



Wadeable Streams Monitoring

2015 Results from Oregon Caves National Monument and Preserve, Redwood National and State Parks, and Crater Lake National Park

Natural Resource Report NPS/KLMN/NRR—2018/1684





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Photograph of Lake Creek, Oregon Caves National Monument and Preserve, Site ORCAWQ02.
Photograph courtesy of the National Park Service (Photo by Eric Dinger)

ON THE COVER

Photograph of Sand Creek, Crater Lake National Park, Site CRLAWQ33.
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Contents

	Page
Figures.....	vi
Tables.....	vi
Appendix Tables	viii
Appendices.....	ix
Executive Summary	x
Acknowledgments.....	xiii
Introduction.....	1
Methods.....	2
Implementation Schedule	2
Site Selection.....	2
Site Layout	3
Water Chemistry and Quality	4
Stream Habitat/Riparian Corridor Characteristics.....	5
Aquatic Communities.....	6
Metric calculation and data processing	6
Calculating Indicators of Ecological Condition	7
Total Phosphorous.....	7
Total Nitrogen	7
Salinity.....	7
Acid Neutralizing Capacity	7
Streambed Stability (aka Relative Bed Stability)	8
In-stream Habitat Cover	8
Riparian Cover.....	9
Riparian Disturbance	9
Biological Indicators	9
Establishing Thresholds of Ecological Condition	11

Contents (continued)

	Page
Additional Macroinvertebrate Measures	11
Relationship of KLMN Indicators to Water Quality Standards	12
Results.....	14
Oregon Caves National Monument and Preserve	14
Physical Characteristics of Oregon Caves Streams.....	14
Physical Condition Metrics of Oregon Caves Streams	14
Chemical Characteristics and Condition Estimates of Oregon Caves Streams.....	18
Riparian Characteristics of Oregon Caves Streams.....	20
Vertebrate Assemblage and Condition of Oregon Caves Streams.....	20
Macroinvertebrate Assemblage and Condition of Oregon Caves Streams	20
Redwood National and State Parks	22
Physical Characteristics of Redwood Parks Streams	25
Physical Condition Metrics of Redwood Parks Streams	26
Chemical Characteristics and Condition Estimates of Redwood Parks Streams	31
Riparian Characteristics of Redwood Parks Streams	35
Vertebrate Assemblage and Condition of Redwood Parks Streams.....	35
Macroinvertebrate Assemblage and Condition of Redwood Parks Streams	40
Crater Lake National Park.....	43
Physical Characteristics of Crater Lake Streams.....	43
Physical Condition Metrics of Crater Lake Streams	43
Chemical Characteristics and Condition Estimates of Crater Lake Streams.....	51
Riparian Characteristics of Crater Lake Streams	54
Vertebrate Assemblage and Condition of Crater Lake Streams.....	54
Macroinvertebrate Assemblage and Condition of Crater Lake Streams	54
Discussion	61
General Issues.....	61

Contents (continued)

	Page
Status versus trends (or a cautionary note on changes from 2012...)	61
Notes about condition assessment	62
Oregon Caves National Monument and Preserve	63
Redwood National and State Parks	64
Crater Lake National Park	66
Conclusions.....	69
Literature Cited	70

Figures

	Page
Figure 1. Schematic of sampling site reach layout	4
Figure 2. Numeric range and thresholds for RBS condition assessment	8
Figure 3. Sites sampled in Oregon Caves National Monument and Preserve, 2015.	15
Figure 4. Photos of three sites sampled in Oregon Caves.....	16
Figure 5. Stream sites sampled in Redwood National and State Parks, 2015.....	23
Figure 6. Examples of typical stream characteristics in Redwoods National and State Parks, 2015.....	25
Figure 7. Stream sites sampled in Crater Lake National Park, 2015.	44
Figure 8. Examples of typical stream characteristics in Crater Lake National Park, 2015.....	46

Tables

	Page
Table 1. Parks and aquatic vital signs monitored on the three year rotation schedule.....	2
Table 2. Threshold for condition rating used in the Klamath Network.....	11
Table 3. Available water quality criteria used for possible exceedances, including drinking water (not applicable for natural waters, but provided for comparative reasons).	13
Table 4. Site list for streams sampled in Oregon Caves National Monument and Preserve.....	14
Table 5. Physical characteristics and locations of streams sampled in Oregon Caves, 2015.....	16
Table 6. Physical condition metrics for Oregon Caves streams sampled in 2015.	17
Table 7. Water chemistry parameters for streams sampled in Oregon Caves, 2015.....	19
Table 8. Riparian characteristics of Oregon Caves streams sampled in 2015.....	21
Table 9. Vertebrate species and metrics for Oregon Caves streams sampled in 2015.....	21
Table 10. Macroinvertebrate indicators for Oregon Caves streams, 2015.....	22
Table 11. Site list for streams to be sampled in Redwood National and State Parks, 2015.....	24

Tables (continued)

	Page
Table 12. Physical characteristic and location of streams sampled in Redwood National and State Parks, 2015.....	27
Table 13. Physical condition metrics for Redwood Parks streams sampled in 2015.	29
Table 14. Water chemistry parameters for streams sampled in Redwood Parks, 2015.	32
Table 15. Riparian characteristics of Redwood Parks streams sampled in 2015.	36
Table 16. Vertebrate species and metrics for Redwood Parks streams sampled in 2015.	38
Table 17. Invertebrate results and metrics for Redwood Park streams, 2015.....	41
Table 18. Original site list for streams to be sampled in Crater Lake, 2015.....	45
Table 19. Physical characteristics and location of streams sampled in Crater Lake, 2015.....	47
Table 20. Physical condition metrics for Crater Lake streams sampled in 2015.	49
Table 21. Water chemistry parameters for streams sampled in Crater Lake, 2015.....	52
Table 22. Riparian characteristics of Crater Lake streams, 2015.....	55
Table 23. Vertebrate species and metrics for Crater Lake streams, 2015.....	57
Table 24. Macroinvertebrate metrics for Crater Lake streams, 2015.....	59
Table 25. Condition summary for Oregon Caves streams, 2015.	63
Table 26. Condition summary for Redwood Parks streams, 2015.....	65
Table 27. Condition summary for Crater Lake streams, 2015.	67

Appendix Tables

	Page
Table A-1. Representative MMI example from Boulder Creek in Whiskeytown in 2011.	73
Table A-2. Example of the eight MMI metrics calculated for Boulder Creek.....	75
Table B-1. Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015.....	76
Table C-1. Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015	82
Table D-1. Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015	96
Table E-1. Physical characteristics and location of streams sampled in Oregon Caves	107
Table E-2. Physical condition metrics for Oregon Caves streams sampled in 2012	107
Table E-3. Water chemistry parameters for streams sampled in Oregon Caves, 2012.....	108
Table E-4. Riparian characteristics of Oregon Caves streams sampled in 2012.....	108
Table E-5. Vertebrate species and metrics for Oregon Caves streams sampled in 2012.....	109
Table E-6. Invertebrate results and metrics for Oregon Caves streams sampled in 2012.....	109
Table E-7. Physical characteristics and location of streams sampled in Redwoods, 2012.....	110
Table E-8. Physical condition metrics for Redwood streams sampled in 2012.....	111
Table E-9. Water chemistry parameters for streams sampled in Redwoods, 2012.....	113
Table E-10. Riparian characteristics of Redwoods streams sampled in 2012	115
Table E-11. Vertebrate species and metrics for Redwood streams sampled in 2012	117
Table E-12. Invertebrate results and metrics for Redwood streams, 2012	119
Table E-13. Physical characteristics and location of streams sampled in Crater Lake, 2012.....	121
Table E-14. Physical condition metrics for Crater Lake streams sampled in 2012	123
Table E-15. Water chemistry parameters for streams sampled in Crater Lake, 2012.....	125
Table E-16. Riparian characteristics of Crater Lake streams sampled in 2012	127
Table E-17. Vertebrate species and metrics for Crater Lake streams sampled in 2012.....	129
Table E-18. Invertebrate results and metrics for Crater Lake streams sampled in 2012.	131

Appendices

	Page
Appendix A. Example of MMI Calculation and Scoring	73
Appendix B. Benthic Macroinvertebrates of Oregon Caves National Monument and Preserve.....	76
Appendix C. Benthic Macroinvertebrates of Redwood National and State Parks.....	82
Appendix D. Benthic Macroinvertebrates of Crater Lake National Park	96
Appendix E. 2012 Data Tables	105

Executive Summary

The Klamath Inventory and Monitoring Network established Wadeable Stream Vital Signs monitoring in 2011, with the peer reviewed protocol finalized in 2012. The protocol measures the ecological condition at a probabilistic sample (random-based) of wadeable stream across the park landscape that are: perennial, accessible, and can be safely sampled. Sampling consists of physical habitat measurements, water quality, water chemistry, riparian measures, and both invertebrate and vertebrate stream communities. Sampling is generally accomplished with a crew of four individuals, working in the summer months.

Sampling was undertaken to determine the ecological condition status of streams in three park units: Oregon Caves National Monument and Preserve, Redwood National and State Parks, and Crater Lake National Park. Sampling previously occurred in 2012 and 2015 marks the second sampling event for these park units. Ecological condition, “the state of the physical, chemical and biological characteristics, and the processes and interactions that connect them,” was assessed by measuring an array of stream biota, in-stream characteristics, water quality, and stream bank variables and metrics. These measures were then either used singularly or integrated, to assign sites to condition categories of “Least disturbed, Intermediate, and Most disturbed.” These condition categories are based on Environmental Protection Agency (EPA) thresholds, which offer broad regional perspectives on condition, and the latter two categories do not necessarily reflect impairment for park streams. Rather, prevalence of “Intermediate” or “Most disturbed” categories should be seen as an indicator for targeted investigations.

A more complete description of indices is provided in the methods, but a short description is provided here, in three categories (chemical, physical, and biological):

Chemistry: (1) Total phosphorous, (2) Total nitrogen – these are both nutrients indicative of pollution, (3) Salinity – an indicator of water withdrawal, and (4) Acid Neutralizing Capacity – indicative of acid deposition, either through rain or acid mine drainages.

Physical: (1) Relative Bed Stability (RBS) – a measure of sediment supply and transport, (2) In-stream Habitat Cover – a measure of habitat complexity, (3) Riparian Cover – a measure of how complex and multi-layered the streamside vegetation is, and (4) Riparian Disturbance – a measure of observed, potential anthropogenic disturbances streamside.

Biological: (1) EPA Regional Vertebrate Multi-Metric Index – a composite measure of the fish and amphibian ecological integrity, (2) EPA Regional Invertebrate Multi-Metric Index – a similar measure using invertebrates for assessing ecological integrity, (3) Observed/Expected ratio – a measure of the amount of observed biodiversity to the expected biodiversity, and (4) a regional, state based Invertebrate Multi-Metric Index.

Oregon Caves National Monument and Preserve

Three sites were sampled and assessed for condition from 3 June to 24 June 2015. Sites were selected subjectively by park staff prior to 2012 and therefore results should not be extrapolated to other

streams of the park. Due to faulty batteries, we were not able to electrofish all sites within Oregon Caves, and slope was not recorded at one site.

One of the **physical habitat measures**, *In Stream Habitat Cover*, was low in one site (No Name Creek, ORCAWQ03). *Riparian Cover* was measured as Intermediate in two sites, but this is likely an effect of dominant fern coverage. *Relative Bed Stability* was high in two sites, and one site (Cave Creek, ORCAWQ01) was high in *Riparian Disturbance* metric, but only due to the presence of a park trail along section (and does not automatically imply impairment).

Based on **chemical indicators**, most streams were assigned to the Least Disturbed category. Two sites were Intermediate for *Total Phosphorous*, likely due to natural geology. One site, Lake Creek (ORCAWQ02) was Intermediate for *Total Nitrogen*.

Based on **biological indicators**, all condition estimates were rated Least Disturbed.

Redwood National and State Parks

Twenty-six sites were sampled at Redwood Parks between 10 June and 29 July 2015. There were no identified issues with data completeness. Data should only be extrapolated to sites within the sampling frame (accessible, safe, and perennial).

Using **physical habitat measures**, four sites were rated as Intermediate (15%) and four Most Disturbed (15%) for *In-Stream Habitat Complexity*; with the remaining 18 sites being Least Disturbed (69%). For *Riparian Cover*, 12 sites were Intermediate (46%) with the rest Least Disturbed (54%). *Relative Bed Stability* was Intermediate at 13 sites (50%), and generally positive (per the metric, suggesting decreased sediment/water withdrawal [although water withdrawal may not be an issue at Redwood Parks]). An additional three sites were Most Disturbed (12%), with a single site being strongly negative, suggesting sedimentation – although this site, McArthur Creek (REDWWQ01) has been subject to natural debris flows. All sites were Least Disturbed for *Riparian Disturbance*.

Using **chemical measures**, all sites were Least Disturbed for *Specific Conductivity* and *Acid Neutralizing Capacity*. For *Total Nitrogen*, there was a prevalence of Most Disturbed (11 of 26 sites, 42%), with another nine sites rated Intermediate (35%). This should be followed up to determine if the pattern is related to low flows (instantaneous discharge) or potential anthropogenic sources. *Total Phosphorous* was also elevated in 15 sites (58%).

Using **biological measures**, the only sites rated as Intermediate for vertebrates (fish and amphibians) were sites on Redwood Creek (4 sites, 15% of total sites). All other sites were Least Disturbed for vertebrates (85%). Invertebrate based metrics provided mixed results, with *O/E (Observed/Expected ratio of biodiversity)* having three sites as Most Disturbed (12%) and seven sites as Intermediate (27%). The *EPA MMI (Multi-Metric Index)* had two sites as Most Disturbed (8%) and seven as Intermediate (27%). The *California state MMI* had three sites as Intermediate (12%) with the remaining 23 sites as Least Disturbed (88%). Except for McArthur Creek (REDWWQ01), all sites had at least one metric rating Least Disturbed.

Crater Lake National Park

Twenty-nine sites were sampled at Crater Lake between 4 August and 1 October 2015. There were only minor issues with data completeness (e.g., water quality probe not available at one site, two sites not electrofished at end of season due to crew departure). Data should only be extrapolated to sites within the sampling frame (accessible, safe, and perennial).

Using **physical habitat measures**, five sites were rated Most Disturbed for ***In-Stream Habitat Complexity*** (17%) with another six being Intermediate (21%); the remainder were Least Disturbed (62%). ***Riparian Cover*** was Intermediate (52%) or Most Disturbed (31%) at most sites, likely due to the mountain meadow nature of many Crater Lake streams. ***Relative Bed Stability*** was dominantly Least Disturbed (90%) with only three sites being Intermediate (10%). Two sites were Most Disturbed (7%) for ***Riparian Disturbance***, with 27 sites being Least Disturbed.

With **chemical condition measures**, all sites were Least Disturbed for ***Specific Conductivity*** and ***Acid Neutralizing Capacity***, but most sites were either Most Disturbed (10%) or Intermediate (86%) for ***Total Phosphorous***, likely due to the natural geology of the park. A further two sites were Intermediate (7%) for ***Total Nitrogen***, with the remaining 27 sites being Least Disturbed (93%).

Due to the presence of non-native Brook Trout, many sites were rated as Intermediate (66%) using the ***EPA Vertebrate Multi-Metric Index (MMI)***. Only sites with native Bull Trout populations were rated as Least Disturbed (17%). Most site estimates using macroinvertebrate indices yielded Least Disturbed, excepting two sites that appeared to be faulty collections. Outside of these two sites, only one site was rated as Intermediate (4%) for ***Observed/Expected ratio of biodiversity***, with the rest being Least Disturbed (96%). Using the ***EPA Invertebrate MMI***, two sites were Most Disturbed (7%) and eight sites as Intermediate (30%). The remainder were Least Disturbed (63%). Outside of the two flawed collections, all sites were rated as Least Disturbed (100%) using ***Oregon State Index of Biological Integrity***.

For these parks, we are beginning to understand the annual variation of the physical, chemical, and biological attributes of streams, however, it is important to interpret early years of data with caution. Additional years of monitoring data will provide a better understanding of unique characteristics of stream reaches, and increase our ability to differentiate anthropogenic impacts from natural variation.

Acknowledgments

This project is the result of many thoughtful discussions with park staff during the development of the streams monitoring protocol, including discussions of reporting strategies. For this field season, we especially acknowledge the diligence of the streams field crew: Heather D’Anna, Christopher Faubion, Hollund Rudolph, and David Reynolds. Park specialists and resource managers were also invaluable in implementing the monitoring. At Oregon Caves National Monument and Preserve, special thanks to John Roth, at Redwood National and State Parks, thanks to David Anderson, and at Crater Lake National Park, thanks to Dave Hering. Additional thanks to Tom Philippi for early assistance in compiling the R Code, Allison Snyder for database management work, and Alice Chung-MacCoubrey for guidance and support.

Introduction

The Klamath Network (KLMN) vital signs selection process identified two freshwater aquatic resource vital signs for monitoring: Aquatic Communities and Water Quality ([Sarr et al. 2007](#)). Prioritization of these vital signs was driven by potential natural and anthropogenic disturbance of freshwater habitats and resources.

Initial selection of aquatic communities and water quality did not differentiate between lentic (lake and pond) versus lotic (stream) habitats. Fundamental differences in ecosystem structure and process between streams and lakes dictated a basic division in sampling methodology. Lentic sampling is covered in a separate protocol ([Dinger et al. 2012](#)).

Because streams are integrated ecosystems central to park landscapes, we have chosen to monitor physical, biological, and chemical parameters in concert. These varied parameters allow measurement of change on multiple scales in time and space. For instance, macroinvertebrate assemblages respond rapidly to impacts, while fish and amphibians (with longer life cycles) will demonstrate longer duration, time-integrated responses. Changes in geomorphic and riparian vegetation features will likely manifest at yet longer time scales. The use of multiple indicators for measuring ecosystem change provides an integrated and robust system for interpreting natural dynamics, and for detecting trends in key ecological features and diverse impacts over time.

Sampling was undertaken to determine the ecological condition status of streams in three network parks: Oregon Caves National Monument and Preserve (hereafter “Oregon Caves”), Redwood National and State Parks (hereafter “Redwoods”), and Crater Lake National Park (hereafter “Crater Lake”). To meet this goal, two definitions are important:

- “Ecological condition” – From the Environmental Protection Agency (EPA) Report on the Environment, “ecological condition” is defined as “the state of the physical, chemical and biological characteristics of the environment, and the processes and interactions that connect them” (USEPA 2008).
- “Status” –defined as “some statistic (e.g., a mean/median/proportion) of a parameter over all monitoring sites within a single or well-bounded window of time. Status will always have some measure of statistical precision (e.g., a confidence interval, standard error, variance)...” (Sarr et al. 2007).

For determining the common conceptual use of “ecological condition” and “status” we use condition thresholds of 12 metrics used by the EPA or states. These thresholds are used to categorize sites into condition classes: “Least Disturbed”, “Intermediate”, and “Most Disturbed”. Other reports by the EPA use “Good”, “Fair”, and “Poor” for the same classes and metrics. These classes, based on west-wide and mountainous reference conditions, are meant to be guides and not absolutes in defining park condition. Final assessment may require follow-up investigations or consultation with park specialists.

Methods

The methods used for monitoring KLMN streams were adapted from the EPA Environmental Monitoring and Assessment Program—now the National Rivers and Streams Assessment program (USEPA 2009)—with modifications to fit KLMN time, logistics, and budgetary constraints. The methods described below are abbreviated descriptions of the methods used in data and sample collection. Full descriptions of methodology are contained in the protocol for Integrated Aquatic Community and Water Quality Monitoring of Wadeable Streams in the Klamath Network (Dinger et al. 2013). Additionally, methods are provided for some field sampling that is not analyzed or reported herein—they are included here for providing an overview of the portfolio of data that will be available in future Analysis and Synthesis reports (Dinger et al. 2013), or upon request.

Implementation Schedule

KLMN aquatics monitoring was initiated in 2011 and occurs on a three-year rotation. The wadeable streams monitoring occurs in years 1 and 2, and the lakes and ponds monitoring occurs in year 3 (Table 1). Wadeable streams were sampled at Oregon Caves, Redwood Parks, and Crater Lake for the first time in 2012 (Dinger 2015), were resampled in 2015 (the subject of this report), and will be revisited again in 2018.

Table 1. Parks and aquatic vital signs monitored on the three year rotation schedule.

Monitoring	Year 1	Year 2	Year 3
Streams	Whiskeytown	Oregon Caves	–
	Lassen Volcanic	Redwood NSP	–
	–	Crater Lake	–
Lakes	–	–	Lassen Volcanic
	–	–	Crater Lake
	–	–	Redwood NSP

Site Selection

For each park, a target goal of 25 to 30 sites was identified in the wadeable streams protocol (Dinger et al. 2013). However, due to particular circumstances of field season logistics, the total number sampled in a year may or may not meet that number. Sample sites were located probabilistically using Generalized Random Tessellation Stratified (GRTS) spatially balanced design (Stevens and Olson 2004) in the spsurvey package (Kincaid 2012) for R statistical software (version 2.11.1; R Core Development Team, Vienna, Austria). The sampling frame included all perennial streams within a park unit that were: (1) <1000 m from an established road or trail, (2) had a streambed gradient less than 15% based on data that were obtained from the USGS National Hydrography Dataset (www.nhd.usgs.gov). This sample frame then defines the population to which the presented status estimates can be applied.

The final selection or rejection of sample sites upon initial visitation was determined by the field crew leader on site, who considered access and safety issues. If a crew comes to a site previously sampled that is dry, it is dropped from the sampling list, and a replacement from the GRTS generated list is used in its place (until the target number of stream sites is obtained).

A total of 58 sites were sampled in 2015, with 3 sites in Oregon Caves, 26 sites in Redwoods, and 29 sites in Crater Lake. All sites had been previously visited in 2012, except for 3 sites in Redwoods and 7 sites in Crater Lake that were new sites this year.

Oregon Caves, due to the limited areal extent, had sites subjectively selected by park staff, including two sites that are not within the original monument area; but are in the expanded preserve area.

Site Layout

At each selected sample site, a sample reach 40 times longer than the typical wetted width of the stream at time of first sampling was established and 11 equally spaced transects perpendicular to stream flow were marked with temporary flagging (Figure 1). A minimum reach length of 150 m and a maximum reach length of 500 m were imposed.

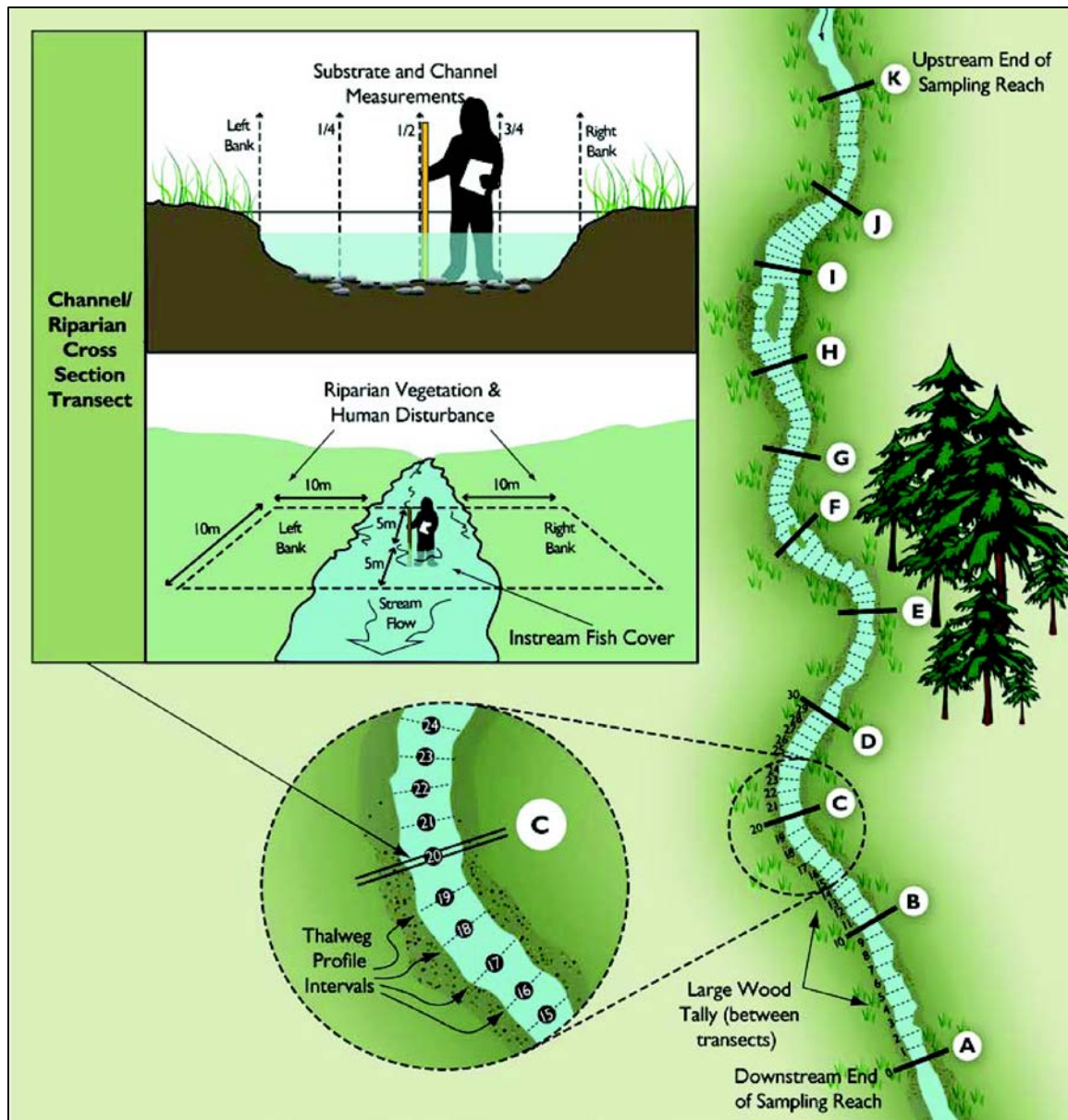


Figure 1. Schematic of sampling site reach layout (from EPA Wadeable Streams Assessment, 2006, Figure 11).

Water Chemistry and Quality

Measurements of temperature ($^{\circ}\text{C}$), pH, specific conductivity ($\mu\text{S cm}^{-1}$), dissolved oxygen (mg L^{-1}), and turbidity (NTU) were made at mid-depth in seven locations along a cross-section that extended perpendicular to stream flow in a well-mixed riffle using an Eureka Environmental “Manta” water quality probe. Specific conductivity was used to ensure that the riffle was well mixed by assessing the seven cross-section measurements for variability. If the specific conductivity varied more than a $5 \mu\text{S cm}^{-1}$ differential across the stream, the measurement was repeated in an upstream riffle until a well-mixed riffle was confirmed.

When a well-mixed riffle was confirmed, a 2 L amber high-density poly-ethylene (HDPE) sample bottle was submerged to collect a water sample. On shore, using a 60 ml syringe and filter holder, a portion of each water sample was filtered through a 0.45 μm nylon membrane filter into an amber, acid washed 250 ml HDPE bottle for cation (Ca^{2+} , Na^+ , K^+ , and Mg^{2+}) and anion (SO_4^{2-} and Cl^-) analyses. An additional unfiltered 250 ml of water was decanted into an identical bottle for nutrient analyses (Total Nitrogen, Total Phosphorous). Both bottles were kept on ice until we were able to freeze them (generally <4 hours). Additionally, 120 mL of water were filtered through precombusted glass fiber filters into an acid-washed, precombusted glass vial for Dissolved Organic Carbon (also kept on ice and later refrigerated). These samples were then shipped to the Cooperative Chemical Analytical Laboratory at Oregon State University, Corvallis. See Dinger et al. (2013) for details on detection limits and analytical techniques for each parameter.

Stream Habitat/Riparian Corridor Characteristics

For the length of the reach, we assessed the following geomorphic characteristics: channel constraint type and percent constrained, channel pattern (braided, anastomosing, single), and evidence of recent torrents. Anastomosing channels are multithreaded, but are much more stable than braided channels and commonly have thick clay and silt banks and occur at lower gradients of stream bed.

At each of the 11 transects, we measured cross-sectional information including wetted width, bank angles, undercut banks, presence and height of incised banks, and bankfull width and height. Across the transect (left bank, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and right bank), we measured depth, substrate embeddedness (proportion of large substrate encased in fine substrates), substrate size, and algal periphyton thickness (as in Fetscher et al. 2010).

On each bank and in the middle of the stream at each transect, we collected measures of overhead shading with a convex, spherical densiometer. Areal categorization of fish habitat cover 5 m above and 5 m below the transect in the following classes were estimated: artificial substrate, boulders, filamentous algae, large wood, macrophytes, overhanging banks, roots, small wood, and undercut banks. In a 10×10 m quadrat next to the transect, we also estimated measures of riparian structure (dominant vegetation type; cover classes [sparse, moderate, heavy, very heavy] of small trees and large trees, herbs, grasses, etc.) in the ground layer (<0.5 m), understory (0.5 to 5.0 m), and overhead canopy (>5 m). In this same quadrat, we quantified the presence of human influences (e.g., walls, dikes, inlet/outlet pipes, camping, etc.).

We also measured thalweg depths along a longitudinal profile that extended throughout the length of the reach, taking equally spaced measurements of max depth, presence of soft or small sediments, and channel form type (pool, glide, riffle, rapid, etc.) (see Figure 1). At the midpoint between transects, we repeat the cross-section measurements (as above) of substrate type and algal thickness.

Inter-transect measures of downed woody debris were also made for the length of the reach. Woody debris was tallied for categories of length and diameter, both within the bankfull stream channel and in adjacent areas above bankfull height.

Stream gradient is measured between transects using a stadia rod and handheld level. An observer with the hand level stands at the approximate halfway point, and a stadia rod is placed at the transects; the difference between upstream and downstream is recorded for the rise. In this way, the total slope and variation in stream gradient can be measured.

The height and broad taxonomic grouping (Alder/Birch, Willow, Maple, Oak, Pine, Spruce, etc.) of the dominant tree located at each cross-sectional transect were also assessed and recorded.

Aquatic Communities

Benthic macroinvertebrates were collected using the EPA reach-wide benthos technique (USEPA 2009). At each transect, a 1 ft. wide D-frame net (500 μ m pore size) was used; in fast water habitats, the upstream substrate in a 1 ft.² area was disturbed so that organisms flowed into the net for collection. In slack water habitats, an active sweep was used in a 1 ft.² area to collect the organisms. The 11 collections were composited and elutriated (i.e., the lighter debris/macroinvertebrates are separated from the heavier inorganic substrates). The sample was then preserved in 90% ethanol and sent to a contract taxonomy lab for enumeration and identification. (For this sampling year, the samples were sent to Rhithron Associates, Inc.).

Aquatic vertebrates were sampled with a Smith-Root LR-24 electrofisher, using single pass. The time spent on a particular reach varies, but total targeted shock time was between 900 and 1,200 seconds. Fish and amphibians netted were stored in a bucket with a battery powered aerator. Specimens were recorded to species, enumerated, and the total lengths of the longest and smallest specimen were recorded. For salmonid species, the number in each size class was also recorded (<60 mm, 60–90 mm, 90–120 mm, 120–150 mm, and >150 mm).

Algal biomass was collected by taking a sample from each transect, following the reach-wide benthic technique. Collection technique varied based on dominant substrate at each transect: (1) if cobble, then a 12.6 cm² area was scrubbed using a stiff brush and a rubber delimiter to mark the area, (2) if gravel/sand, then a 12.6 cm² core was used to collect the substrate, and (3) if bedrock, then a 5.3 cm² sample was taken with a disposable scrubber in situ. Samples from each transect were processed, and composited into a single container. An aliquot was then taken for Ash Free Dry Mass and filtered onto a glass-fiber filter. A second aliquot was filtered on nylon membrane filters for chlorophyll *a* analysis. Filters were then kept on ice and frozen as soon as possible (along with water samples). Chlorophyll processing (extraction and measurement of concentration with fluorometer) was completed at a contract laboratory; in this sample year we worked with Cascade Research (John Salinas of Grants Pass, Oregon).

Metric calculation and data processing

The protocol produces large amounts of data that are entered into a Microsoft Access database in the field on a ruggedized tablet computer (Dinger et al. 2012). After the data are verified and validated, computer code compiled for R statistical software (R Core Team 2016) was used to provide summary statistics. R is a powerful software to accomplish not only statistical analyses, but also data manipulation; and in this case is used to do batch processing of multiple metrics calculated from raw physical, chemical, and biological measures. The R code used to compose the tables in the Results

section of this report is publically available, so that the calculated metrics can be recreated by others and offers full transparency on how the status assessments were determined (NPS 2018, includes link to downloadable data and R-code).

Because use of the automated code improves several aspects of metric calculation, the code was also used to recreate the data tables from the 2011 report (Dinger and Sarr 2014). These revised tables are presented in Appendix D, including an itemized list of improvements and changes associated with using the code.

Calculating Indicators of Ecological Condition

Following the EPA established “indicators of aquatic stress” in its Wadeable Streams Assessment (USEPA 2006) and the EPA EMAP (Environmental Monitoring and Assessment Program) Ecological Assessment of Western Streams and Rivers (Stoddard, Peck, Paulsen et al. 2005a), we use 12 indicators of condition, including a state indicator for macroinvertebrates. These indicators cover three broad categories of assessment: 1) biological, 2) chemical, and 3) physical habitat conditions of a stream. For each indicator, the EPA uses thresholds for determining three condition classes: Least Disturbed, Intermediate, and Most Disturbed. Additionally, a regional macroinvertebrate Multi-Metric Index using state of California thresholds was used in assessing condition. Each indicator and its calculation are described briefly below (text adapted from Stoddard, Peck, Paulsen et al. 2005a).

Total Phosphorous

Phosphorous is a nutrient and is usually considered to be the most likely nutrient limiting algal growth in freshwaters throughout the United States. It is a common ingredient in fertilizers, and high concentrations may be associated with agricultural and urban land use. In the KLMN, this sample is taken at a single, well-mixed riffle near the midpoint of the stream reach, and an unfiltered portion is frozen and sent to an analytical laboratory for analysis.

Total Nitrogen

Nitrogen is another nutrient and is particularly important as a contributor to coastal and estuarine algal blooms. Sources include fertilizers, wastewater, animal wastes, and atmospheric deposition. In the KLMN, this sample is taken at a single, well-mixed riffle near the midpoint of the stream reach, and an unfiltered portion is frozen and sent to an analytical laboratory.

Salinity

Excessive salinity occurs in areas with high evaporative losses of water, and can be exacerbated by repeated use of water for irrigation, or by water withdrawals (by slowing transit time of flowing waters). Both electrical conductivity and total dissolved solids (TDS) can be used as measures of salinity; for KLMN monitoring we follow NPS Water Resources Division (WRD) guidance and measure specific conductivity.

Acid Neutralizing Capacity

From the Wadeable Streams Assessment (USEPA 2006), streams and rivers can become acidic through the effect of acid deposition (e.g., acid rain) or acid mine drainage, particularly from coal mining. In assessing acid pollution (either acid rain or mine drainage), the KLMN relies on a measure of water’s ability to buffer inputs of acid (Acid Neutralizing Capacity; ANC). When ANC

falls below zero, the water is considered acidic and can be directly or indirectly toxic to biota (i.e., by mobilizing toxic metals, such as aluminum). When ANC is between 0 and 25 $\mu\text{eq/L}$ (0 and 1.25 mg/L CaCO_3), a stream is considered sensitive to episodic acidification.

Streambed Stability (aka Relative Bed Stability)

Streams and rivers adjust their channel shape and streambed particle size in response to the supply of water and sediments from their drainage areas. One measure of this interplay between sediment supply and transport is relative bed stability (RBS). The measure of RBS used here is a ratio comparing the particle size of observed sediments to the size of sediment each stream can move or scour during flood stage, based on the size, slope and other physical characteristics of the stream channel. The RBS ratio differs naturally among regions, depending upon landscape characteristics that include geology, topography, hydrology, natural vegetation, and natural disturbance history. Values of the RBS can be substantially lower (prevalence of fine sediments) or higher (coarser, more stable streambeds) than those expected based on the range of the least disturbed sites—both high (stressor-altered flow) and low (stressor-increased sedimentation) values are considered to be indicative of impairment (Figure 2). Currently we utilize an RBS value based purely on stream gradient and average stream depth to predict sediment sizes (Kaufmann et al. 1999). A more refined RBS, incorporating residual pool depth, woody debris, and bankfull characteristics will be used in later reports when reporting and analysis tools are available from the EPA.

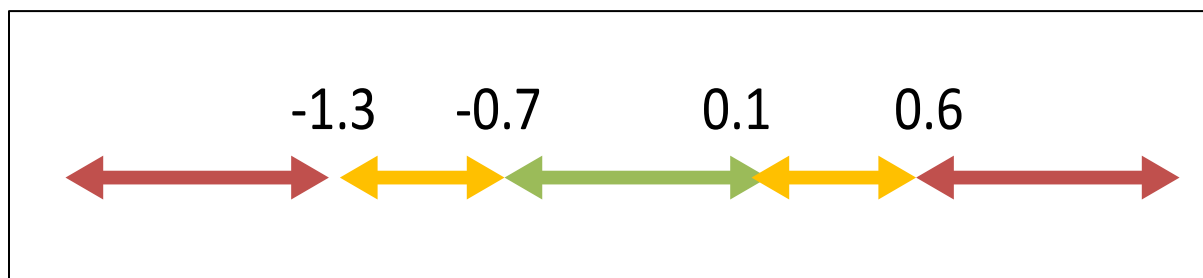


Figure 2. Numeric range and thresholds for RBS condition assessment. Red line = Most Disturbed, yellow line = Intermediate, and green line = Least Disturbed. Higher values suggest stable streambeds with altered flow regimes (e.g., upstream dams) and lower values suggest increased sediments from human landscape use. See text for more details.

In-stream Habitat Cover

This metric is termed “habitat complexity” in Stoddard, Peck, Paulsen et al. (2005b), but is synonymous with In-stream Fish Habitat in USEPA (2006), and Fish Cover in Kaufmann et al. (1999). We follow the terminology of Stoddard, Peck, Paulsen et al (2005).

The most diverse fish and macroinvertebrate assemblages are found in streams and rivers that have complex forms of habitat: large wood, boulders, undercut banks, tree roots, etc. Human use of streams and riparian areas often results in the simplification of this habitat, with potential effects on biotic integrity. We use a measure that sums the amount of in-stream habitat consisting of undercut banks, boulders, large pieces of wood, and cover from overhanging vegetation within a meter of the water surface. It is a scalar metric for which the highest values represent the highest habitat

complexity. Because multiple categories of areal coverage are summed, values can exceed 100% (or 1.0 on a decimal scale).

