditions, create new riparian vegetation seedbeds in lee deposits of boulders, further reducing available gravel storage in the Early Intake Reach and leading to undesirable riparian vegetation establishment and fossilization of these in-channel sediment deposits.

Summer 2014 tasks focused on repeating the pre-winter 2013 field surveys at study sites where fine sediment deposition (sand) has occurred. Because the winter of 2013/2014 was relatively dry, no O'Shaughnessy Dam spill events occurred, thus there was no significant fine sediment flushing events within Hetch Hetchy Reach.

Specific geomorphic and riparian tasks conducted in 2013 and 2014 included:

1) Repeat photographs at photopoints of sand/gravel experiments and documenting fine sediment deposition in the O'Shaughnessy Dam, Poopenaut Valley, Upper Preston, Mystery Bar, Albino Pool, Early Intake Calibration Pool, and Early Intake Boulder Garden reaches;
2) Repeating large wood surveys in the Upper Preston (1 and 2), Albino Pool, and Early Intake subreaches;
3) Establishing elevation control for study sites within the Preston Falls reach;

4) Field reconnaissance of cross sections and pools in the Early Intake and Preston Falls subreaches to evaluate whether repeat topographic surveys are warranted; and

5) Field reconnaissance of newly formed sand bars to evaluate whether emerging riparian establishment is occurring on cross sections at the O'Shaughnessy Dam USGS gaging station, Poopenaut Valley, Mystery Bar, Albino Pool, Calibration Pool, and Boulder Garden riparian study sites.

The effect of the 2014 dry water year on the breeding and reproductive conditions for foothill yellow-legged frog (FYLF) recruitment was also investigated in the Preston Falls and Early Intake subreaches. Recent monitoring on other Sierra Nevada rivers suggested a wider range of suitable breeding habitat for FYLF. Given that dry water years should provide relatively good reproductive conditions for FYLF, it was hypothesized that 2014 would be a good year to observe breeding and reproductive conditions for FYLF and to conduct additional amphibian surveys in alternative breeding areas.

2.0 METHODS

2.1 Photopoint monitoring

In May 2008, 18 photo points were installed throughout the Hetch Hetchy Reach to support the instream flow study, and were initially used to photo-document flows that ranged from 80 cfs to 6,250 cfs. Photo points were monumented using a 1-inch washer epoxied to a boulder or bedrock outcrop with photo point stationing (feet upstream of Wards Ferry Bridge) stamped on it (SFPUC 2014). 17 additional habitat-specific photo points accessible at all flows were selected to ensure overlapping panoramic photomosaics within all study sites for a total of 35 potential photo points. A Nikon D90 DSLR with a polarizing lens filter minimized solar glare off the water surface. Photomosaics were typically 180° upstream to downstream panoramas of complete mesohabitat units.

In November 2013, immediately following the Rim Fire, all existing photopoints between Upper Preston Falls and Early Intake were reoccupied to document fire related changes in aquatic and terrestrial habitats. Additional photos were taken along the river where substantial wood loading and sediment delivery were occurring as a result of the fire, but no new permanent monuments were established. A total of 60 photomosaics were taken in the fall of 2013 to document fire related changes to the riverine environment and evaluate future changes in response to wind, runoff, and flow releases from O'Shaughnessy Dam. In July 2014, all photo points were reoccupied to document changes in wood loading and slide slope sediment delivery caused by winter/spring rain surface runoff.

2.2 Sand and gravel experiment photomonitoring

Work conducted under the Upper Tuolumne River Ecosystem Program (UTREP) documented pulses of sand entering and transporting through study sites below Preston Falls. Managed high flows could be an important tool for fine sediment management in the mainstem. Between 2008 and 2010, scour nests were used to qualitatively assess bed scour and deposition at the Early Intake, Albino Pool, and Mystery Bar sub reaches (SFPUC 2014). Scour nests are piles of tracer material set in natural boulder and bedrock lee or obstruction deposits. Deposits were previously photo documented in boulder lee deposits, pools, and pool tails and were originally composed of sand and gravel.

In November 2013 and July 2014, the scour nest experiments were relocated and photographed to note any changes in sediment size and quantity resulting from sediment introduction due to the Rim Fire and to provide a readily repeatable source of observations and over the long term. Photo monitoring gravel and sand experiment locations may be easier to manage information exchange about the effects of the fire in the mainstem. Our underlying hypothesis is that these deposits may fill with more sand given the increased sand supply resulting from the Rim Fire.

