



Integrated Aquatic Community and Water Quality Monitoring of Mountain Ponds and Lakes in the Klamath Network – Annual Data Report

*2013 results from Lassen Volcanic National Park, Crater Lake
National Park, and Redwood National Park*

Natural Resource Data Series NPS/KLMN/NRDS—2016/1055





ON THIS PAGE

Likely Four-Spotted Skimmer (*Libellula quadrimaculata*) observing Kirsten Underwood, Field Crew Leader at Lily Pond, Lassen Volcanic National Park.

Photograph by Eric C. Dinger, KLMN Aquatic Ecologist

ON THE COVER

Summit Lake, Lassen Volcanic National Park

Photograph by Eric C. Dinger, KLMN Aquatic Ecologist.

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Abstract

The Inventory and Monitoring Program of the National Park Service sampled the biotic and abiotic parameters of mountain ponds and lakes of the Klamath Network in three park units: Lassen Volcanic National Park, Crater Lake National Park, and Redwood National Park. Sampling of lentic habitats in these parks occurs every three years (2013, 2016, 2019, etc.).

The purpose of the Klamath Inventory and Monitoring Network Mountain Ponds and Lakes protocol is to determine status and trends of ecological condition in mountain ponds and lakes. This report serves to report the measured values and as the first year of monitoring, set the baseline for future trend reports. Included in the report are measurements of physical habitat, water chemistry and quality, and aquatic communities.

In Lassen Volcanic National Park, a total of 30 probabilistically chosen ponds and lakes were visited along with a single judgment site (Lake Helen). Sampling occurred from 17 July 2013 to 29 August 2013. Three of the 30 probabilistic ponds-lakes were found to be dry, for a total of 27 probabilistic ponds and lakes sampled.

In Crater Lake National Park, six ponds outside the Crater Lake caldera were sampled from 4 September 2013 to 9 September 2013, excluding a single site that was inaccessible. Based on visits in prior years and the current visits, it was determined that this constitutes all the known perennial sampleable ponds outside the Crater Lake caldera. There are no judgment sites in Crater Lake National Park.

In Redwood National Park, a single judgment site, Freshwater Lagoon, was sampled on 17 and 18 September 2013.

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Introduction

The Klamath Network (KLMN) vital signs selection process identified two freshwater 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 impacts to freshwater habitats and resources.

During the initial process of selecting Aquatic Communities and Water Quality as vital signs, National Park Service (NPS) staff did not differentiate between lentic (pond and lake) and lotic (stream) habitats. However, fundamental differences in ecosystem structure and process between streams and lakes dictated a basic division in sampling methodology and the development of separate protocols and reporting for each of these habitats. This report covers lentic habitats for the mountain ponds and lakes (Dinger et al. 2012); lotic sampling is covered in separate reports and protocol (Dinger et al. 2013).

Ponds and lakes are integral ecosystems in the landscape of many parks. Not only are lakes attractive visitor destinations, but they also serve as watering holes and habitat for park wildlife. Lake ecosystems have been studied for over a century, both as isolated “mesocosms” (i.e., stand alone, self-contained systems) and as part of a broader landscape; providing a rich context for understanding linkages between natural and anthropogenic stressors and their effects.

The overall aquatic community of a lake serves as an integrated biomonitoring tool, encompassing short-term and long-term responses to impacts (Rosenberg and Resh 1993). Invertebrates (benthic and planktonic) can rapidly respond to impacts, while fish and amphibians (with longer life cycles) will manifest time-integrated responses. Trends in aquatic communities reflect changes in water and habitat quality; therefore, monitoring aquatic communities and associated habitat characteristics will detect changes in ecological integrity over time. We have chosen to monitor multiple indicators of the lake ecosystem, encompassing key attributes of habitat, chemistry, and biology. The use of multiple indicators for measuring potential ecosystem change will provide us with an integrated and robust system for detecting trends and changes over time.

The primary goal of the Mountain Ponds and Lakes protocol is to *determine the status and trends of ecological condition in the mountain lakes of the Klamath Network*. The two Klamath Network parks with substantial pond and lake habitats are Lassen Volcanic and Crater Lake National Parks. An additional park, Redwood National Park has several coastal lagoons, and one freshwater lagoon (named Freshwater Lagoon) is also included in this sampling and report.