Riparian Cover

The presence of a complex, multilayered vegetation corridor along streams and rivers is an indication of how well the stream network is buffered against sources of stress in the watershed. Intact riparian areas can help reduce nutrient and sediment runoff from the surrounding landscape, prevent bank erosion, provide shade to reduce water temperature, and provide leaf litter and large wood that serve as food and habitat for stream organisms. The presence of canopy trees in the riparian corridor indicates longevity; the presence of smaller woody vegetation typically indicates that riparian vegetation is reproducing, and suggests the potential for future sustainability of the riparian corridor. As in Stoddard, Peck, Paulsen et al. (2005b), we use a measure of riparian complexity that sums the amount of woody cover provided by three layers of riparian vegetation: ground layer, woody shrubs (understory layer), and the overhead canopy. Because multiple categories of areal coverage are summed, values can exceed 100% (or 1.0 on a decimal scale).

Riparian Disturbance

The vulnerability of the stream network to potentially detrimental human activities increases with the proximity of those activities to the streams themselves. For this assessment, we use a direct measure of riparian human disturbance that tallies 11 specific forms of human activities and disturbances (e.g., roads/trails, landfills, piping, building, farming, etc.), and weights them according to how close to the stream channel they are observed. The index generally varies from 0 (no observed disturbance) to 6 (multiple types observed in the stream, throughout the reach). Note that the presence of a “disturbance” does not equate to a known impact. For example, a well-designed trail along a stream is an indicator of riparian disturbance, but does not necessarily equate to impacts upon the ecological integrity of the stream.

Biological Indicators

Ecological condition can be assessed using biological assemblages because of the inherent capacity of organisms to integrate chemical and physical stressors that affect them over varying spatial and temporal time scales (Rosenberg and Resh 1993, Karr and Chu 1999, Brousseau and Randall 2008). We use three Multi-Metric Indices (MMIs) to assess each stream: 1) Aquatic Vertebrates index; 2) West-wide Macroinvertebrates index, 3) Observed to Expected ratios of macroinvertebrate diversity, and 4) a regional or state-based Macroinvertebrate index. Multi-Metric Indices use a sum of scores for a variety of individual measures that make up the key characteristics of biotic integrity (e.g., taxonomic richness, habitat/trophic composition, sensitivity to human disturbance, etc.). Examples of how the metrics were calculated are presented in Appendix A.

Aquatic Vertebrate MMI

Aquatic vertebrates were assessed using the Aquatic Vertebrate MMI that included measures chosen to represent selected key characteristics of biological integrity: taxonomic richness, taxonomic composition, habitat use, reproductive strategies, pollution tolerance, feeding groups, and the presence of nonnative species. The resulting MMI combines all the measures into an index for which

values range from 0 to 100, with 100 denoting the best possible condition. The development process is given in more detail in the EMAP West statistical summary (Stoddard, Peck, Olsen et al. 2005b).

West-Wide Macroinvertebrate MMI

Characteristics used for the West-Wide Macroinvertebrate MMI were: taxonomic richness, taxonomic compositions, taxonomic diversity, feeding groups, habits, and pollution tolerance. Like the Vertebrate MMI, the scores in each category are summed, and scaled to a 0 to 100 range, with 100 denoting the best possible condition.

Observed/Expected Ratios of Biodiversity

Observed/Expected ratios (O/E scores) operate on multi-variate modeling of reference, non-impacted sites using predictive models. Essentially, the model is able to predict what taxa of macroinvertebrates would occur given that a site is unimpaired, based on a large regional survey of reference sites. The collected (observed sample) taxa list is then compared to the predicted list to develop a ratio, which is a direct reflection of biodiversity loss (or gain). Hence, a value of 0.9 indicates that 90% of the expected biodiversity was present; indicating good condition. Full details of O/E scores and modelling is given in Wright et al. (1989) and also known as RIVPACS (River Invertebrate Prediction and Classification System). The model used here was developed for the US EPA EMAP (Environmental Monitoring and Assessment Program) by Utah State University for 11 western US states, using Chironomidae midge taxonomy to sub-family identifications.

Regional or State Macroinvertebrate Indices

We utilized two regionally relevant MMIs developed by state or academic researchers in different part of the Klamath Region: 1) the California Surface Water Ambient Monitoring Program (SWAMP) developed an MMI for the North Coast Region, including the coastal area of the Redwoods Parks (Rehn et al. 2005); and 2) the Oregon Watershed Enhancement Board (1999) developed the Western Oregon MMI, which covers both Oregon Caves and Crater Lake. Both of these are briefly described below.

California Northern Coastal Region MMI for Redwood National and State Parks

This MMI was developed for three northern California Omernik Level III ecoregions (Omernik 1987): coast range, Klamath mountains, and the southern and central California chaparral and oak woodlands. The components used were: total richness of mayflies, stoneflies, and caddis flies; beetle richness; true fly richness, tolerant individuals, non-snail scraping individuals, predatory individuals, and shredding functional feeding groups taxa; and the number of non-insect taxa. It is scored from 0 to 100 (100 denoting the best possible condition), and condition assessed using categories of Very Poor, Poor, Fair, Good, and Very Good.

The Western Oregon MMI for Oregon Caves National Monument and Crater Lake National Park

This MMI was developed by the state of Oregon Watershed Enhancement Board as part of the Oregon Plan for Salmon and Watershed (Oregon Watershed Enhancement Board 1999), and is regionally relevant to the streams of Crater Lake and Oregon Caves. The components used were taxa richness, mayfly richness, stonefly richness, caddisfly richness, sensitive taxa, sediment sensitive taxa, modified HBI (modified for Oregon specific taxa), % tolerant taxa, % sediment tolerant taxa,

and % of the single most dominant taxa. It is scored on a scale of 10–50 (50 denoting the best possible score), and assessed in the categories of 1) >39 “no impairment,” 2) 30–39 “slight impairment,” 3) 20–29 “moderate impairment,” and 4) <20 “severe impairment.” However, to facilitate comparisons of this MMI to the others, we have scaled the original scores from 20 to 100, with 100 denoting the best possible condition.

Establishing Thresholds of Ecological Condition

The EPA derived three categories (Least Disturbed, Intermediate, and Most Disturbed) that can be used to describe the status of the ecological condition of a stream. These thresholds were established using data collected across the western United States and we applied these thresholds to determine the status of the streams sampled for this project (Table 2).

Table 2. Threshold for condition rating used in the Klamath Network. See text for further description and source of threshold values.

Category	Parameter	Most Disturbed	Intermediate Disturbed	Least Disturbed
Biological	EPA Invert West-wide MMI	<57	57 to 70	≥71
	EPA Vertebrate MMI	<37	37 to 61	≥62
	EPA Observed/Expected	<62	63 to 80	≥81
Chemical	Acid Neutralizing Capacity (µeq/L)	<0	Not Applicable	>0
	Specific Conductance (µS/cm)	>1000	1000 to 501	≤500
	Total Nitrogen (mg/L)	>0.2	0.2 to 0.126	≤0.125
	Total phosphorous (mg/L)	>0.04	0.04 to .011	≤0.01
Physical	In-stream Habitat Cover	<0.14	0.14 to 0.34	≥0.33
	Relative Bed Stability	<-1.3 or >0.6	-1.3 to -0.71 and 0.6 to 0.11	≥-0.7 or ≤0.1
	Riparian Cover	<0.23	0.23 to 0.66	≥0.67
	Riparian Disturbance	>0.95	0.95 to 0.36	≤0.35
State Regional Macroinvertebrate Metrics	Western Oregon MMI	<60 (severe to moderate impairment)	Not Applicable	>60 (slight to no impairment)
	CA North Coast MMI	<60 (fair to poor)	Not Applicable	>60 (good to very good)

Additional Macroinvertebrate Measures

In addition to the metrics used for condition assessment, we report on two commonly used macroinvertebrate metrics (Shannon Index and Hilsenhoff Biotic Index). The Shannon Index (H') is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundance, incorporating both into a single number. It is calculated as: $H' =$

– $\sum p_i \ln p_i$ where p_i is the proportion of the i th species. Values generally range from 0 to 3. Higher

values generally suggest a more balanced, diverse and cosmopolitan assemblage. The Hilsenhoff Biotic Index (HBI) is a weighted average of tolerance values derived from empirical observations of macroinvertebrate responses to pollution (Hilsenhoff 1987, 1988). It is calculated as $HBI = \frac{\sum n_i a_i}{N}$ where n_i = the number of individuals for taxa i , a_i = the assigned tolerance value of taxa i , and N = the total number of individuals for a sample. The HBI sums the overall tolerances of the taxa collected. This index is used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. Shifts in HBI from low values to high values suggest a community change towards a more pollutant tolerant community. The source of tolerance values we used was the list developed by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) (<http://www.safit.org/index.php>). Despite the name, the taxa lists are broadly applicable to the entire western United States.

Relationship of KLMN Indicators to Water Quality Standards

States implement water quality criteria with strict methodologies (for example, a 4,5 or 7 day average water temperature, so there is no applicability using KLMN methods). This protocol, focused on ecological and environmental status and trends, is not a perfect fit for many of these parameters because it only collects single measurements triennially. However, when there is some indication of an exceedance, it should be reported with the suggestion that the park follow up with site-specific measurements, if warranted. The thresholds used are based on NPS criteria established by the NPS Water Resources Division, the State of California drinking water criteria, and EPA criteria for drinking water, health advisory, and National Ambient Water Quality Criteria (Table 3). However, note that although these are promulgated thresholds, their applicability is not strict; we provide the drinking water criteria and health advisory criteria only for comparative purposes, because the KLMN wadeable streams protocol is an ecological integrity based methodology and not designed for monitoring drinking water.

Table 3. Available water quality criteria used for possible exceedances, including drinking water (not applicable for natural waters, but provided for comparative reasons). See Dinger et al. 2013 for sources.

Parameter	NPS Criteria	Oregon Department of Environmental Quality	California Drinking Water	EPA Criteria		
				Drinking Water	Health Advisory	National Ambient Water Quality Criteria
Alkalinity (mg/l)	>10	>20	–	–	–	>20
Chloride (mg/l)	–	–	<250	–	–	<230 ^a ; <860 ^b - when associated only with Sodium
Dissolved Oxygen (mg/l)	>4	>8	–	–	–	>8.0 1-day minimum (water column)
Total Nitrogen (as NO ₂ + NO ₃) (mg/l)	–	–	<10	<10	–	–
pH	>6.5	6.5–8.5		6.5 to 8.5	–	5 to 9 ^c , 6.5 to 9 ^a (max)
Sodium (mg/l)	–	–	–		20	–
Sulfate (mg/l)	–	–	–	500	–	250 ^c
Turbidity (NTU)	<50	<10% above natural	<1	<1	–	–

^a Freshwater aquatic life protection (4 day average)

^b Max concentration (1 hour average)

^c Taste and odor

Results

Oregon Caves National Monument and Preserve

Three sites were sampled in and around Oregon Caves between June 3 and June 24, 2015 (Table 4, Figure 3). Due to the limited acreage of the monument, the sites were subjectively selected by monument staff (Chief of Resources, John Roth, and Physical Scientist Emily Ring). Since these sites were not selected using probabilistic methodology, they cannot be used for park-wide inferences of status (i.e., average condition). However, since streams integrate upstream impacts and disturbances, the sample sites can be used to assess water quality and the ecological condition for the watersheds that contain them. Two sites (ORCAWQ01 and ORCAWQ02) were sampled in the first week as part of field training for the crew, while ORCAWQ03 was sampled later in a day trip while the crew was duty stationed in Redwoods.

Because the sample sites were selected by staff, the standard protocol (Dinger et al. 2013) sampling frame limits were not enforced, so that two of the sites (ORCAWQ01, Cave Creek; and ORCAWQ03, No Name Creek) had substantially higher gradients than other streams sampled under this protocol. The sampled streams of Oregon Caves are small, high gradient, headwater streams characterized by large amounts of woody debris. Photos typifying the three stream reaches are presented in Figure 4.

Table 4. Site list for streams sampled in Oregon Caves National Monument and Preserve.

Stream Name	Site Code	Date Sampled
Cave Creek	ORCAWQ01	6/3/2015
Lake Creek	ORCAWQ02	6/5/2015
No Name Creek	ORCAWQ03	6/24/2015

Physical Characteristics of Oregon Caves Streams

Summary statistics for the monitored streams are presented in Table 5. These are general geomorphological characteristics of the streams (e.g., location, elevation, slope, discharge) and are used to provide a context for the environmental setting; they are not intended to impart any information about the ecological condition of a sample site. All streams had low discharge, with Lake Creek being the highest, at only $0.003 \text{ m}^3 \text{ s}^{-1}$. During the training of the field crews, we were unable to collect data on slope at Cave Creek (ORCAWQ01) (the recorded slope in 2012 was 19.4%).

Physical Condition Metrics of Oregon Caves Streams

The four EPA physical condition metrics along with substrate size and average embeddedness for the Oregon Caves are presented in Table 6.

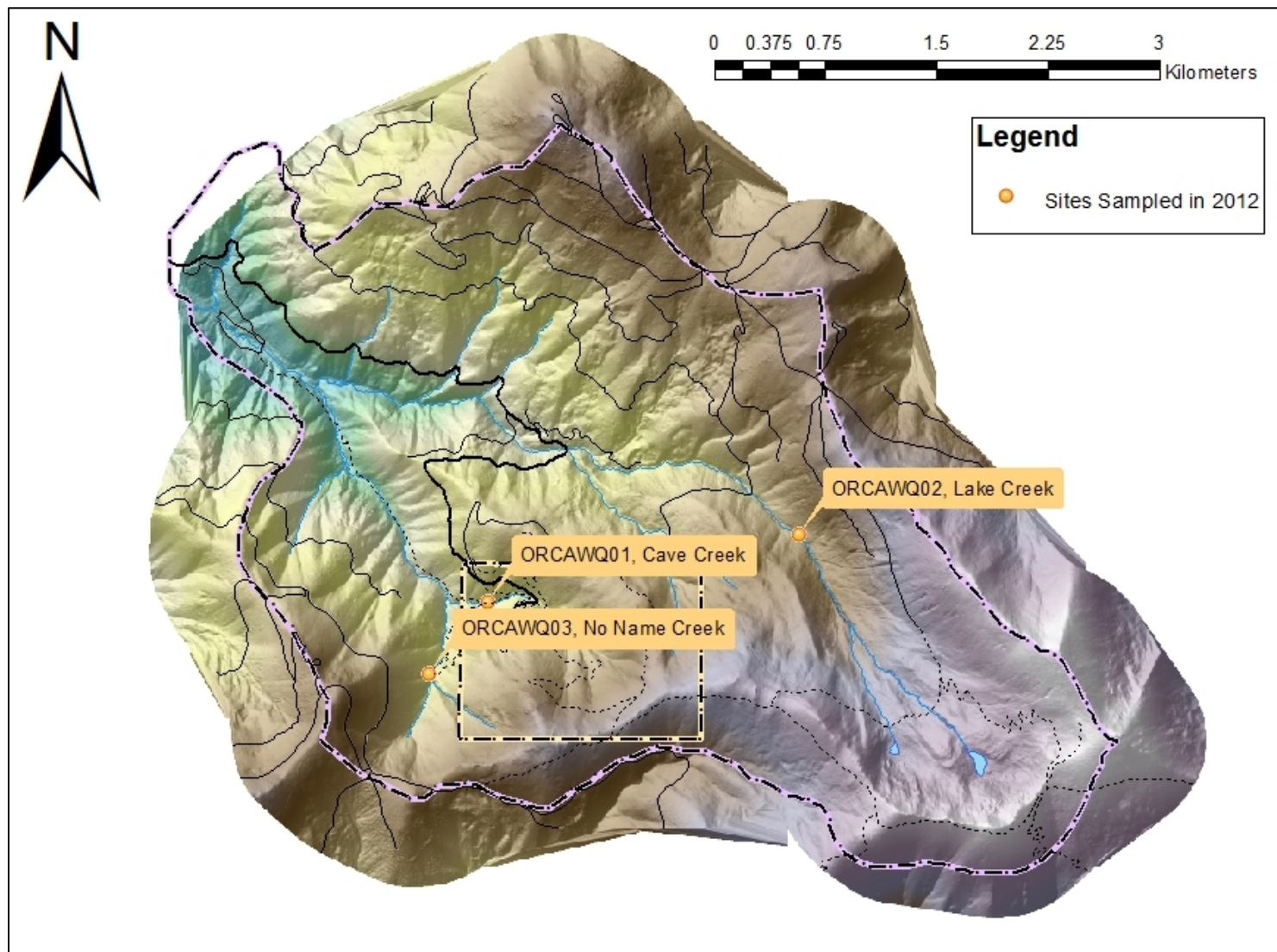


Figure 3. Sites sampled in Oregon Caves National Monument and Preserve, 2015.



Figure 4. Photos of three sites sampled in Oregon Caves. A = Cave Creek (ORCAWQ01); B = Lake Creek (ORCAWQ02); and C = No Name Creek (ORCAWQ03).

Table 5. Physical characteristics and locations of streams sampled in Oregon Caves, 2015.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Cave Creek	ORCAWQ01	6/3/2015	466070	4660784	1184	150	1.7	11	N/A ^b	0.001	0.03
Lake Creek	ORCAWQ02	6/5/2015	468074	4661225	1399	150	3.2	12.3	16.7%	0.003	0.11
No Name Creek	ORCAWQ03	6/24/2015	465609	4660320	1272	150	1.4	6.3	19.2%	0.002	0.07

^a UTM = Universal Transverse Mercator, Zone 10N.

^b NA indicates data Not Available.

Table 6. Physical condition metrics for Oregon Caves streams sampled in 2015.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Cave Creek	ORCAWQ01	6/3/2015	31.6	38	11.3	27%	60%	0.55 ^a	0.43 ^b	NA ^d	0.36 ^b
Lake Creek	ORCAWQ02	6/5/2015	818.1	1047.1	31.1	37%	63%	0.7 ^a	0.73 ^a	0.46 ^b	0 ^a
No Name Creek	ORCAWQ03	6/24/2015	543.1	9549.9	65.8	17%	83%	0.07 ^c	0.42 ^b	0.68 ^c	0.14 ^a

^a Sites meeting EPA threshold criteria for Least Disturbed (also with light sage background).

^b Sites meeting EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA threshold criteria for Most Disturbed (also with dark red background).

^d NA indicates data Not Available.

In-stream Habitat Cover, an indicator of habitat complexity (consisting of boulders, overhanging banks, and the like) was high in all Oregon Caves monitored streams, except being substantially lower in No Name Creek, ORCAWQ03. The low value at No Name Creek is the result of low amounts of available cover, possibly from lower flow amounts and reduced depth and width, but a prevalence of bedrock (which offers no habitat complexity). Riparian Cover was mixed, with Least Disturbed amounts in Lake Creek (ORCAWQ02), but Intermediate in the other two sites. The Riparian Disturbance indicator was correspondingly low in all streams, with most meeting the EPA threshold of Least Disturbed, and Cave Creek (ORCAWQ01), a stream in close proximity to visitor use hiking trails, rating as Intermediate.

Examination of Stream Substrate diameter and the Relative Bed Stability metric shows that one stream, Cave Creek (ORCAWQ01), had a smaller sediment size compared to the other two Oregon Caves streams. The lack of slope data at Cave Creek (ORCAWQ01) prohibits the calculation of Relative Bed Stability. Conversely, the other streams (Lake Creek, ORCAWQ02; No Name Creek, ORCAWQ03) had large median substrate sizes and positive values for Relative Bed Stability, suggesting low levels of sediment recruitment.

Chemical Characteristics and Condition Estimates of Oregon Caves Streams

Selected water chemistry results are presented in Table 7. Parameters measured in-situ with a water probe (see Methods) are listed under “Water Quality” and parameters measured in an analytical laboratory or with a stream-side assay (Acid Neutralizing Capacity) are presented as “Water Chemistry”.

Distinct differences between Lake Creek (ORCAWQ02) and the two other streams suggest edaphic factors vary between the water sources. For example, Lake Creek has lower pH, Specific Conductivity, cations/anions, and Acid Neutralizing Capacity than both Cave Creek and No Name Creek, suggesting that Lake Creek water is derived from rain water, whereas the other two have groundwater influences.

pH found at the three streams was circum-neutral (pH of 7 = neutral), with alkaline values at Cave Creek (ORCAWQ01) and No Name Creek (ORCAWQ03). Values at No Name Creek (ORCAWQ03) were just slightly elevated in respect to water quality criteria (Table 2), at 8.51 with a threshold of 8.5 for pH. **Acid Neutralizing Capacities** were all positive, indicating Least Disturbed.

Temperature is presented as a descriptor of conditions during sampling, but varies on a daily, monthly, and seasonal basis. As such, no status or condition should be inferred from temperature readings. **Specific Conductivity** was uniformly low, and well under the EPA threshold criteria for Least Disturbed at all sites (used as a surrogate for salinity by the EPA). **Dissolved Oxygen** values are all well above regulatory thresholds (Table 2).

Table 7. Water chemistry parameters for streams sampled in Oregon Caves, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	(µeq/L)	(mg/L)
Cave Creek	ORCAWQ01	8.31	6.9	210 ^c	10.6	0	2.42	0.42	1.12	0.07 ^c	0.028 ^d	2388 ^c	120 ^c
Lake Creek	ORCAWQ02	7.9	7.8	45 ^c	10.2	0	1.93	0.23	0.39	0.17 ^d	0.009 ^c	209 ^c	10 ^c
No Name Creek	ORCAWQ03	8.51	9	212 ^c	9.7	1.2	2.82	0.68	0.97	0.04 ^c	0.013 ^d	2148 ^c	108 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites meeting EPA threshold criteria for Least Disturbed (also with light sage background).

^d Sites meeting EPA threshold criteria for Intermediate disturbance (also with medium amber background).

Turbidity readings were low (Table 7), and no sites were above the NPS criteria. The **anions and cations** with available thresholds for water quality were all far below promulgated values (Table 3). **Total Nitrogen** values were all well below EPA thresholds for Least Disturbed, except for Lake Creek (ORCAWQ02) which was Intermediate. **Total Phosphorous** values for two sites, Cave Creek (ORCAWQ01) and No Name Creek (ORCAWQ03) were in the elevated EPA threshold for Intermediate.

Riparian Characteristics of Oregon Caves Streams

All the streams of Oregon Caves were well shaded, with the lowest value at No Name Creek (ORCAWQ03) with 81% shading in the stream center (Table 8). Canopy cover at all three sites were dominated by conifer trees, with only conifer cover at Lake Creek (ORCAWQ02). Understory was varied, with all sites having large amounts of conifer, deciduous and mixed species. Time constraints prohibited the collection of Legacy Tree data at No Name Creek (ORCAWQ03).

Vertebrate Assemblage and Condition of Oregon Caves Streams

We were unable to electrofish sites in Oregon Caves due to faulty batteries, and could only electrofish a single site (No Name Creek, ORCAWQ01). Within this one stream reach, we encountered four Pacific Giant Salamanders (*Dicamptodon tenebrosus*) and five Tailed Frog (*Ascaphus truei*) tadpoles (Table 9), both species on the existing park species list.

The condition assessment of No Name Creek, utilizing the EPA Vertebrate MMI, ranked the site as Least Disturbed.

Macroinvertebrate Assemblage and Condition of Oregon Caves Streams

A total of 1,855 macroinvertebrates were collected from all three sample reaches and 128 taxa were identified by taxonomists (a complete list of taxa from Oregon Caves samples is given in Appendix B.) Accounting for ambiguous taxa following Cuffney et al. (2007) and Dinger et al. (2013), the estimated richness for the sampled streams was 111 species and all of the sites were within the range of Least Disturbed conditions. Summary statistics (Taxa Richness and measures of biological condition) for each site are provided in Table 10.

All three sites were characterized by high diversity (Cave Creek, ORCAWQ01, was the highest at 70 taxa). The HBI for the three streams were well within the range for “excellent” water quality conditions (Hilsenhoff 1988).

Table 8. Riparian characteristics of Oregon Caves streams sampled in 2015.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Cave Creek	ORCAWQ01	96%	94%	32.1	12%	7%	41% C,32% D, 27% M	19%	6%	5% C,73% D, 9% N,14% M
Lake Creek	ORCAWQ02	85%	86%	53.2	26%	10%	100% C	26%	4%	29% C,24% D, 5% N,43% M
No Name Creek	ORCAWQ03	91%	81%	NA ^b	2%	24%	91% C,5% D,5% N	16%	9%	64% C,36% D

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

^b NA indicates data not available.

Table 9. Vertebrate species and metrics for Oregon Caves streams sampled in 2015.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Pacific Giant Salamander	Red-legged Frog
Cave Creek	ORCAWQ01	No ^b	–	–	–	–	–
Lake Creek	ORCAWQ02	No ^b	–	–	–	–	–
No Name Creek	ORCAWQ03	Yes	7	2	78.6 ^a	6	1

^a Sites are Least Disturbed (also with light sage background).

^b In 2015, only one site was electrofished due to faulty batteries.

Table 10. Macroinvertebrate indicators for Oregon Caves streams, 2015. All metrics scored the streams as Least Disturbed, indicated by sage-colored shaded cells.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	CA North Coast MMI ^{c,f}	Oregon Western Streams IBI ^d
Cave Creek	ORCAWQ01	70	3.68	3.97	1.04 ^e	79 ^e	87 ^e	92 ^e
Lake Creek	ORCAWQ02	60	3.02	3.08	1.07 ^e	82 ^e	71 ^e	92 ^e
No Name Creek	ORCAWQ03	64	3.61	3.9	1.13 ^e	85 ^e	76 ^e	88 ^e

^a HBI = Hilsenhoff Biotic Index

^b O/E = Observed/Expected ratio;

^c MMI = Multi-Metric Index

^d IBI = Index of Biotic Integrity

^e Sites in the O/E and MMI columns are Least Disturbed (also with light sage background).

^f Sites in the CA North Coast MMI column, cells are equal “good to very good” condition (also with light sage background).

Redwood National and State Parks

Twenty-six sites were sampled at Redwood Parks between June 10 and July 29 (Figure 5, Table 11), at which point the crew transitioned to Crater Lake. The original target was 25 to 30, and we were able to meet the low end of this range. One site, West Fork Clark Creek (REDWWQ27) was unable to be safely sampled due to the overall travel distance.

The first 22 sites (REDWWQ01 – REDWWQ22) were sites co-located with KLMN Vegetation Community Sampling (Odion et al. 2011), and selected under the KLMN Vegetation GRTS routine. The additional sites (REDWWQ23 – REDWWQ32) were selected under an additional GRTS routine to increase the sample size per the streams protocol (Dinger et al. 2013). There were no major challenges in data completeness (all measures performed at all sites).

The sampled streams (those in the specified sampling frame) of the Redwood Parks are densely shaded, heavily forested, lower gradient streams (<15%). Stream order ranges from 1st order headwater streams with low seasonal discharge, to 5th order streams with inaccessible deep pools (Redwood Creek). Examples of stream reaches sampled are presented in Figure 6. Access to these streams was slow, owing to the heavy undergrowth, downed trees, and general hazardous conditions of off-trail travel in redwood country.

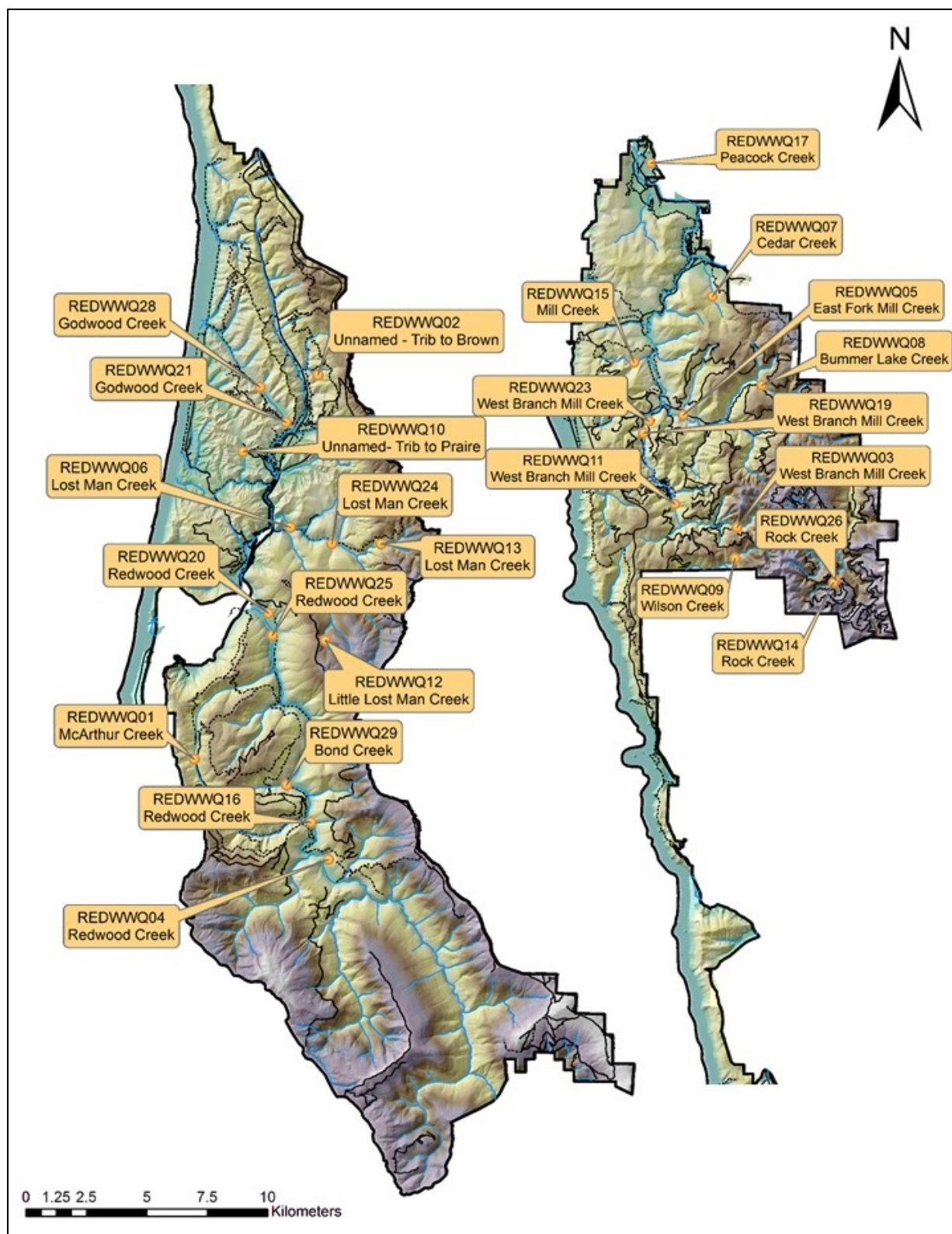


Figure 5. Stream sites sampled in Redwood National and State Parks, 2015. South portion of park on left, North portion on right.

Table 11. Site list for streams to be sampled in Redwood National and State Parks, 2015.

Stream Name	Site Code	Date Sampled	Reason for not sampling
McArthur Creek	REDWWQ01	6/16/2015	n/a
Unnamed - Trib to Brown	REDWWQ02	6/15/2015	n/a
West Branch Mill Ck	REDWWQ03	6/29/2015	n/a
Redwood Creek	REDWWQ04	7/1/2015	n/a
East Fork Mill Creek	REDWWQ05	6/18/2015	n/a
Lost Man Creek	REDWWQ06	6/10/2015	n/a
Cedar Creek	REDWWQ07	7/6/2015	n/a
Bummer Lake Creek	REDWWQ08	6/25/2015	n/a
Wilson Creek	REDWWQ09	7/14/2015	n/a
Unnamed	REDWWQ10	6/12/2015	n/a
West Branch Mill Ck	REDWWQ11	6/17/2015	n/a
Little Lost Man Creek	REDWWQ12	6/23/2015	n/a
Lost Man Creek	REDWWQ13	6/22/2015	n/a
Rock Creek	REDWWQ14	6/30/2015	n/a
Mill Creek	REDWWQ15	7/9/2015	n/a
Redwood Creek	REDWWQ16	7/15/2015	n/a
Peacock Creek	REDWWQ17	7/8/2015	n/a
West Branch Mill Ck	REDWWQ19	7/13/2015	n/a
Redwood Creek	REDWWQ20	7/16/2015	n/a
Godwood Creek	REDWWQ21	6/11/2015	n/a
West Branch Mill Ck	REDWWQ23	7/20/2015	n/a
Lost Man Creek	REDWWQ24	7/22/2015	n/a
Redwood Creek	REDWWQ25	7/21/2015	n/a
Rock Creek	REDWWQ26	7/23/2015	n/a
West Fork Clarks Creek	REDWWQ27	— ^a	Too distant from vehicle ^b
Godwood Creek	REDWWQ28	7/27/2015	n/a
Bond Creek	REDWWQ29	7/29/2015	n/a
West Branch Mill Ck	REDWWQ30	— ^a	Not sampled due to seasonal time constraints
Unnamed Streams	REDWWQ31	— ^a	Not sampled due to seasonal time constraints
Godwood Creek	REDWWQ32	— ^a	Not sampled due to seasonal time constraints

^a Sites were not sampled either due to the site being distant or was planned to be sampled later.

^b Sites more than 1.5 hours hiking time are too distant to accomplish safe working in a work day.

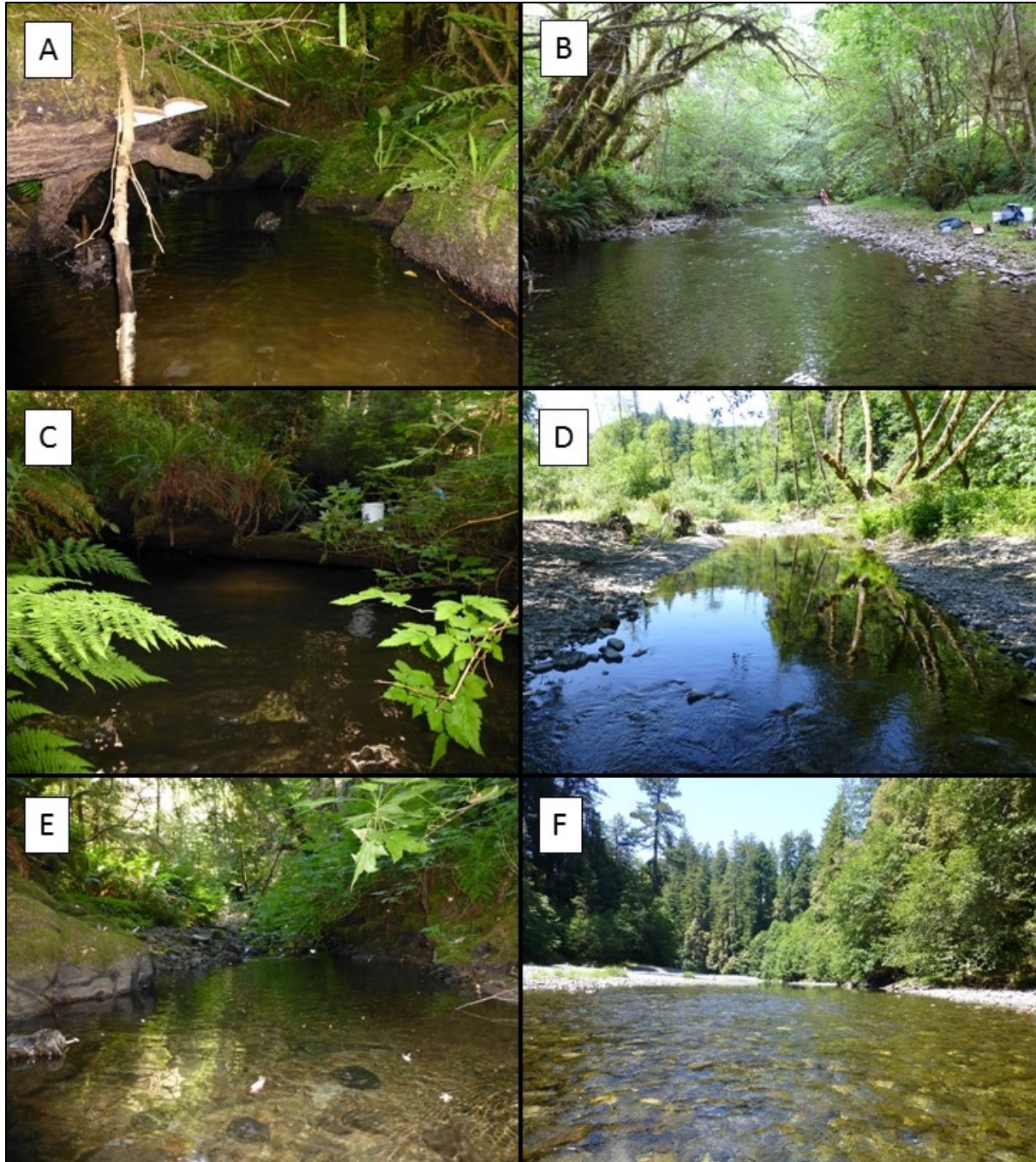


Figure 6. Examples of typical stream characteristics in Redwoods National and State Parks, 2015. A = McArthur Creek (REDWWQ01); B = Lost Man Creek (REDWWQ06); C = Godwood Creek (REDWWQ21); D = West Branch Mill Creek (REDWWQ11); E = Lost Man Creek (REDWWQ13); and F = Redwood Creek (REDWWQ04).

Physical Characteristics of Redwood Parks Streams

Summary statistics for the monitored streams are presented in Table 12. These are general geomorphological characteristics of the streams (e.g., location, elevation, slope, discharge) and do not impart any conditional information. The smallest stream sampled was an unnamed stream

(REDWWQ02), a 1st order tributary to Brown Creek, with both the smallest average width (1.2 m) and one of the lowest measured discharges ($0 \text{ ft}^3 \text{ s}^{-1}$). Several streams had flows low enough that our instrumentation did not record measureable flow. The largest stream sampled was Redwood Creek (4 reaches – REDWWQ04, REDWWQ16, REDWWQ20, and REDWWQ25). This is a fifth order stream with average widths during sampling from 16.3 m to 29.6 m for the reaches sampled, and discharge up to $0.111 \text{ m}^3 \text{ s}^{-1}$ ($3.93 \text{ ft}^3 \text{ s}^{-1}$). Overall, instantaneous discharge were well below values seen in 2012.