2.3 Large wood mapping

Large wood monitoring was conducted in November 2013 and July 2014. Monitoring included a field survey of wood with a diameter greater than 20 cm within the active channel, post-field data processing, and preliminary analysis. Large wood data was collected in the Upper Preston, Albino Pool, and Early Intake sub-reaches within the Hetch Hetchy Reach. Locations of large wood pieces were recorded using a Trimble GeoXH handheld GPS with external Zephyr antennae capable of achieving 2-foot accuracy.

Attributes of each piece of wood, such as species and stem diameter, were recorded. Debris piles were mapped as a single point, and the most prevalent size class of debris was noted, as well as general number (e.g., >20 pieces). However, the precise number of wood pieces within each debris pile was not always counted particularly for larger accumulations.

When each large wood piece was surveyed, the location was entered into a data logger and attributes were assigned that described the piece of wood. This method only focused on changes in large wood storage in a subreach and did not necessarily assess large wood recruitment, routing, or budgeting throughout the sub-reaches (i.e. individual large wood pieces were not tagged or tracked if it mobilized from the site and routed downstream). Data processing was conducted using GPS Pathfinder Office (Trimble), ArcMap (ESRI), and Excel (Microsoft) software. Survey attributes included:

- Sub-reach name;
- A unique identification number for individual large wood pieces;
- Date;
- Origin (i.e., natural, fire-fall, wind-fall, unknown);
- Location of wood relative to stream bank;
- Diameter measured at root collar (DRC), assigned to one of six size classes (8-12 in, 12-18 in, 18-24 in, 24-36 in, 36-48 in, and >48 in);
- Root wad width (i.e., total and wet widths; measured at widest point of root wad, feet);
- Stem length total and wetted lengths measured from root collar to tip of stem, feet;
- Orientation of stem relative to magnetic north measured with compass from root collar;
- Species;
- Status of large wood decay (using criteria adapted from Wohl et al. 2011);
- Additional comments or ancillary information.

2.4 Cross sections and pool reconnaissance

In the fall 2013, cross section surveys were performed at the Fireplace and at Mystery Bar sites. Cross section 1623+00 was surveyed at the Fireplace site and cross section 1589+50 was surveyed at the Mystery Bar Site. Field reconnaissance of cross sections and pools was

conducted in summer 2014 to evaluate whether repeat topographic surveys were warranted at the O'Shaughnessy Dam USGS gaging station, Mystery Bar, Albino Pool, Calibration Pool, and Boulder Garden riparian study sites.

2.5 Riparian colonization of in-channel deposits and newly formed sand bars

During the summer of 2014, exposed fine sediment deposits near the summer low water channel were opportunistically visited and riparian colonization observed. Seedlings were surveyed using intuitive controlled searches (BLM 2012). Intuitive controlled searches rely on plants affinity for particular environments and common plant associates for constraining the search to those areas where seedlings likely to occur.

2.6 Herpetofauna Surveys

Three amphibian surveys over 2-days each were conducted from Preston Falls to Early Intake during the summer 2014. NPS staff surveyed the upstream surveys (i.e., Poopenaut Valley, O'Shaughnessy Dam). Herpetofauna surveys were conducted using diurnal Visual Estimation Surveys (VES) at historic transect sites, snorkel surveys for the entire length, and targeted night time spotlighting at the locations where FYLF have previously been detected. Herpetofauna surveys focused on FYLF in addition to other species, with an emphasis on finding FYLF egg masses and individual frogs during a dry year where reproduction success was hypothesized to be high. NPS staff conducted the upstream surveys (i.e., Poopenaut Valley, O'Shaughnessy Dam).