Future analysis and reporting on lake ecological condition and trends will be in Analysis and Synthesis Reports to follow, allowing for a more comprehensive interpretation beyond the scope of an annual report. These future reports will focus on identifying pond and lake attributes and trends in resources over time. The purpose of this current report is the quick dissemination of raw data and selected derived response measures for park specialists, managers, scientists, and the public.

Methods

The methods used for monitoring KLMN mountain ponds and lakes come from three primary sources: (1) USGS protocols for sampling lakes and ponds (Hoffman et al. 2005), (2) Techniques developed by Roland Knapp for sampling Sierra Nevada lakes (Knapp et al. 2005), and (3) USEPA National Lakes Assessment techniques (2011); 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 Mountain Ponds and Lakes in the Klamath Network (Dinger et al. 2012). Additionally, methods are provided for some field sampling that is not analyzed or reported herein—they are included here to provide an overview of the portfolio of data that will be available in future Analysis and Synthesis reports or upon request.

Implementation Schedule

The KLMN aquatics sampling plan stipulates that mountain pond and lake sampling be implemented one year out of three, alternating with two years of wadeable stream sampling. This report covers data from the first year of implementation of mountain pond and lake sampling (2013). Mountain ponds and lakes will be sampled again in 2016.

Site Selection and Lake Identifiers

Selection of sites varied by park unit, and included both judgment and probabilistically chosen sites.

Judgment Sites

In Lassen Volcanic National Park, there was a single judgment lake: Lake Helen, selected by park staff due to its high recreation use, proximity to a major park roadway, and low buffering capacity. In Redwood National Park, Freshwater Lagoon was selected by park staff because it is no longer a true lagoon (being cut off by US Highway 101), is partly on park land and partly on state lands, and is stocked extensively with exotic fish.

Non-Judgment Sites

Excluding the judgment sites, the target sample-site population for the Integrated Aquatic Community and Water Quality Monitoring of Mountain Ponds and Lakes protocol is all mountain ponds and lakes that are:

- Perennial – This selection criterion is applied to remove habitats that are influenced by seasonal desiccation which could mask other stressors of interest. It also ensures that data collection can always occur at the sites, assisting in data completion goals.
- <25m maximum depth – This selection criterion removes large lakes that are characterized by physical and environmental processes that are different than those for smaller lakes and ponds. While monitoring large lakes is valuable, separate methodology would be required to adequately assess them, and they are a numerical minority of sites within the Klamath Network. (Note that a judgment lake, Lake Helen is deeper than 25 m, but limited in surface area ~11 hectares).

- <1000 m from a travelable road or trail – This selection criterion reduces logistical constraints to field crews, such as travel time, to ensure that each site can be sampled in the allotted time frame for achieving sampling objectives.
- Located in topographies with slope <30 degrees – This selection criterion ensures crew safety and that access to lakes is feasible.

Lassen Volcanic National Park

Within Lassen Volcanic National Park there are a total of 239 ponds and lakes. Thirty-six of these ponds and lakes were excluded based on the above criteria. The target sample size for the protocol at Lassen Volcanic National Park was 30 sites, and these sites were chosen from the remaining 203 ponds and lakes using a Generalized Random Tessellation Stratified design (GRTS – pronounced “grits”) (Stevens and Olsen 1999, 2004). This design employs a systematic sampling technique to obtain a spatially balanced probabilistic sample. This procedure also produces a spatially balanced over-sample (i.e., a list of additional sites to sample if sample points need to be replaced or added). Since the GRTS method creates spatially balanced and dispersed sample sites, it minimizes spatial autocorrelation among sites and maximizes the effective sample size for a given number of sample sites, which should help increase statistical power.

Within Lassen Volcanic National Park, many of the ponds and lakes are unnamed waterbodies, complicating the identification and reporting on each. However, the state of California (CA) has assigned a unique number to each water body within the state. Using these numbers, we can track each site, be it named or not. In cases where a pond or lake has a geographical name, we report both the CA code (“Site Code”) and the name.