Physical Condition Metrics of Redwood Parks Streams

The four EPA physical condition metrics, along with substrate size and average embeddedness for Redwood Parks streams are presented in Table 13. A stream's median substrate size is a more useful descriptor because the average substrate size can be influenced by a few, very large pieces of substrate. Redwood Parks streams were characterized by small sediment sizes; however the Relative Bed Stability metric (a predictive metric based on slope and other geomorphic features) that compares the observed sediment size to expected sediment size was occasionally in the Least Disturbed state for many of the streams (38% of streams), even those characterized by small sediments. Thirteen stream reaches were in an Intermediate state (50%), and three site reaches were rated as Most Disturbed (12%). One, McArthur Creek (REDWWQ01), was in the Most Disturbed category for having higher than expected amounts of small sediments, while Redwood Creek (REDWWQ04) and West Branch Mill Creek (REDWWQ11) had larger sediment sizes than expected (generally indicative of water withdrawal by the US EPA metrics).

Twelve stream reaches were in the Intermediate condition based on the Riparian Cover metric (46%). The high number of sites categorized as Intermediate is detailed more in the discussion.

All sites were in the Least Disturbed condition for the Riparian Disturbance metric. Most sites were also within the Least Disturbed condition for In-stream Habitat Cover, a measure of stream habitat complexity (69%). Only four sites were Intermediate (15%) and four in the Most Disturbed (15%).

Table 12. Physical characteristic and location of streams sampled in Redwood National and State Parks, 2015.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m3 s-1	ft3 s-1
McArthur Creek	REDWWQ01	6/16/2015	410488	4566201	228	150	2.1	27.5	1.4%	0.002	0.06
Unnamed- Trib to Brown	REDWWQ02	6/15/2015	415603	4582109	161	150	1.2	6.8	7.8%	0 ^b	0 ^b
West Branch Mill Ck	REDWWQ03	6/29/2015	411833	4615354	245	150	4	21.7	4.2%	0.003	0.09
Redwood Creek	REDWWQ04	7/1/2015	416040	4562046	89	500	16.8	53.5	0.3%	0.111	3.93
East Fork Mill Creek	REDWWQ05	6/18/2015	409470	4620311	99	280	8.5	36	0.5%	0.002	0.06
Lost Man Creek	REDWWQ06	6/10/2015	414467	4575799	47	352	7.1	23.7	0.6%	0.025	0.9
Cedar Creek	REDWWQ07	7/6/2015	410761	4625534	175	150	2.9	12.3	3.6%	0 ^b	0.02
Bummer Lake Creek	REDWWQ08	6/25/2015	412922	4621625	246	150	5.9	12.3	11.4%	0.003	0.1
Wilson Creek	REDWWQ09	7/14/2015	411754	4613998	298	150	2.9	14.3	4.4%	0.001	0.03
Unnamed- Streelow Creek Trail	REDWWQ10	6/12/2015	412500	4578934	87	150	1.7	16.4	1.2%	0 ^b	0.01
West Branch Mill Ck	REDWWQ11	6/17/2015	409119	4616387	154	236	4.2	21.9	0.4%	0.004	0.14
Little Lost Man Creek	REDWWQ12	6/23/2015	415919	4571118	438	150	2.7	11.6	4.4%	0.001	0.02
Lost Man Creek	REDWWQ13	6/22/2015	418215	4575114	237	152	3.6	14.2	4.1%	0.002	0.07
Rock Creek	REDWWQ14	6/30/2015	416077	4612934	405	150	2.3	10.2	3.0%	0 ^b	0 ^b
Mill Creek	REDWWQ15	7/9/2015	407311	4622635	102	150	2.1	7.3	1.5%	0.001	0.03
Redwood Creek	REDWWQ16	7/15/2015	415326	4563589	43	500	16.3	60.2	0.2%	0.063	2.22
Peacock Creek	REDWWQ17	7/8/2015	408047	4631421	56	168	3	11.3	1.7%	0.002	0.09
West Branch Mill Ck	REDWWQ19	7/13/2015	407717	4619518	108	200	6.6	23.3	1.1%	0.007	0.26
Redwood Creek	REDWWQ20	7/16/2015	413564	4572245	16	500	29.6	18.3	0.3%	0.068	2.41
Godwood Creek	REDWWQ21	6/11/2015	414292	4580150	97	150	3.1	22.4	0.5%	0.003	0.09
West Branch Mill Ck	REDWWQ23	7/20/2015	407971	4620050	109	200	6	38.1	1.5%	0.006	0.2
Lost Man Creek	REDWWQ24	7/22/2015	416183	4575117	107	200	8	11.8	1.8%	0.002	0.09
Redwood Creek	REDWWQ25	7/21/2015	413719	4571331	40	500	18.2	30	0.1%	0.051	1.79
Rock Creek	REDWWQ26	7/23/2015	416165	4613036	416	150	2.2	8.9	3.8%	0 ^b	0 ^b

^a UTM = Universal Transverse Mercator, Zone 10N. ^bIndicates flow discharge below instrumentation capabilities, and not complete absence of flow.

Table 12 (continued). Physical characteristic and location of streams sampled in Redwood National and State Parks, 2015.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m3 s-1	ft3 s-1
Godwood Creek	REDWWQ28	7/27/2015	413217	4581599	114	150	1.5	6.5	2.6%	0 ^b	0.01
Bond Creek	REDWWQ29	7/29/2015	414309	4565127	77	150	2.1	9.7	9.4%	0.002	0.06
Average	—	—	—	—	161.3	226	6.3	20.4	2.8%	0.014	0.49
SD	—	—	—	—	119.7	128	6.7	13.8	2.9%	0.028	0.98
Median	—	—	—	—	108.5	150	3.4	15.4	1.6%	0.002	0.08
Range	—	—	—	—	16 - 438	150 - 500	1.2 - 29.6	6.5 - 60.2	0.1% - 11.4%	0 ^b - 0.111	0 - 3.93

^a UTM = Universal Transverse Mercator, Zone 10N. ^bIndicates flow discharge below instrumentation capabilities, and not complete absence of flow.

Table 13. Physical condition metrics for Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Date Sampled	Stream Substrate Diameter (mm)		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
McArthur Creek	REDWWQ01	6/16/2015	0.6	0.5	47.6	62%	14%	0.82 ^a	1.06 ^a	-1.68 ^c	0 ^a
Unnamed- Trib to Brown	REDWWQ02	6/15/2015	21.1	38.0	33.9	18%	66%	0.62 ^a	0.45 ^b	-0.38 ^a	0 ^a
West Branch Mill Ck	REDWWQ03	6/29/2015	83.7	38.0	27.8	32%	39%	0.37 ^a	0.65 ^a	0.01 ^a	0 ^a
Redwood Creek	REDWWQ04	7/1/2015	36.5	38.0	46.5	53%	9%	0.15 ^b	1.06 ^a	0.27 ^b	0 ^a
East Fork Mill Creek	REDWWQ05	6/18/2015	31.0	38.0	35.2	43%	17%	0.23 ^b	0.8 ^a	0.29 ^b	0 ^a
Lost Man Creek	REDWWQ06	6/10/2015	23.4	38.0	43	22%	27%	0.43 ^a	0.67 ^a	0.3 ^b	0 ^a
Cedar Creek	REDWWQ07	7/6/2015	164.8	114.8	34.9	24%	38%	0.66 ^a	0.81 ^a	0.52 ^b	0 ^a
Bummer Lake Creek	REDWWQ08	6/25/2015	67.1	38.0	32.5	40%	41%	0.25 ^b	0.45 ^b	-0.43 ^a	0 ^a
Wilson Creek	REDWWQ09	7/14/2015	108.9	38.0	14.5	42%	43%	0.35 ^a	0.76 ^a	0.22 ^b	0 ^a
Unnamed- Streelow Creek Trail	REDWWQ10	6/12/2015	7.4	4.2	32	43%	30%	1.08 ^a	0.72 ^a	-0.38 ^a	0 ^a
West Branch Mill Ck	REDWWQ11	6/17/2015	33.2	38.0	14.5	44%	23%	0.24 ^b	0.74 ^a	0.63 ^c	0 ^a
Little Lost Man Creek	REDWWQ12	6/23/2015	52.1	114.8	41	23%	58%	0.52 ^a	0.62 ^b	0.08 ^a	0 ^a
Lost Man Creek	REDWWQ13	6/22/2015	31.2	38.0	42.2	32%	52%	0.56 ^a	0.64 ^b	-0.24 ^a	0 ^a
Rock Creek	REDWWQ14	6/30/2015	98.9	114.8	31.7	19%	56%	0.12 ^c	0.61 ^b	0.53 ^b	0 ^a
Mill Creek	REDWWQ15	7/9/2015	41.4	38.0	33.6	17%	54%	0.85 ^a	1.12 ^a	0.47 ^b	0 ^a
Redwood Creek	REDWWQ16	7/15/2015	19.1	38.0	44.8	71%	8%	0.05 ^c	0.49 ^b	0.26 ^b	0 ^a
Peacock Creek	REDWWQ17	7/8/2015	21.2	38.0	56.2	25%	55%	0.62 ^a	0.77 ^a	0.01 ^a	0 ^a
West Branch Mill Ck	REDWWQ19	7/13/2015	36.8	38.0	40.5	46%	11%	0.36 ^a	0.72 ^a	0.1 ^a	0 ^a
Redwood Creek	REDWWQ20	7/16/2015	29.9	38.0	20.7	30%	25%	0.05 ^c	0.4 ^b	0.53 ^b	0 ^a

^a Sites meeting EPA threshold criteria for Least Disturbed (also with light sage background).

^b Sites meeting EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA threshold criteria for Most Disturbed (also with dark red background).

Table 13 (continued). Physical condition metrics for Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Date Sampled	Stream Substrate Diameter (mm)		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Godwood Creek	REDWWQ21	6/11/2015	19.6	38.0	19.8	43%	24%	0.55 ^a	0.33 ^b	0.24	0.12 ^a
West Branch Mill Ck	REDWWQ23	7/20/2015	36.0	38.0	39.3	49%	26%	0.45 ^a	0.63 ^b	-0.12 ^a	0.06 ^a
Lost Man Creek	REDWWQ24	7/22/2015	78.6	114.8	62.5	11%	57%	0.42 ^a	0.6 ^b	0.41 ^b	0 ^a
Redwood Creek	REDWWQ25	7/21/2015	20.4	38.0	15.7	28%	13%	0.04 ^c	0.38 ^b	0.78 ^c	0 ^a
Rock Creek	REDWWQ26	7/23/2015	157.5	114.8	35.1	15%	5%	0.51 ^a	0.57 ^b	0.53 ^b	0 ^a
Godwood Creek	REDWWQ28	7/27/2015	20.1	38.0	0.5	22%	43%	1.07 ^a	0.78 ^a	0.06 ^a	0 ^a
Bond Creek	REDWWQ29	7/29/2015	20.2	38.0	19.9	38%	44%	1.38 ^a	0.87 ^a	-0.72 ^b	0 ^a
Average	–	–	48.5	50.0	33.3	34%	34%	0.49 ^a	0.68 ^a	0.09 ^a	0.01 ^a
SD	–	–	42.9	33.6	14.0	15%	18%	0.34	0.20	0.52	0.03
Median	–	–	32.2	38.0	34.4	32%	34%	0.44 ^a	0.66 ^b	0.23 ^b	0.00 ^a
Range	–	–	0.6 - 164.8	0.5 - 114.8	0.5 - 62.5	11 % - 71%	5% - 66%	0.04 - 1.38	0.33 - 1.12	-1.38 - 0.78	0 - 0.12

^a Sites meeting EPA threshold criteria for Least Disturbed (also with light sage background).
^b Sites meeting EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^c Sites meeting EPA threshold criteria for Most Disturbed (also with dark red background).

Chemical Characteristics and Condition Estimates of Redwood Parks Streams

Selected water chemistry results are presented in Table 14. Parameters measured in-situ with a water probe (see Methods) are listed under “Water Quality” and parameters measured in an analytical laboratory or with a stream-side assay (Acid Neutralizing Capacity) are presented as “Water Chemistry”.

At two sites, Cedar Creek (REDWWQ07) and Rock Creek (REDWWQ14), the water probe was not functioning correctly, preventing the collection of water quality data at these sites.

pH was found to be circum-neutral (pH of 7 = neutral), with an average of 7.60. Values did not exceed any water quality criteria (Table 3), and the average pH was solidly within the acceptable range. **Acid Neutralizing Capacities** were all positive, indicating Least Disturbed.

Temperature is presented as a descriptor of conditions during sampling, but varies on a daily, monthly, and seasonal basis. As such, no status or condition should be inferred from temperature readings. However, not surprisingly, the highest temperatures recorded were on Redwood Creek (REDWWQ04, REDWWQ16, REDWWQ20 and REDWWQ25), with temperatures ranging from 16.9 °C to 20.7 °C. Redwood Creek is a 303(d) site listed under the Clean Water Act as temperature (and sediment) impaired (Hoffman et al. 2005), and is currently monitored by Redwood.

Specific Conductivity was uniformly low, and well under the EPA threshold criteria for Least Disturbed at all sites (used as a surrogate for salinity by the EPA). **Dissolved Oxygen** values also appear well within regulatory criteria for available water quality thresholds (Table 3). **Turbidity** readings were generally low, with recorded values only above 0 NTUs at seven sites. Although these values were above strict *drinking water* criteria, they were under the NPStoret thresholds. Additionally, sedimentation problems in stream water quality are best addressed by continuous measurements, and not instantaneous readings.

The **anions and cations** with available thresholds for water quality were all far below promulgated values. Although no strong patterns emerged with a stream having uniformly high anions and cations, all Redwood Creek sites were substantially higher in sulfate than other Redwood Parks streams.

Total Nitrogen, a key ecosystem nutrient, had low measured levels in six sites (23%), all well below the EPA threshold for Least Disturbed. However, nine sites were Intermediate (35%), and 11 were rated Most Disturbed (42%). The presence of a substantial number of low level sites in the parks suggests that the background level of Total Nitrogen is low, and there are potential secondary sources of nitrogen in the Intermediate and Most Disturbed sites. **Total Phosphorous**, another key ecosystem nutrient, was low in 11 Redwood Park stream sites, meeting the EPA criteria for Least Disturbed. Fifteen sites were Intermediate, but several of these were very close to the threshold for Least Disturbed. Overall, values for both Total Phosphorous and Total Nitrogen were higher for 2015 than 2012.

Table 14. Water chemistry parameters for streams sampled in Redwood Parks, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^g	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
West Branch Mill Ck	REDWWQ11	6.9	13.4	57 ^c	8.7	0	4.35	0.64	3.87	0.27 ^e	0.011 ^d	350 ^c	18 ^c
Little Lost Man Creek	REDWWQ12	7.65	12.4	58 ^c	10.3	0	5.52	0.48	5.53	0.13 ^d	0.027 ^d	509 ^c	26 ^c
Lost Man Creek	REDWWQ13	7.5	11.1	67 ^c	10.7	2.5	4.88	0.83	4.54	0.08 ^c	0.009 ^c	49 ^c	2 ^c
Rock Creek	REDWWQ14	7.48	12.8	44 ^c	11.1	0	2.96	0.73	3.45	0.22 ^e	0.01 ^c	495 ^c	25 ^c
Mill Creek	REDWWQ15	7.68	13.1	65 ^c	10.1	65.3	6.06	0.64	7.3	0.41 ^e	0.011 ^d	289 ^c	14 ^c
Redwood Creek	REDWWQ16	7.7	19	156 ^c	9	0	4.43	2.78	3.82	0.13 ^d	0.007 ^c	1203 ^c	60 ^c
Peacock Creek	REDWWQ17	7.89	14	122 ^c	10.1	57.2	4.23	0.82	5.13	0.32 ^e	0.013 ^d	1122	56
West Branch Mill Ck	REDWWQ19	7.14	15	55 ^c	8.8	0	4.53	0.59	4.45	0.2 ^d	0.009 ^c	334 ^c	17 ^c
Redwood Creek	REDWWQ20	7.94	16.9	149 ^c	9.2	0	4.51	2.41	4.27	0.14 ^d	0.005 ^c	1148 ^c	57 ^c
Godwood Creek	REDWWQ21	7.85	11.6	121 ^c	11	0	8.48	0.76	10.49	0.05 ^c	0.021 ^d	960 ^c	48 ^c
West Branch Mill Ck	REDWWQ23	7.29	16.1	55 ^c	9.6	0	4.43	0.6	4.39	0.28 ^e	0.013 ^d	395 ^c	20 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 14 (continued). Water chemistry parameters for streams sampled in Redwood Parks, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^g	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
West Branch Mill Ck	REDWWQ11	6.9	13.4	57 ^c	8.7	0	4.35	0.64	3.87	0.27 ^e	0.011 ^d	350 ^c	18 ^c
Little Lost Man Creek	REDWWQ12	7.65	12.4	58 ^c	10.3	0	5.52	0.48	5.53	0.13 ^d	0.027 ^d	509 ^c	26 ^c
Lost Man Creek	REDWWQ13	7.5	11.1	67 ^c	10.7	2.5	4.88	0.83	4.54	0.08 ^c	0.009 ^c	49 ^c	2 ^c
Rock Creek	REDWWQ14	7.48	12.8	44 ^c	11.1	0	2.96	0.73	3.45	0.22 ^e	0.01 ^c	495 ^c	25 ^c
Mill Creek	REDWWQ15	7.68	13.1	65 ^c	10.1	65.3	6.06	0.64	7.3	0.41 ^e	0.011 ^d	289 ^c	14 ^c
Redwood Creek	REDWWQ16	7.7	19	156 ^c	9	0	4.43	2.78	3.82	0.13 ^d	0.007 ^c	1203 ^c	60 ^c
Peacock Creek	REDWWQ17	7.89	14	122 ^c	10.1	57.2	4.23	0.82	5.13	0.32 ^e	0.013 ^d	1122	56
West Branch Mill Ck	REDWWQ19	7.14	15	55 ^c	8.8	0	4.53	0.59	4.45	0.2 ^d	0.009 ^c	334 ^c	17 ^c
Redwood Creek	REDWWQ20	7.94	16.9	149 ^c	9.2	0	4.51	2.41	4.27	0.14 ^d	0.005 ^c	1148 ^c	57 ^c
Godwood Creek	REDWWQ21	7.85	11.6	121 ^c	11	0	8.48	0.76	10.49	0.05 ^c	0.021 ^d	960 ^c	48 ^c
West Branch Mill Ck	REDWWQ23	7.29	16.1	55 ^c	9.6	0	4.43	0.6	4.39	0.28 ^e	0.013 ^d	395 ^c	20 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 14 (continued). Water chemistry parameters for streams sampled in Redwood Parks, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^g	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Lost Man Creek	REDWWQ24	7.77	13.4	82 ^c	10.8	0	5.71	0.79	4.93	0.11 ^c	0.01 ^c	984 ^c	49 ^c
Redwood Creek	REDWWQ25	7.74	17.8	154 ^c	9.1	0	4.6	2.4	4.3	0.18 ^d	0.006 ^c	1136 ^c	57 ^c
Rock Creek	REDWWQ26	7.58	13.2	49 ^c	10	0	3.29	0.95	2.52	0.41 ^e	0.015 ^d	264 ^c	13 ^c
Godwood Creek	REDWWQ28	7.59	13.1	109	9.7	0	8.37	0.49	11.95	0.05 ^c	0.029 ^d	869 ^c	44 ^c
Bond Creek	REDWWQ29	7.27	13.6	57 ^c	10	0	4.48	0.58	5.82	0.35 ^e	0.009 ^c	308 ^c	15 ^c
Average	–	7.60	13.8	84 ^c	10.0	7	5.09	1.00	5.42	0.23 ^e	0.013 ^d	615 ^c	31 ^c
SD	–	0.24	2.5	36	0.7	20	1.52	0.72	2.62	0.16	0.006	351	18
Median	–	7.63	13.2	68 ^c	10.1	0	4.52	0.75	4.42	0.20 ^d	0.011 ^d	516 ^c	26 ^c
Range	–	6.90 - 7.94	10.6 - 20.7	44 - 156	8.7 - 11.1	0 - 65.3	2.96 - 8.8	0.48 - 2.89	2.52 - 11.95	0.05 - 0.78	0.005 - 0.029	49 - 1218	2 - 61

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Riparian Characteristics of Redwood Parks Streams

The riparian zones of Redwood Parks streams were characterized by heavy shading in the center of the stream (average stream shading of 84%), with a median shading of 96% (Table 15). Likewise, most sites were characterized by tall legacy trees with an average height of 46.2 m. The tallest average height was in an Unnamed stream (REDWWQ02) that is a tributary to Brown Creek. The canopy cover was often mixed, with deciduous, coniferous, and mixed compositions composing the canopy. The understory, however, was largely deciduous in most locations.

Vertebrate Assemblage and Condition of Redwood Parks Streams

Results of electrofishing and visual encounters of vertebrate species, along with summaries of abundance, richness, and the EPA Vertebrate MMI are presented in Table 16. A total of seven amphibian and seven fish taxa were encountered, with at least one species at each site. The most widespread was Coastal Giant Salamander (*Dicamptodon tenebrosus*) at 22 of the 26 sampled reaches. The next most widespread was Steelhead/Rainbow Trout (*Oncorhynchus mykiss*) at 13 of the 26 sampled reaches. Note that species richness estimates are conservative, since field collection and growth stage of many species prevent species identification (e.g., lampreys were seen at three sites, but we could only identify them to genus [*Lampetra* or *Entopneustes*], and there may be as many six species in this region).

Condition assessments using the EPA Vertebrate MMI ranked all sites as Least Disturbed, except for sites on Redwood Creek. No species that we could assess as nonnative fish were collected or encountered.

Table 15. Riparian characteristics of Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
McArthur Creek	REDWWQ01	100%	100%	37.4	8%	54%	32% D,68% M	38%	46%	95% D,5% M
Unnamed- Trib to Brown	REDWWQ02	97%	97%	97.7	34%	3%	100% C	8%	63%	91% C,9% D
West Branch Mill Ck	REDWWQ03	100%	100%	28.7	9%	34%	9% C,64% D,27% M	19%	39%	77% D,23% M
Redwood Creek	REDWWQ04	56%	38%	66.5	34%	40%	100% M	30%	14%	60% D,40% M
East Fork Mill Creek	REDWWQ05	89%	78%	23	15%	44%	68% D,32% M	18%	23%	100% D
Lost Man Creek	REDWWQ06	96%	93%	39.2	5%	30%	14% C,82% D,5% M	26%	58%	91% D,5% N,5% M
Cedar Creek	REDWWQ07	94%	92%	63.4	29%	32%	59% C,41% M	16%	18%	41% D,59% M
Bummer Lake Creek	REDWWQ08	99%	99%	50.8	4%	18%	9% C,91% D	23%	40%	100% D
Wilson Creek	REDWWQ09	99%	100%	41.3	7%	31%	23% C,64% D,14% M	30%	20%	9% C,91% D
Unnamed- Streelow Creek Trail	REDWWQ10	99%	99%	26.5	7%	45%	91% C,9% M	16%	17%	41% C,45% D,14% M
West Branch Mill Ck	REDWWQ11	73%	67%	29	1%	38%	73% D,27% M	30%	15%	100% D
Little Lost Man Creek	REDWWQ12	99%	96%	96.3	18%	15%	91% C,9% D	25%	35%	23% C,73% D,5% N
Lost Man Creek	REDWWQ13	97%	95%	46.8	0%	53%	100% C	11%	50%	73% C,27% M
Rock Creek	REDWWQ14	99%	99%	22.3	5%	27%	100% D	22%	52%	9% C,91% D
Mill Creek	REDWWQ15	100%	100%	23.9	11%	31%	86% D,14% M	59%	6%	100% D
Redwood Creek	REDWWQ16	84%	70%	66.8	11%	20%	45% C,55% D	18%	26%	5% C,95% D
Peacock Creek	REDWWQ17	99%	99%	31.2	17%	34%	9% C,27% D,64% M	22%	5%	9% C,59% D,32% M
West Branch Mill Ck	REDWWQ19	94%	79%	22.3	15%	35%	5% C,77% D,18% M	18%	5%	91% D,9% M
Redwood Creek	REDWWQ20	8%	3%	17.5	1%	18%	62% D,38% N	15%	6%	79% D,21% N
Godwood Creek	REDWWQ21	98%	96%	78.2	5%	9%	73% C,9% D,18% N	20%	55%	5% C,91% D,5% N
West Branch Mill Ck	REDWWQ23	90%	82%	22.5	8%	28%	9% C,91% D	21%	18%	100% D
Lost Man Creek	REDWWQ24	98%	88%	69.7	11%	19%	41% C,59% D	27%	37%	100% D
Redwood Creek	REDWWQ25	35%	7%	32.3	2%	14%	82% D,18% N	22%	18%	100% D
Rock Creek	REDWWQ26	100%	100%	24.2	7%	25%	5% C,95% D	22%	46%	100% D

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 15 (continued). Riparian characteristics of Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Godwood Creek	REDWWQ28	99%	99%	63.5	50%	12%	55% C,45% M	15%	56%	5% E,5% N,91% M
Bond Creek	REDWWQ29	99%	99%	81.2	11%	40%	64% C,9% D,27% M	25%	25%	5% C,45% D,5% N,45% M
Average	—	89%	84%	46.2	13%	29%	n/a	23%	31%	n/a
SD	—	22%	27%	24.5	12%	13%	n/a	10%	18%	n/a
Median	—	98%	96%	38.3	9%	31%	n/a	22%	26%	n/a
Range	—	8% - 100%	3% - 100%	17.5 - 97.7	0% - 50%	3% - 54%	n/a	8 - 59%	5% - 63%	n/a

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 16. Vertebrate species and metrics for Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Chinook Salmon	Coho Salmon	Cutthroat Trout	Coastal Giant Salamander	Pacific Tree Frog	Red-legged Frog	Rough Skinned Newt	Steelhead	Tailed Frog	Three-spined Stickleback	Unknown Frog	Unknown Lamprey	Unknown Sculpin	Unknown Toad	Unknown Trout	Western Toad	Yellow-legged Frog
McArthur Creek	REDWWQ01	Yes	24	4	73.1 ^a	–	–	–	18	–	4	1	–	–	–	–	–	–	–	1	–	–
Unnamed- Trib to Brown	REDWWQ02	Yes	23	3	85.5 ^a	–	–	–	13	–	–	–	–	8	–	–	–	–	–	2	–	–
West Branch Mill Ck	REDWWQ03	Yes	8	2	100 ^a	–	–	5	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Redwood Creek	REDWWQ04	Yes	6	1	42.9 ^b	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–
East Fork Mill Creek	REDWWQ05	Yes	28	8	69.9 ^a	1	2	–	2	–	–	–	4	–	2	–	1	12	–	3	–	1
Lost Man Creek	REDWWQ06	Yes	52	7	74.3 ^a	1	3	–	3	–	–	–	21	–	3	1	–	19	–	1	–	–
Cedar Creek	REDWWQ07	Yes	33	5	90.4 ^a	–	–	2	8	–	–	–	3	5	–	–	–	–	–	11	–	4
Bummer Lake Creek	REDWWQ08	Yes	19	4	86.8 ^a	–	–	1	10	–	1	–	–	7	–	–	–	–	–	–	–	–
Wilson Creek	REDWWQ09	Yes	30	3	93.8 ^a	–	–	–	26	–	–	–	1	3	–	–	–	–	–	–	–	–
Unnamed- Streelow Creek Trail	REDWWQ10	Yes	20	4	88.6 ^a	–	–	2	9	–	3	–	–	1	–	–	–	–	–	5	–	–
West Branch Mill Ck	REDWWQ11	Yes	91	5	91.3 ^a	–	6	–	14	–	–	–	38	12	–	–	–	1	–	20	–	–
Little Lost Man Creek	REDWWQ12	Yes	24	2	90.5 ^a	–	–	–	20	–	–	–	–	2	–	1	–	–	1	–	–	–
Lost Man Creek	REDWWQ13	Yes	51	2	86.1 ^a	–	–	–	27	–	–	–	–	24	–	–	–	–	–	–	–	–
Rock Creek	REDWWQ14	Yes	44	5	93 ^a	–	–	5	12	–	2	–	13	2	–	–	–	–	–	10	–	–
Mill Creek	REDWWQ15	Yes	36	3	94 ^a	–	–	3	23	–	–	–	–	3	–	–	–	–	–	7	–	–
Redwood Creek	REDWWQ16	Yes	11	1	42.9 ^b	–	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–
Peacock Creek	REDWWQ17	Yes	32	6	69.3 ^a	–	–	1	13	–	1	–	3	–	–	–	–	13	–	–	–	1
West Branch Mill Ck	REDWWQ19	Yes	27	6	82 ^a	–	–	–	5	–	–	–	3	1	–	–	1	7	–	10	–	–

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

Table 16 (continued). Vertebrate species and metrics for Redwood Parks streams sampled in 2015.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Chinook Salmon	Coho Salmon	Cutthroat Trout	Coastal Giant Salamander	Pacific Tree Frog	Red-legged Frog	Rough Skinned Newt	Steelhead	Tailed Frog	Three-spined Stickleback	Unknown Frog	Unknown Lamprey	Unknown Sculpin	Unknown Toad	Unknown Trout	Western Toad	Yellow-legged Frog
Redwood Creek	REDWWQ20	Yes	45	5	57.2 ^b	–	–	–	–	–	–	–	3	1	–	–	–	39	–	–	1	1
Godwood Creek	REDWWQ21	Yes	31	6	91.1 ^a	–	2	7	7	–	–	–	2	5	–	–	–	2	–	6	–	–
West Branch Mill Ck	REDWWQ23	Yes	25	5	83.9 ^a	–	–	14	7	–	1	–	–	1	–	–	–	2	–	–	–	–
Lost Man Creek	REDWWQ24	Yes	43	6	89.2 ^a	–	–	7	11	1	–	–	7	9	–	–	–	1	–	7	–	–
Redwood Creek	REDWWQ25	Yes	119	8	50.1 ^b	–	1	–	–	4	–	–	1	–	14	–	2	74	–	–	20	3
Rock Creek	REDWWQ26	Yes	70	4	90.5 ^a	–	–	11	27	1	–	–	30	–	–	1	–	–	–	–	–	–
Godwood Creek	REDWWQ28	Yes	21	3	95.2 ^a	–	–	6	13	–	–	–	–	–	–	–	–	–	–	2	–	–
Bond Creek	REDWWQ29	Yes	37	6	80.6 ^a	–	–	12	14	–	1	–	–	4	–	–	–	–	–	–	3	3
Average	–	–	37	4.4	80.5 ^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD	–	–	25	2.0	16.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median	–	–	31	4.5	86.5 ^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range	–	–	6 - 119	1 - 8	42.9 - 100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

Macroinvertebrate Assemblage and Condition of Redwood Parks Streams

A total of 13,389 individual macroinvertebrates were collected, sorted, and identified from Redwood Parks streams (a complete taxa list for the Redwood Parks samples is given in Appendix C). A conservative estimate of the total species richness is 272 separate species (many taxa are only identified to family or genus level, hence the true species richness is likely higher; likewise there are instances where a specific individual was only able to be identified to family, but a separate individual was identified to genus or species, duplicating the “taxonomic units.” (See the full protocol [Dinger et al. 2013] or Cuffney et al. 2007 for more detail on ambiguous taxa). Summary statistics (Taxa Richness and measures of biological integrity) for each site are provided in Table 17. The most diverse site was Bummer Lake Creek (REDWWQ08) with 75 taxa, although East Fork Mill Creek (REDWWQ05) also had high taxa richness, with 73. The most depauperate site was Redwood Creek (REDWWQ25), with 41 taxa.

For calculating Hilsenhoff Biotic Index (HBI), tolerance values were available for 370 of the 383 taxonomic units (which include individuals only identified to higher taxonomic units due to poor keys, damaged specimens, or immature life stages) for the combined 2015 data (including Crater Lake and Oregon Caves). Taxa with no tolerance value were excluded from HBI calculations. The lowest HBI (indicating a preponderance of intolerant, clean-water indicating organisms) was Bond Creek (REDWWQ29)—paradoxically the one of the lower taxa richness site —suggesting lower diversity but composed of mostly intolerant, clean water organisms. The highest HBI (indicating more organisms tolerant of poor water quality conditions) was Redwood Creek (REDWWQ16).

All but nine stream reaches were categorized as Least Disturbed by the EPA Macroinvertebrate MMI index. Seven of these were rated as Intermediate (27%), and two were rated as Most Disturbed (8%). Ecosystem condition based on the California Department of Fish and Wildlife North Coast IBI (Rehn et al. 2005) rated most sites as “good” (61–80). Three reaches were rated at “fair” (41–60).

Sixteen reaches were rated as Least Disturbed using O/E (Observed/Expected ratio of biodiversity) (62%). Seven were Intermediate (27%) and three were Most Disturbed (11%). Individual site values can be interpreted as having X% of their expected biodiversity under a scenario of no impact (for example, McArthur Creek (REDWWQ01) was found to have 60% of the expected macroinvertebrates.

Overall, park averages and medians for condition were generally in the Least Disturbed category, except for the park wide average for O/E (0.80), which was marginally under the Least Disturbed threshold of 0.81.

Table 17. Invertebrate results and metrics for Redwood Park streams, 2015

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBIa	O/Eb	EPA West-Wide Invertebrate MMI	CA North Coast MMI
McArthur Creek	REDWWQ01	60	3.34	4.83	0.6 ^e	68 ^d	60 ^g
Unnamed- Trib to Brown	REDWWQ02	45	3.2	2.88	0.82 ^c	87 ^c	72 ^f
West Branch Mill Ck	REDWWQ03	70	3.33	3.36	0.82 ^c	86 ^c	76 ^f
Redwood Creek	REDWWQ04	52	2.36	4.85	0.87 ^c	60 ^d	73 ^f
East Fork Mill Creek	REDWWQ05	73	3.56	5	0.69 ^d	77 ^c	74 ^f
Lost Man Creek	REDWWQ06	66	3.69	4.4	0.78	88 ^c	76 ^f
Cedar Creek	REDWWQ07	51	3.59	3.86	0.57 ^e	81 ^c	73 ^f
Bummer Lake Creek	REDWWQ08	75	3.45	3.78	0.94 ^c	78 ^c	80 ^f
Wilson Creek	REDWWQ09	47	3.47	3.04	0.65 ^d	83 ^c	76 ^f
Unnamed- Streeflow Creek Trail	REDWWQ10	44	2.97	3.93	0.66 ^d	55 ^e	61 ^f
West Branch Mill Ck	REDWWQ11	71	3.46	4.8	0.77 ^d	80 ^c	74 ^f
Little Lost Man Creek	REDWWQ12	51	3.48	3.55	0.9 ^c	87 ^c	71 ^f
Lost Man Creek	REDWWQ13	64	3.29	3.89	0.85 ^c	76 ^c	73 ^f
Rock Creek	REDWWQ14	62	3.08	3.26	0.82 ^c	76 ^c	80 ^f
Mill Creek	REDWWQ15	65	2.79	4.82	0.98	64 ^d	71 ^f
Redwood Creek	REDWWQ16	54	2.29	5.76	0.88 ^c	40 ^e	54 ^g
Peacock Creek	REDWWQ17	70	3.47	4.85	0.94 ^c	77 ^c	71 ^f
West Branch Mill Ck	REDWWQ19	46	2.88	3.6	0.34 ^e	72 ^c	77 ^f

^a HBI = Hilsenhoff Biotic Index

^b O/E = Observed/Expected ratio; MMI = Multi=Metric

^c Sites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^d Sites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed.

^f Sites in the CA North Coast MMI column, cells are equal "good to very good" condition (also with light sage background).

^g Sites in the CA North Coast MMI column, cells are equal "fair to poor" condition (also with medium amber background).

Table 17 (continued). Invertebrate results and metrics for Redwood Park streams, 2015

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBIa	O/Eb	EPA West-Wide Invertebrate MMI	CA North Coast MMI
Redwood Creek	REDWWQ20	50	2.38	3.35	0.88 ^c	66 ^d	63 ^f
Godwood Creek	REDWWQ21	60	3.61	3.62	1.03 ^c	80 ^c	72 ^f
West Branch Mill Ck	REDWWQ23	58	3.41	4.48	0.69 ^d	70 ^d	76 ^f
Lost Man Creek	REDWWQ24	54	3.3	3.29	0.69 ^d	74 ^c	75 ^f
Redwood Creek	REDWWQ25	41	1.85	2.92	0.99 ^c	63 ^d	65 ^f
Rock Creek	REDWWQ26	62	3.02	3.46	0.82 ^c	77 ^c	76 ^f
Godwood Creek	REDWWQ28	48	2.01	3.65	0.9 ^c	58 ^d	55 ^g
Bond Creek	REDWWQ29	53	2.62	1.67	0.86 ^c	82 ^c	87
Average	–	57	3.07	3.88	0.8 ^d	73.3 ^c	71.6 ^f
SD	–	9.8	0.52	0.88	0.15	11.5	7.7
Median	–	56	3.30	3.72	0.82 ^c	76.5 ^c	73 ^f
Range	–	41 - 75	1.85 - 3.69	1.67 - 5.76	0.34 - 1.03	40 - 88	54 - 87

^a HBI = Hilsenhoff Biotic Index

^b O/E = Observed/Expected ratio; MMI = Multi=Metric

^c Sites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^d Sites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed.

^f Sites in the CA North Coast MMI column, cells are equal "good to very good" condition (also with light sage background).

^g Sites in the CA North Coast MMI column, cells are equal "fair to poor" condition (also with medium amber background).

Crater Lake National Park

Sampling began on August 4, 2015, following the arrival of the field crew from Redwood Parks and continued until October 1 2015. A total of 29 sites were sampled (Figure 7, Table 18), from the original target of 25 to 30 sites. A single site sampled in 2012, Rogue River (CRLAWQ04) was unable to be sampled due to the National Creek Fire Complex, which burned from August 1, 2015 to October 23, 2015. This site will be revisited in 2018.

Most sampled streams in sampling frame of Crater Lake originate on the outside caldera walls, especially the south and east portions. They drain volcanic soils and geology, especially basalt, and although many are steep gradient on the caldera, our sampling is limited to the safer gradients. The streams vary from wider subalpine meadow streams to narrow first order streams, all usually with large amounts of woody debris. Examples of sampled streams in Crater Lake are presented in Figure 8.

The only issues affecting data completeness is that the water probe was unavailable for sampling at Crater Creek (CRLAWQ19) and we were unable to complete Acid Neutralizing Capacity analyses at Sun Creek (CRLAWQ31). Lastly, the presence of threatened Bull Trout limited electrofishing to sites with no known populations (sites with confirmed Bull Trout – Sun Creek and Lost Creek) were sampled when possible with the Crater Lake Fisheries Biologist, David Hering. Other sites at the end of the season were unable to be electrofished due to an early crew departure, leaving the crew shorthanded.