3.0 RESULTS

3.1 Fine sediment delivery, deposition, and changes in channel morphology

Since 2012, the Upper Tuolumne River annual water yield has been below normal. Daily average streamflow peaks above Early Intake at USGS Station #11-276600 in 2013 and 2014 did not exceed 250 cfs in either year. Fine sand and silt increased near and in-channel between fall 2013 and summer 2014. Several instances of fine sediment introduction to the channel through gullies were observed (Figure 1). Evidence of debris flows was observed in two gullies upstream of lower Preston Falls. Upslope surface erosion and overland flow deposited sand and fine silts on surfaces adjacent to the channel upstream at the Albino Rock site and at locations above lower Preston Falls. Fine sand and silts from surface erosion filled the interstitial spaces on a boulder bar at the Albino Pool site (Figure 2). Upstream of lower Preston Falls, a location on the mainstem at longitudinal Station 1581+50 that had been previously classified as a pool by USFWS was less than a foot deep and full of sand (Figure 4) and a pool habitat unit at Mystery Bar was also filling in with fine sediments (Figure 5). Field observations suggested that fine sediment did not necessarily occur at cross section locations or in previously monitored pools, making quantification of the sediment volume delivered at a specific location difficult.

3.2 Changes in large wood storage

Each mapped piece of wood was assigned a longitudinal stationing (distance upstream from Wards Ferry Bridge) and the cumulative number of pieces was plotted through the three sub-reaches and compared between years (Figure 6). An evaluation of whether large wood storage in the active channel is increasing, decreasing, or being maintained was conducted for each sub-reach between fall 2013 and summer 2014 (Table 1). The Early Intake sub-reach had the greatest increase in large wood loading. The decrease of large wood pieces mapped in the

Fireplace sub-reach was likely due to the decrease in water clarity within the deep backwater. Overall, the increase of wood loading between winter 2013 and summer 2014 mapping efforts was six pieces.

Table 1. *Summary of number of large wood pieces mapped within each sub-reach.*

	Number of LWD Pieces Mapped					
Date	**Early Intake**	**Albino Rock**	**Mystery Bar**	**Fireplace**	**Preston**	**Grand Total**
Nov-13	21	48	10	97	16	192
Jul-14	38	46	11	89	14	198
Change	+17	-2	+1	-8	-2	+6

3.3 Riparian colonization of in-channel deposits and newly formed sand bars

Riparian plants have colonized exposed fine sediment deposits shortly after they became exposed. Overall observations downstream of Preston Falls suggest that alder seedling recruitment was particularly high (Figure 7). Riparian plants rapidly colonized eddy deposits and fine sediment deltas at delivery points presumably due to their long exposure during dry years, readily available soil moisture, and fine textured sediment (Figure 8). Seeds have germinated in fine organic debris caught on the woody debris and on shoreline silts (Figure 9).

3.4 Herptofauna Surveys

Adult and larval newts, garter snakes, and a lone mussel (*Margaritifera falcata*) were observed, but no foothill yellow-legged frogs. A brown silt layer from the fire was quite deep in places, with cobbles and boulders only being exposed in the swiftest moving water (Figure 10). Only large mussels were observed, and only the largest individuals could keep part of their shell above the silt to be able to filter water (Figure 11). Qualitatively, the brown sediment covering the cobble bed was warm to the touch of during snorkeling surveys, compared to the white granite rocks below. One question that could affect amphibian larval development is whether the difference in reflectivity between the silt and the rocky stream bed was changing the heat budget, allowing water to warm more which would cause more rapid development of amphibian larvae stages. Newt egg masses are often found on sticks and branches, whereas foothill yellow-legged frogs almost always oviposit on rocks. Newts may be able to continue reproducing successfully under post-fire conditions because the frequent addition of large coniferous wood debris to the channel may have increased oviposition sites for newts while the siltation greatly reduced oviposition sites for foothill yellow-legged frogs. The rocky substrate where foothill yellow-legged frog breeding could occur was often covered with silt.

4.0 DISCUSSION AND RECOMMENDATIONS

Rim Fire-related fine sediment is clearly being deposited and stored in-channel within the Hetch Hetchy Reach despite the overall dry water year conditions in 2013/2014. Pulse flows from O'Shaughnessy Dam could be used to manage these fine sediment deposits and potentially provide some aquatic ecological benefits. A managed pulse flow release greater than 1,200 cfs for more than two days should be of sufficient magnitude and duration to mobilize and transport existing fine sediment. Even lower magnitude releases may cleanse the ash, fine sediment and sand from many locations along the channel bed and improve aquatic habitat

and water quality. Seedlings less than 1 yr-old growing in these fine sediments in close proximity to the summer low water edge could potentially be scoured away using a pulse flow release >1,200 cfs.