Physical Characteristics of Crater Lake Streams

Basic summary statistics of the monitoring streams are presented in Table 19. These are general geomorphological characteristics of the streams (e.g., elevation, slope, discharge) and do not impart any conditional information. An Unnamed tributary (CRLAWQ15) to Bybee Creek was the smallest stream sampled, with only an average width of 0.9 m and a discharge of $0.01 \text{ ft}^3 \text{ s}^{-1}$.

Physical Condition Metrics of Crater Lake Streams

The four EPA physical condition metrics, along with substrate size and average embeddedness for Crater Lake are presented in Table 20. The median substrate size for a stream is a more common descriptor, since the average can be influenced by a few, very large pieces of substrate. Overall coarse gravel (median particle size = 38 mm) was the predominate substrate. One site, Lost Creek (CRLAWQ09), had the smallest diameter of substrate (median = 0.5 mm)—so that half of the particles measured in the stream reach were fine sediments. The largest substrates were on Sun Creek (CRLAWQ03 and CRLAWQ31), with a median particle size of 114.8 mm—a large cobble size. Embeddedness, a measure of the amount of fine sediments entrapping gravel or large substrate averaged 40.4% across the park, with the highest embeddedness in an Unnamed Tributary to Sand Creek (CRLAWQ37). The lowest embeddedness was in a different reach of an Unnamed Tributary to Sand Creek (CRLAWQ21).

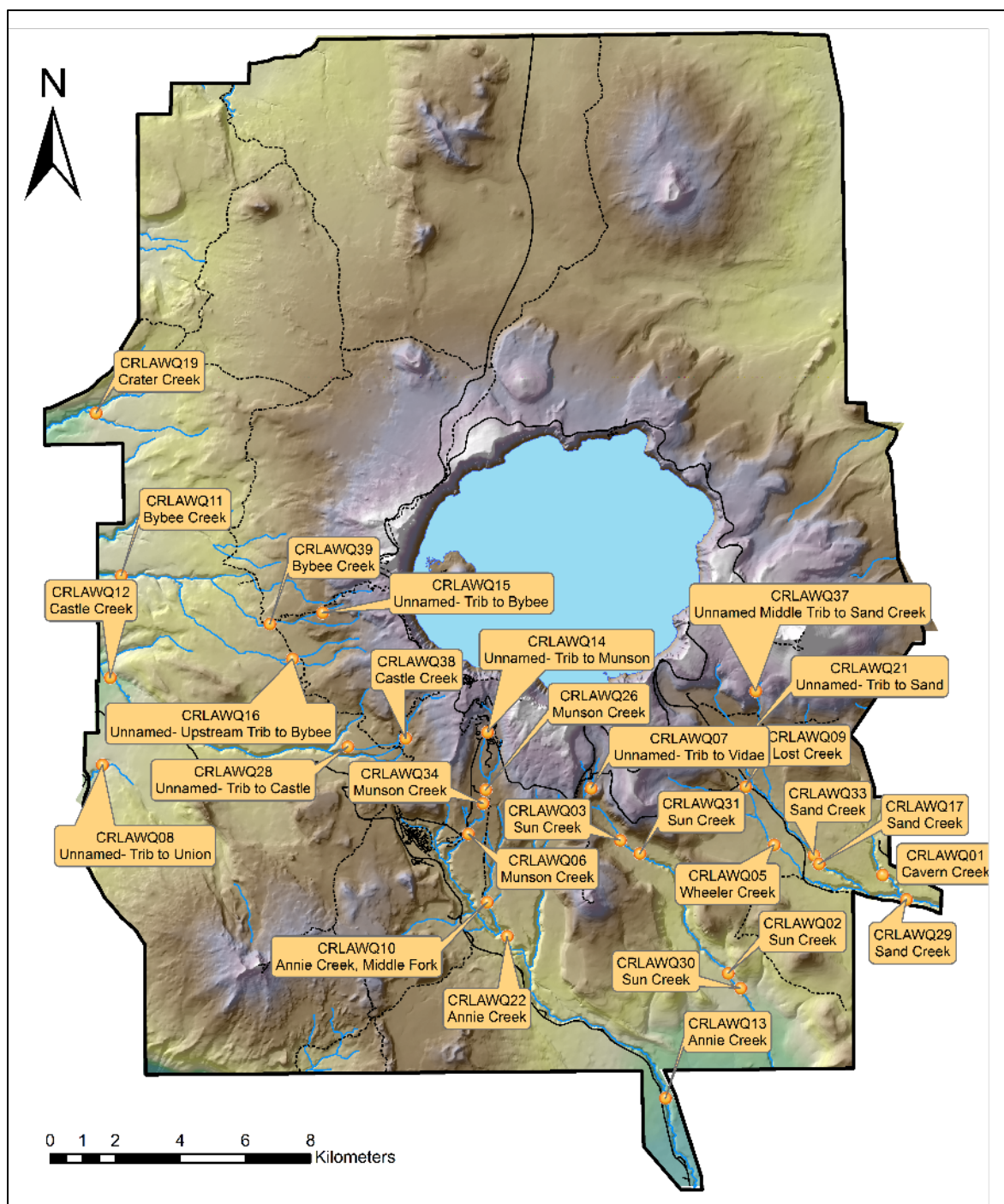


Figure 7. Stream sites sampled in Crater Lake National Park, 2015.

Table 18. Original site list for streams to be sampled in Crater Lake, 2015.

Stream Name	Site Code	Date Sampled	Reason for not sampling
Cavern Creek	CRLAWQ01	8/6/2015	
Sun Creek	CRLAWQ02	8/17/2015	
Sun Creek	CRLAWQ03	8/18/2015	
Rogue River	CRLAWQ04	.. ^a	National Creek Complex Fire ^c
Wheeler Creek	CRLAWQ05	8/5/2015	n/a
Munson Creek	CRLAWQ06	8/26/2015	n/a
Unnamed- Trib to Vidae	CRLAWQ07	8/19/2015	n/a
Unnamed -Trib to Union	CRLAWQ08	9/9/2015	n/a
Lost Creek	CRLAWQ09	8/10/2015	n/a
Annie Creek, Middle Fork	CRLAWQ10	8/13/2015	n/a
Bybee Creek	CRLAWQ11	9/2/2015	n/a
Castle Creek	CRLAWQ12	8/11/2015	n/a
Annie Creek	CRLAWQ13	8/20/2015	n/a
Unnamed- Trib to Munson	CRLAWQ14	8/4/2015	n/a
Unnamed- Trib to Bybee	CRLAWQ15	9/1/2015	n/a
Unnamed	CRLAWQ16	8/27/2015	n/a
Sand Creek	CRLAWQ17	8/24/2015	n/a
Crater Creek	CRLAWQ19	8/31/2015	n/a
Unnamed- Trib to Sand	CRLAWQ21	9/3/2015	n/a
Annie Creek	CRLAWQ22	8/12/2015	n/a
Munson Creek	CRLAWQ26	8/25/2015	n/a
Unnamed- Trib to Castle	CRLAWQ28	9/8/2015	n/a
Sand Creek	CRLAWQ29	9/15/2015	n/a
Sun Creek	CRLAWQ30	8/17/2015	n/a
Sun Creek	CRLAWQ31	8/18/2015	n/a
Unnamed	CRLAWQ32	.. ^a	Dry creek bed – not perennial
Sand Creek	CRLAWQ33	9/22/2015	n/a
Munson Creek	CRLAWQ34	8/25/2015	n/a
Copeland Creek	CRLAWQ35	.. ^b	Too distant from vehicle
Unnamed	CRLAWQ36	.. ^b	Too distant from vehicle
Unnamed Middle Trib to Sand Creek	CRLAWQ37	9/23/2015	n/a
Castle Creek	CRLAWQ38	9/30/2015	n/a
Bybee Creek	CRLAWQ39	10/1/2015	n/a

^a Sites were not sampled either due to the site being dry or was planned to be sampled later.

^b Sites requiring more than 1.5 hours to access were deemed too far to safely sample in a single day.

^c National Creek Complex fire burned from August 1st, 2015 to October 23rd, 2015.

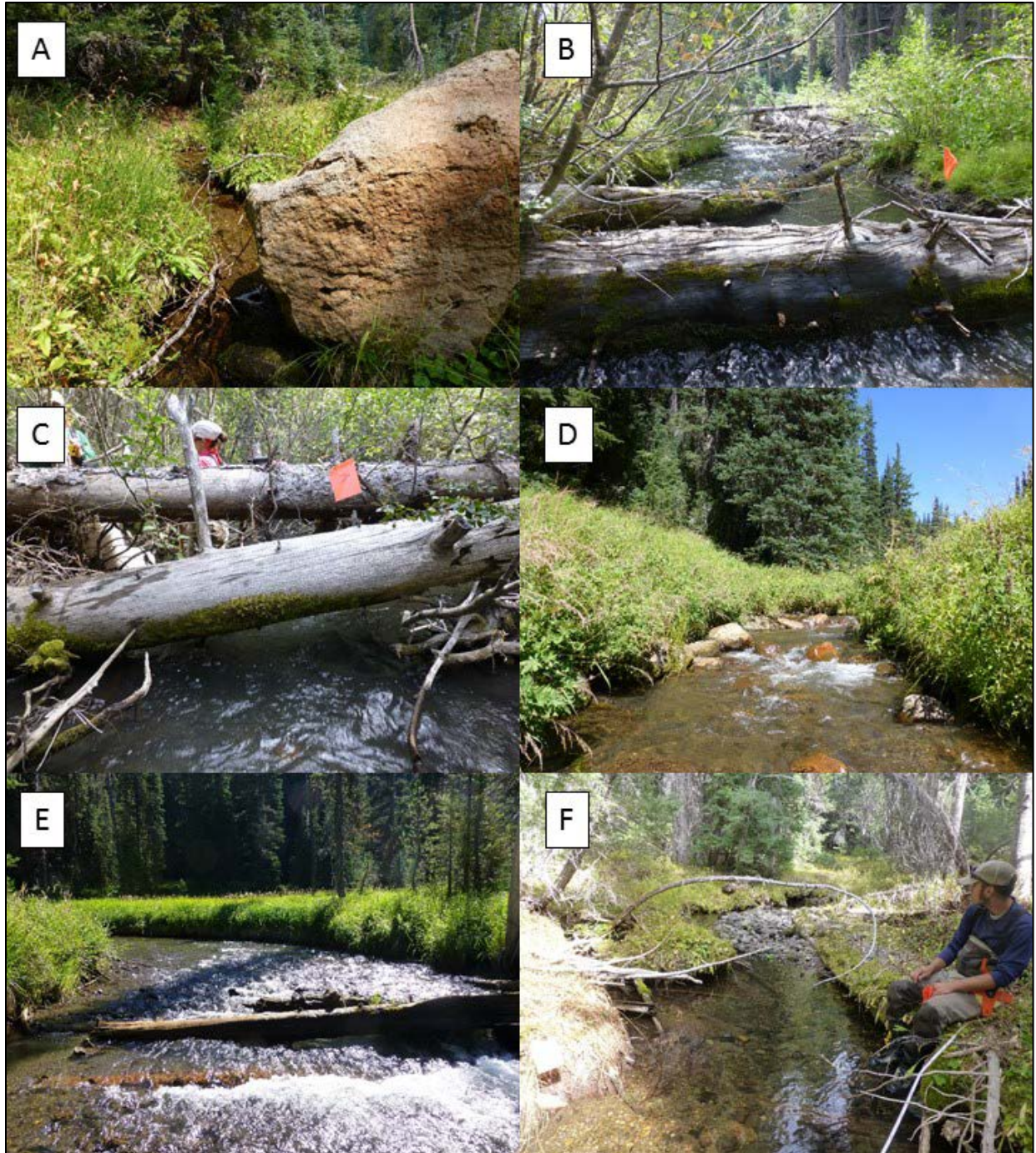


Figure 8. Examples of typical stream characteristics in Crater Lake National Park, 2015. A = Unnamed Stream (CRLAWQ14), B, C = Castle Creek (CRLAWQ12), D = Middle Fork Annie Creek (CRLAWQ10), E = Annie Creek (CRLAWQ22), and F = Sand Creek (CRLAWQ29).

Table 19. Physical characteristics and location of streams sampled in Crater Lake, 2015. Coordinates in NAD 10983, Zone 10N.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Cavern Creek	CRLAWQ01	8/6/2015	582665	4745143	1607	150	2.7	16.2	0.9%	0.005	0.17
Sun Creek	CRLAWQ02	8/17/2015	577913	4742112	1549	150	3.7	21.8	1.8%	0.028	1.01
Sun Creek	CRLAWQ03	8/18/2015	574596	4746209	1795	150	3.9	17.2	5.1%	0.008	0.29
Wheeler Creek	CRLAWQ05	8/5/2015	579320	4746072	1754	150	1.5	8.8	2.0%	0.001	0.05
Munson Creek	CRLAWQ06	8/26/2015	569931	4746405	1853	160	4.3	12.1	2.0%	0.021	0.76
Unnamed- Trib to Vidae	CRLAWQ07	8/19/2015	573702	4747806	1973	150	3.1	14.5	5.2%	0.003	0.11
Unnamed- Trib to Union Creek	CRLAWQ08	9/9/2015	558676	4748535	1526	150	5.4	20.8	1.4%	1.234	43.58
Lost Creek	CRLAWQ09	8/10/2015	578449	4747857	1839	150	1	7.8	1.7%	0.001	0.03
Annie Creek, Middle Fork	CRLAWQ10	8/13/2015	570511	4744301	1771	150	2.3	21.7	5.4%	0.012	0.44
Bybee Creek	CRLAWQ11	9/2/2015	559254	4754358	1515	260	6	26.9	1.7%	0.055	1.94
Castle Creek	CRLAWQ12	8/11/2015	558921	4751216	1466	200	4.6	26	1.4%	0.035	1.25
Annie Creek	CRLAWQ13	8/20/2015	575991	4738263	1410	280	8.4	30.2	0.6%	0.12	4.23
Unnamed- Trib to Munson	CRLAWQ14	8/4/2015	570513	4749538	1977	150	1.2	7.2	3.8%	0.006	0.21
Unnamed- Trib to Bybee	CRLAWQ15	9/1/2015	565449	4753221	1902	150	0.9	5	4.9%	0	0.01
Unnamed	CRLAWQ16	8/27/2015	564521	4751798	1798	150	1.6	7.8	3.3%	0.001	0.04
Sand Creek	CRLAWQ17	8/24/2015	580709	4745481	1657	200	4	21.1	2.7%	0.035	1.23
Crater Creek	CRLAWQ19	8/31/2015	558480	4759366	1451	150	4	25.8	3.0%	0.011	0.4
Unnamed- Trib to Sand	CRLAWQ21	9/3/2015	578297	4749172	1851	150	3.8	20.7	3.8%	0.019	0.66
Annie Creek	CRLAWQ22	8/12/2015	571121	4743259	1661	280	5.9	23.2	1.3%	0.066	2.34
Munson Creek	CRLAWQ26	8/25/2015	570467	4747762	1899	150	2.9	14.8	1.8%	0.007	0.26
Unnamed- Trib to Castle	CRLAWQ28	9/8/2015	566220	4749088	1810	150	1	4.5	6.6%	0	0.01
Sand Creek	CRLAWQ29	9/15/2015	583385	4744389	1587	200	5.5	21.6	1.4%	0.054	1.89
Sun Creek	CRLAWQ30	8/17/2015	578296	4741656	1501	150	5.1	18.8	1.8%	0.027	0.97
Sun Creek	CRLAWQ31	8/18/2015	575199	4745799	1765	150	4	20.3	5.9%	1.433	50.59

^a UTM = Universal Transverse Mercator, Zone 10N

Table 19 (continued). Physical characteristics and location of streams sampled in Crater Lake, 2015. Coordinates in NAD 10983, Zone 10N.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Sand Creek	CRLAWQ33	9/22/2015	580549	4745751	1675	160	3.5	22.8	3.3%	0.033	1.15
Munson Creek	CRLAWQ34	8/25/2015	570382	4747348	1890	150	2.8	14.3	1.2%	0.007	0.26
Unnamed Middle Trib to Sand Creek	CRLAWQ37	9/23/2015	578888	4750983	2096	150	0.9	5	12.9%	0	0
Castle Creek	CRLAWQ38	9/30/2015	567999	4749343	1882	150	2.7	15	3.3%	0.001	0.05
Bybee Creek	CRLAWQ39	10/1/2015	563826	4752867	1793	150	1.8	5.9	4.2%	0.001	0.02
Average	–	–	–	–	1733	169	3.4	16.5	3.3%	0.111	3.93
SD	–	–	–	–	179	39	1.8	7.5	2.5%	0.341	12.03
Median	–	–	–	–	1771	150	3.5	17.2	2.7%	0.011	0.40
Range	–	–	–	–	1410 - 2096	150 - 280	0.9 - 8.4	4.5 - 30.2	0.6% - 12.9%	0 - 1.43	0 - 50.59

^a UTM = Universal Transverse Mercator, Zone 10N

Table 20. Physical condition metrics for Crater Lake streams sampled in 2015.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Cavern Creek	CRLAWQ01	8/6/2015	12.1	38	35.4	58%	15%	0.16 ^b	0.13 ^c	-0.05 ^a	0 ^a
Sun Creek	CRLAWQ02	8/17/2015	23.8	38	18.4	27%	54%	0.1 ^c	0.53 ^b	-0.21 ^a	0 ^a
Sun Creek	CRLAWQ03	8/18/2015	74.4	114.8	37.5	34%	66%	0.56 ^a	0.42 ^b	-0.09 ^a	0 ^a
Wheeler Creek	CRLAWQ05	8/5/2015	4.1	6.2	50.3	20%	31%	0.62 ^a	0.37 ^b	-0.6 ^a	0 ^a
Munson Creek	CRLAWQ06	8/26/2015	16.7	38	37.6	43%	21%	0.36 ^a	0.83 ^a	-0.29 ^a	0 ^a
Unnamed- Trib to Vidae	CRLAWQ07	8/19/2015	26.9	38	40.9	33%	52%	0.54 ^a	0.55 ^b	-0.36 ^a	0 ^a
Unnamed- Trib to Union Creek	CRLAWQ08	9/9/2015	5.5	4.2	56.8	61%	21%	0.65 ^a	0.6 ^b	-0.8 ^a	0 ^a
Lost Creek	CRLAWQ09	8/10/2015	1.2	0.5	64.9	11%	23%	0.09 ^c	0.22 ^c	-1.03 ^b	1.49 ^c
Annie Creek, Middle Fork	CRLAWQ10	8/13/2015	46.5	38	43.8	45%	55%	0.6 ^a	0.32 ^b	-0.3 ^a	0 ^a
Bybee Creek	CRLAWQ11	9/2/2015	18.9	38	36.5	72%	22%	0.57 ^a	0.62 ^b	-0.44 ^a	0 ^a
Castle Creek	CRLAWQ12	8/11/2015	9.1	4.2	47.8	30%	23%	0.98 ^a	0.64 ^b	-0.52 ^a	0 ^a
Annie Creek	CRLAWQ13	8/20/2015	8.7	38	47.5	55%	40%	0.52 ^a	0.6 ^b	-0.34 ^a	0 ^a
Unnamed- Trib to Munson	CRLAWQ14	8/4/2015	9.3	4.2	50.8	13%	29%	0.12 ^c	0.31 ^b	-0.55 ^a	1.06 ^c
Unnamed- Trib to Bybee	CRLAWQ15	9/1/2015	16.3	38	46.3	30%	14%	0.16 ^b	0.11 ^c	-0.3 ^a	0 ^a
Unnamed	CRLAWQ16	8/27/2015	10.6	38	36.3	16%	60%	0.33 ^a	0.16 ^c	-0.44 ^a	0 ^a
Sand Creek	CRLAWQ17	8/24/2015	18.9	38	40.2	20%	78%	0.07 ^c	0.18 ^c	-0.49 ^a	0 ^a
Crater Creek	CRLAWQ19	8/31/2015	11.6	12.6	40.7	57%	16%	0.31 ^b	0.22 ^c	-0.85 ^b	0 ^a
Unnamed- Trib to Sand	CRLAWQ21	9/3/2015	42.4	38	14.4	52%	45%	0.85 ^a	0.74 ^a	-0.24 ^a	0 ^a
Annie Creek	CRLAWQ22	8/12/2015	18.4	38	39.8	54%	30%	0.49 ^a	0.49 ^b	-0.3 ^a	0 ^a
Munson Creek	CRLAWQ26	8/25/2015	21.4	38	34.4	21%	37%	0.05 ^c	0.07 ^c	-0.08 ^a	0 ^a
Unnamed- Trib to Castle	CRLAWQ28	9/8/2015	12.7	38	29.7	8%	92%	0.17 ^b	0.2 ^c	-0.4 ^a	0 ^a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 20 (continued). Physical condition metrics for Crater Lake streams sampled in 2015.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddedness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Sand Creek	CRLAWQ29	9/15/2015	8.2	4.2	50.9	61%	26%	0.81 ^a	0.8 ^a	-0.69 ^a	0 ^a
Sun Creek	CRLAWQ30	8/17/2015	13.8	38	37	41%	41%	0.83 ^a	1.59 ^a	-0.5 ^a	0 ^a
Sun Creek	CRLAWQ31	8/18/2015	99.9	114.8	32.5	37%	59%	0.15 ^b	0.22 ^c	-0.09 ^a	0 ^a
Sand Creek	CRLAWQ33	9/22/2015	27	38	39.6	33%	59%	0.45 ^a	0.61 ^b	-0.46 ^a	0 ^a
Munson Creek	CRLAWQ34	8/25/2015	20.6	38	31.6	52%	17%	0.3 ^b	0.22 ^c	-0.01 ^a	0 ^a
Unnamed Middle Trib to Sand Creek	CRLAWQ37	9/23/2015	28.6	38	67.3	21%	50%	0.38 ^a	0.57 ^b	-0.21 ^a	0 ^a
Castle Creek	CRLAWQ38	9/30/2015	20.5	38	19.4	48%	23%	0.83 ^a	0.54 ^b	-0.35 ^a	0 ^a
Bybee Creek	CRLAWQ39	10/1/2015	51.8	38	43	29%	34%	0.64 ^a	0.4 ^b	0.16 ^b	0 ^a
Average	–	Average	23.4	35.4	40.4	37%	39%	0.44 ^a	0.46 ^b	-0.37 ^a	0.09 ^a
SD	–	SD	21.6	26.2	12.0	17%	20%	0.27	0.31	0.26	0.33
Median	–	Median	18.4	38.0	39.8	34%	34%	0.45 ^a	0.42 ^b	-0.35 ^a	0.00 ^a
Range	–	Range	1.2 - 99.9	0.5 - 114.8	14.4 - 67.3	8% - 72%	14% - 92%	0.05 - 0.98	0.07 - 1.59	-1.03 - 0.16	0 - 1.49

^a Sites are Least Disturbed (also with light sage background).
^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Relative Bed Stability, the EPA metric that compares a geomorphically predicted median sediment size and compares it to the observed median sediment, was strongly negative for all Crater Lake streams. The negativity is interpreted as an excess of smaller, fine sediments that would be expected, generally suggesting an anthropogenic source (such as dirt roads). Only three sites were rated as Intermediate (10%), with the rest (despite being slightly negative) being in the Least Disturbed (90%).

Due to the nature of these montane and subalpine streams, some of which meander in meadows, riparian cover is largely shrub or graminoid plants. Riparian Cover, a measure of the complexity of the riparian zone immediately on the stream banks, is naturally low in these meadow systems. Due to this, when using West-wide criteria for Intermediate or Most Disturbed, these natural streams are classified as degraded or impacted, despite the conditions being a natural character of the stream. Hence, ten sites were Most Disturbed (34%) and another 15 were Intermediate (52%).

In-stream Habitat Cover was high in many sampled Crater Lake streams, with six being rated as Intermediate (21%), and five sites were Most Disturbed (17%). The remaining 18 sites were all Least Disturbed (62%). Riparian Disturbance was low in almost all sites, except two sites with Most Disturbed conditions: Lost Creek (CRLAWQ09) and an Unnamed stream (CRLAWQ14). Lost Creek is directly next to a campground, and CRLAWQ14 is located in a developed section of the park close to park headquarters.

Chemical Characteristics and Condition Estimates of Crater Lake Streams

Selected water chemistry results are presented in Table 21. Parameters measure in-situ with a water probe (see methods) are listed under “Water Quality” and parameters measured in an analytical laboratory or with a stream-side assay (Acid Neutralizing Capacity) are presented as “Water Chemistry.”

pH was found to be circum-neutral (pH of 7 = neutral) to slightly alkaline, at an average of 7.9. All pH data attained the water quality criteria in Table 3 and the average pH was in the middle of the acceptable range. **Acid Neutralizing Capacities** were all positive, indicating Least Disturbed.

Temperature is presented as a descriptor of conditions during sampling, but varies on a daily, monthly, and seasonal basis. As such, no status or condition should be inferred from temperature readings. However, the stream temperatures measured were on the cold side, with an average of 6.4 °C, typical for high elevation, montane, and subalpine streams. **Specific Conductivity** was uniformly low, and well under the EPA threshold criteria for Least Disturbed at all sites (used as a surrogate for salinity by the EPA). **Dissolved Oxygen** values were all high, and appear well within available regulatory thresholds for available water quality criteria (Table 3). No sites had measureable **Turbidity**.

All **anion** and **cation** measurements were far below any available water quality criteria.

Only two site had a **Total Nitrogen** level above the EPA criteria for Least Disturbed, Unnamed stream, (CRLAWQ16) and Unnamed Tributary to Munson Creek (CRLAWQ14). **Total Phosphorous** levels were elevated at all but one park stream (Unnamed tributary to Bybee Creek,

Table 21. Water chemistry parameters for streams sampled in Crater Lake, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Cavern Creek	CRLAWQ01	7.71	7.7	38 ^c	9.8	0	3.03	0.24	0.69	0.06 ^c	0.013 ^d	279 ^c	14 ^c
Sun Creek	CRLAWQ02	8.03	8.1	61 ^c	10.1	0	4.09	2.2	0.45	0.05 ^c	0.023 ^d	470 ^c	24 ^c
Sun Creek	CRLAWQ03	7.94	6.9	39 ^c	9.6	0	3.29	0.23	0.49	0.03 ^c	0.026 ^d	326 ^c	16 ^c
Wheeler Creek	CRLAWQ05	8.12	7.4	70 ^c	9.5	0	3.56	1.64	0.4	0.05 ^c	0.031 ^d	427 ^c	21 ^c
Munson Creek	CRLAWQ06	8.11	4.8	43 ^c	9.9	0	3.23	0.66	0.38	0.09 ^c	0.032 ^d	402 ^c	20 ^c
Unnamed- Trib to Vidae	CRLAWQ07	7.87	4.1	36 ^c	9.9	0	2.74	0.27	0.44	0.02 ^c	0.022 ^d	689 ^c	34 ^c
Unnamed- Trib to Union Creek	CRLAWQ08	7.92	3.2	61 ^c	10.4	0	3.16	0.06	0.46	0.04 ^c	0.056 ^e	689 ^c	34 ^c
Lost Creek	CRLAWQ09	7.96	6	41 ^c	9.7	0	2.7	0.07	0.29	0.08 ^c	0.016 ^d	517 ^c	26 ^c
Annie Creek, Middle Fork	CRLAWQ10	8.01	6.6	61 ^c	10.2	0	4.3	2.32	0.4	0.05 ^c	0.036 ^d	579 ^c	29 ^c
Bybee Creek	CRLAWQ11	7.84	5.6	53 ^c	10.2	0	4.52	0.58	0.53	0.03 ^c	0.042 ^e	506 ^c	25 ^c
Castle Creek	CRLAWQ12	7.89	7.3	54 ^c	9.4	0	3.94	0.94	0.57	0.02 ^c	0.04 ^d	611 ^c	31 ^c
Annie Creek	CRLAWQ13	7.86	6.5	59 ^c	9.9	0	4.16	1.37	0.35	0.02 ^c	0.034 ^d	529 ^c	26 ^c
Unnamed- Trib to Munson	CRLAWQ14	7.84	14.3	20 ^c	8	0	2.09	0.17	0.29	0.18 ^d	0.015 ^d	191 ^c	10 ^c
Unnamed- Trib to Bybee	CRLAWQ15	7.93	5.2	30 ^c	9.8	0	2.15	0.04	0.48	0.08 ^c	0.006	325 ^c	16 ^c
Unnamed	CRLAWQ16	7.97	8.7	31 ^c	9.5	0	2.51	0.1	0.61	0.2 ^d	0.019 ^d	252 ^c	13 ^c
Sand Creek	CRLAWQ17	8.29	8	68 ^c	8.3	0	4.04	1.44	0.34	0.03 ^c	0.035 ^d	316 ^c	16 ^c
Crater Creek	CRLAWQ19	N/A ^f	N/A ^f	N/A ^f	N/A ^f	N/A ^f	3.89	0.12	0.47	0.05 ^c	0.037 ^d	400 ^c	20 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

^f N/A indicates data not collected (faulty probe or unavailable test)

Table 21 (continued). Water chemistry parameters for streams sampled in Crater Lake, 2015.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Unnamed- Trib to Sand	CRLAWQ21	7.88	4.5	54 ^c	10.2	0	3.81	0.49	0.36	0.04 ^c	0.041 ^e	523 ^c	26 ^c
Annie Creek	CRLAWQ22	8.09	5.7	55 ^c	10.1	0	3.89	1.01	0.41	0.03 ^c	0.031 ^d	360 ^c	18 ^c
Munson Creek	CRLAWQ26	7.76	9.3	43 ^c	8.1	0	3.08	0.52	0.43	0.09 ^c	0.032 ^d	749 ^c	38 ^c
Unnamed- Trib to Castle	CRLAWQ28	7.93	6.7	34 ^c	9.6	0	2.66	0.1	0.42	0.07 ^c	0.019 ^d	415 ^c	21 ^c
Sand Creek	CRLAWQ29	8.16	5.1	72 ^c	10	0	4.25	1.95	0.33	0.04 ^c	0.038 ^d	1169 ^c	58 ^c
Sun Creek	CRLAWQ30	7.8	4.2	64 ^c	10.1	0	4.13	2.36	0.47	0.03 ^c	0.02 ^d	549 ^c	28 ^c
Sun Creek	CRLAWQ31	7.71	6.5	49 ^c	9.1	0	3.59	0.65	0.36	0.04 ^c	0.034 ^d	N/A ^f	N/A ^f
Sand Creek	CRLAWQ33	8.06	6.4	67 ^c	9.8	0	4.07	1.4	0.4	0.05 ^c	0.038 ^d	679 ^c	34 ^c
Munson Creek	CRLAWQ34	7.98	4.7	44 ^c	10.2	0	3.08	0.53	0.55	0.08 ^c	0.031 ^d	545 ^c	27 ^c
Unnamed Middle Trib to Sand Creek	CRLAWQ37	7.97	4.8	38 ^c	9.2	0	2.76	0.09	0.38	0.04 ^c	0.021 ^d	450 ^c	22 ^c
Castle Creek	CRLAWQ38	7.13	3.1	33 ^c	10.2	0	2.52	0.09	0.35	0.05 ^c	0.015 ^d	200 ^c	10 ^c
Bybee Creek	CRLAWQ39	7.94	6.7	27 ^c	9.6	0	2.31	0.06	0.47	0.09 ^c	0.012 ^d	460 ^c	23 ^c
Average	—	7.9	6.4	48.0 ^c	9.7	0.0	3.36	0.75	0.43	0.06 ^c	0.028 ^d	486.0 ^c	24.3 ^c
SD	—	0.2	2.2	14.5	0.6	0.0	0.72	0.76	0.09	0.04	0.011	200.0	9.9
Median	—	7.94	6.45	46.5 ^c	9.8	0	3.29	0.52	0.42	0.05 ^c	0.031 ^d	465 ^c	23.5 ^c
Range	—	7.13 - 8.29	3.1 - 14.3	20 - 72	8 - 10.4	0 - 0	2.09 - 4.52	0.04 - 2.36	0.29 - 0.69	0.02 - 0.2	0.006 - 0.056	191 - 1169	10 - 58

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

^f N/A indicates data not collected (faulty probe or unavailable test)

CRLAWQ15). Three sites were above the Intermediate category and in the Most Disturbed condition: Bybee Creek (CRLAWQ11), and two Unnamed streams, CRLAWQ08 and CRLAWQ21. The widespread prevalence of high phosphorous levels suggests a natural landscape source and is a topic in the discussion.

Riparian Characteristics of Crater Lake Streams

The riparian zones of Crater Lake streams are dominated by coniferous canopy cover (Table 22), although the meadows abutting many of the streams limit the overall shading (average of 60% stream center shading). Park-wide canopy cover is close to equal between big trees (>0.3 m dbh) and small trees (<0.3 m dbh), at 8% and 13% average respectively, and generally a conifer canopy. Understory composition was more varied, with an increase in the prevalence of mixed and deciduous cover.

Vertebrate Assemblage and Condition of Crater Lake Streams

Results of electrofishing and visual encounters of vertebrate species, along with summaries of abundance, richness, and the EPA Vertebrate MMI are presented in Table 23. The most widespread vertebrate was the Brook Trout (*Salvelinus fontinalis*), at 15 of the 27 sites surveyed. Brook Trout is an introduced nonnative, and its presence is a contributor to the rating of all but five sites in the Intermediate condition according to the EPA Vertebrate MMI. All observed vertebrate species have been previously recorded in the park. Several sites were electrofished with assistance from the Crater Lake Fisheries Biologist, David Hering, due to reported presence of Bull Trout. The only sites with a Least Disturbed rating was Sun Creek sites and Lost Creek where substantial restoration efforts to save the headwaters population of the endangered Bull Trout (*Salvelinus confluentus*) have occurred over the past decade.

Macroinvertebrate Assemblage and Condition of Crater Lake Streams

A total of 15,579 individual macroinvertebrates were collected, sorted, and identified from Crater Lake streams (a complete taxa list is given in Appendix D). A conservative estimate of the total species richness is 167 species (many taxa are only identified to family or genus level, hence the true species richness is likely higher; likewise there are instances where a specific individual was only able to be identified to family, but a separate individual was identified to genus or species, duplicating the “taxonomic units.” (See the full protocol [Dinger et al. 2013] or Cuffney et al. 2007 for more detail on ambiguous taxa). Summary statistics (Taxa Richness and measures of biological integrity) for each site are provided in Table 24. The most diverse site was Wheeler Creek (CRLAWQ05) with 73 total taxa, while the most depauperate site was Castle Creek (CRLAWQ12) with only 3 taxa.

For calculating Hilsenhoff Biotic Index (HBI), tolerance values were available for 370 of the 383 taxonomic units (which include individuals only identified to higher taxonomic units due to poor keys, damaged specimens, or immature life stages) for the combined 2015 data (including Redwood Parks and Oregon Caves). Taxa with no tolerance value were excluded from HBI calculations. The lowest HBI (indicating a preponderance of intolerant, clean-water indicating organisms) was Munson Creek (CRLAWQ26), while the highest HBI (indicating more organisms tolerant of poor water quality) was Unnamed Tributary to Sand Creek (CRLAWQ37).