Specific monitoring recommendations related to evaluating pulse flows include:

- Resurvey all cross sections thru fine sediment deposits and conduct new topographic surveys in pools/runs/glides/deltas with finer sediment deposits (small gravel, sand, silt) before and after pulse releases to assess changes in sediment volume or scour depth;
- Sample establishing seedlings less than 1 yr-old growing in fine sediments in close proximity to the summer low water edge before and after pulse releases to assess changes in densities.

Large wood and sediment delivered to the river in 2013 and 2014 has and will continue to affect many aspects of the riparian and riverine environment. Future Rim Fire monitoring tasks should focus on evaluating the efficacy of management actions (primarily flows). Periodic photo monitoring should be continued, as well as monitoring large wood, fine sediment, and water temperature.

5.0 REFERENCES

Bureau of Land Management (BLM). 2012. California State Office Manual Handbook H-6840-1, the Special Status Plant Management Manual Handbook for California BLM. 48pp.

SFPUC. 2014. The Upper Tuolumne River Ecosystem Program. O'Shaughnessy Dam Instream Flow Management Plan.

Wohl, E., Cenderelli, D.A., Dwire, K.A., Ryan-Burkett, S.E., Young, M.K., and K.D. Fausch. 2011. Large in-stream wood studies: A call for common metrics. Earth Surface Processes and Landforms 35: 618-625.

6.0 FIGURES

Figure 1. *A gully located upstream of lower Preston Falls delivering fine sediment to the mainstem channel.*

Figure 2. *Boulder bar at Albino pool with interstitial spaces filled in with fine sediments.*

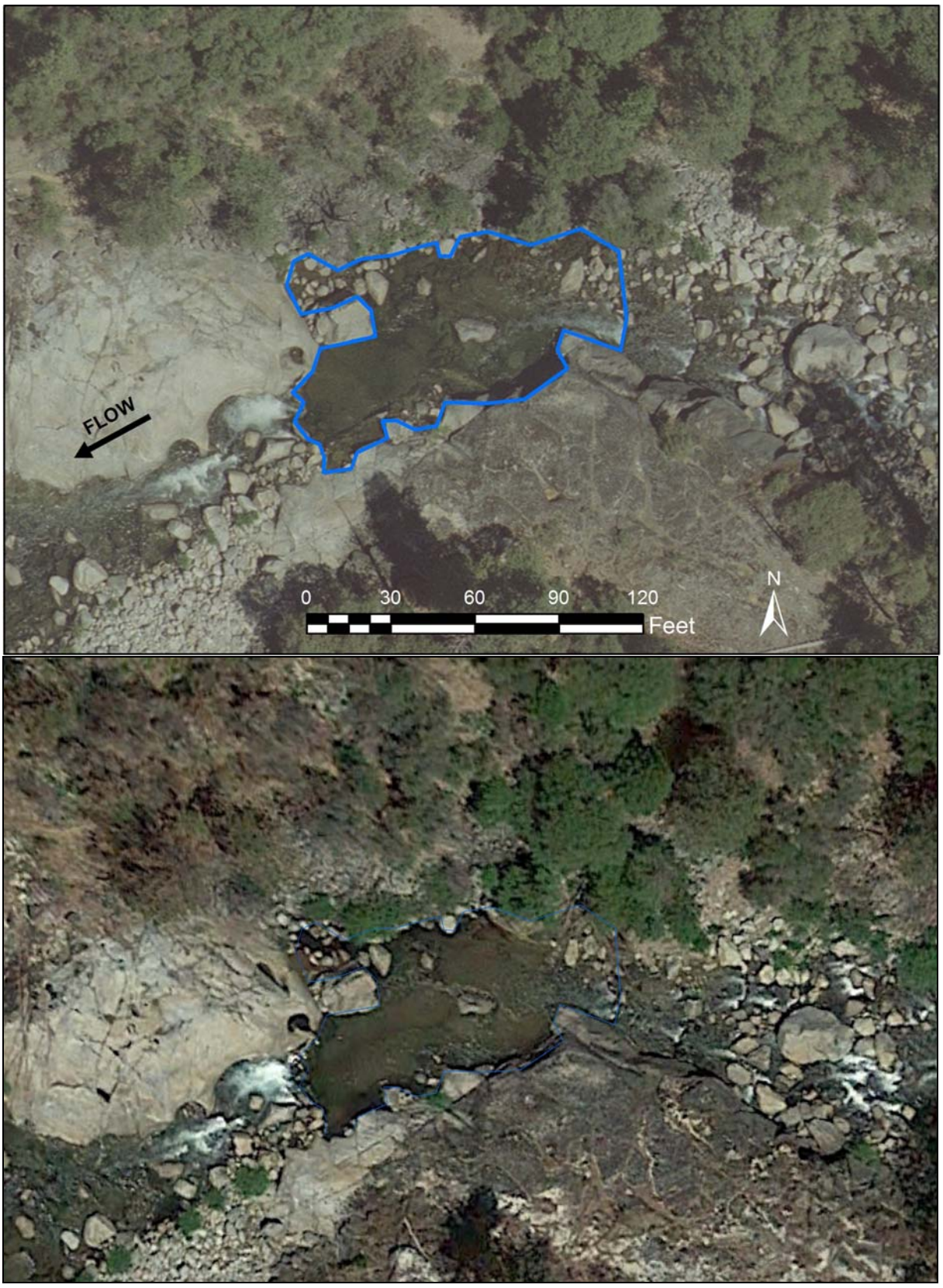

Figure 3. *Aerial photo comparison at longitudinal Station 1581+50 that had been previously classified as a pool by USFWS in 1991 (top is 2007 pre-fire photo and bottom is 2014 post-fire photo).*

Figure 4. *A location on the mainstem at longitudinal Station 1581+50 that had been previously classified as a pool by USFWS in 1991 is now less than a foot deep and full of sand.*

Figure 5. *A pool habitat unit at Mystery Bar observed filling in with fine sediments.*