Table 22. Riparian characteristics of Crater Lake streams, 2015.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Cavern Creek	CRLAWQ01	90%	85%	34.2	4%	4%	100% C	4%	4%	100% C
Sun Creek	CRLAWQ02	87%	72%	45.5	6%	3%	32% C,68% N	43%	7%	100% D
Sun Creek	CRLAWQ03	73%	55%	30	7%	23%	100% C	7%	23%	86% C,14% N
Wheeler Creek	CRLAWQ05	74%	56%	22.4	5%	14%	100% C	13%	24%	100% C
Munson Creek	CRLAWQ06	80%	54%	28.5	17%	20%	100% C	21%	16%	91% C,9% M
Unnamed- Trib to Vidae	CRLAWQ07	80%	69%	31.6	14%	11%	95% C,5% N	16%	7%	95% C,5% N
Unnamed	CRLAWQ08	86%	68%	28.5	10%	25%	100% C	13%	18%	100% C
Lost Creek	CRLAWQ09	83%	79%	15.5	2%	5%	91% C,9% N	12%	6%	100% C
Annie Creek, Middle Fork	CRLAWQ10	76%	34%	27.5	4%	15%	50% C,50% N	7%	50%	50% C,50% N
Bybee Creek	CRLAWQ11	91%	54%	40.5	12%	12%	73% C,27% N	30%	6%	50% C,23% D,27% M
Castle Creek	CRLAWQ12	93%	76%	29.7	6%	8%	68% C,23% D,9% N	40%	18%	14% C,86% D
Annie Creek	CRLAWQ13	80%	44%	51	18%	11%	68% C,27% N,5% M	18%	21%	18% C,36% D,14% N,32% M
Unnamed- Trib to Munson	CRLAWQ14	67%	75%	16.7	3%	5%	95% C,5% N	20%	7%	95% C,5% D
Unnamed- Trib to Bybee	CRLAWQ15	79%	66%	22.2	1%	4%	91% C,9% N	5%	0%	95% C,5% N
Unnamed	CRLAWQ16	75%	27%	19.5	2%	4%	29% C,71% N	7%	11%	57% C,4% E,39% N
Sand Creek	CRLAWQ17	81%	55%	32.9	2%	3%	55% C,45% N	12%	5%	59% C,27% D,14% N
Crater Creek	CRLAWQ19	96%	85%	44.3	1%	3%	82% C,18% N	18%	1%	55% C,45% D
Unnamed- Trib to Sand	CRLAWQ21	86%	64%	21.1	11%	27%	100% C	16%	16%	95% C,5% M
Annie Creek	CRLAWQ22	79%	29%	22.2	1%	31%	95% C,5% N	12%	27%	95% C,5% N
Munson Creek	CRLAWQ26	55%	28%	16.9	0%	2%	50% C,50% N	5%	0%	82% C,18% N
Unnamed- Trib to Castle	CRLAWQ28	66%	61%	24.3	4%	4%	73% C,27% N	9%	2%	100% C
Sand Creek	CRLAWQ29	84%	64%	28.9	6%	24%	100% C	31%	17%	27% C,45% D,18% N,9% M
Sun Creek	CRLAWQ30	91%	67%	51	8%	10%	73% C,27% N	85%	23%	100% D
Sun Creek	CRLAWQ31	78%	51%	33.3	2%	2%	32% C,68% N	16%	2%	18% C,50% D,14% N,18% M

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 22 (continued). Riparian characteristics of Crater Lake streams, 2015.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Sand Creek	CRLAWQ33	77%	66%	42.6	29%	23%	95% C,5% D	16%	0%	100% C
Munson Creek	CRLAWQ34	66%	33%	16.9	2%	10%	36% C,64% N	7%	27%	86% C,14% N
Unnamed Middle Trib to Sand Creek	CRLAWQ37	92%	81%	27.4	11%	20%	100% C	12%	1%	77% C,23% N
Castle Creek	CRLAWQ38	82%	70%	24.8	5%	25%	100% C	18%	17%	100% C
Bybee Creek	CRLAWQ39	77%	74%	24.4	5%	20%	100% C	10%	0%	95% C,5% D
Average	–	80%	60%	29.4	6%	13%	n/a	18%	13%	n/a
SD	–	9%	17%	10.0	5%	9%	n/a	16%	11%	n/a
Median	–	80%	64%	28.5	5%	11%	n/a	13%	11%	n/a
Range	–	55% - 96%	27% - 85%	15.5 - 51	0 - 18%	2% - 31%	n/a	4% - 85%	0 - 50%	n/a

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table 23. Vertebrate species and metrics for Crater Lake streams, 2015.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Bull Trout	Cascade Frog	Pacific Tree Frog	Tailed Frog	Unknown Frog	Western Toad
Cavern Creek	CRLAWQ01	Yes	39	1	57.1 ^b	39	–	–	–	–	–	–
Sun Creek	CRLAWQ02	Yes	8	1	85.7 ^a	–	8	–	–	–	–	–
Sun Creek	CRLAWQ03	Yes	4	1	85.7 ^a	–	4	–	–	–	–	–
Wheeler Creek	CRLAWQ05	Yes	2	1	42.9 ^b	–	–	–	–	–	2	–
Munson Creek	CRLAWQ06	Yes	8	1	57.1 ^b	8	–	–	–	–	–	–
Unnamed- Trib to Vidae	CRLAWQ07	Yes	–	–	Null	–	–	–	–	–	–	–
Unnamed	CRLAWQ08	No	–	–	–	–	–	–	–	–	–	–
Lost Creek	CRLAWQ09	Yes	4	1	85.7 ^a	–	4	–	–	–	–	–
Annie Creek, Middle Fork	CRLAWQ10	Yes	13	2	46.9 ^b	11	–	–	1	–	1	–
Bybee Creek	CRLAWQ11	Yes	6	1	57.1 ^b	6	–	–	–	–	–	–
Castle Creek	CRLAWQ12	Yes	10	3	60 ^b	7	–	–	1	1	1	–
Annie Creek	CRLAWQ13	Yes	26	2	46.9 ^b	11	–	15	–	–	–	–
Unnamed- Trib to Munson	CRLAWQ14	Yes	32	1	57.1 ^b	32	–	–	–	–	–	–
Unnamed- Trib to Bybee	CRLAWQ15	Yes	8	3	47.6 ^b	–	–	6	1	–	–	1
Unnamed	CRLAWQ16	Yes	2	1	42.9 ^b	–	–	2	–	–	–	–
Sand Creek	CRLAWQ17	Yes	15	1	57.1 ^b	15	–	–	–	–	–	–
Crater Creek	CRLAWQ19	Yes	4	1	42.9 ^b	–	–	4	–	–	–	–
Unnamed- Trib to Sand	CRLAWQ21	Yes	17	1	57.1 ^b	17	–	–	–	–	–	–
Annie Creek	CRLAWQ22	Yes	17	2	46.9 ^b	16	–	–	1	–	–	–
Munson Creek	CRLAWQ26	Yes	2	1	57.1 ^b	2	–	–	–	–	–	–
Unnamed- Trib to Castle	CRLAWQ28	Yes	–	–	Null	–	–	–	–	–	–	–
Sand Creek	CRLAWQ29	Yes	23	1	57.1 ^b	23	–	–	–	–	–	–
Sun Creek	CRLAWQ30	Yes	5	1	85.7 ^a	–	5	–	–	–	–	–

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites not sampled, but with species information indicate visual sightings.

Table 23 (continued). Vertebrate species and metrics for Crater Lake streams, 2015.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Bull Trout	Cascade Frog	Pacific Tree Frog	Tailed Frog	Unknown Frog	Western Toad
Sun Creek	CRLAWQ31	Yes	18	1	85.7 ^a	–	18	–	–	–	–	–
Sand Creek	CRLAWQ33	Yes	17	1	57.1 ^b	17	–	–	–	–	–	–
Munson Creek	CRLAWQ34	Yes	13	2	46.9 ^b	10	–	3	–	–	–	–
Unnamed Middle Trib to Sand	CRLAWQ37	Yes	–	–	Null	–	–	–	–	–	–	–
Castle Creek	CRLAWQ38	No	–	–	–	–	–	–	–	–	–	–
Bybee Creek	CRLAWQ39	No ^c	6	1	57.1 ^b	6	–	–	–	–	–	–
Average	–	n/a	12.5	1.3	59.3 ^b	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD	–	n/a	9.8	0.6	14.9	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median	–	n/a	9	1	57.1 ^b	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range	–	n/a	2 - 39	1 - 3	42.9 - 85.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites not sampled, but with species information indicate visual sightings.

Table 24. Macroinvertebrate metrics for Crater Lake streams, 2015.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	Oregon Western Streams IBI ^d
Cavern Creek	CRLAWQ01	56	3.32	3.15	1.23 ^e	78 ^e	80 ^e
Sun Creek	CRLAWQ02	52	3.43	3.3	1.36 ^e	85 ^e	88 ^e
Sun Creek	CRLAWQ03	46	2.96	2.31	1.37 ^e	82 ^e	88 ^e
Wheeler Creek	CRLAWQ05	73	3.56	4.02	1.24 ^e	79 ^e	88 ^e
Munson Creek	CRLAWQ06	38	2.58	3.07	0.94 ^e	74 ^e	76 ^e
Unnamed- Trib to Vidae	CRLAWQ07	59	2.95	2.9	1.18 ^e	80 ^e	84 ^e
Unnamed- Trib to Union	CRLAWQ08	32	2.75	2.22	1.04 ^e	62 ^f	76 ^e
Lost Creek	CRLAWQ09	55	2.91	5.11	0.99 ^e	51 ^g	68 ^e
Annie Creek, Middle Fork	CRLAWQ10	14	1.78	4.78	0.71 ^f	66 ^f	48 ^g
Bybee Creek	CRLAWQ11	46	2.75	2.07	1.28 ^e	81 ^e	80 ^e
Castle Creek	CRLAWQ12	3	1.1	3	0.11 ^g	17 ^g	44 ^g
Annie Creek	CRLAWQ13	20	2.38	3.42	0.8 ^f	60 ^f	72 ^e
Unnamed- Trib to Munson	CRLAWQ14	65	3.22	5.42	1.3 ^e	56 ^g	68 ^e
Unnamed- Trib to Bybee	CRLAWQ15	52	2.72	2.85	0.94 ^e	66 ^f	84 ^e
Unnamed	CRLAWQ16	38	2.74	4.55	0.94 ^e	63 ^f	64 ^e
Sand Creek	CRLAWQ17	56	3.06	4.37	0.93 ^e	81 ^e	88 ^e
Crater Creek	CRLAWQ19	64	3.53	2.69	1.4 ^e	73 ^e	88 ^e
Unnamed- Trib to Sand	CRLAWQ21	54	3.14	2.64	0.99 ^e	66 ^f	76 ^e
Annie Creek	CRLAWQ22	37	2.55	3.36	1.16 ^e	82 ^e	80 ^e
Munson Creek	CRLAWQ26	42	2.43	1.87	1.06 ^e	67 ^f	84 ^e
Unnamed- Trib to Castle	CRLAWQ28	53	3.07	2.19	1.17 ^e	78 ^e	88 ^e
Sand Creek	CRLAWQ29	45	2.96	4.35	1.03 ^e	82 ^e	84 ^e
Sun Creek	CRLAWQ30	42	2.87	3.97	1.28 ^e	79 ^e	80 ^e
Sun Creek	CRLAWQ31	49	3.33	2.61	1.37 ^e	84 ^e	88 ^e

^a HBI = Hilsenhoff Biotic Index.

^b O/E = Observed/Expected ratio.

^c MMI = Multi=Metric Index.

^d IBI = Index of Biotic Integrity

^e Sites are Least Disturbed (also with light sage background).

^f Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^g Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table 24 (continued). Macroinvertebrate metrics for Crater Lake streams, 2015.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	Oregon Western Streams IBI ^d
Sand Creek	CRLAWQ33	46	3.11	3.21	1.23 ^e	86 ^e	92 ^e
Munson Creek	CRLAWQ34	45	2.64	2.92	1.18 ^e	67 ^f	72 ^e
Unnamed Middle Trib to Sand Creek	CRLAWQ37	50	3.23	6.32	1.24 ^e	61 ^f	64 ^e
Castle Creek	CRLAWQ38	57	3.35	3.42	1.18 ^e	76 ^e	96 ^e
Bybee Creek	CRLAWQ39	63	3.39	2.29	1.06 ^e	80 ^e	80 ^e
Average	–	46.6	2.9	3.39	1.09 ^e	71.1 ^e	78.2 ^e
SD	–	15.2	0.5	1.09	0.26	14.1	12.1
Median	–	49	2.96	3.15	1.17 ^e	76 ^e	80 ^e
Range	–	3 - 73	1.1 - 3.56	1.87 - 6.32	0.11 - 1.4	17 - 86	44 - 96

^a HBI = Hilsenhoff Biotic Index.

^b O/E = Observed/Expected ratio.

^c MMI = Multi=Metric Index.

^d IBI = Index of Biotic Integrity

^e Sites are Least Disturbed (also with light sage background).

^f Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^g Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Nine streams rated Intermediate (31%) under the EPA Invertebrate MMI condition rating, while the three other sites were Most Disturbed (10%). All but two of the 29 sites were rated as “Slight impairment to no impairment” under the Oregon Western Streams IBI condition assessment. Lastly, the O/E (observed to expected ratio) of biodiversity was high for most sites in Crater Lake, with only two sites being Intermediate (6%) and one site being Most Disturbed (3%). Castle Creek near the park border, CRLAWQ12, was the lowest at only 0.11, and also was the site with the lowest taxa richness (3) – which was comprised of only three individuals. The lack of diversity and abundance likely represents collector error, and not ambient conditions.

Discussion

General Issues

This was the second implementation of wadeable streams monitoring at Oregon Caves, Redwood Parks, and Crater Lake. The first was 2012, and the next implementation will be in 2018.

Of note, the protocol has a goal of 25 to 30 sites, with 30 sites representing the ideal (excepting Oregon Caves with three judgement sites). This marks the first year that the wadeable streams vital signs monitoring was able to surpass 25 sites in the sampling season. Hopefully, as sites are visited, and a growing knowledge of which sites are feasible (e.g., safe, accessible, and permanent), most years will meet the 25 to 30 goal.

No large issues affecting data completeness were encountered this year compared to previous years (e.g., short staffed crews, faulty probes, etc.). The only minor issues was the issue of faulty batteries for the electrofishers which prohibited full sampling in Oregon Caves for vertebrates.

Status versus trends (or a cautionary note on changes from 2012...)

The above point about comparing 2015 data and condition to 2012 data as an assessment of accuracy is an important one. With only the second sampling of wadeable streams complete, the program is just beginning to understand annual variability inherent in the ecosystem. Observed differences at this point in the program should not be taken as a trend, but rather each year should be considered as separate status estimates. Indeed, a full comparison of 2012 data to 2015 data is beyond the scope of an annual status report.

However, when interpreting status, we recognize that context is important. Considering this, there are three events/factors that are important to interpreting the 2015 data:

1. 2012 precipitation versus 2015 precipitation

The 2012 Redwood Parks water year (October 1st, 2011 to September 30th, 2012) was characterized by an average of 70.9 inches of precipitation (from the Advanced Hydrologic Prediction Service of the National Weather Service: water.weather.gov/precip; average of points surrounding the general sampling locales). 2015, in contrast had an average of 60.3 inches; or 15% less water in 2015 than 2012, which may explain variability in discharge and cascade into other measurements. On the converse, in Crater Lake, the 2012 water year precipitation was 47.2 inches; and 2015 had 46.7 inches of precipitation almost identical amounts. The basic availability of water has cascading effects into discharge, stream depth, and stream width. Less water is also connected with warmer temperatures, lower dissolved oxygen, less riparian coverage, and higher solute concentrations. In future years, we expect precipitation and drought/wet years to be cofactors in explaining the variance seen over the years.

2. National Creek Fire Complex in Crater Lake National Park

Although the current data are not affected by the fire that burned in the northwest portion of the park, future sampling will show potential impacts and recovery depending upon the severity.

3. Scope of Inference

The sampling design differs between Oregon Caves and Redwood Parks/Crater Lake. It bears repeating that data on Oregon Caves streams cannot be expanded or inferred to other streams of Oregon Caves National Monument and Preserve. Likewise, for both Redwood Parks and Crater Lake, the data can only be inferred to streams meeting the sampling frame: accessible, safe, and lower gradient.

Notes about condition assessment

This protocol makes use of EPA developed threshold criteria for assigning “condition” to ecological integrity from a diversity array of variable and metrics (physical, chemical, and biological). From a management perspective, three main points should be emphasized:

1. The programmatic goal of the Wadeable Streams Assessment is an assessment of the amount of overall impairment in the sampling frame, and not the identification of site-specific impairment. Hence, within the EPA program, errors in site-specific condition do occur, are recognized to occur, and hopefully minimized; but region-wide averages have still driven the development of threshold criteria. Intermediate or Most Disturbed sites identified by this program should be investigated, but are not an immediate call for “crisis mode.”
2. Threshold criteria are based on regional (mountain west-wide models) reference conditions. Localized values based on park reference sites may provide more accurate per-site and park-wide assessment. An example is the threshold criteria used for total phosphorous, where Crater Lake shows possible influence of local geology, exhibiting naturally higher phosphorous than the EPA derived values. When a majority of park sites show increased values in a single metric, and the park can conclusively show that these sites should be rated as Least Disturbed due to the lack of stressors, the creation of park-specific thresholds may be necessary through research programs or research partners.
3. The use of multiple indices allows for the potential of some indices to rate a stream condition as Least Disturbed whereas others might rate it as Most Disturbed – creating a perceived paradox of a stream condition. Indeed, many sites had one or more “flags” (Intermediate or Most Disturbed). Rather than view this as a paradox, managers should consider two points; (a) a weight of evidence approach, and (b) a specificity of impact approach. In the weight of evidence approach, a stream site that has multiple “flags” across multiple categories (e.g., biological, chemical, and biological) would suggest a truly imperiled stream. In the specificity of impact approach, a stream that is Intermediate in one category and not the others can be used to help pinpoint what the impact is that might be affecting water quality. As an example, a stream or lake that has elevated phosphorous and low nitrogen may be indicative of a system impacted by agriculture, whereas a system with low phosphorous and

high nitrogen may be indicative of a system impacted by depositional pollution (although nitrogen is also associated with fertilizer run-off).

Oregon Caves National Monument and Preserve

The streams of Oregon Caves were classified as being in the Least Disturbed condition based on applying the metrics and thresholds of EPA and regional invertebrate metrics. One pattern that emerged in Oregon Caves is several flags (up to 3 per stream reach) in physical metrics (Table 25), and no flags in biological metrics, although we were unable to electrofish two sites to measure the full complement of indicators.

Table 25. Condition summary for Oregon Caves streams, 2015.

Stream Name	Site Code	Number of Flags ^a			
		Physical	Chemical	Biological	Sum
Cave Creek	ORCAWQ01	2	1	0	3
Lake Creek	ORCAWQ02	1	1	0	2
No Name Creek	ORCAWQ03	3	1	0	4

^a Flags indicate each incidence of Intermediate or Most Disturbed condition.

The physical flags are for a range of metrics – but for at least In-Stream Habitat Complexity and Riparian Cover, these are likely a function of reduced flows, which narrows the wetted width, reducing the overhead canopy and also the available habitat (e.g., boulders, brush, etc.) that contributes to habitat complexity. Additionally, Riparian Cover is a combination of the estimated areal coverage of woody vegetation at the canopy, understory, and ground cover along the stream reach. However, much of the understory and ground cover in Oregon Caves (and Redwood Parks) is composed of ferns (probably Sword Fern, *Polystichum munitum*), which does not fall in the “woody vegetation” category, but rather is an herbaceous type of understory. Hence, despite lush and complex riparian vegetation in both the understory and ground cover, the stream reaches of Oregon Caves are ranked as having an underdeveloped riparian zone. This illustrates the necessity of follow-up interpretation on all EPA and other water quality metric scoring.

The second set of flags in the physical category was for RBS. This is a potentially valuable metric, in that the scoring can suggest causes of impairment in two opposite ends of a disturbance spectrum; strong negative values indicate increased sedimentation, and strong positive values suggest a lack of sediments. Common to many impacted western streams, these disturbances arise from (1) timber and road impacts causing increased sediments, and (2) water withdrawal or diversion/dams that prevent natural sedimentation. Neither of these are identified stressors within Oregon Caves. On Lake Creek, (ORCAWQ02), water is diverted for the monument’s water supply, but the sampled reach is above the withdrawal. What is clear is that the nature of these streams is different—Cave Creek (ORCAWQ01) is a narrow, forested stream with moderate hillslopes, and Lake Creek (ORCAWQ02) and No Name Creek (ORCAWQ03) are more open, with higher amounts of bedrock, more boulders, and steep hillslopes. Lastly, these RBS values are calculated using a rapid, quantitatively simplified measure that does not incorporate woody debris; the eventual incorporation

of downed woody debris in the stream channel will impact the final numbers and provide more accurate assessments of the sediment surplus or paucity.

The additional flags were from Total Phosphorous levels being elevated in the Intermediate category. However, the sites with elevated Total Phosphorous levels (Cave Creek and No Name Creek) occur in areas of meta-basalt drainages (KellerLynn 2011). Igneous rock, like basalt, is a naturally high source of phosphorous (Cole 1994; Wetzel 2001). Lastly, Lake Creek (ORCAWQ02) was elevated for Total Nitrogen.

As in 2012, the sampled sites in Oregon Caves were characterized by high macroinvertebrate diversity, ranging from 60 to 70 invertebrate taxa. All metrics of condition were high, with Oregon State IBI ranging from 88 to 92. In sum, the streams of Oregon Caves are characterized by high diversity indicative of high biological integrity.

Redwood National and State Parks

All stream sites at Redwood Parks had at least one flag, and streams with less than three flags should be considered good examples of relatively unimpaired streams (Table 26). Although discharge is not an indicator of condition, a notable observation is much reduced discharge in 2015 vs 2012. The average $\text{m}^3 \text{s}^{-1}$ in 2012 was 15, whereas in 2015 it was 0.49

Notable too, is that the Redwood Parks had large amounts of fern understory, which is not counted as a “woody stem,” and as such does not contribute to Riparian Cover by the standards of the EPA metric (see description in Oregon Caves section above for more information). A full 12 sites were flagged due to this, but the regional reality of the Pacific Northwest is that these sites have well developed riparian zones, and should not be considered impaired. Riparian Cover at Redwood Creek sites were flagged, but these sites experience large amounts of fluctuation in water levels in a season, and sampling commenced when much of the streamside zone was a previously inundated stream channel.

Estimates of condition based on Relative Bed Stability varied, with a strong negative value at McArthur Creek (REDWWQ01) and strong positive values at Redwood Creek (REDWWQ25). Negative values suggest an excess of fine sediments, whereas strong positives indicate a preponderance of large substrates. However, the park wide average for Relative Bed Stability was in the Least Disturbed condition. Site specific patterns may suggest landscape disturbance history or past impacts and should be followed up by targeted questions.

Conditions based on nutrients in Redwood Parks streams sampled suggest widespread issues, especially with Total Nitrogen. In 2012, only three sites were rated as Most Disturbed, but 2015 had 11 sites, including a park wide average in the Most Disturbed. The Inventory and Monitoring program is not designed to provide causative factors, but two clear possibilities are: (1) higher ambient levels due to low discharge and a concentration effect, and (2) anthropogenic sources such as fertilizer.

Table 26. Condition summary for Redwood Parks streams, 2015.

Stream Name	Site Code	Number of Flags ^a			
		Physical	Chemical	Biological	Sum
McArthur Creek	REDWWQ01	1	1	3	5
Unnamed- Trib to Brown	REDWWQ02	1	1	0	2
West Branch Mill Ck	REDWWQ03	0	2	0	2
Redwood Creek	REDWWQ04	2	0	2	4
East Fork Mill Creek	REDWWQ05	2	2	1	5
Lost Man Creek	REDWWQ06	1	2	1	4
Cedar Creek	REDWWQ07	1	1	1	3
Bummer Lake Creek	REDWWQ08	2	2	0	4
Wilson Creek	REDWWQ09	1	2	1	4
Unnamed- Streelow Creek Trail	REDWWQ10	0	2	2	4
West Branch Mill Ck	REDWWQ11	2	2	1	5
Little Lost Man Creek	REDWWQ12	1	2	0	3
Lost Man Creek	REDWWQ13	1	0	0	1
Rock Creek	REDWWQ14	3	1	0	4
Mill Creek	REDWWQ15	1	2	1	4
Redwood Creek	REDWWQ16	3	1	3	7
Peacock Creek	REDWWQ17	0	2	0	2
West Branch Mill Ck	REDWWQ19	0	1	1	2
Redwood Creek	REDWWQ20	3	1	2	6
Godwood Creek	REDWWQ21	2	1	0	3
West Branch Mill Ck	REDWWQ23	1	2	2	5
Lost Man Creek	REDWWQ24	2	0	1	3
Redwood Creek	REDWWQ25	3	1	2	6
Rock Creek	REDWWQ26	2	2	0	4
Godwood Creek	REDWWQ28	0	1	2	3
Bond Creek	REDWWQ29	1	1	0	2

^a Flags indicate each incidence of Intermediate or Most Disturbed condition.

Conditions based on vertebrates showed overall excellent condition, with the populations of Redwood Creek being the only area of concern. The vertebrate stream fauna comprised some of the most diverse fish and amphibian assemblages sampled in any of the Klamath Network parks, and they all ranked as Least Disturbed according to the Aquatic Vertebrate MMI, excepting the aforementioned Redwood Creek sites.

The sampled streams of Redwood Parks were characterized by a high overall diversity of aquatic macroinvertebrates (~ >272 taxa), which could potentially be due to the diversity of stream sizes sampled. Our sampling frame included both 1st order headwater streams, and larger order (4th and 5th) downstream reaches of substantial watersheds. This is in contrast to the other parks of the

network, especially Crater Lake and Lassen Volcanic, where most of the streams are 1st and 2nd order headwaters. This introduces greater habitat variability and niches for a larger range of macroinvertebrates.

Conclusions on overall condition of ecological integrity using macroinvertebrate assessments is problematic when different metrics give contrasting results (see above). However, alignment of metrics all suggesting common patterns are the most robust for estimates. In this regard, the alignment of the O/E, EPA MMI, and CA MMI for McArthur Creek (REDWWQ01) is informative. McArthur Creek has been the site of debris flows in the past, which is a naturally occurring disturbance in the Pacific Northwest, but in this case triggered by logging roads.

Finally, using a weight of evidence approach, the stream receiving the most number of flags (6 and 7) were on Redwood Creek (REDWWQ16, REDWWQ20, REDWWQ25). The reduced flows are likely a factor in increased flags, but should be watched for improvement or decline in future years.

Crater Lake National Park

Only one stream site only had a single flag, Sun Creek (CRLAWQ30) (Table 27). However, the widespread prevalence of increased Total Phosphorous due to the local geology sets a local standard that most sites already have a single flag under ambient conditions (Dinger 2015).

Riparian Cover, a measure of complexity based on the areal coverage of woody canopy, woody understory, and woody ground cover, was flagged in a large percentage of sites (e.g., sites that were Intermediate or Most Disturbed). Similar to Lassen Volcanic NP (Dinger and Sarr 2014), the streams of Crater Lake move through montane meadows, with a large number of naturally occurring sedge and forb meadows. Although they are naturally occurring and unimpaired habitats, these meadow bordered streams still rank as Intermediate or Most Disturbed. Likewise, the heavy snow pack of Crater Lake in most years may also create conditions precluding a more developed riparian zone.

The geology of Crater Lake also affected Relative Bed Stability, a measure of expected particle size for stream substrate versus the actual, observed particle size. For all the streams sampled in Crater Lake, this was strongly negative, indicating that substrate particle size was smaller than expected based on geomorphological features (like slope). The general interpretation based on this EPA condition metric would be that the streams of Crater Lake have an anthropogenic source of increased silt and sediment. The overall median substrate size for the combined pebble counts was 38 mm diameter, which is the size of coarse gravel (marble to tennis ball size). Rather than reflecting an input of small sediments, this pattern is likely a representation of the source material. Crater Lake and the Mount Mazama caldera were formed by a geologically recent (~7,700 years ago) volcanic eruption, and much of the hillslope and terrain are dominated by volcanic, igneous rock. A high proportion of stream sampling sites are in “felsic pyroclastic” terrain, which is composed of large proportions of pumiceous lapilli (common to the Pumice Desert) that range in size from 2 to 64 mm in diameter (i.e., coarse gravel). Other streams sites lie in fine grain lithic- and crystal-rich ignimbrite (KellerLynn 2013). Hence, for the majority of sites, the strong negative readings do not indicate sediment pollution, but simply the source material.

Table 27. Condition summary for Crater Lake streams, 2015. Flags indicate each incidence of Intermediate or Most Disturbed condition.

Stream Name	Site Code	Number of Flags ^a			
		Physical	Chemical	Biological	Sum
Cavern Creek	CRLAWQ01	2	1	1	4
Sun Creek	CRLAWQ02	2	1	0	3
Sun Creek	CRLAWQ03	1	1	0	2
Wheeler Creek	CRLAWQ05	1	1	1	3
Munson Creek	CRLAWQ06	0	1	1	2
Unnamed- Trib to Vidae	CRLAWQ07	1	1	0	2
Unnamed- Trib to Union	CRLAWQ08	1	1	1	3
Lost Creek	CRLAWQ09	4	1	1	6
Annie Creek, Middle Fork	CRLAWQ10	1	1	4	6
Bybee Creek	CRLAWQ11	1	1	2	4
Castle Creek	CRLAWQ12	1	1	4	6
Annie Creek	CRLAWQ13	1	1	3	5
Unnamed- Trib to Munson	CRLAWQ14	3	2	2	7
Unnamed- Trib to Bybee	CRLAWQ15	2	0	2	4
Unnamed	CRLAWQ16	1	2	2	5
Sand Creek	CRLAWQ17	2	1	1	4
Crater Creek	CRLAWQ19	3	1	1	5
Unnamed- Trib to Sand	CRLAWQ21	0	1	2	3
Annie Creek	CRLAWQ22	1	1	1	3
Munson Creek	CRLAWQ26	2	1	2	5
Unnamed- Trib to Castle	CRLAWQ28	2	1	0	3
Sand Creek	CRLAWQ29	0	1	1	2
Sun Creek	CRLAWQ30	0	1	0	1
Sun Creek	CRLAWQ31	2	1	0	3
Sand Creek	CRLAWQ33	1	1	1	3
Munson Creek	CRLAWQ34	2	1	2	5
Unnamed Middle Trib to Sand Creek	CRLAWQ37	1	1	1	3
Castle Creek	CRLAWQ38	1	1	0	2
Bybee Creek	CRLAWQ39	2	1	1	4

^a Flags indicate each incidence of Intermediate or Most Disturbed condition.

Two sites in Crater Lake rank as Most Disturbed for Riparian Disturbance; these were Lost Creek (CRLAWQ09) and an Unnamed Stream (CRLAWQ14). Lost Creek is next to an NPS campground, and the observed disturbances included the campground itself, trash, and trails. The Unnamed stream (CRLAWQ14) is quite close to park facilities in the headquarters and visitor center area, and includes both disturbances from park buildings, pavement, pipes, and trash.

Water chemistry for Crater Lake reflected mostly Least Disturbed conditions, with the exception of Total Phosphorous, where many sites were Intermediate and Most Disturbed. Similar to Lassen Volcanic NP (Dinger and Sarr 2014) and Oregon Caves (this report), this is likely a reflection of the volcanic nature of the park unit, and not widespread nutrient pollution.

The only sites in Crater Lake that were sampled for vertebrates and ranked as Least Disturbed were Sun Creek (CRLAWQ02, 03, 30, 31) and Lost Creek (CRLAWQ09) which are sites for Bull Trout (*Salvelinus confluentus*) restoration. All other sites with fish in Crater Lake (15 sites) were Intermediate due to the presence of Brook Trout (*Salvelinus fontinalis*). This is an unusual situation, where the occurrence of the Brook Trout, a cold water species requiring clean, fresh, relatively pristine water, would often be an indicator of good water quality, but the trout itself is a nonnative species and represents a strong stressor to native aquatic communities.

Most sites for macroinvertebrate diversity ranked high in terms of condition assessment (e.g., Least Disturbed). However, two sites stand out as problematic: (1) Annie Creek, Middle Fork – CRLAWQ10 and (2) Castle Creek – CRLAWQ12. Both of the macroinvertebrate samples from these sites are characterized by low diversity and low abundances. In the absence of identifiable impacts (e.g., landslides/sedimentation, ephemeral stream [stream was recently dry], fire retardant or piscicide applications, etc.), the most likely explanation is a faulty sample (either collector error or compromised collection net). The low diversity and abundance affects the condition using all three metrics (O/E, EPA MMI, OR MMI). Both sites had ample diversity and abundances in 2012 (see Table E-23, this report).

Conclusions

This was the second year of monitoring streams in the Klamath Network at Oregon Caves, Redwood Parks, and Crater Lake. Overall stream conditions in the three parks surveyed appear to be mostly good, with specific concerns identified (e.g., Total Nitrogen in Redwood Parks). Criteria set forth by the EPA Wadeable Streams Assessment provide some guidance and assessment for stream condition. Regional calibration to natural, localized reference conditions is desirable, but would require additional sampling effort at sites representing a range of disturbance regimes and is beyond the scope of this project. Sampling will continue in 2018, with annual reports and more comprehensive Analysis and Synthesis reports completed thereafter.

At this stage in the monitoring, we are beginning to understand the annual variation of the physical, chemical, and biological attributes of the streams and how they respond to annual climatic variables, such as precipitation. Also new this year was the adoption of automated computer code to produce metrics, which will speed future reporting, offer transparency, and repeatability. Lastly, this report also includes observed/expected ratios of macroinvertebrate diversity as a condition estimate.

In general, the application of broadly developed multi-metric and multi-variate indices should be approached cautiously in the early years such as this. Site-specific characteristics or distinctive disturbance histories may yield conflicting results. Interpretation should be cautious. In future years, a better understanding of the unique characteristics of the stream reaches in each park will hopefully allow us to better differentiate anthropogenic impacts from natural variation.

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Appendix A. Example of MMI Calculation and Scoring

To facilitate understanding of MMIs, below is an exposition on how a representative MMI, the California Northern Coastal Region Benthic Index of Biotic Integrity (Rehn et al. 2005), is calculated using data collected from Boulder Creek in Whiskeytown (WHISWQ02) in 2011 (Table A-1). Metric calculations begin using the species list provided by the contractor, Rhithron Associates, Inc.

Table A-1. Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Non-insect taxa	Turbellaria	1	–
	Sphaeriidae - immature	1	–
	<i>Lebertia</i>	1	–
	<i>Torrenticola</i>	15	–
	<i>Mesenchytraeus</i>	2	–
	Lumbriculidae - damaged	1	–
	<i>Spirosperma</i>	4	–
Ephemeroptera	<i>Ameletus</i>	16	–
	<i>Baetis tricaudatus</i>	23	–
	<i>Dipheter hageni</i>	43	–
	<i>Caudatella</i> - early instar or damaged	4	no
	<i>Caudatella heterocaudata</i>	7	–
	<i>Drunella</i> - early instar	7	no
	<i>Drunella doddsii</i>	4	–
	<i>Drunella flavilinea</i>	3	–
	<i>Drunella pelosa</i>	1	–
	<i>Ephemerella excrucians</i>	5	–
	Ephemerellidae - early instar or damaged	4	no
	<i>Epeorus</i>	42	–
	<i>Ironodes</i>	2	–
	<i>Rhithrogena</i>	1	–
	<i>Paraleptophlebia</i>	3	–
Plecoptera	<i>Suwallia</i>	4	–
	<i>Moselia infuscata</i>	1	–
	<i>Zapada cinctipes</i>	2	–
	<i>Calineuria californica</i>	2	–
	Perlidae - early instar	1	no
Trichoptera	<i>Amiocentrus aspilus</i>	1	–
	<i>Micrasema</i>	5	–
	<i>Heteroplectron californicum</i>	4	–

Table A-1 (continued). Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Trichoptera (continued)	<i>Glossosoma</i>	3	–
	Glossosomatidae - damaged or pupa	9	no
	<i>Helicopsyche</i>	140	–
	<i>Hydropsyche</i>	14	–
	<i>Parapsyche</i>	6	–
	<i>Lepidostoma</i>	9	–
	<i>Allocosmoecus partitus</i>	1	–
	Limnephilidae - early instar or damaged	5	–
	<i>Polycentropus</i>	1	–
	<i>Rhyacophila</i> - early instar or damaged	4	–
	<i>Rhyacophila Betteni</i> Gr.	9	–
	<i>Gumaga</i>	18	–
	Sericostomatidae - pupa	5	–
	<i>Neophylax splendens</i>	9	–
Diptera	Ceratopogoninae - early instar	3	–
	Empididae - early instar, damaged, or pupa	1	–
	<i>Antocha monticola</i>	3	–
	<i>Cryptolabis</i>	14	–
	<i>Dicranota</i>	3	–
	<i>Hexatoma</i>	1	–
	Tipulidae - damaged or pupa	2	no
Diptera (Chironomidae)	<i>Brillia</i>	4	–
	<i>Cricotopus (Nostococladius) nostocicola</i>	3	–
	<i>Cryptochironomus</i>	1	–
	<i>Demicryptochironomus</i>	6	–
	<i>Eukiefferiella Brevicalcar</i> Gr.	1	–
	<i>Lopescladius</i>	1	–
	<i>Micropsectra</i>	5	–
	<i>Monodiamesa</i>	2	–
	<i>Pagastia</i>	5	–
	<i>Paratendipes</i>	3	–
	<i>Polypedilum</i>	10	–
	<i>Prodiamesa</i>	2	–
	<i>Rheotanytarsus</i>	5	–
	<i>Stempellinella</i>	7	–
	Tanypodinae - early instar or damaged	1	no

Table A-1 (continued). Representative MMI example from Boulder Creek in Whiskeytown (WHISWQ02) in 2011.

Category	Taxon	Count	Unique?
Diptera (Chironomidae) (continued)	Tanytarsini - early instar or damaged	3	no
	<i>Tanytarsus</i>	2	–
	<i>Thienemannimyia</i> Gr.	6	–
	<i>Tvetenia Bavarica</i> Gr.	1	–

The values for the eight metrics that comprise the MMI are then calculated (Table A-2). The first metric is EPT taxa richness (Ephemeroptera, Plecoptera, and Trichoptera). In this example, a quick count of the number of taxa in these three insect orders is 37; but this must be adjusted for non-unique taxa. There are often incomplete taxonomic determinations by the taxonomist, but who can determine that they do not represent other unique taxa. For EPT, there are 5 non-unique taxa, so the final EPT taxa richness is 32. Once the values for each eight metrics are calculated, they are scored according to the metric creation (either on a scale from the original authors or linearly interpreted).

Table A-2. Example of the eight MMI metrics calculated for Boulder Creek.

Component Metric	Boulder Creek Value	Score
EPT Richness	32	10
Coleoptera Richness	6	10
Diptera Richness	6	6
% Intolerant Individuals	63.90%	10
%Non-gastropod Individuals	35%	10
% Predator Individuals	7.1%	3
% Shredder Taxa	13.4%	8
% Non-insect Taxa	6.0%	10
Sum	–	67
Scaled to 100	–	83.75

The final step is to scale it to a 0 – 100 range for interpretation. In this example, the summed score is multiplied by 1.25 for a final score of “83.75”.

Interpretation is then based on a traditional scale; 100 = pristine; 10 = severely degraded. Furthermore, scores from 10 to 20 can be considered “very poor”, 20 – 40 are “poor”, 40 – 60 are “fair”, 60 – 80 are “good”, and 80 – 100 are “very good”. Secondly, scores below 52 are considered “impaired”.

Appendix B. Benthic Macroinvertebrates of Oregon Caves National Monument and Preserve

Table B-1 is an accounting of all macroinvertebrate taxonomic units reported by the contract laboratory. The Interagency Taxonomic Information System (ITIS) Serial Number is provided for each taxon when available.

Note that due to taxonomic ambiguity, taxa used in analyses may differ from the taxa presented here. See the full protocol for more on dealing with taxonomic ambiguity.

Table B-1. Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Acari	–	Acari	733321	2	1	33.30%
Coleoptera	Amphizoidae	<i>Amphizoa insolens</i>	111958	1	1	33.30%
Coleoptera	Elmidae	<i>Bryelmis</i>	945749	44	2	66.70%
Coleoptera	Elmidae	<i>Bryelmis siskiyou</i>	945823	4	2	66.70%
Coleoptera	Elmidae	Elmidae	114093	7	2	66.70%
Coleoptera	Elmidae	<i>Heterlimnius corpulentus</i>	114169	41	3	100.00%
Coleoptera	Elmidae	<i>Lara</i>	114137	3	1	33.30%
Coleoptera	Hydrophilidae	<i>Ametor</i>	112890	1	1	33.30%
Coleoptera	Hydrophilidae	Hydrophilidae	112811	1	1	33.30%
Diptera	Ceratopogonidae	<i>Atrichopogon</i>	127113	1	1	33.30%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	4	2	66.70%
Diptera	Chironomidae	<i>Boreochlus</i>	127954	3	1	33.30%
Diptera	Chironomidae	<i>Brillia</i>	128477	60	3	100.00%
Diptera	Chironomidae	<i>Bryophaenocladus</i>	128488	5	1	33.30%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a "species group", or a recently redescribed taxon with no number yet designated.

Table B-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	Chironomidae	127917	1	1	33.30%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	3	2	66.70%
Diptera	Chironomidae	<i>Cricotopus</i>	128575	13	2	66.70%
Diptera	Chironomidae	<i>Cricotopus nostocicola</i>	128628	4	1	33.30%
Diptera	Chironomidae	<i>Eukiefferiella</i>	128689	2	2	66.70%
Diptera	Chironomidae	<i>Eukiefferiella Claripennis</i> Gr.	NA ^b	24	3	100.00%
Diptera	Chironomidae	<i>Eukiefferiella Devonica</i> Gr.	NA ^b	12	3	100.00%
Diptera	Chironomidae	<i>Eukiefferiella Gracei</i> Gr.	NA ^b	9	3	100.00%
Diptera	Chironomidae	<i>Eukiefferiella tirolensis</i>	NA ^b	10	2	66.70%
Diptera	Chironomidae	<i>Krenosmittia</i>	128771	2	1	33.30%
Diptera	Chironomidae	<i>Larsia</i>	128183	4	1	33.30%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	1	1	33.30%
Diptera	Chironomidae	<i>Micropsectra</i>	129890	31	3	100.00%
Diptera	Chironomidae	Orthoclaadiinae	128457	15	3	100.00%
Diptera	Chironomidae	Orthoclaadiinae sp. (RAI Taxon # 0001)	NA ^b	23	1	33.30%
Diptera	Chironomidae	<i>Orthocladus</i>	128874	60	2	66.70%
Diptera	Chironomidae	<i>Pagastia</i>	128401	12	1	33.30%
Diptera	Chironomidae	<i>Parakiefferiella</i>	128968	38	1	33.30%
Diptera	Chironomidae	<i>Parametriocnemus</i>	128978	34	3	100.00%
Diptera	Chironomidae	<i>Paratendipes</i>	129623	3	1	33.30%
Diptera	Chironomidae	<i>Parorthocladus</i>	129011	3	1	33.30%
Diptera	Chironomidae	<i>Platysmittia</i>	129013	26	1	33.30%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	1	1	33.30%

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Table B-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Pseudodiamesa</i>	128416	4	2	66.70%
Diptera	Chironomidae	<i>Rheocricotopus</i>	129086	10	3	100.00%
Diptera	Chironomidae	<i>Rheotanytarsus</i>	129952	22	2	66.70%
Diptera	Chironomidae	<i>Stempellina</i>	129962	12	1	33.30%
Diptera	Chironomidae	<i>Stempellinella</i>	129969	9	2	66.70%
Diptera	Chironomidae	Tanypodinae	127994	1	1	33.30%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	2	1	33.30%
Diptera	Chironomidae	<i>Thienemannimyia</i> Gr.	NA ^b	1	1	33.30%
Diptera	Chironomidae	<i>Tvetenia</i>	129197	1	1	33.30%
Diptera	Chironomidae	<i>Tvetenia Bavarica</i> Gr.	NA ^b	36	3	100.00%
Diptera	Dixidae	<i>Dixa</i>	125810	2	1	33.30%
Diptera	Empididae	<i>Clinocera</i>	135849	12	3	100.00%
Diptera	Empididae	Empididae	135830	4	2	66.70%
Diptera	Empididae	Empididae sp. (RAI Taxon # 0001)	NA ^b	8	2	66.70%
Diptera	Empididae	<i>Neoplasta</i>	136352	11	1	33.30%
Diptera	Pelecorhynchidae	<i>Glutops</i>	130915	12	3	100.00%
Diptera	Simuliidae	<i>Prosimulium</i>	126703	37	2	66.70%
Diptera	Simuliidae	Simuliidae	126640	18	1	33.30%
Diptera	Simuliidae	<i>Simulium</i>	126774	1	1	33.30%
Diptera	Tipulidae	<i>Dicranota</i>	121027	6	2	66.70%
Diptera	Tipulidae	<i>Hexatoma</i>	120094	2	1	33.30%
Diptera	Tipulidae	Tipulidae	118840	2	1	33.30%
Enchytraeida	Enchytraeidae	<i>Enchytraeus</i>	68531	1	1	33.30%

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Table B-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Enchytraeida	Enchytraeidae	<i>Fridericia</i>	204785	14	1	33.30%
Enchytraeida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	13	3	100.00%
Ephemeroptera	Ameletidae	<i>Ameletus</i>	100996	87	2	66.70%
Ephemeroptera	Baetidae	<i>Baetis bicaudatus</i> complex	NA ^b	106	2	66.70%
Ephemeroptera	Baetidae	<i>Baetis piscatoris</i> complex	NA ^b	14	1	33.30%
Ephemeroptera	Baetidae	<i>Baetis Rhodani</i> Gr.	NA ^b	146	3	100.00%
Ephemeroptera	Baetidae	<i>Baetis tricaudatus</i> complex	NA ^b	3	2	66.70%
Ephemeroptera	Baetidae	<i>Dipheter hageni</i>	568598	19	2	66.70%
Ephemeroptera	Ephemerellidae	<i>Caudatella</i>	101347	16	3	100.00%
Ephemeroptera	Ephemerellidae	<i>Caudatella hystrix</i>	101348	2	1	33.30%
Ephemeroptera	Ephemerellidae	<i>Drunella</i>	101365	1	1	33.30%
Ephemeroptera	Ephemerellidae	<i>Drunella coloradensis</i>	101389	8	1	33.30%
Ephemeroptera	Ephemerellidae	<i>Drunella spinifera</i>	101385	5	2	66.70%
Ephemeroptera	Ephemerellidae	<i>Ephemerella alleni</i>	101251	2	1	33.30%
Ephemeroptera	Ephemerellidae	Ephemerellidae	101232	15	3	100.00%
Ephemeroptera	Heptageniidae	<i>Cinygma</i>	100598	2	2	66.70%
Ephemeroptera	Heptageniidae	<i>Cinygmula</i>	100557	14	2	66.70%
Ephemeroptera	Heptageniidae	<i>Epeorus</i>	100626	50	3	100.00%
Ephemeroptera	Heptageniidae	<i>Ironodes</i>	100666	53	2	66.70%
Ephemeroptera	Heptageniidae	<i>Rhithrogena</i>	100572	2	1	33.30%
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	101095	16	2	66.70%
Lumbriculida	Lumbriculidae	Lumbriculidae	68440	1	1	33.30%
Nemata	—	Nemata	563956	52	3	100.00%

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Table B-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Nematomorpha	–	Nematomorpha	64183	1	1	33.30%
Plecoptera	Chloroperlidae	Chloroperlidae	103202	19	2	66.70%
Plecoptera	Chloroperlidae	<i>Suwallia</i>	103254	10	1	33.30%
Plecoptera	Chloroperlidae	<i>Sweltsa</i>	103273	2	1	33.30%
Plecoptera	Leuctridae	Leuctridae	102840	4	1	33.30%
Plecoptera	Leuctridae	<i>Moselia infuscata</i>	102910	35	3	100.00%
Plecoptera	Nemouridae	<i>Malenka</i>	102567	54	2	66.70%
Plecoptera	Nemouridae	Nemouridae	102517	11	2	66.70%
Plecoptera	Nemouridae	<i>Soyedina</i>	102556	1	1	33.30%
Plecoptera	Nemouridae	<i>Visoka cataractae</i>	102615	3	1	33.30%
Plecoptera	Nemouridae	<i>Zapada columbiana</i>	102596	3	1	33.30%
Plecoptera	Peltoperlidae	<i>Sierraperla cora</i>	102515	17	3	100.00%
Plecoptera	Peltoperlidae	<i>Yoraperla</i>	102510	46	3	100.00%
Plecoptera	Peltoperlidae	<i>Yoraperla mariana</i>	103312	55	1	33.30%
Plecoptera	Perlidae	<i>Doroneuria baumanni</i>	103123	7	3	100.00%
Plecoptera	Perlodidae	Perlodidae	102994	26	3	100.00%
Sarcoptiformes	–	Oribatida	733326	7	2	66.70%
Trepaxonemata	–	Trepaxonemata	914204	7	3	100.00%
Trichoptera	Apataniidae	<i>Moselyana comosa</i>	116380	1	1	33.30%
Trichoptera	Brachycentridae	<i>Micrasema</i>	116958	19	2	66.70%
Trichoptera	Glossosomatidae	<i>Anagapetus</i>	117154	2	2	66.70%
Trichoptera	Goeridae	<i>Goeracea oregona</i>	116300	8	2	66.70%
Trichoptera	Hydropsychidae	<i>Parapsyche</i>	115556	9	3	100.00%

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Table B-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Oregon Caves National Monument and Preserve, 2015. Total number of sites sampled was three.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>	116794	1	1	33.30%
Trichoptera	Limnephilidae	<i>Cryptochia</i>	115907	1	1	33.30%
Trichoptera	Limnephilidae	<i>Dicosmoecus pallicornis</i>	116272	1	1	33.30%
Trichoptera	Limnephilidae	Limnephilidae	115933	3	2	66.70%
Trichoptera	Philopotamidae	<i>Dolophilodes</i>	115319	12	2	66.70%
Trichoptera	Philopotamidae	<i>Wormaldia</i>	115258	2	1	33.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>	115097	4	1	33.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Betteni</i> Gr.	NA ^b	20	3	100.00%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Brunnea/Vemna</i> Gr.	NA ^b	2	1	33.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Grandis</i> Gr.	NA ^b	5	2	66.70%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Nevadensis</i> Gr.	NA ^b	2	1	33.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Sibirica</i> Gr.	NA ^b	13	3	100.00%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Verrula</i> Gr.	NA ^b	2	1	33.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Vofixa</i> Gr.	NA ^b	26	2	66.70%
Trichoptera	Uenoidae	<i>Neophylax</i>	116046	6	1	33.30%
Trichoptera	–	<i>Trichoptera</i>	115095	3	1	33.30%
Trombidiformes	Hydryphantidae	<i>Protzia</i>	83170	26	2	66.70%
Trombidiformes	Krendowskiidae	<i>Krendowskia</i>	83502	1	1	33.30%
Trombidiformes	Lebertiidae	<i>Estelloxus</i>	83048	3	1	33.30%
Trombidiformes	Sperchontidae	<i>Sperchon</i>	83006	10	2	66.70%
Trombidiformes	Torrenticolidae	<i>Testudacarus</i>	83250	1	1	33.30%
Tubificida	Naididae	Tubificinae	NA	1	1	33.30%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

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Appendix C. Benthic Macroinvertebrates of Redwood National and State Parks

Table C-1 is an accounting of all macroinvertebrate taxonomic units reported by the contract laboratory. The Interagency Taxonomic Information System (ITIS) Serial Number is provided for each taxon when available.

Note that due to taxonomic ambiguity, taxa used in analyses may differ from the taxa presented here. See the full protocol for more on dealing with taxonomic ambiguity.

Table C-1. Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Amphipoda	Anisogammaridae	<i>Ramellogammarus</i>	93953	471	8	30.80%
Amphipoda	–	Amphipoda	93294	53	2	7.70%
Basommatophora	Physidae	<i>Physella acuta</i>	76699	1	1	3.80%
Basommatophora	Planorbidae	<i>Menetus opercularis</i>	76628	4	2	7.70%
Coleoptera	Dytiscidae	Agabinae	728212	1	1	3.80%
Coleoptera	Dytiscidae	<i>Agabinus sculpturellus</i>	112071	3	2	7.70%
Coleoptera	Dytiscidae	Dytiscidae	111963	14	9	34.60%
Coleoptera	Dytiscidae	Hydroporinae	678402	3	3	11.50%
Coleoptera	Dytiscidae	<i>Ilybius</i>	112181	1	1	3.80%
Coleoptera	Dytiscidae	<i>Oreodytes</i>	112314	33	11	42.30%
Coleoptera	Dytiscidae	<i>Oreodytes congruus</i>	568828	3	3	11.50%
Coleoptera	Dytiscidae	<i>Oreodytes crassulus</i>	728440	2	2	7.70%
Coleoptera	Dytiscidae	<i>Oreodytes obesus</i>	112316	35	7	26.90%
Coleoptera	Dytiscidae	<i>Oreodytes rhyacophilus</i>	728446	1	1	3.80%
Coleoptera	Dytiscidae	<i>Oreodytes scitulus bisulcatus</i>	728557	2	1	3.80%
Coleoptera	Dytiscidae	<i>Oreodytes subrotundus</i>	112318	3	3	11.50%

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^b NA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Coleoptera	Dytiscidae	<i>Sanfilippodytes</i>	728253	1	1	3.80%
Coleoptera	Elmidae	<i>Ampumixis dispar</i>	114197	6	3	11.50%
Coleoptera	Elmidae	<i>Bryelmis</i>	945749	3	1	3.80%
Coleoptera	Elmidae	Elmidae	114093	51	8	30.80%
Coleoptera	Elmidae	<i>Heterolimnius corpulentus</i>	114169	647	17	65.40%
Coleoptera	Elmidae	<i>Lara</i>	114137	14	8	30.80%
Coleoptera	Elmidae	<i>Narpus</i>	114142	11	7	26.90%
Coleoptera	Elmidae	<i>Narpus angustus</i>	114143	2	2	7.70%
Coleoptera	Elmidae	<i>Narpus concolor</i>	114144	22	9	34.60%
Coleoptera	Elmidae	<i>Optioservus</i>	114177	883	17	65.40%
Coleoptera	Elmidae	<i>Optioservus quadrimaculatus</i>	114180	90	11	42.30%
Coleoptera	Elmidae	<i>Optioservus seriatus</i>	114181	37	6	23.10%
Coleoptera	Elmidae	<i>Ordobrevia nubifera</i>	114236	30	10	38.50%
Coleoptera	Elmidae	<i>Zaitzevia</i>	114205	119	15	57.70%
Coleoptera	Elmidae	<i>Zaitzevia parvula</i>	NA ^b	68	10	38.50%
Coleoptera	Halplidae	<i>Brychius pacificus</i>	111949	3	2	7.70%
Coleoptera	Hydraenidae	<i>Hydraena</i>	112757	5	4	15.40%
Coleoptera	Hydrophilidae	<i>Ametor</i>	112890	4	4	15.40%
Coleoptera	Hydrophilidae	<i>Ametor latus</i>	112891	1	1	3.80%
Coleoptera	Hydrophilidae	<i>Laccobius</i>	112858	1	1	3.80%
Coleoptera	Psephenidae	<i>Acneus</i>	114082	9	6	23.10%
Coleoptera	Psephenidae	<i>Eubrianax edwardsii</i>	114086	5	2	7.70%
Coleoptera	Psephenidae	<i>Psephenus</i>	114070	1	1	3.80%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Coleoptera	Ptilodactylidae	<i>Anchyteis velutina</i>	114267	8	4	15.40%
Copepoda	–	Copepoda	85257	1	1	3.80%
Diptera	Ceratopogonidae	<i>Atrichopogon</i>	127113	14	4	15.40%
Diptera	Ceratopogonidae	Ceratopogonidae	127076	1	1	3.80%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	75	20	76.90%
Diptera	Chironomidae	<i>Ablabesmyia</i>	128079	1	1	3.80%
Diptera	Chironomidae	<i>Bilyjomyia algens</i>	NA ^b	1	1	3.80%
Diptera	Chironomidae	<i>Boreochlus</i>	127954	5	4	15.40%
Diptera	Chironomidae	<i>Brillia</i>	128477	527	22	84.60%
Diptera	Chironomidae	<i>Brundiniella eumorpha</i>	128028	35	9	34.60%
Diptera	Chironomidae	<i>Cardiocladius</i>	128511	2	2	7.70%
Diptera	Chironomidae	Chironomini	129229	4	3	11.50%
Diptera	Chironomidae	<i>Chironomus</i>	129254	14	5	19.20%
Diptera	Chironomidae	<i>Cladotanytarsus</i>	129873	19	2	7.70%
Diptera	Chironomidae	<i>Conchapelopia</i>	128130	1	1	3.80%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	5	2	7.70%
Diptera	Chironomidae	<i>Cricotopus</i>	128575	16	5	19.20%
Diptera	Chironomidae	<i>Cryptochironomus</i>	129368	1	1	3.80%
Diptera	Chironomidae	<i>Demicryptochironomus</i>	129421	1	1	3.80%
Diptera	Chironomidae	<i>Eukiefferiella</i>	128689	7	3	11.50%
Diptera	Chironomidae	<i>Eukiefferiella Brehmi</i> Gr.	NA ^b	6	4	15.40%
Diptera	Chironomidae	<i>Eukiefferiella Brevicalcar</i> Gr.	NA ^b	1	1	3.80%
Diptera	Chironomidae	<i>Eukiefferiella Coerulescens</i> Gr.	NA ^b	2	1	3.80%

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^b NA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Eukiefferiella tirolensis</i>	NA ^b	7	2	7.70%
Diptera	Chironomidae	<i>Gymnometriocnemus</i>	128718	1	1	3.80%
Diptera	Chironomidae	<i>Heleniella</i>	128730	7	3	11.50%
Diptera	Chironomidae	<i>Helopelopia</i>	128131	3	1	3.80%
Diptera	Chironomidae	<i>Heterotanytarsus</i>	128734	10	2	7.70%
Diptera	Chironomidae	<i>Heterotrissocladius Marcidus</i> Gr.	NA ^b	49	11	42.30%
Diptera	Chironomidae	<i>Krenopelopia</i>	128170	2	2	7.70%
Diptera	Chironomidae	<i>Krenosmittia</i>	128771	5	4	15.40%
Diptera	Chironomidae	<i>Larsia</i>	128183	71	12	46.20%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	3	2	7.70%
Diptera	Chironomidae	<i>Lopescladius</i>	128811	18	3	11.50%
Diptera	Chironomidae	<i>Macropelopia</i>	128034	20	1	3.80%
Diptera	Chironomidae	<i>Micropsectra</i>	129890	374	16	61.50%
Diptera	Chironomidae	<i>Microtendipes Pedellus</i> Gr.	NA ^b	26	9	34.60%
Diptera	Chironomidae	<i>Microtendipes Rydalsensis</i> Gr.	NA ^b	3	3	11.50%
Diptera	Chironomidae	<i>Monodiamesa</i>	128440	5	1	3.80%
Diptera	Chironomidae	<i>Natarsia</i>	128070	3	1	3.80%
Diptera	Chironomidae	<i>Nilotanypus</i>	128202	14	6	23.10%
Diptera	Chironomidae	<i>Odontomesa</i>	128446	4	1	3.80%
Diptera	Chironomidae	Orthoclaadiinae	128457	14	7	26.90%
Diptera	Chironomidae	Orthoclaadiinae sp. (RAI Taxon # 0001)	NA ^b	14	4	15.40%
Diptera	Chironomidae	<i>Orthocladus</i>	128874	69	8	30.80%
Diptera	Chironomidae	<i>Orthocladus lignicola</i>	128913	5	3	11.50%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Pagastia</i>	128401	13	5	19.20%
Diptera	Chironomidae	<i>Pagastiella</i>	129561	2	1	3.80%
Diptera	Chironomidae	<i>Parachaetocladius</i>	128951	9	4	15.40%
Diptera	Chironomidae	<i>Paracladopelma</i>	129597	8	4	15.40%
Diptera	Chironomidae	<i>Parakiefferiella</i>	128968	10	3	11.50%
Diptera	Chironomidae	<i>Parametriocnemus</i>	128978	58	17	65.40%
Diptera	Chironomidae	<i>Paratanytarsus</i>	129935	7	2	7.70%
Diptera	Chironomidae	<i>Paratendipes</i>	129623	1	1	3.80%
Diptera	Chironomidae	<i>Parorthocladius</i>	129011	3	2	7.70%
Diptera	Chironomidae	<i>Pentaneura</i>	128215	2	2	7.70%
Diptera	Chironomidae	<i>Phaenopsectra</i>	129637	124	11	42.30%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	279	17	65.40%
Diptera	Chironomidae	<i>Pothastia Gaedii</i> Gr.	NA ^b	4	3	11.50%
Diptera	Chironomidae	<i>Procladius</i>	128277	3	2	7.70%
Diptera	Chironomidae	<i>Psectrocladius</i>	129018	67	2	7.70%
Diptera	Chironomidae	<i>Pseudosmittia</i>	129071	1	1	3.80%
Diptera	Chironomidae	<i>Radotanytus</i>	NA ^b	13	5	19.20%
Diptera	Chironomidae	<i>Rheocricotopus</i>	129086	63	11	42.30%
Diptera	Chironomidae	<i>Rheopelopia</i>	128226	4	4	15.40%
Diptera	Chironomidae	<i>Rheotanytarsus</i>	129952	38	9	34.60%
Diptera	Chironomidae	<i>Stempellina</i>	129962	1	1	3.80%
Diptera	Chironomidae	<i>Stempellinella</i>	129969	93	17	65.40%
Diptera	Chironomidae	<i>Stictochironomus</i>	129785	2	2	7.70%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Synorthocladius</i>	129161	2	2	7.70%
Diptera	Chironomidae	Tanypodinae	127994	7	5	19.20%
Diptera	Chironomidae	Tanytarsini	129872	6	4	15.40%
Diptera	Chironomidae	<i>Tanytarsus</i>	129978	103	10	38.50%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	10	5	19.20%
Diptera	Chironomidae	<i>Thienemannimyia</i> Gr.	NA ^b	215	22	84.60%
Diptera	Chironomidae	<i>Tvetenia</i>	129197	1	1	3.80%
Diptera	Chironomidae	<i>Tvetenia Bavarica</i> Gr.	NA ^b	17	8	30.80%
Diptera	Chironomidae	<i>Zavrelimyia</i>	128259	223	19	73.10%
Diptera	Dixidae	<i>Dixa</i>	125810	32	8	30.80%
Diptera	Dixidae	<i>Meringodixa chalonensis</i>	125874	4	3	11.50%
Diptera	Empididae	<i>Chelifera / Metachela</i>	NA ^b	10	4	15.40%
Diptera	Empididae	<i>Clinocera</i>	135849	2	2	7.70%
Diptera	Empididae	Empididae	135830	2	2	7.70%
Diptera	Empididae	<i>Hemerodromia</i>	136327	3	3	11.50%
Diptera	Empididae	<i>Neoplasta</i>	136352	15	7	26.90%
Diptera	Empididae	<i>Oreogeton</i>	136377	4	4	15.40%
Diptera	Empididae	<i>Trichoclinocera</i>	135903	1	1	3.80%
Diptera	Ephydriidae	Ephydriidae	146893	1	1	3.80%
Diptera	Pelecorhynchidae	<i>Glutops</i>	130915	24	10	38.50%
Diptera	Psychodidae	<i>Maruina</i>	125392	1	1	3.80%
Diptera	Psychodidae	<i>Pericoma / Telmatoscopus</i>	NA ^b	1	1	3.80%
Diptera	Ptychopteridae	<i>Ptychoptera</i>	125786	8	3	11.50%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Simuliidae	<i>Simulium</i>	126774	61	14	53.80%
Diptera	Simuliidae	<i>Simulium (Eusimulium)</i>	NA ^b	3	2	7.70%
Diptera	Simuliidae	<i>Simulium arcticum</i> complex	NA ^b	2	1	3.80%
Diptera	Stratiomyidae	<i>Euparyphus</i>	130436	9	4	15.40%
Diptera	Stratiomyidae	Stratiomyidae	130150	2	1	3.80%
Diptera	Tipulidae	<i>Antocha monticola</i>	119660	20	8	30.80%
Diptera	Tipulidae	<i>Dicranota</i>	121027	15	10	38.50%
Diptera	Tipulidae	<i>Hexatoma</i>	120094	9	5	19.20%
Diptera	Tipulidae	<i>Limnophila</i>	120164	5	2	7.70%
Diptera	Tipulidae	<i>Tipula</i>	119037	10	6	23.10%
Diptera	Tipulidae	Tipulidae	118840	13	6	23.10%
Enchytraeida	Enchytraeidae	<i>Enchytraeus</i>	68531	15	8	30.80%
Enchytraeida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	8	6	23.10%
Ephemeroptera	Ameletidae	<i>Ameletus</i>	100996	75	15	57.70%
Ephemeroptera	Baetidae	<i>Acentrella turbida</i>	568574	1	1	3.80%
Ephemeroptera	Baetidae	<i>Anafroptilum</i>	NA ^b	31	5	19.20%
Ephemeroptera	Baetidae	Baetidae	100755	2	2	7.70%
Ephemeroptera	Baetidae	<i>Baetis</i>	100800	79	10	38.50%
Ephemeroptera	Baetidae	<i>Baetis bicaudatus</i> complex	NA ^b	2	2	7.70%
Ephemeroptera	Baetidae	<i>Baetis flavistriga</i> complex	NA ^b	17	1	3.80%
Ephemeroptera	Baetidae	<i>Baetis piscatoris</i> complex	NA ^b	42	7	26.90%
Ephemeroptera	Baetidae	<i>Baetis Rhodani</i> Gr.	NA ^b	97	11	42.30%
Ephemeroptera	Baetidae	<i>Baetis tricaudatus</i> complex	NA ^b	93	11	42.30%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Ephemeroptera	Baetidae	<i>Dipheter hageni</i>	568598	68	16	61.50%
Ephemeroptera	Ephemerellidae	<i>Drunella</i>	101365	3	2	7.70%
Ephemeroptera	Ephemerellidae	<i>Drunella coloradensis</i>	101389	13	5	19.20%
Ephemeroptera	Ephemerellidae	<i>Drunella doddsii</i>	698494	28	5	19.20%
Ephemeroptera	Ephemerellidae	<i>Drunella flavilinea</i>	101392	1	1	3.80%
Ephemeroptera	Ephemerellidae	<i>Drunella spinifera</i>	101385	1	1	3.80%
Ephemeroptera	Ephemerellidae	<i>Ephemerella tibialis</i>	101401	18	8	30.80%
Ephemeroptera	Ephemerellidae	Ephemerellidae	101232	14	4	15.40%
Ephemeroptera	Ephemerellidae	<i>Matriella teresa</i>	776979	4	4	15.40%
Ephemeroptera	Ephemerellidae	<i>Serratella levis</i>	568638	689	4	15.40%
Ephemeroptera	Ephemerellidae	<i>Timpanoga hecuba</i>	101318	116	10	38.50%
Ephemeroptera	Heptageniidae	<i>Cinygma</i>	100598	47	13	50.00%
Ephemeroptera	Heptageniidae	<i>Cinygmula</i>	100557	29	10	38.50%
Ephemeroptera	Heptageniidae	<i>Ecdyonurus criddlei</i>	698149	165	6	23.10%
Ephemeroptera	Heptageniidae	<i>Epeorus</i>	100626	12	5	19.20%
Ephemeroptera	Heptageniidae	Heptageniidae	100504	23	9	34.60%
Ephemeroptera	Heptageniidae	<i>Ironodes</i>	100666	21	8	30.80%
Ephemeroptera	Heptageniidae	<i>Rhithrogena</i>	100572	1	1	3.80%
Ephemeroptera	Leptohyphidae	<i>Tricorythodes explicatus</i>	101419	38	4	15.40%
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	101095	61	6	23.10%
Ephemeroptera	Leptophlebiidae	<i>Paraleptophlebia</i>	101187	286	17	65.40%
Ephemeroptera	Siphonuridae	Siphonuridae	100951	1	1	3.80%
Haplontaxida	Haplontaxidae	<i>Haplontaxis</i>	68505	6	5	19.20%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Hemiptera	Corixidae	Corixidae	103364	15	2	7.70%
Hemiptera	Corixidae	<i>Sigara grossolineata</i>	103382	1	1	3.80%
Hemiptera	Gerridae	Gerridae	103801	14	7	26.90%
Hemiptera	Naucoridae	<i>Ambrysus</i>	103614	1	1	3.80%
Hydrozoa	–	Hydrozoa	48739	1	1	3.80%
Isopoda	Asellidae	Caecidotea	92686	7	2	7.70%
Isopoda	–	Isopoda	92120	1	1	3.80%
Lumbriculida	Lumbriculidae	<i>Kincaidiana hexatheca</i>	68471	1	1	3.80%
Lumbriculida	Lumbriculidae	Lumbriculidae	68440	27	5	19.20%
Megaloptera	Corydalidae	<i>Orohermes crepusculus</i>	115045	9	5	19.20%
Megaloptera	Sialidae	<i>Sialis</i>	115002	84	16	61.50%
Nemata	–	Nemata	563956	4	3	11.50%
Neotaenioglossa	Hydrobiidae	<i>Pristinicola hemphilli</i>	568126	2	1	3.80%
Neotaenioglossa	Pleuroceridae	<i>Juga</i>	71570	701	15	57.70%
Odonata	Gomphidae	Gomphidae	101664	10	8	30.80%
Odonata	Gomphidae	<i>Octogomphus specularis</i>	101737	26	5	19.20%
Odonata	Gomphidae	<i>Ophiogomphus occidentis</i>	101760	3	1	3.80%
Plecoptera	Chloroperlidae	<i>Alloperla</i>	103203	3	3	11.50%
Plecoptera	Chloroperlidae	Chloroperlidae	103202	137	17	65.40%
Plecoptera	Chloroperlidae	Chloroperlinae	609855	12	5	19.20%
Plecoptera	Chloroperlidae	<i>Kathroperla</i>	103236	13	7	26.90%
Plecoptera	Chloroperlidae	<i>Paraperla</i>	103233	12	7	26.90%
Plecoptera	Chloroperlidae	<i>Suwallia</i>	103254	40	4	15.40%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Plecoptera	Chloroperlidae	<i>Sweltsa</i>	103273	240	18	69.20%
Plecoptera	Leuctridae	<i>Despaxia augusta</i>	102842	46	5	19.20%
Plecoptera	Leuctridae	Leuctridae	102840	52	14	53.80%
Plecoptera	Leuctridae	<i>Moselia infuscata</i>	102910	54	11	42.30%
Plecoptera	Nemouridae	<i>Malenka</i>	102567	108	14	53.80%
Plecoptera	Nemouridae	Nemouridae	102517	6	5	19.20%
Plecoptera	Nemouridae	<i>Zapada</i>	102591	1	1	3.80%
Plecoptera	Nemouridae	<i>Zapada cinctipes</i>	102594	9	4	15.40%
Plecoptera	Nemouridae	<i>Zapada frigida</i>	102601	1	1	3.80%
Plecoptera	Nemouridae	<i>Zapada Oregonensis</i> Gr.	NA ^b	2	2	7.70%
Plecoptera	Peltoperlidae	Peltoperlidae	102488	1	1	3.80%
Plecoptera	Peltoperlidae	<i>Sierraperla cora</i>	102515	2	2	7.70%
Plecoptera	Peltoperlidae	<i>Yoraperla</i>	102510	54	8	30.80%
Plecoptera	Perlidae	<i>Calineuria californica</i>	102986	240	24	92.30%
Plecoptera	Perlidae	<i>Doroneuria baumanni</i>	103123	22	9	34.60%
Plecoptera	Perlidae	<i>Hesperoperla pacifica</i>	102972	9	4	15.40%
Plecoptera	Perlidae	Perlidae	102914	577	16	61.50%
Plecoptera	Perlodidae	<i>Isoperla</i>	102995	2	2	7.70%
Plecoptera	Perlodidae	<i>Kogotus nonus</i>	103150	1	1	3.80%
Plecoptera	Perlodidae	Perlodidae	102994	45	8	30.80%
Plecoptera	Pteronarcyidae	<i>Pteronarcys</i>	102471	3	1	3.80%
Plecoptera	Pteronarcyidae	<i>Pteronarcys princeps</i>	102484	11	5	19.20%
Rissooidea	—	Rissooidea	NA ^b	3	3	11.50%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Sarcoptiformes	–	Oribatida	733326	58	17	65.40%
Trepaxonemata	–	Trepaxonemata	914204	24	8	30.80%
Trichoptera	Apataniidae	<i>Apatania</i>	115935	281	16	61.50%
Trichoptera	Apataniidae	Apataniidae	598182	1	1	3.80%
Trichoptera	Brachycentridae	<i>Micrasema</i>	116958	5	2	7.70%
Trichoptera	Calamoceratidae	<i>Heteroplectron californicum</i>	116538	129	17	65.40%
Trichoptera	Glossosomatidae	<i>Agapetus</i>	117121	7	6	23.10%
Trichoptera	Glossosomatidae	<i>Glossosoma</i>	117159	23	15	57.70%
Trichoptera	Glossosomatidae	Glossosomatidae	117120	8	4	15.40%
Trichoptera	Hydropsychidae	<i>Hydropsyche</i>	115453	22	4	15.40%
Trichoptera	Hydropsychidae	Hydropsychidae	115398	11	7	26.90%
Trichoptera	Hydropsychidae	<i>Parapsyche</i>	115556	17	6	23.10%
Trichoptera	Hydroptilidae	<i>Hydroptila</i>	115641	2	1	3.80%
Trichoptera	Hydroptilidae	Hydroptilidae	115629	15	3	11.50%
Trichoptera	Hydroptilidae	<i>Neotrichia</i>	115833	1	1	3.80%
Trichoptera	Hydroptilidae	<i>Ochrotrichia</i>	115714	37	5	19.20%
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>	116794	316	22	84.60%
Trichoptera	Limnephilidae	<i>Cryptochia</i>	115907	3	3	11.50%
Trichoptera	Limnephilidae	<i>Dicosmoecus gilvipes</i>	116268	2	2	7.70%
Trichoptera	Limnephilidae	<i>Ecclisomyia</i>	116025	13	3	11.50%
Trichoptera	Limnephilidae	<i>Hesperophylax</i>	116001	1	1	3.80%
Trichoptera	Limnephilidae	<i>Hydatophylax hesperus</i>	115998	1	1	3.80%
Trichoptera	Limnephilidae	Limnephilidae	115933	82	9	34.60%

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Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Limnephilidae	<i>Onocosmoecus</i>	116315	3	2	7.70%
Trichoptera	Limnephilidae	<i>Psychoglypha</i>	115974	10	6	23.10%
Trichoptera	Odontoceridae	<i>Namamyia plutonis</i>	116521	1	1	3.80%
Trichoptera	Odontoceridae	<i>Nerophilus californicus</i>	116523	1	1	3.80%
Trichoptera	Philopotamidae	<i>Dolophilodes / Sisko</i>	NA ^b	55	7	26.90%
Trichoptera	Philopotamidae	Philopotamidae	115257	2	2	7.70%
Trichoptera	Philopotamidae	<i>Wormaldia</i>	115258	99	8	30.80%
Trichoptera	Polycentropodidae	Polycentropodidae	117043	8	7	26.90%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>	115097	12	6	23.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Angelita</i> Gr.	NA ^b	15	10	38.50%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Betteni</i> Gr.	NA ^b	111	19	73.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Brunnea/Vemna</i> Gr.	NA ^b	4	3	11.50%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Grandis</i> Gr.	NA ^b	16	10	38.50%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Sibirica</i> Gr.	NA ^b	16	6	23.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Vofixa</i> Gr.	NA ^b	6	1	3.80%
Trichoptera	Sericostomatidae	<i>Gumaga</i>	117003	223	11	42.30%
Trichoptera	Sericostomatidae	Sericostomatidae	116982	2	2	7.70%
Trichoptera	Uenoidae	<i>Farula</i>	116331	185	6	23.10%
Trichoptera	Uenoidae	<i>Neophylax</i>	116046	1	1	3.80%
Trichoptera	Uenoidae	<i>Neophylax rickeri</i>	116054	14	3	11.50%
Trichoptera	Uenoidae	<i>Neophylax splendens</i>	116063	4	2	7.70%
Trichoptera	Uenoidae	Uenoidae	568757	3	2	7.70%
Trichoptera	—	Trichoptera	115095	2	2	7.70%

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Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trombidiformes	Anisitsiellidae	<i>Oregonacarus</i>	NA ^b	2	1	3.80%
Trombidiformes	Aturidae	<i>Woolastookia</i>	83461	1	1	3.80%
Trombidiformes	Hydrodromidae	<i>Hydrodroma</i>	83225	7	3	11.50%
Trombidiformes	Hydryphantidae	<i>Protzia</i>	83170	15	8	30.80%
Trombidiformes	Hygrobatidae	<i>Atractides</i>	83282	19	8	30.80%
Trombidiformes	Hygrobatidae	<i>Hygrobates</i>	83297	31	9	34.60%
Trombidiformes	Lebertiidae	<i>Estelloxus</i>	83048	9	3	11.50%
Trombidiformes	Lebertiidae	<i>Lebertia</i>	83034	77	18	69.20%
Trombidiformes	Limnesiidae	<i>Limnesia</i>	83051	1	1	3.80%
Trombidiformes	Limnocharidae	<i>Limnochares</i>	83146	3	1	3.80%
Trombidiformes	Mideopsidae	<i>Mideopsis</i>	83479	84	12	46.20%
Trombidiformes	Nautarachnidae	<i>Nautarachna</i>	83326	5	5	19.20%
Trombidiformes	Oxidae	<i>Oxus</i>	83244	6	3	11.50%
Trombidiformes	Sperchontidae	<i>Sperchon</i>	83006	46	10	38.50%
Trombidiformes	Sperchontidae	<i>Sperchonopsis</i>	83029	15	9	34.60%
Trombidiformes	Torrenticolidae	<i>Monatractides</i>	NA ^b	108	21	80.80%
Trombidiformes	Torrenticolidae	<i>Testudacarus</i>	83250	1	1	3.80%
Trombidiformes	Torrenticolidae	<i>Torrenticola</i>	83254	564	18	69.20%
Tubificida	Naididae	<i>Aulodrilus</i>	68679	2	1	3.80%
Tubificida	Naididae	<i>Limnodrilus</i>	68638	1	1	3.80%
Tubificida	Naididae	Naididae	68854	16	5	19.20%
Tubificida	Naididae	Naidinae	NA ^b	1	1	3.80%
Tubificida	Naididae	<i>Nais</i>	68946	10	5	19.20%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a "species group", or a recently redescribed taxon with no number yet designated.

Table C-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Redwood National and State Parks, 2015. Total number of sites sampled was 26.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Tubificida	Naididae	<i>Spirosperma</i>	68780	3	3	11.50%
Tubificida	Naididae	Tubificinae	NA ^b	14	2	7.70%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	7	1	3.80%
Veneroida	Sphaeriidae	Sphaeriidae	81389	6	5	19.20%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a "species group", or a recently redescribed taxon with no number yet designated.

Appendix D. Benthic Macroinvertebrates of Crater Lake National Park

Table D-1 is an accounting of all macroinvertebrate taxonomic units reported by the contract laboratory. The Interagency Taxonomic Information System (ITIS) Serial Number is provided for each taxon when available.

Note that due to taxonomic ambiguity, taxa used in analyses may differ from the taxa presented here. See the full protocol for more on dealing with taxonomic ambiguity.