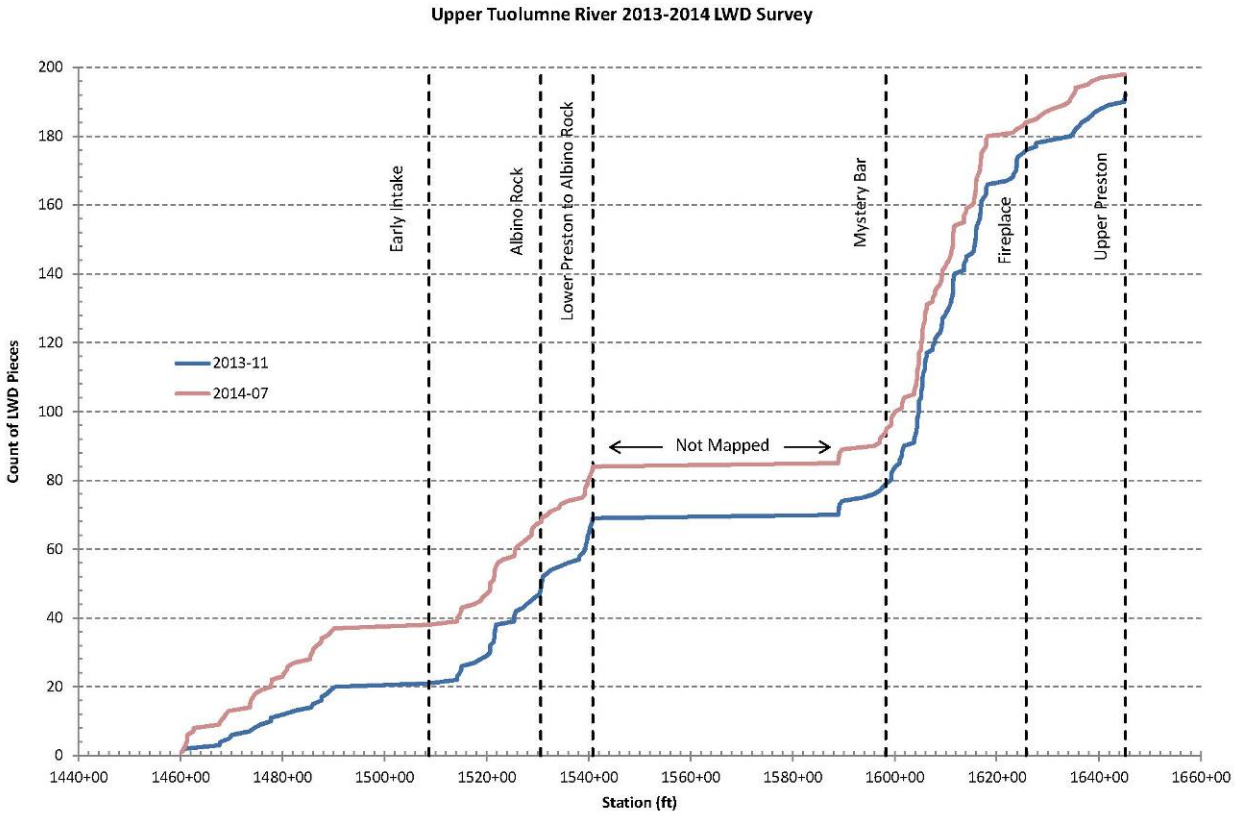

Figure 6. *A chart of the cumulative count of pieces was plotted with stationing to show comparison between winter 2013 and summer 2014.*

Figure 7. *Freshly deposited sand bar colonized with riparian seedlings.*

Figure 8. *A fine sediment delivery point delta colonized with riparian plants.*

Figure 9. *Seeds germinated in fine organic debris caught on the woody debris and shoreline silts.*

Figure 10. *Brown silt layer in boulders and cobbles reduced foothill yellow-legged frog breeding habitat.*

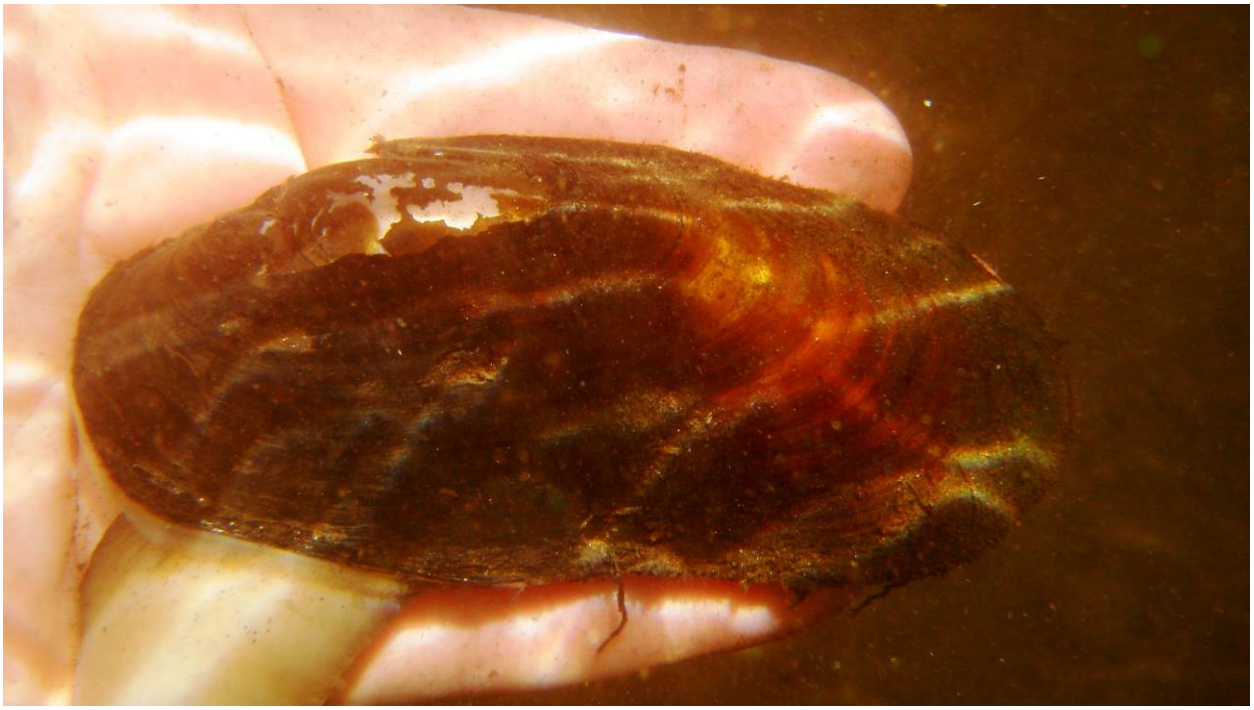

Figure 11. *Only the largest mussels could keep part of their shell above the silt and filter water.*

7.0 APPENDIX A: EXAMPLE PHOTO POINT MONITORING

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Photopoint 1481+50 showing pre-Rim Fire conditions and accumulations of silt and ash post Rim Fire.