Table D-1. Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Coleoptera	Dytiscidae	<i>Oreodytes sanmarkii</i>	728513	1	1	3.00%
Coleoptera	Elmidae	<i>Heterolimnius corpulentus</i>	114169	2	2	6.10%
Coleoptera	Elmidae	<i>Optioservus</i>	114177	1	1	3.00%
Coleoptera	Hydrophilidae	<i>Ametor scabrosus</i>	112892	1	1	3.00%
Coleoptera	Hydrophilidae	<i>Crenitis</i>	113220	1	1	3.00%
Copepoda	–	Copepoda	85257	2	1	3.00%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	9	7	21.20%
Diptera	Ceratopogonidae	<i>Forcipomyia</i>	127152	1	1	3.00%
Diptera	Chironomidae	<i>Bilyjomyia algens</i>	NA ^b	94	9	27.30%
Diptera	Chironomidae	<i>Boreochlus</i>	127954	1	1	3.00%
Diptera	Chironomidae	<i>Boreoheptagyia</i>	128343	3	2	6.10%
Diptera	Chironomidae	<i>Brillia</i>	128477	209	24	72.70%
Diptera	Chironomidae	<i>Brundiniella eumorpha</i>	128028	2	2	6.10%
Diptera	Chironomidae	<i>Cardiocladius</i>	128511	41	5	15.20%
Diptera	Chironomidae	<i>Chaetocladius</i>	128520	75	15	45.50%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	32	10	30.30%

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^b NA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Cricotopus</i>	128575	16	5	15.20%
Diptera	Chironomidae	<i>Cricotopus nostocicola</i>	128628	461	15	45.50%
Diptera	Chironomidae	<i>Diamesa</i>	128355	5	3	9.10%
Diptera	Chironomidae	Diamesinae	128341	2	1	3.00%
Diptera	Chironomidae	<i>Eukiefferiella</i>	128689	56	9	27.30%
Diptera	Chironomidae	<i>Eukiefferiella Brehmi</i> Gr.	NA ^b	38	7	21.20%
Diptera	Chironomidae	<i>Eukiefferiella Brevicalcar</i> Gr.	NA ^b	13	5	15.20%
Diptera	Chironomidae	<i>Eukiefferiella Claripennis</i> Gr.	NA ^b	3	3	9.10%
Diptera	Chironomidae	<i>Eukiefferiella Coerulescens</i> Gr.	NA ^b	1	1	3.00%
Diptera	Chironomidae	<i>Eukiefferiella Devonica</i> Gr.	NA ^b	51	11	33.30%
Diptera	Chironomidae	<i>Eukiefferiella Gracei</i> Gr.	NA ^b	223	22	66.70%
Diptera	Chironomidae	<i>Euryhapsis</i>	128707	3	2	6.10%
Diptera	Chironomidae	<i>Heleniella</i>	128730	5	4	12.10%
Diptera	Chironomidae	<i>Heterotrissocladius Marcidus</i> Gr.	NA ^b	10	3	9.10%
Diptera	Chironomidae	<i>Hydrobaenus</i>	128750	106	8	24.20%
Diptera	Chironomidae	<i>Krenopelopia</i>	128170	4	4	12.10%
Diptera	Chironomidae	<i>Krenosmittia</i>	128771	11	5	15.20%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	4	3	9.10%
Diptera	Chironomidae	<i>Metriocnemus</i>	128821	6	4	12.10%
Diptera	Chironomidae	<i>Micropsectra</i>	129890	198	21	63.60%
Diptera	Chironomidae	<i>Monodiamesa</i>	128440	20	3	9.10%
Diptera	Chironomidae	<i>Odontomesa</i>	128446	1	1	3.00%
Diptera	Chironomidae	Orthoclaadiinae	128457	86	17	51.50%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a "species group", or a recently redescribed taxon with no number yet designated.

Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	Orthoclaadiinae sp. (RAI Taxon # 0001)	NA ^b	78	16	48.50%
Diptera	Chironomidae	<i>Orthocladus</i>	128874	285	28	84.80%
Diptera	Chironomidae	<i>Orthocladus lignicola</i>	128913	8	5	15.20%
Diptera	Chironomidae	<i>Pagastia</i>	128401	575	26	78.80%
Diptera	Chironomidae	<i>Parachaetocladus</i>	128951	13	3	9.10%
Diptera	Chironomidae	<i>Parakiefferiella</i>	128968	18	6	18.20%
Diptera	Chironomidae	<i>Parametriocnemus</i>	128978	65	12	36.40%
Diptera	Chironomidae	<i>Paraphaenocladus</i>	128989	5	4	12.10%
Diptera	Chironomidae	<i>Parorthocladus</i>	129011	17	7	21.20%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	2	2	6.10%
Diptera	Chironomidae	<i>Prodiamesa</i>	128452	3	3	9.10%
Diptera	Chironomidae	<i>Psectrocladius</i>	129018	1	1	3.00%
Diptera	Chironomidae	<i>Pseudodiamesa</i>	128416	186	14	42.40%
Diptera	Chironomidae	<i>Pseudosmittia</i>	129071	3	1	3.00%
Diptera	Chironomidae	<i>Psilometriocnemus</i>	129083	5	3	9.10%
Diptera	Chironomidae	<i>Rheocricotopus</i>	129086	20	11	33.30%
Diptera	Chironomidae	<i>Stempellina</i>	129962	7	1	3.00%
Diptera	Chironomidae	<i>Stempellinella</i>	129969	27	3	9.10%
Diptera	Chironomidae	<i>Stilocladus</i>	129152	13	3	9.10%
Diptera	Chironomidae	Tanypodinae	127994	1	1	3.00%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	13	8	24.20%
Diptera	Chironomidae	<i>Tvetenia</i>	129197	13	5	15.20%
Diptera	Chironomidae	<i>Tvetenia Bavarica</i> Gr.	NA ^b	521	29	87.90%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a "species group", or a recently redescribed taxon with no number yet designated.

Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Zavreliomyia</i>	128259	1	1	3.00%
Diptera	Dixidae	<i>Dixa</i>	125810	8	6	18.20%
Diptera	Dixidae	Dixidae	125809	1	1	3.00%
Diptera	Dixidae	<i>Meringodixa chalonensis</i>	125874	1	1	3.00%
Diptera	Empididae	<i>Chelifera / Metachela</i>	NA ^b	40	3	9.10%
Diptera	Empididae	<i>Clinocera</i>	135849	342	25	75.80%
Diptera	Empididae	Empididae	135830	15	8	24.20%
Diptera	Empididae	Empididae sp. (RAI Taxon # 0001)	NA ^b	1	1	3.00%
Diptera	Empididae	<i>Neoplasta</i>	136352	107	18	54.50%
Diptera	Empididae	<i>Oreogeton</i>	136377	36	10	30.30%
Diptera	Pelecorhynchidae	<i>Glutops</i>	130915	159	16	48.50%
Diptera	Psychodidae	<i>Pericoma / Telmatoscopus</i>	NA ^b	20	11	33.30%
Diptera	Simuliidae	<i>Helodon</i>	NA ^b	30	3	9.10%
Diptera	Simuliidae	<i>Helodon onychodactylus</i> complex	NA ^b	177	12	36.40%
Diptera	Simuliidae	Prosimuliini	126648	3	3	9.10%
Diptera	Simuliidae	<i>Prosimulium</i>	126703	2	2	6.10%
Diptera	Simuliidae	Simuliidae	126640	13	3	9.10%
Diptera	Simuliidae	<i>Simulium</i>	126774	69	18	54.50%
Diptera	Thaumaleidae	<i>Thaumalea</i>	126629	1	1	3.00%
Diptera	Tipulidae	<i>Dicranota</i>	121027	35	13	39.40%
Diptera	Tipulidae	<i>Hesperoconopa</i>	120732	41	8	24.20%
Diptera	Tipulidae	<i>Limnophila</i>	120164	5	5	15.20%
Diptera	Tipulidae	<i>Limonia</i>	119704	2	1	3.00%

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Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Diptera	Tipulidae	Limoniinae	119654	1	1	3.00%
Diptera	Tipulidae	<i>Molophilus</i>	120758	1	1	3.00%
Diptera	Tipulidae	<i>Ormosia</i>	120830	1	1	3.00%
Diptera	Tipulidae	<i>Pedicia</i>	121118	10	4	12.10%
Diptera	Tipulidae	<i>Rhabdomastix</i>	120968	9	3	9.10%
Diptera	Tipulidae	<i>Tipula</i>	119037	2	1	3.00%
Diptera	Tipulidae	Tipulidae	118840	7	6	18.20%
Enchytraeida	Enchytraeidae	<i>Enchytraeus</i>	68531	81	16	48.50%
Enchytraeida	Enchytraeidae	<i>Fridericia</i>	204785	80	16	48.50%
Enchytraeida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	242	24	72.70%
Ephemeroptera	Ameletidae	<i>Ameletus</i>	100996	61	20	60.60%
Ephemeroptera	Baetidae	<i>Baetis</i>	100800	212	5	15.20%
Ephemeroptera	Baetidae	<i>Baetis bicaudatus</i> complex	NA ^b	29	11	33.30%
Ephemeroptera	Baetidae	<i>Baetis Rhodani</i> Gr.	NA ^b	664	22	66.70%
Ephemeroptera	Baetidae	<i>Baetis tricaudatus</i> complex	NA ^b	117	10	30.30%
Ephemeroptera	Baetidae	<i>Dipheter hageni</i>	568598	2	1	3.00%
Ephemeroptera	Ephemerellidae	<i>Caudatella</i>	101347	449	25	75.80%
Ephemeroptera	Ephemerellidae	<i>Caudatella jacobii</i>	568632	1	1	3.00%
Ephemeroptera	Ephemerellidae	<i>Drunella</i>	101365	350	20	60.60%
Ephemeroptera	Ephemerellidae	<i>Drunella coloradensis</i>	101389	54	15	45.50%
Ephemeroptera	Ephemerellidae	<i>Drunella doddsii</i>	698494	47	18	54.50%
Ephemeroptera	Ephemerellidae	<i>Ephemerella</i>	101233	39	9	27.30%
Ephemeroptera	Ephemerellidae	Ephemerellidae	101232	60	10	30.30%

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Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Ephemeroptera	Heptageniidae	<i>Cinygma</i>	100598	32	9	27.30%
Ephemeroptera	Heptageniidae	<i>Cinygmula</i>	100557	84	20	60.60%
Ephemeroptera	Heptageniidae	<i>Epeorus</i>	100626	184	19	57.60%
Ephemeroptera	Heptageniidae	<i>Ironodes</i>	100666	4	1	3.00%
Ephemeroptera	Heptageniidae	<i>Rhithrogena</i>	100572	77	18	54.50%
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	101095	9	5	15.20%
Ephemeroptera	Leptophlebiidae	<i>Paraleptophlebia</i>	101187	29	5	15.20%
Haplotaxida	Haplotaxidae	<i>Haplotaxis</i>	68505	2	2	6.10%
Lumbriculida	Lumbriculidae	Lumbriculidae	68440	5	4	12.10%
Nemata	–	Nemata	563956	377	17	51.50%
Ostracoda	–	Ostracoda	84195	319	18	54.50%
Plecoptera	Capniidae	Capniidae	102643	11	5	15.20%
Plecoptera	Chloroperlidae	Chloroperlidae	103202	37	6	18.20%
Plecoptera	Chloroperlidae	<i>Kathroperla</i>	103236	14	8	24.20%
Plecoptera	Chloroperlidae	<i>Paraperla</i>	103233	7	5	15.20%
Plecoptera	Chloroperlidae	<i>Suwallia</i>	103254	1	1	3.00%
Plecoptera	Chloroperlidae	<i>Sweltsa</i>	103273	215	19	57.60%
Plecoptera	Leuctridae	Leuctridae	102840	9	5	15.20%
Plecoptera	Leuctridae	<i>Moselia infuscata</i>	102910	33	11	33.30%
Plecoptera	Nemouridae	Nemouridae	102517	26	10	30.30%
Plecoptera	Nemouridae	<i>Visoka cataractae</i>	102615	44	15	45.50%
Plecoptera	Nemouridae	<i>Zapada</i>	102591	12	2	6.10%
Plecoptera	Nemouridae	<i>Zapada cinctipes</i>	102594	9	2	6.10%

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Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Plecoptera	Nemouridae	<i>Zapada columbiana</i>	102596	289	22	66.70%
Plecoptera	Nemouridae	<i>Zapada Oregonensis</i> Gr.	NA ^b	21	4	12.10%
Plecoptera	Peltoperlidae	<i>Yoraperla</i>	102510	1416	16	48.50%
Plecoptera	Peltoperlidae	<i>Yoraperla mariana</i>	103312	1240	29	87.90%
Plecoptera	Peltoperlidae	<i>Yoraperla nigrisoma</i>	568730	334	17	51.50%
Plecoptera	Perlidae	<i>Doroneuria baumanni</i>	103123	21	3	9.10%
Plecoptera	Perlidae	Perlidae	102914	17	2	6.10%
Plecoptera	Perlodidae	<i>Isoperla</i>	102995	112	19	57.60%
Plecoptera	Perlodidae	<i>Kogotus</i>	103149	18	10	30.30%
Plecoptera	Perlodidae	<i>Megarcys</i>	103110	119	23	69.70%
Plecoptera	Perlodidae	Perlodidae	102994	79	15	45.50%
Plecoptera	Perlodidae	<i>Salmoperla sylvanica</i>	103192	1	1	3.00%
Plecoptera	Pteronarcyidae	<i>Pteronarcys</i>	102471	2	1	3.00%
Plecoptera	Pteronarcyidae	<i>Pteronarcys princeps</i>	102484	15	3	9.10%
Plecoptera	Taeniopterygidae	Taeniopterygidae	102788	1	1	3.00%
Sarcoptiformes	–	Oribatida	733326	4	4	12.10%
Stygothrombium	Stygothrombiidae	<i>Stygothrombium</i>	NA ^b	1	1	3.00%
Trepaxonemata	–	Trepaxonemata	914204	153	22	66.70%
Trichoptera	Apataniidae	<i>Allomyia</i>	116438	5	3	9.10%
Trichoptera	Apataniidae	<i>Apatania</i>	115935	66	13	39.40%
Trichoptera	Apataniidae	<i>Pedomoecus sierra</i>	115973	57	12	36.40%
Trichoptera	Brachycentridae	<i>Micrasema</i>	116958	110	9	27.30%
Trichoptera	Glossosomatidae	<i>Anagapetus</i>	117154	15	2	6.10%

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^b NA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Glossosomatidae	<i>Glossosoma</i>	117159	9	2	6.10%
Trichoptera	Glossosomatidae	Glossosomatidae	117120	8	7	21.20%
Trichoptera	Hydropsychidae	Arctopsychinae	568763	25	4	12.10%
Trichoptera	Hydropsychidae	Hydropsychidae	115398	11	5	15.20%
Trichoptera	Hydropsychidae	<i>Parapsyche</i>	115556	62	16	48.50%
Trichoptera	Hydroptilidae	Hydroptilidae	115629	3	2	6.10%
Trichoptera	Limnephilidae	<i>Cryptochia</i>	115907	46	16	48.50%
Trichoptera	Limnephilidae	<i>Dicosmoecus</i>	116265	1	1	3.00%
Trichoptera	Limnephilidae	<i>Ecclisocosmoecus scylla</i>	116342	24	8	24.20%
Trichoptera	Limnephilidae	<i>Ecclisomyia</i>	116025	27	6	18.20%
Trichoptera	Limnephilidae	<i>Eocosmoecus frontalis</i>	605199	4	2	6.10%
Trichoptera	Limnephilidae	Limnephilidae	115933	95	17	51.50%
Trichoptera	Limnephilidae	<i>Psychoglypha</i>	115974	22	4	12.10%
Trichoptera	Philopotamidae	<i>Dolophilodes</i>	115319	2	1	3.00%
Trichoptera	Philopotamidae	Philopotamidae	115257	4	2	6.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>	115097	49	16	48.50%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Alberta</i> Gr.	NA ^b	2	2	6.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Betteni</i> Gr.	NA ^b	188	24	72.70%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Brunnea/Vemna</i> Gr.	NA ^b	74	17	51.50%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Hyalinata</i> Gr.	NA ^b	27	9	27.30%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Nevadensis</i> Gr.	NA ^b	3	2	6.10%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Sibirica</i> Gr.	NA ^b	204	22	66.70%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Vagrita</i> Gr.	NA ^b	5	3	9.10%

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Table D-1 (continued). Taxonomic units of benthic macroinvertebrates encountered in Crater Lake National Park, 2015. Total number of sites sampled was 29.

Order (or higher)	Family	Taxon	TSN ^a	Total No.	No. of Sites	Percent of Sites
Trichoptera	Rhyacophilidae	<i>Rhyacophila Verrula</i> Gr.	NA ^b	14	7	21.20%
Trichoptera	Rhyacophilidae	<i>Rhyacophila Vofixa</i> Gr.	NA ^b	105	16	48.50%
Trichoptera	Uenoidae	<i>Neothremma</i>	116388	819	21	63.60%
Trichoptera	Uenoidae	<i>Oligophlebodes</i>	116039	70	5	15.20%
Trichoptera	–	Trichoptera	115095	4	3	9.10%
Trombidiformes	Aturidae	<i>Aturus</i>	82974	1	1	3.00%
Trombidiformes	Hydryphantidae	<i>Albertathyas montana</i>	NA ^b	1	1	3.00%
Trombidiformes	Hydryphantidae	<i>Protzia</i>	83170	3	1	3.00%
Trombidiformes	Hygrobatidae	<i>Atractides</i>	83282	16	8	24.20%
Trombidiformes	Lebertiidae	<i>Estelloxus</i>	83048	1	1	3.00%
Trombidiformes	Lebertiidae	<i>Lebertia</i>	83034	158	27	81.80%
Trombidiformes	Sperchontidae	<i>Sperchon</i>	83006	318	27	81.80%
Trombidiformes	Sperchontidae	<i>Sperchonopsis</i>	83029	9	4	12.10%
Trombidiformes	Torrenticolidae	<i>Testudacarus</i>	83250	10	5	15.20%
Tubificida	Naididae	Naididae	68854	13	5	15.20%
Tubificida	Naididae	<i>Spirosperma</i>	68780	23	4	12.10%
Tubificida	Naididae	<i>Telmatodrilus vej dovskyi</i>	68760	1	1	3.00%
Tubificida	Naididae	<i>Tubificinae</i>	NA ^b	3	2	6.10%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	174	7	21.20%

^a TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy.

^b NA indicates cases where no TSN exists, either due to it being a “species group”, or a recently redescribed taxon with no number yet designated.

Appendix E. 2012 Data Tables

Included in this report are the data tables for Oregon Caves National Monument and Preserve, Redwood National and State Park, and Crater Lake National Park from the 2012 Annual Report (Dinger 2015) (Tables E1 – 18). These are reproduced here as a result of instituting computer code for the calculations of metrics provided in the Wadeable Streams Annual Reports. These tables should be taken as the most accurate reporting of the streams parameters. Table numbering follows the numbering in the original 2012 Annual Report.

Prior, the tables and metrics were the result of large amounts of data crunching and manipulation in spreadsheet programs. This allowed sorting errors, was laborious and slow, and facilitated differing calculation methods from year to year. For example, previous reports would include laboratory duplicates and triplicates in the reporting of water chemistry values; or average stream width was calculated only with transect measures (and did not include half-transect measures).

The computer code used to analyze and report on the tables offer distinct advantages:

1. Reduces human error
2. Reduces rounding errors
3. Standardizes reporting techniques between years
4. Is easily reproducible
5. Lastly, the computer code is transparent and publically available through the Integrated Resource Management Applications (irma.nps.gov), allowing full repeatability and checking of metric methods to practioners and managers.
 - a. Although not exhaustive, the following is a list of known changes from the 2012 to 2015 reporting techniques, which are incorporated in the following tables.
 - i. Average depth and width calculations now include midpoint estimates.
 - ii. Previous discharge calculations had conversion errors.
 - iii. Acid Neutralizing Capacity has set rules to determine if three or two analyses are averaged for reporting.
 - iv. Shading of stream now separated into Bank Shading and Center of Stream shading (previously was all incorporated into single measure).
 - v. Rounding errors are absent.
 - vi. Clearer display of when stream sites were electrofished or not.

- vii. Observed/Expected ratios of macroinvertebrate diversity provided (were not included in prior reports).
- viii. EPA MMI standardized to use strict use of invertebrate character traits (e.g., tolerance values). (Note that the EPA MMI uses a random draw of 300 individuals so that each time it is calculated there is minor variance).
- ix. There is a standardized technique for determining if turbidity readings were erroneous (e.g., crew step above the meter and caused influx of sediments; or crew bumped stream bottom and caused rise in turbidity).
- x. Duplicates and Triplicates removed from stream water chemistry results.
- xi. Use of Operational Taxonomic Units for determining invertebrate taxa standardized, and customized to specific metric (e.g., EPA uses genus level IDs for certain taxa, but Oregon state uses sub-family and tribe levels of taxonomy).
- xii. Coordinates for sites standardized to coordinates taken at the site by crews.

Table E-1. Physical characteristics and location of streams sampled in Oregon Caves, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation ^b (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Cave Creek	ORCAWQ01	6/13/2012	465986 ^c	4660780 ^c	1099	150	2.1	12	19.4%	0.032	1.15
Lake Creek	ORCAWQ02	6/15/2012	468082	4661234	1406	150	3.1	30.7	14.4%	0.126	4.44
No Name Creek	ORCAWQ03	6/14/2012	465591	4660289	1226	150	1.5	10.1	22.1%	0.023	0.82

^a UTM = Universal Transverse Mercator, Zone 10N.
^b Data provided uses original GRTS coordinates and elevation.
^c Indicates coordinates not available through crew collected data.

Table E-2. Physical condition metrics for Oregon Caves streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embeddeness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Cave Creek	ORCAWQ01	6/13/2012	35.3	38	15.6	17%	64%	0.82 ^a	0.36 ^b	-0.83 ^b	0.27 ^a
Lake Creek	ORCAWQ02	6/15/2012	1966.1	9549.9	1.1	19%	79%	0.87 ^a	0.23 ^b	0.81 ^c	0 ^a
No Name Creek	ORCAWQ03	6/14/2012	716.9	9549.9	2.5	9%	91%	0.48 ^a	0.34 ^b	0.55 ^b	0.07 ^a

^a Sites are Least Disturbed (also with light sage background).
^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-3. Water chemistry parameters for streams sampled in Oregon Caves, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Cave Creek	ORCAWQ01	8.4	7	198 ^c	11.4	0	2.32	0.34	1.06	0.05 ^c	0.026 ^d	1608 ^c	80 ^c
Lake Creek	ORCAWQ02	7.48	7.1	27 ^c	10.1	139.2	1.24	0.13	0.34	0.1 ^c	0.006 ^c	200 ^c	10 ^c
No Name Creek	ORCAWQ03	8.25	7.6	162 ^c	10.2	1.3	2.61	0.56	0.87	0.02 ^c	0.013 ^d	1858 ^c	93 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

Table E-4. Riparian characteristics of Oregon Caves streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Cave Creek	ORCAWQ01	94%	91%	34.2	12%	10%	32% C,23% D,9% N,36% M	12%	0%	9% C,55% D,18% N,18% M
Lake Creek	ORCAWQ02	91%	90%	NA ^b	6%	0%	55% C,45% N	15%	0%	55% C,14% D,9% N,23% M
No Name Creek	ORCAWQ03	91%	80%	21.7	2%	4%	32% C,68% N	26%	0%	41% C,23% D,36% M

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

^b NA indicated Not Available (rangefinder non responsive that day).

Table E-5. Vertebrate species and metrics for Oregon Caves streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Pacific Giant Salamander	Tailed Frog
Cave Creek	ORCAWQ01	Yes	9	2	84.9 ^a	4	5
Lake Creek	ORCAWQ02	No	–	–	–	–	–
No Name Creek	ORCAWQ03	No	–	–	–	–	–

^a Sites are Least Disturbed (also with light sage background).

Table E-6. Invertebrate results and metrics for Oregon Caves streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	CA North Coast MMI ^c	Oregon Western Streams IBI ^d
Cave Creek	ORCAWQ01	74	3.54	3.01	1.15 ^e	84 ^e	88 ^e	96 ^e
Lake Creek	ORCAWQ02	72	3.23	3	1.14 ^e	87 ^e	94 ^e	92 ^e
No Name Creek	ORCAWQ03	64	3.1	2.71	1 ^e	84 ^e	83 ^e	96 ^e

^a HBI = Hilsenhoff Biotic Index.

^b O/E = Observed to Expected ratio of macroinvertebrate diversity.

^c MMI = MultiMetric Index.

^d IBI = Index of Biological Integrity

^e Sites are Least Disturbed (also with light sage background).

Table E-7. Physical characteristics and location of streams sampled in Redwoods, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
McArthur Creek	REDWWQ01	6/26/2012	410483	4566199	224	150	2.4	26	1.1%	0.051	1.79
Unnamed- Trib to Brown	REDWWQ02	6/25/2012	415606	4582095	153	150	1.9	9.5	NA	0.01	0.35
West Branch Mill Ck	REDWWQ03	7/12/2012	411845	4615344	237	150	2.6	14.4	3.3%	0.034	1.19
Redwood Creek	REDWWQ04	7/10/2012	416027	4562040	35	500	19.5	72.9	0.6%	2.462	86.93
East Fork Mill Creek	REDWWQ05	7/4/2012	409469	4620310	70	280	9.3	41.2	0.6%	0.335	11.82
Lost Man Creek	REDWWQ06	6/21/2012	414475	4575812	42	360	8.8	24.1	0.7%	0.259	9.15
Cedar Creek	REDWWQ07	7/16/2012	410759	4625524	155	150	3.4	13.2	3.8%	0.019	0.68
Bummer Lake Creek	REDWWQ08	7/9/2012	412905	4621603	239	150	3.5	16.9	8.2%	0.016	0.55
Wilson Creek	REDWWQ09	7/17/2012	411762	4613997	298	150	3.1	18.1	3.9%	0.03	1.05
Unnamed	REDWWQ10	6/20/2012	412504	4578942	79	150	1.7	13.6	1.4%	0.006	0.23
West Branch Mill Ck	REDWWQ11	7/3/2012	409125	4616390	137	160	6	19.4	0.6%	0.148	5.24
Little Lost Man Creek	REDWWQ12	7/5/2012	415935	4571098	440	150	3.1	14.3	4.4%	0.021	0.73
Lost Man Creek	REDWWQ13	7/6/2012	418223	4575118	207	150	3.9	15.8	6.3%	0.052	1.85
Rock Creek	REDWWQ14	7/11/2012	416061	4612949	381	150	3.3	11.6	2.7%	0.021	0.74
Mill Creek	REDWWQ15	7/18/2012	407306	4622635	88	150	2.4	12.5	1.9%	0.017	0.6
Redwood Creek	REDWWQ16	7/26/2012	415325	4563602	32	500	29.6	56.4	0.3%	1.805	63.73
Peacock Creek	REDWWQ17	7/24/2012	408042	4631414	42	160	4.4	15.7	1.3%	0.028	0.98
West Branch Mill Ck	REDWWQ19	7/25/2012	407711	4619515	103	200	7.2	29.2	0.6%	0.141	4.97
Redwood Creek	REDWWQ20	7/27/2012	413534	4572248	11	500	29.5	33.4	0.3%	1.691	59.72
Godwood Creek	REDWWQ21	6/22/2012	414299	4580152	48	150	3.5	26	0.8%	0.121	4.28
West Branch Mill Ck	REDWWQ23	7/31/2012	407963	4620043	90	200	8.3	32.9	0.6%	0.155	5.48
Lost Man Creek	REDWWQ24	8/2/2012	416173	4575132	82	200	7.4	18.1	1.7%	0.165	5.83
Redwood Creek	REDWWQ25	8/1/2012	413715	4571321	13	500	19.6	45.9	0.2%	1.602	56.58

^a UTM = Universal Transverse Mercator, Zone 10N.

Table E-7 (continued). Physical characteristics and location of streams sampled in Redwoods, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Average	—	—	—	—	139	233	8.0	25.3	2.1%	0.400	14.11
SD	—	—	—	—	118	135	8.3	15.9	2.1%	0.719	25.39
Median	—	—	—	—	90	150	3.9	18.1	1.2%	0.052	1.85
Range	—	—	—	—	11 - 400	150 - 500	1.7 - 29.6	9.5 - 72.9	0.2% - 8.2%	0.006 - 2.462	0.23 - 86.93

^a UTM = Universal Transverse Mercator, Zone 10N.

Table E-8. Physical condition metrics for Redwood streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embedded-ness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
McArthur Creek	REDWWQ01	6/26/2012	0.1	0.5	9.5	38%	11%	0.38 ^a	0.64 ^b	-2.42 ^c	0 ^a
Unnamed- Trib to Brown	REDWWQ02	6/25/2012	16.6	38	24.5	37%	59%	0.91 ^a	0.63 ^b	NA ^d	0 ^a
West Branch Mill Ck	REDWWQ03	7/12/2012	133.2	114.8	8.4	46%	47%	0.51 ^a	0.47 ^b	0.38 ^b	0 ^a
Redwood Creek	REDWWQ04	7/10/2012	36.1	38	41.1	62%	22%	0.78 ^a	0.32 ^b	1.90 ^c	0.03 ^a
East Fork Mill Creek	REDWWQ05	7/4/2012	43.7	38	33.6	72%	19%	0.98 ^a	0.88 ^a	0.16 ^b	0 ^a
Lost Man Creek	REDWWQ06	6/21/2012	27.2	38	33.5	35%	21%	0.34 ^a	0.8 ^a	0.15 ^b	0 ^a
Cedar Creek	REDWWQ07	7/16/2012	52.1	114.8	26.7	31%	43%	1.47 ^a	0.51 ^b	-0.10 ^a	0 ^a
Bummer Lake Creek	REDWWQ08	7/9/2012	80.8	114.8	20.4	35%	50%	0.5 ^a	0.68 ^a	-0.35 ^a	0 ^a
Wilson Creek	REDWWQ09	7/17/2012	83.3	114.8	20.9	44%	40%	1.39 ^a	0.83 ^a	0.06 ^a	0 ^a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

^d NA indicates Not Available.

Table E-8 (continued). Physical condition metrics for Redwood streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embedded-ness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Unnamed	REDWWQ10	6/20/2012	6.3	12.6	37.3	60%	24%	1.26 ^a	0.57 ^b	-0.58 ^a	0 ^a
West Branch Mill Ck	REDWWQ11	7/3/2012	24.8	38	34.9	48%	14%	0.55 ^a	0.54 ^b	0.29 ^b	0.07 ^a
Little Lost Man Creek	REDWWQ12	7/5/2012	39.3	38	26.2	40%	45%	0.9 ^a	0.55 ^b	-0.21 ^a	0 ^a
Lost Man Creek	REDWWQ13	7/6/2012	29.4	38	40.9	25%	60%	1.8 ^a	0.59 ^b	-0.56 ^a	0 ^a
Rock Creek	REDWWQ14	7/11/2012	84.4	114.8	17.6	40%	43%	0.36 ^a	0.67 ^a	0.34 ^b	0 ^a
Mill Creek	REDWWQ15	7/18/2012	42.3	38	11.1	13%	55%	0.49 ^a	0.89 ^a	0.30 ^b	0 ^a
Redwood Creek	REDWWQ16	7/26/2012	21.9	38	45.5	60%	5%	0.22 ^b	0.54 ^b	0.01 ^a	0.33 ^a
Peacock Creek	REDWWQ17	7/24/2012	17.9	38	40	51%	39%	0.42 ^a	0.72 ^a	-0.07 ^a	0 ^a
West Branch Mill Ck	REDWWQ19	7/25/2012	33.4	38	22.5	49%	24%	0.18 ^b	0.53 ^b	0.25 ^b	0 ^a
Redwood Creek	REDWWQ20	7/27/2012	20.1	38	25.6	37%	14%	0.44 ^a	0.25 ^b	0.25 ^b	0.07 ^a
Godwood Creek	REDWWQ21	6/22/2012	8.3	4.2	42.2	58%	18%	1.69 ^a	0.52 ^b	-0.38 ^a	0 ^a
West Branch Mill Ck	REDWWQ23	7/31/2012	29.6	38	27.5	52%	20%	0.81 ^a	0.46 ^b	0.10 ^a	0.07 ^a
Lost Man Creek	REDWWQ24	8/2/2012	118.5	114.8	39.3	43%	42%	0.48 ^a	0.9 ^a	0.46 ^b	0.33 ^a
Redwood Creek	REDWWQ25	8/1/2012	20.6	38	33.3	25%	28%	0.35 ^a	0.15 ^c	0.29 ^b	0.33 ^a
Average	–	–	42.2	53.8	28.8	44%	32%	0.75 ^a	0.59 ^b	0.01 ^a	0.05 ^a
SD	–	–	35.0	38.6	10.9	14%	16%	0.48	0.20	0.74	0.11
Median	–	–	29.6	38.0	27.5	43%	28%	0.51 ^a	0.57 ^b	0.13 ^b	0.00 ^a
Range	–	–	0.1 - 133.2	0.5 - 114.8	8.4 - 45.5	13% - 72%	5% - 60%	0.18 - 1.8	0.15 - 0.9	-2.42 - 1.9	0 - 0.33

^a Sites are Least Disturbed (also with light sage background).
^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).
^d NA indicates Not Available.

Table E-9. Water chemistry parameters for streams sampled in Redwoods, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^f	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU) ^g	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
McArthur Creek	REDWWQ01	6.74	9.7	61 ^c	10.5	2.8	5.82	0.62	7.97	0.94 ^e	0.006 ^c	210 ^c	10 ^c
Unnamed- Trib to Brown	REDWWQ02	7.57	10.4	75 ^c	11.3	0	6.23	0.85	7.83	0.07 ^c	0.022 ^d	445 ^c	22 ^c
West Branch Mill Ck	REDWWQ03	7.15	11.7	53 ^c	10.2	0	3.93	0.61	3.36	0.09 ^c	0.012 ^d	389 ^c	19 ^c
Redwood Creek	REDWWQ04	7.71	17.7	116 ^c	9	0	3.56	2.49	3.04	0.08 ^c	0.006 ^c	898 ^c	45 ^c
East Fork Mill Creek	REDWWQ05	7.35	11.9	60 ^c	10.6	0	3.59	0.62	3.32	0.14 ^d	0.013 ^d	458 ^c	23 ^c
Lost Man Creek	REDWWQ06	7.34	11	66 ^c	10.4	0	4.91	0.79	4.83	0.1 ^c	0.008 ^c	478 ^c	24 ^c
Cedar Creek	REDWWQ07	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f	3.1	0.63	4.83	0.09 ^c	0.007 ^c	470 ^c	24 ^c
Bummer Lake Creek	REDWWQ08	7.55	11.5	107 ^c	10.5	0	3.06	0.49	2.96	0.12 ^c	0.009 ^c	569 ^c	28 ^c
Wilson Creek	REDWWQ09	7.29	11.6	56 ^c	10	0	3.63	0.73	3.07	0.09 ^c	0.009 ^c	445 ^c	22 ^c
Unnamed	REDWWQ10	7.05	9.3	76 ^c	10	2.4	7.4	0.64	11.02	0.17 ^d	0.007 ^c	327 ^c	16 ^c
West Branch Mill Ck	REDWWQ11	6.98	11.6	50 ^c	10.6	0	4	0.59	3.9	0.12 ^c	0.011 ^d	371 ^c	19 ^c
Little Lost Man Creek	REDWWQ12	7.18	10.2	53 ^c	10.2	0	5.01	0.42	4.93	0.03 ^c	0.014 ^d	356 ^c	18 ^c
Lost Man Creek	REDWWQ13	7.37	10.6	58 ^c	10.8	0	4.3	0.76	4.25	0.06 ^c	0.008 ^c	392 ^c	20 ^c
Rock Creek	REDWWQ14	7.08	11.8	39 ^c	10.1	0	2.81	0.49	2.32	0.1 ^c	0.008 ^c	277 ^c	14 ^c
Mill Creek	REDWWQ15	7.11	11.7	62 ^c	10.3	0	5.56	0.64	7.2	0.61 ^e	0.009 ^c	360 ^c	18 ^c
Redwood Creek	REDWWQ16	7.74	17.6	124 ^c	9	0	3.75	2.49	3.33	0.08 ^c	0.002 ^c	930 ^c	47 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

^f NA indicates Not Available – probe non-functioning

Table E-9 (continued). Water chemistry parameters for streams sampled in Redwoods, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH ^f	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU) ^g	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Peacock Creek	REDWWQ17	7.62	12.5	112 ^c	10.3	0	3.83	0.72	4.69	0.36 ^e	0.01 ^c	898 ^c	45 ^c
West Branch Mill Ck	REDWWQ19	6.92	13.8	52 ^c	9.9	0	2.1	0.32	2.13	0.05 ^c	0.006 ^c	328 ^c	16 ^c
Redwood Creek	REDWWQ20	7.57	16.5	123 ^c	8.9	0	3.92	2.22	3.8	0.1 ^c	0.006 ^c	976 ^c	49 ^c
Godwood Creek	REDWWQ21	7.48	10.4	104 ^c	10.4	0	7.73	0.67	10.69	0.04 ^c	0.018 ^d	631 ^c	32 ^c
West Branch Mill Ck	REDWWQ23	7.14	13.5	53 ^c	9.9	0	4.2	0.58	4.2	0.15 ^d	0.007 ^c	361 ^c	18 ^c
Lost Man Creek	REDWWQ24	7.55	12	73 ^c	10.9	0	5.12	0.78	4.72	0.11 ^c	0.011 ^d	521 ^c	26 ^c
Redwood Creek	REDWWQ25	7.63	16.6	128 ^c	8.7	0	4	2.24	3.87	0.11 ^c	0.008 ^c	973 ^c	49 ^c
Average	–	7.32	12.4	77 ^c	10.1	0.2	4.42	0.93	4.88	0.17 ^d	0.009 ^c	524 ^c	26 ^c
SD	–	0.28	2.5	29	0.7	0.8	1.39	0.68	2.44	0.21	0.004	240	12
Median	–	7.35	11.7	64 ^c	10.3	0	4	0.64	4.2	0.1 ^c	0.008 ^c	445 ^c	22 ^c
Range	–	6.74 - 7.74	9.3 - 17.7	39 - 128	8.7 - 11.3	0 - 2.8	2.1 - 7.73	0.32 - 2.49	2.13 - 11.02	0.03 - 0.94	0.002 - 0.022	210 - 976	10 - 49

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

^f NA indicates Not Available – probe non-functioning

Table E-10. Riparian characteristics of Redwoods streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
McArthur Creek	REDWWQ01	100%	100%	27.6	25%	6%	14% C,59% D,5% N,23% M	31%	25%	100% D
Unnamed- Trib to Brown	REDWWQ02	98%	98%	101.6	16%	6%	77% C,14% N,9% M	39%	40%	86% D,14% M
West Branch Mill Ck	REDWWQ03	99%	99%	43.7	3%	14%	9% C,68% D,18% N,5% M	30%	10%	95% D,5% M
Redwood Creek	REDWWQ04	73%	41%	76.2	2%	9%	41% D,5% E,55% N	20%	4%	45% D,55% N
East Fork Mill Creek	REDWWQ05	97%	75%	24.1	19%	28%	5% C,73% D,5% N,18% M	41%	16%	95% D,5% M
Lost Man Creek	REDWWQ06	88%	82%	47.9	3%	31%	100% D	25%	19%	100% D
Cedar Creek	REDWWQ07	99%	97%	57.1	16%	10%	64% C,14% D,18% N,5% M	25%	54%	77% D,23% M
Bummer Lake Creek	REDWWQ08	99%	98%	37.3	18%	14%	64% D,36% M	34%	2%	100% D
Wilson Creek	REDWWQ09	99%	99%	28	10%	28%	64% D,5% N,32% M	45%	19%	82% D,18% M
Unnamed	REDWWQ10	99%	98%	31.2	16%	17%	82% C,14% N,5% M	24%	14%	5% C,86% D,9% M
West Branch Mill Ck	REDWWQ11	76%	63%	30.5	8%	10%	59% D,41% N	34%	26%	91% D,5% N,5% M
Little Lost Man Creek	REDWWQ12	98%	95%	66.1	15%	18%	91% C,9% N	21%	11%	14% C,50% D,9% N,27% M
Lost Man Creek	REDWWQ13	99%	97%	45.4	21%	18%	50% C,14% D,36% M	20%	40%	18% C,59% D,23% M
Rock Creek	REDWWQ14	100%	100%	32.5	20%	20%	95% D,5% N	26%	3%	95% D,5% M
Mill Creek	REDWWQ15	99%	96%	18.6	19%	15%	100% D	53%	2%	100% D
Redwood Creek	REDWWQ16	84%	49%	NA	22%	13%	41% D,41% N,18% M	18%	2%	73% D,27% N
Peacock Creek	REDWWQ17	98%	99%	38.5	24%	18%	23% D,5% N,73% M	29%	0%	100% D
West Branch Mill Ck	REDWWQ19	85%	72%	26.1	7%	29%	82% D,18% M	14%	16%	86% D,9% N,5% M
Redwood Creek	REDWWQ20	20%	5%	18.4	1%	7%	27% D,68% N,5% M	15%	2%	68% D,32% N
Godwood Creek	REDWWQ21	99%	94%	73.2	12%	4%	59% C,5% D,36% N	36%	78%	77% D,23% M
West Branch Mill Ck	REDWWQ23	87%	69%	25.1	11%	13%	73% D,27% N	22%	6%	91% D,9% N
Lost Man Creek	REDWWQ24	96%	82%	63	26%	21%	5% C,64% D,5% N,27% M	40%	4%	100% D
Redwood Creek	REDWWQ25	40%	15%	24.1	0%	6%	36% D,64% N	9%	4%	50% D,50% N

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table E-10 (continued). Riparian characteristics of Redwoods streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Average	–	88%	79%	42.6	14%	15%	n/a	28%	17%	n/a
SD	–	20%	28%	21.9	8%	8%	n/a	11%	20%	n/a
Median	–	98%	95%	34.9	16%	14%	n/a	26%	11%	n/a
Range	–	20% - 100%	5% - 100%	18.4 - 101.6	0% - 26%	4% - 31%	n/a	9% - 53%	0% - 78%	n/a

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table E-11. Vertebrate species and metrics for Redwood streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Coho Salmon	Crayfish	Cuttbow Hybrid Trout	Cutthroat Trout	Coastal Giant Salamander	Rainbow Trout	Red-legged Frog	Tailed Frog	Three-spined Stickleback	Unknown	Unknown Dace ^c	Unknown Lamprey	Unknown Salmonid	Unknown Sculpin	Yellow-legged Frog
McArthur Creek	REDWWQ01	Yes	28	1	100 ^a	–	–	–	–	28	–	–	–	–	–	–	–	–	–	–
Unnamed- Trib to Brown	REDWWQ02	Yes	20	3	93.8 ^a	–	–	–	4	14	–	–	2	–	–	–	–	–	–	–
West Branch Mill Ck	REDWWQ03	Yes	31	3	94.3 ^a	–	–	–	17	12	–	–	2	–	–	–	–	–	–	–
Redwood Creek	REDWWQ04	No	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
East Fork Mill Creek	REDWWQ05	Yes	34	6	81.1 ^a	12	–	–	–	3	10	–	1	3	–	–	–	2	3	–
Lost Man Creek	REDWWQ06	Yes	74	8	74 ^a	19	–	1	3	–	22	–	1	1	–	–	2	–	25	–
Cedar Creek	REDWWQ07	Yes	62	5	86.9 ^a	–	1	1	11	13	7	–	14	–	–	–	–	15	–	–
Bummer Lake Creek	REDWWQ08	Yes	61	5	92.2 ^a	–	–	2	22	9	19	–	7	–	–	–	–	2	–	–
Wilson Creek	REDWWQ09	Yes	27	3	93.7 ^a	–	–	–	–	23	1	–	3	–	–	–	–	–	–	–
Unnamed	REDWWQ10	Yes	25	2	100 ^a	–	–	–	15	10	–	–	–	–	–	–	–	–	–	–
West Branch Mill Ck	REDWWQ11	Yes	65	8	78.9 ^a	32	–	–	2	9	9	–	3	6	–	–	–	–	4	–
Little Lost Man Creek	REDWWQ12	Yes	49	3	88.4 ^a	–	–	–	–	42	–	1	6	–	–	–	–	–	–	–
Lost Man Creek	REDWWQ13	Yes	65	2	87.8 ^a	–	–	–	–	42	–	–	23	–	–	–	–	–	–	–
Rock Creek	REDWWQ14	Yes	79	4	79.4 ^a	–	–	–	3	5	21	–	3	–	–	–	–	47	–	–
Mill Creek	REDWWQ15	Yes	58	3	86.9 ^a	–	–	–	27	10	–	–	4	–	1	–	–	16	–	–
Redwood Creek	REDWWQ16	Yes	60	4	66.2 ^a	–	–	–	–	–	33	–	–	–	–	–	3	–	23	1
Peacock Creek	REDWWQ17	Yes	86	5	68.5 ^a	–	–	2	–	3	9	–	3	–	–	–	–	30	39	–
West Branch Mill Ck	REDWWQ19	Yes	83	7	83.4 ^a	11	–	–	–	7	45	–	1	2	–	–	1	9	7	–

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c The identification of unknown dace should be interpreted with caution, no known dace are found in Redwood Creek. Likely a small Sacramento Sucker.

Table E-11 (continued). Vertebrate species and metrics for Redwood streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Coho Salmon	Crayfish	Cuttbow Hybrid Trout	Cutthroat Trout	Coastal Giant Salamander	Rainbow Trout	Red-legged Frog	Tailed Frog	Three-spined Stickleback	Unknown	Unknown Dace ^c	Unknown Lamprey	Unknown Salmonid	Unknown Sculpin	Yellow-legged Frog
Redwood Creek	REDWWQ20	Yes	71	7	60 ^b	1	–	–	1	–	16	–	–	8	–	4	3	–	38	–
Godwood Creek	REDWWQ21	Yes	20	6	88.8 ^a	8	–	2	3	5	1	–	1	–	–	–	–	–	–	–
West Branch Mill Ck	REDWWQ23	Yes	91	7	83.4 ^a	12	–	–	5	8	48	–	–	3	–	–	1	1	13	–
Lost Man Creek	REDWWQ24	Yes	87	7	86.3 ^a	13	–	5	4	11	21	–	17	–	–	–	1	15	–	–
Redwood Creek	REDWWQ25	Yes	89	5	63.4 ^a	–	–	–	–	1	26	–	–	–	–	–	10	–	51	1
Average	–	–	58	5	83.5 ^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD	–	–	24	2	11.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median	–	–	62	5	86.6 ^a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range	–	–	20 - 91	1 - 8	60 - 100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^a Sites are Least Disturbed (also with light sage background).
^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).
^c The identification of unknown dace should be interpreted with caution, no known dace are found in Redwood Creek. Likely a small Sacramento Sucker.

Table E-12. Invertebrate results and metrics for Redwood streams, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^b	CA North Coast MMI ^c
McArthur Creek	REDWWQ01	59	3.52	4.16	0.61 ^e	74 ^c	65 ^f
Unnamed- Trib to Brown	REDWWQ02	66	3.55	3.44	0.83 ^c	78 ^c	72 ^f
West Branch Mill Ck	REDWWQ03	58	3.28	3.09	0.78 ^d	81 ^c	77 ^f
Redwood Creek	REDWWQ04	75	3.4	4.97	0.93 ^c	81 ^c	72 ^f
East Fork Mill Creek	REDWWQ05	61	3.4	4.46	0.76 ^d	84 ^c	77 ^f
Lost Man Creek	REDWWQ06	59	3.32	3.56	0.74 ^d	89 ^c	79 ^f
Cedar Creek	REDWWQ07	66	3.76	2.93	0.92 ^c	90 ^c	78 ^f
Bummer Lake Creek	REDWWQ08	56	1.99	4.34	0.74 ^d	65 ^d	67 ^f
Wilson Creek	REDWWQ09	45	3.31	2.94	0.79 ^d	81 ^c	79 ^f
Unnamed	REDWWQ10	52	3.15	3.33	0.69 ^d	70 ^d	71 ^f
West Branch Mill Ck	REDWWQ11	58	3.23	4.12	0.76 ^d	91 ^c	78 ^f
Little Lost Man Creek	REDWWQ12	63	3.5	3.06	0.75 ^d	84 ^c	76 ^f
Lost Man Creek	REDWWQ13	55	2.84	3.32	0.69 ^d	77 ^c	78 ^f
Rock Creek	REDWWQ14	63	3.1	3.45	0.79 ^d	79 ^c	76 ^f
Mill Creek	REDWWQ15	67	3.41	3.18	0.87 ^c	80 ^c	80 ^f
Redwood Creek	REDWWQ16	67	3.32	4.47	0.93 ^c	73 ^c	76 ^f
Peacock Creek	REDWWQ17	76	3.29	3.86	0.93 ^c	69 ^c	81 ^f
West Branch Mill Ck	REDWWQ19	59	3.21	4.66	0.81 ^c	77 ^c	69 ^f
Redwood Creek	REDWWQ20	46	2.32	3.25	0.68 ^d	73 ^c	72 ^f
Godwood Creek	REDWWQ21	65	3.58	2.99	0.89 ^c	88 ^c	74 ^f

^a HBI = Hilsenhoff Biotic Index

^b O/E = Observed/Expected ratio; MMI = Multi=Metric

^c Sites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^d Sites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed (also with dark red background).

^f Sites in the CA North Coast MMI column, cells are equal “good to very good” condition (also with light sage background).

Table E-12 (continued). Invertebrate results and metrics for Redwood streams, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^b	CA North Coast MMI ^c
West Branch Mill Ck	REDWWQ23	62	3.34	4.91	0.96 ^c	84 ^c	68 ^f
Lost Man Creek	REDWWQ24	71	3.19	4.18	1 ^c	83 ^c	80 ^f
Redwood Creek	REDWWQ25	49	2.39	3.22	0.76 ^d	74 ^c	73 ^f
Average	–	60.8	3.19	3.73	0.81 ^c	79.3 ^c	74.7 ^f
SD	–	8.2	0.43	0.67	0.10	6.9	4.5
Median	–	61	3.31	3.45	0.79 ^d	80 ^c	76 ^f
Range	–	45 - 7	1.99 - 3.76	2.93 - 4.97	0.61 - 1	65 - 91	65 - 81

^a HBI = Hilsenhoff Biotic Index

^b O/E = Observed/Expected ratio; MMI = Multi=Metric

^c Sites in the O/E and EPA West-Wide Invertebrate MMI columns are Least Disturbed (also with light sage background).

^d Sites in the O/E and EPA West-Wide Invertebrate MMI columns meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites in the O/E and EPA West-Wide Invertebrate MMI columns meeting EPA criteria for Most Disturbed (also with dark red background).

^f Sites in the CA North Coast MMI column, cells are equal “good to very good” condition (also with light sage background).

Table E-13. Physical characteristics and location of streams sampled in Crater Lake, 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Cavern Creek	CRLAWQ01	8/7/2012	582664	4745150	1597	150	3.4	22.9	1.50%	0.103	3.65
Sun Creek	CRLAWQ02	8/27/2012	577903	4742140	1531	150	4.5	27.6	1.70%	0.439	15.52
Sun Creek	CRLAWQ03	8/28/2012	574607	4746208	1780	150	3.9	19.5	5.20%	0.199	7.04
Rogue River	CRLAWQ04	8/21/2012	562523	4768956	1565	320	15.9	30.9	2.80%	1.396	49.31
Wheeler Creek	CRLAWQ05	8/8/2012	579321	4746080	1742	150	1.7	16.5	1.90%	0.064	2.28
Munson Creek	CRLAWQ06	9/10/2012	569924	4746412	1841	160	4.4	20.6	1.90%	0.195	6.89
Unnamed- Trib to Vidae	CRLAWQ07	8/29/2012	573700	4747808	1971	150	3	16.1	4.90%	0.101	3.56
Unnamed	CRLAWQ08	8/22/2012	558689	4748504	1508	150	2.6	23.8	3.10%	0.163	5.74
Lost Creek	CRLAWQ09	8/13/2012	578474	4747852	1819	150	1.3	11.8	1.60%	0.021	0.73
Annie Creek, Middle Fork	CRLAWQ10	8/16/2012	570542	4744220	1708	150	2.4	23	4.60%	0.126	4.44
Bybee Creek	CRLAWQ11	8/30/2012	559257	4754346	1458	160	6.3	36.1	2.50%	0.746	26.34
Castle Creek	CRLAWQ12	8/14/2012	558930	4751202	1469	200	5.2	34.1	1.50%	0.493	17.41
Annie Creek	CRLAWQ13	9/4/2012	575987	4738322	1384	280	9.4	34.5	0.70%	NA ^b	NA ^b
Unnamed- Trib to Munson	CRLAWQ14	8/9/2012	570517	4749533	1965	150	1.2	12.7	3.70%	0.018	0.63
Unnamed- Trib to Bybee	CRLAWQ15	9/5/2012	565457	4753228	1890	150	1.1	9.3	5.40%	0.012	0.43
Unnamed	CRLAWQ16	9/12/2012	564514	4751798	1787	150	1.8	11.6	3.20%	0.043	1.53
Sand Creek	CRLAWQ17	9/6/2012	580724	4745488	1617	200	4.8	27.5	2.00%	0.603	21.28
Crater Creek	CRLAWQ19	9/13/2012	558481	4759352	1420	150	4.6	36.8	2.40%	0.457	16.13
Unnamed- Trib to Sand	CRLAWQ21	9/19/2012	578300	4749177	1844	150	3.4	21.2	3.60%	0.295	10.4
Annie Creek	CRLAWQ22	8/20/2012	571127	4743255	1643	280	7.4	25.5	1.50%	1.063	37.56
Munson Creek	CRLAWQ26	9/11/2012	570471	4747760	1898	150	3.3	21.9	1.60%	0.178	6.3
Unnamed- Trib to Castle	CRLAWQ28	9/17/2012	566219	4749086	1795	150	1.3	7.3	6.10%	0.009	0.32
Munson Creek	CRLAWQ34	9/18/2012	570389	4747318	1886	150	2.9	21.6	0.70%	0.171	6.03

^a UTM = Universal Transverse Mercator, Zone 10N.

^b NA = indicates Not Available (flow meter non-functioning).

Table E-13 (continued). Physical characteristics and location of streams sampled in Crater Lake, 2012 Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	UTM Coordinates ^a		Elevation (m)	Reach Length (m)	Average Width (m)	Average Depth (cm)	Slope	Instantaneous Discharge	
			X	Y						m ³ s ⁻¹	ft ³ s ⁻¹
Average	–	–	–	–	1701	174	4.2	22.3	2.79%	0.313	11.07
SD	–	–	–	–	182	50	3.3	8.6	1.56%	0.364	12.85
Median	–	–	–	–	1742	150	3.4	21.9	2.40%	0.175	6.17
Range	–	–	–	–	1384 - 1971	150 - 320	1.1 - 15.9	7.3 - 36.8	0.7% - 6.1%	0.009 - 1.396	0.32 - 49.31

^a UTM = Universal Transverse Mercator, Zone 10N.

^b NA = indicates Not Available (flow meter non-functioning).

Table E-14. Physical condition metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embedded-ness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Cavern Creek	CRLAWQ01	8/7/2012	6	4.2	50.8	15%	46%	1.15 ^a	0.8 ^a	-0.74 ^b	0 ^a
Sun Creek	CRLAWQ02	8/27/2012	8.2	38	43.5	28%	55%	0.99 ^a	0.78 ^a	-0.72 ^b	0 ^a
Sun Creek	CRLAWQ03	8/28/2012	48.3	114.8	24.5	9%	86%	0.58 ^a	0.25 ^b	-0.33 ^a	0 ^a
Rogue River	CRLAWQ04	8/21/2012	18.3	38	28.7	3%	71%	2.15 ^a	0.89 ^a	-0.75 ^b	0.44 ^b
Wheeler Creek	CRLAWQ05	8/8/2012	1.6	0.5	51.1	18%	38%	1 ^a	0.51 ^b	-1.31 ^c	0 ^a
Munson Creek	CRLAWQ06	9/10/2012	16.8	38	55.9	18%	36%	0.74 ^a	0.45 ^b	-0.37 ^a	0 ^a
Unnamed- Trib to Vidae	CRLAWQ07	8/29/2012	18.7	38	40	20%	59%	0.91 ^a	1.05 ^a	-0.55 ^a	0 ^a
Unnamed	CRLAWQ08	8/22/2012	5.8	4.2	46.3	10%	80%	1.07 ^a	0.57 ^b	-1.04	0 ^a
Lost Creek	CRLAWQ09	8/13/2012	0.8	0.5	82	31%	17%	0.3 ^b	0.53 ^b	-1.41 ^c	1.29 ^c
Annie Creek, Middle Fork	CRLAWQ10	8/16/2012	38.8	114.8	34.7	9%	87%	1.37 ^a	0.08 ^c	-0.42 ^a	0
Bybee Creek	CRLAWQ11	8/30/2012	7.5	38	44.1	28%	56%	1.41 ^a	0.87 ^a	-1.1 ^b	0 ^a
Castle Creek	CRLAWQ12	8/14/2012	2.8	6.2	49.5	8%	76%	1.23 ^a	0.87 ^a	-1.21 ^b	0 ^a
Annie Creek	CRLAWQ13	9/4/2012	5.6	4.2	55.1	34%	61%	0.9 ^a	0.46 ^b	-0.65 ^b	0 ^a
Unnamed- Trib to Munson	CRLAWQ14	8/9/2012	1.6	0.5	58.2	19%	53%	1.2 ^a	0.69 ^a	-1.45	1.37 ^c
Unnamed- Trib to Bybee	CRLAWQ15	9/5/2012	4.5	4.2	58	50%	41%	0.82 ^a	0.7 ^a	-1.05 ^b	0.33 ^a
Unnamed	CRLAWQ16	9/12/2012	7.9	38	55.6	37%	53%	0.32 ^b	0.4 ^b	-0.66 ^a	0 ^a
Sand Creek	CRLAWQ17	9/6/2012	7.3	38	45.1	14%	86%	0.41 ^a	0.41 ^b	-0.87 ^b	0 ^a
Crater Creek	CRLAWQ19	9/13/2012	4.4	6.2	60.4	58%	15%	1.35 ^a	0.7 ^a	-1.25 ^b	0 ^a
Unnamed- Trib to Sand	CRLAWQ21	9/19/2012	13.3	38	46.9	31%	67%	1.18 ^a	0.42 ^b	-0.81 ^b	0 ^a
Annie Creek	CRLAWQ22	8/20/2012	8.6	38	40.4	10%	79%	1.52 ^a	0.55 ^b	-0.77 ^b	0 ^a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-14 (continued). Physical condition metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Date Sampled	Stream Substrate diameter (mm)		Average Embedded-ness (%)	Pool (%)	Riffle (%)	Physical Habitat Condition Metrics			
			Average	Median				In-Stream Habitat Complexity	Riparian Cover	Relative Bed Stability	Riparian Disturbance
Munson Creek	CRLAWQ26	9/11/2012	16.3	38	31.6	6%	85%	0.51 ^a	0.3 ^b	-0.27 ^a	0 ^a
Unnamed- Trib to Castle	CRLAWQ28	9/17/2012	6.5	4.2	55.6	29%	70%	0.92 ^a	0.53 ^b	-0.91 ^b	0 ^a
Munson Creek	CRLAWQ34	9/18/2012	5.4	38	45.8	64%	28%	0.62 ^a	0.11 ^c	-0.44 ^a	0 ^a
Average	–	–	11.1	29.7	48.0	24%	58%	0.98 ^a	0.56 ^b	-0.83 ^b	0.15 ^a
SD	–	–	11.6	31.7	12.3	17%	22%	0.43	0.25	0.35	0.39
Median	–	–	7.3	38	46.9	19%	59%	0.99 ^a	0.53 ^b	-0.77 ^b	0 ^a
Range	–	–	0.8 - 48.3	0.5 - 114.8	24.5 - 82	3% - 64%	15% - 87%	0.3 - 2.15	0.08 - 1.05	-1.45 - -0.27	0 - 1.37

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-15. Water chemistry parameters for streams sampled in Crater Lake, 2012. Data collected with water probe are under “Water Quality,” whereas data from laboratory analyses are under “Water Chemistry.” Cells marked in sage (lightest shading) are sites for Least Disturbed, amber (medium shading) are sites meeting EPA threshold criteria for Intermediate, whereas cells marked in red (darkest shading) are sites meeting criteria for Most Disturbed. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Cavern Creek	CRLAWQ01	7.29	8.5	35 ^c	10.7	0	2.63	0.13	0.23	0.01 ^c	0.016 ^d	342 ^c	17 ^c
Sun Creek	CRLAWQ02	7.92	6.8	57 ^c	12.1	1.4	3.78	1.81	0.23	0 ^c	0.022 ^d	460 ^c	23 ^c
Sun Creek	CRLAWQ03	7.55	5.2	38 ^c	15.2	0	2.88	0.23	0.26	0.02 ^c	0.027 ^d	378 ^c	19 ^c
Rogue River	CRLAWQ04	7.95	3.6	61 ^c	16.3	0	4.02	0.18	0.39	0.02 ^c	0.06 ^e	799 ^c	40 ^c
Wheeler Creek	CRLAWQ05	7.79	4.6	63 ^c	12.4	0	3.32	1.27	0.23	0.03 ^c	0.035 ^d	579 ^c	29 ^c
Munson Creek	CRLAWQ06	7.85	9.5	45 ^c	9.2	1.4	3.02	0.56	0.27	0.06 ^c	0.035 ^d	415 ^c	21 ^c
Unnamed- Trib to Vidae	CRLAWQ07	7.06	2.4	34 ^c	14.9	0	2.45	0.27	0.38	0.02 ^c	0.021 ^d	328 ^c	16 ^c
Unnamed	CRLAWQ08	7.67	3.4	62 ^c	16.3	0	3.12	0.06	0.31	0.02 ^c	0.053 ^e	599 ^c	30 ^c
Lost Creek	CRLAWQ09	7.64	6.2	46 ^c	14.5	0	2.61	0.07	0.17	0.05 ^c	0.02 ^d	429 ^c	21 ^c
Annie Creek, Middle Fork	CRLAWQ10	7.63	7.2	62 ^c	12.6	0.5	3.98	1.88	0.36	0.02 ^c	0.038 ^d	482 ^c	24 ^c
Bybee Creek	CRLAWQ11	7.65	4.9	51 ^c	11	0	4.13	0.45	0.38	0.04 ^c	0.038 ^d	539 ^c	27 ^c
Castle Creek	CRLAWQ12	7.65	6.9	51 ^c	12.8	0	3.47	0.65	0.36	0.01 ^c	0.036 ^d	364 ^c	18 ^c
Annie Creek	CRLAWQ13	7.72	4.5	57 ^c	15.4	0	3.86	1.14	0.28	0.01 ^c	0.035 ^d	492 ^c	25 ^c
Unnamed- Trib to Munson	CRLAWQ14	7.24	4.9	23 ^c	13.9	0	1.74	0.17	0.15	0.03 ^c	0.01 ^c	214 ^c	11 ^c
Unnamed- Trib to Bybee	CRLAWQ15	6.93	4.4	27 ^c	16.6	1.2	1.73	0.04	0.32	0.05 ^c	0.007 ^c	254 ^c	13 ^c
Unnamed	CRLAWQ16	7.81	5.1	32 ^c	10.4	0	2.35	0.1	0.34	0.13 ^d	0.02 ^d	299 ^c	15 ^c

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-15 (continued). Water chemistry parameters for streams sampled in Crater Lake, 2012. Data collected with water probe are under “Water Quality,” whereas data from laboratory analyses are under “Water Chemistry.” Cells marked in sage (lightest shading) are sites for Least Disturbed, amber (medium shading) are sites meeting EPA threshold criteria for Intermediate, whereas cells marked in red (darkest shading) are sites meeting criteria for Most Disturbed. Table updated for 2016 computer code.

Stream Name	Site Code	Water Quality ^a					Water Chemistry ^b					Acid Neutralizing Capacity ^b	
		pH	Temp (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Sulfate (mg/L)	Chloride mg/L	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	(µeq/L)	(mg/L)
Sand Creek	CRLAWQ17	7.82	5.8	63 ^c	14.4	0	3.79	1.25	0.18	0.02 ^c	0.034 ^d	580 ^c	29 ^c
Crater Creek	CRLAWQ19	7.83	5.2	46 ^c	10.5	0	3.58	0.11	0.36	0.02 ^c	0.036 ^d	501 ^c	25 ^c
Unnamed- Trib to Sand	CRLAWQ21	7.77	5.1	55 ^c	10.2	0	3.75	0.49	0.19	0.04 ^c	0.042 ^e	573 ^c	29 ^c
Annie Creek	CRLAWQ22	7.76	5.8	52 ^c	15.3	0	3.53	0.77	0.26	0.02 ^c	0.032 ^d	410 ^c	20 ^c
Munson Creek	CRLAWQ26	7.76	3.4	41 ^c	10.2	0	2.83	0.44	0.3	0.08 ^c	0.031 ^d	356 ^c	18 ^c
Unnamed- Trib to Castle	CRLAWQ28	7.88	6.6	35 ^c	9.5	0	2.46	0.11	0.22	0.02 ^c	0.017 ^d	338 ^c	17 ^c
Munson Creek	CRLAWQ34	8.14	7.7	41 ^c	8.8	0	2.85	0.46	0.28	0.1 ^c	0.033 ^d	338 ^c	17 ^c
Average	–	7.67	5.6	47 ^c	12.7	0.2	3.13	0.55	0.28	0.04 ^c	0.030 ^d	438 ^c	22 ^c
SD	–	0.29	1.7	12	2.5	0.5	0.71	0.55	0.07	0.03	0.013	134	7
Median	–	7.76	5.2	46 ^c	12.6	0	3.12	0.44	0.28	0.02 ^c	0.033 ^d	415 ^c	21 ^c
Range	–	6.93 - 8.14	2.4 - 9.5	23 - 63	8.8 -16.6	0 - 1.4	1.73 - 4.13	0.04 - 1.88	0.15 - 0.39	0 - 0.13	0.007 - 0.06	214 - 799	11 - 40

^a Data collected with water probe.

^b Data from laboratory analysis.

^c Sites are Least Disturbed (also with light sage background).

^d Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^e Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-16. Riparian characteristics of Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Cavern Creek	CRLAWQ01	91%	86%	25.6	27%	15%	100% C	33%	20%	27% C,27% D,45% M
Sun Creek	CRLAWQ02	85%	73%	42.4	2%	10%	23% C,14% D,64% N	66%	24%	100% D
Sun Creek	CRLAWQ03	60%	35%	21.7	8%	10%	64% C,36% N	7%	61%	32% C,59% N,9% M
Rogue River	CRLAWQ04	84%	50%	32.2	15%	22%	100% C	47%	1%	50% C,50% M
Wheeler Creek	CRLAWQ05	84%	79%	27.4	19%	11%	82% C,18% N	15%	48%	86% C,5% N,9% M
Munson Creek	CRLAWQ06	78%	53%	28.4	11%	10%	59% C,41% N	22%	10%	91% C,9% M
Unnamed- Trib to Vidae	CRLAWQ07	89%	76%	36.2	25%	10%	95% C,5% N	48%	11%	14% C,5% D,82% M
Unnamed	CRLAWQ08	76%	68%	25.8	2%	13%	77% C,23% N	35%	5%	14% C,14% N,73% M
Lost Creek	CRLAWQ09	83%	85%	18.3	11%	14%	95% C,5% D	21%	5%	45% D,55% M
Annie Creek, Middle Fork	CRLAWQ10	67%	29%	37.8	4%	3%	18% C,82% N	1%	83%	18% C,82% N
Bybee Creek	CRLAWQ11	93%	69%	38.5	17%	14%	77% C,23% N	57%	20%	14% C,27% D,59% M
Castle Creek	CRLAWQ12	93%	78%	29.1	12%	13%	77% C,23% N	60%	13%	5% C,55% D,5% N,36% M
Annie Creek	CRLAWQ13	73%	40%	56.7	8%	4%	45% C,55% N	33%	62%	77% D,5% N,18% M
Unnamed- Trib to Munson	CRLAWQ14	91%	79%	17	9%	15%	82% C,5% D,14% N	43%	16%	50% C,14% D,36% M
Unnamed- Trib to Bybee	CRLAWQ15	83%	72%	26.6	8%	16%	91% C,9% N	26%	12%	91% C,9% N
Unnamed	CRLAWQ16	68%	44%	23.3	8%	12%	68% C,32% N	17%	0%	82% C,18% N
Sand Creek	CRLAWQ17	75%	51%	35.4	9%	5%	41% C,59% N	26%	1%	18% C,45% D,23% N,14% M
Crater Creek	CRLAWQ19	95%	84%	42.5	12%	7%	68% C,32% N	46%	8%	18% C,14% D,68% M
Unnamed- Trib to Sand	CRLAWQ21	79%	55%	22.9	2%	18%	86% C,14% N	21%	21%	100% C
Annie Creek	CRLAWQ22	72%	45%	30.7	15%	22%	100% C	17%	71%	73% C,5% D,18% N,5% M
Munson Creek	CRLAWQ26	48%	26%	24.4	4%	7%	41% C,59% N	19%	51%	91% C,9% N
Unnamed- Trib to Castle	CRLAWQ28	80%	72%	29.2	6%	10%	85% C,15% N	32%	11%	100% C
Munson Creek	CRLAWQ34	40%	14%	23.3	2%	1%	14% C,86% N	8%	67%	77% C,23% N

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table E-16 (continued). Riparian characteristics of Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Bank Shading	Center Shading	Legacy Tree Height (m)	Canopy			Understory		
					Big Tree	Small Tree	Composition ^a	Woody	Non-Woody	Composition ^a
Average	–	78%	59%	30.23	10%	11%	n/a	30%	27%	n/a
SD	–	14%	21%	9.13	7%	5%	n/a	18%	26%	n/a
Median	–	80%	68%	28.40	9%	11%	n/a	26%	16%	n/a
Range	–	40% - 80%	14% - 86%	17.0 - 56.7	2% - 27%	1 - 22%	n/a	1% - 66%	0% - 83%	n/a

^a For compositions: D = Deciduous, C = Coniferous, E = Broadleaf Evergreen, N = None, and M = Mixed (10% or more of multiple types).

Table E-17. Vertebrate species and metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Bull Trout	Cascade Frog	Pacific Tree Frog	Tailed Frog	Unknown Frog	Unknown Salmonid
Cavern Creek	CRLAWQ01	Yes	13	1	57.1 ^b	12	–	–	–	–	–	1
Sun Creek	CRLAWQ02	Yes	13	1	85.7 ^a	–	13	–	–	–	–	–
Sun Creek	CRLAWQ03	No	–	–	–	–	–	–	–	–	–	–
Rogue River	CRLAWQ04	Yes	–	–	Null ^c	–	–	–	–	–	–	–
Wheeler Creek	CRLAWQ05	Yes	1	1	42.9 ^b	–	–	–	–	–	1	–
Munson Creek	CRLAWQ06	Yes	4	2	46.9 ^b	3	–	–	1	–	–	–
Unnamed- Trib to Vidae	CRLAWQ07	Yes	–	–	Null ^c	–	–	–	–	–	–	–
Unnamed	CRLAWQ08	Yes	–	–	Null ^c	–	–	–	–	–	–	–
Lost Creek	CRLAWQ09	No	–	–	–	–	–	–	–	–	–	–
Annie Creek, Middle Fork	CRLAWQ10	Yes	6	1	57.1 ^b	6	–	–	–	–	–	–
Bybee Creek	CRLAWQ11	Yes	11	1	57.1 ^b	11	–	–	–	–	–	–
Castle Creek	CRLAWQ12	Yes	4	2	60.7 ^b	3	–	–	–	1	–	–
Annie Creek	CRLAWQ13	Yes	6	2	46.9 ^b	5	–	1	–	–	–	–
Unnamed- Trib to Munson	CRLAWQ14	Yes	18	1	57.1 ^b	18	–	–	–	–	–	–
Unnamed- Trib to Bybee	CRLAWQ15	Yes	1	1	42.9 ^b	–	–	1	–	–	–	–
Unnamed	CRLAWQ16	Yes	–	–	Null ^d	–	–	–	–	–	–	–
Sand Creek	CRLAWQ17	Yes	5	1	57.1 ^b	5	–	–	–	–	–	–
Crater Creek	CRLAWQ19	Yes	6	1	42.9 ^b	–	–	6	–	–	–	–
Unnamed- Trib to Sand	CRLAWQ21	No	–	–	–	–	–	–	–	–	–	–
Annie Creek	CRLAWQ22	Yes	2	1	57.1 ^b	1	–	–	–	–	–	1
Munson Creek	CRLAWQ26	Yes	3	2	46.9 ^b	2	–	–	1	–	–	–
Unnamed- Trib to Castle	CRLAWQ28	No	–	–	–	–	–	–	–	–	–	–

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Null indicates no species present to calculate a metric.

Table E-17 (continued). Vertebrate species and metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Sampled: Yes or No	Total Abundance	Total Richness	EPA Vertebrate MMI	Brook Trout	Bull Trout	Cascade Frog	Pacific Tree Frog	Tailed Frog	Unknown Frog	Unknown Salmonid
Munson Creek	CRLAWQ34	No	5	2	42.9 ^b	–	–	4	1	–	–	–
Average	–	–	6.5	1.3	53.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SD	–	–	5.0	0.5	11.2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Median	–	–	5	1	57.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Range	–	–	1 - 18	1 - 2	42.9 - 85.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a

^a Sites are Least Disturbed (also with light sage background).

^b Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^c Null indicates no species present to calculate a metric.

Table E-18. Invertebrate results and metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	Oregon Western Streams IBI ^d
Cavern Creek	CRLAWQ01	49	2.88	3.39	0.97 ^e	70 ^f	76 ^e
Sun Creek	CRLAWQ02	51	3.08	2.72	1.13 ^e	87 ^e	92 ^e
Sun Creek	CRLAWQ03	48	2.79	2.34	1.13 ^e	79 ^e	92 ^e
Rogue River	CRLAWQ04	44	2.4	2.45	1.05 ^e	65 ^f	64 ^e
Wheeler Creek	CRLAWQ05	57	2.92	3.49	1.2 ^e	80 ^e	88 ^e
Munson Creek	CRLAWQ06	54	3.12	3.37	1.03 ^e	83 ^e	96 ^e
Unnamed- Trib to Vidae	CRLAWQ07	42	2.78	3.89	0.96 ^e	68 ^f	72 ^e
Unnamed	CRLAWQ08	35	2.68	2.25	0.52 ^g	66 ^f	68 ^e
Lost Creek	CRLAWQ09	34	2.99	2.92	0.6 ^g	57 ^g	72 ^e
Annie Creek, Middle Fork	CRLAWQ10	51	2.64	3.38	0.99 ^e	66 ^f	84 ^e
Bybee Creek	CRLAWQ11	36	2.32	3.74	0.96 ^e	72 ^e	80 ^e
Castle Creek	CRLAWQ12	34	2.04	3.13	0.86 ^e	67 ^f	64 ^e
Annie Creek	CRLAWQ13	42	2.63	3.73	1 ^e	76 ^e	92 ^e
Unnamed- Trib to Munson	CRLAWQ14	44	2.88	3.78	0.85 ^e	77 ^e	76 ^e
Unnamed- Trib to Bybee	CRLAWQ15	35	2.76	3.74	0.92 ^e	68 ^f	76 ^e
Unnamed	CRLAWQ16	38	2.78	4.34	0.85 ^e	77 ^e	84 ^e
Sand Creek	CRLAWQ17	46	2.98	3.41	1.1 ^e	83 ^e	88 ^e
Crater Creek	CRLAWQ19	65	3.42	2.93	1.22 ^e	79 ^e	96 ^e
Unnamed- Trib to Sand	CRLAWQ21	32	1.88	1.16	0.61 ^g	71 ^e	80 ^e

^a HBI = Hilsenhoff Biotic Index.

^b O/E = Observed/Expected ratio.

^c MMI = Multi=Metric Index.

^d IBI = Index of Biotic Integrity

^e Sites are Least Disturbed (also with light sage background).

^f Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^g Sites meeting EPA criteria for Most Disturbed (also with dark red background).

Table E-18 (continued). Invertebrate results and metrics for Crater Lake streams sampled in 2012. Table updated for 2016 computer code.

Stream Name	Site Code	Total Taxa Richness	Shannon Diversity	HBI ^a	O/E ^b	EPA West-Wide Invertebrate MMI ^c	Oregon Western Streams IBI ^d
Annie Creek	CRLAWQ22	46	2.49	3.26	0.96 ^e	82 ^e	88 ^e
Munson Creek	CRLAWQ26	48	2.66	2.29	0.95 ^e	81 ^e	92 ^e
Unnamed- Trib to Castle	CRLAWQ28	52	3.36	3.29	1.12 ^e	76 ^e	92 ^e
Munson Creek	CRLAWQ34	46	2.51	1.87	1.03 ^e	82 ^e	92 ^e
Average	–	45	2.74	3.08	0.96 ^e	74 ^e	83 ^e
SD	–	8	0.37	0.75	0.18	8	10
Median	–	46	2.78	3.29	0.97 ^e	76 ^e	84 ^e
Range	–	32 - 65	1.88 - 3.42	1.16 - 4.34	0.52 - 1.22	57 - 87	64 - 96

^a HBI = Hilsenhoff Biotic Index.

^b O/E = Observed/Expected ratio.

^c MMI = Multi=Metric Index.

^d IBI = Index of Biotic Integrity

^e Sites are Least Disturbed (also with light sage background).

^f Sites meet EPA threshold criteria for Intermediate disturbance (also with medium amber background).

^g Sites meeting EPA criteria for Most Disturbed (also with dark red background).

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