Crater Lake National Park

Within Crater Lake National Park, outside of the caldera, there were a total of 38 potential sites identified by park staff. Initial site visits in 2008 during protocol development showed that a large majority of these were ephemeral and prone to drying prior to crews being able to sample them (Dinger et al. 2012). After further field verification, we identified a total of six ponds that were perennial and suitable for sampling, and one site that was inaccessible. Hence, sampling of perennial ponds in Crater Lake constitutes a complete census of known sites fitting the site-selection criteria summarized above.

At Crater Lake National Park, many of the ponds were also unnamed waterbodies. We assigned an arbitrary site code to each water body identifying the park (e.g., CRLA = Crater Lake), type of protocol (e.g., Water Quality = WQ), and habitat type (L = Lake) resulting in: CRLAWQL01 to CRLAWQL38. Both the site code and geographical name, when applicable, are used in reporting.

Site Set-up and Sampling Scheme

The sampling crew utilizes an arbitrarily selected set-up station, from which sampling occurs at three secondary site types: (1) An index site located at the deepest point of the lake, (2) 15 roughly equally spaced sampling stations around the lake perimeter, and (3) a nearby gill-net deployment station for

fish sampling (Figure 1). In addition to these sampling locations, the crew walks the perimeter of the lake, recording the lake outline with a GPS unit and characterizing habitat substrates.

In a small inflatable boat, the crew spends approximately 30 minutes determining the deepest measured point of the pond or lake using a hand-held sonar device. This point is the index station and establishes the location for collecting samples for water chemistry, the water quality profile, Secchi Disk depth measurements, and zooplankton sampling.

The crew identifies 15 points estimated to be evenly and systematically spread around the lake perimeter. This is accomplished by estimating a point half-way around the perimeter of the pond or lake and deducing a rough spacing for each sampling location. At each of these locations, the crew collects a macroinvertebrate sample, searches aquatic habitats for amphibians, and characterizes the riparian zone for vegetation and human disturbance.

The crew also searches for a suitable location to stretch out and deploy the gill net for fish sampling near the set-up site so that the gill net can be monitored for fish activity. The site needs to be relatively free of substrate, which can snag and potentially damage the net (e.g., large boulders and submerged tree trunks and branches).

Water Chemistry and Water Quality Profile

At the deepest part of a pond or lake, one or two water samples are collected using a horizontal Beta Van-Dorn-style water sampler. In deeper ponds and lakes (>2 m deep), a sample is collected at 0.5 m below the surface, and at 0.5 m above the lake bottom. In shallow ponds and lakes (<2 m deep), a single sample is collected at the mid-point depth of the water column. Water collected in the Van-Dorn bottle is stored in a 2-L amber high-density polyethylene (HDPE) sample bottle. On shore, using a 60-mL syringe and filter holder, a 250 mL portion of each water sample is filtered through a 0.45- μ m 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 is decanted into an identical bottle for nutrient analyses (Total Nitrogen, Total Phosphorous). Both bottles are kept cool until they can be frozen (generally <4 hours). Additionally, 120 mL of water is filtered through a precombusted glass-fiber filter into an acid-washed, precombusted glass vial for the quantification of Dissolved Organic Carbon sample (also kept cool and later refrigerated). These samples are then shipped to the Cooperative Chemical Analytical Laboratory at Oregon State University, Corvallis. See Dinger et al. (2012) for details on detection limits and analytical techniques for each parameter.

Measurements of temperature ($^{\circ}\text{C}$), pH, specific conductivity ($\mu\text{S cm}^{-1}$), dissolved oxygen (mg L^{-1}), and turbidity (NTU) are completed in a 0.5-m profile at the deepest point of the pond or lake using a Eureka Environmental “Manta” water quality probe. The probe is deployed over the side of the inflatable boat, with an initial measurement at the water surface, and then lowered at 0.5-m increments to obtain measurements until the probe is just above the pond or lake bottom. At each interval the probe is held steady until all parameters being measured have reached equilibrium.

At the deepest point, a 20-cm diameter Secchi Disk is used to measure water clarity.

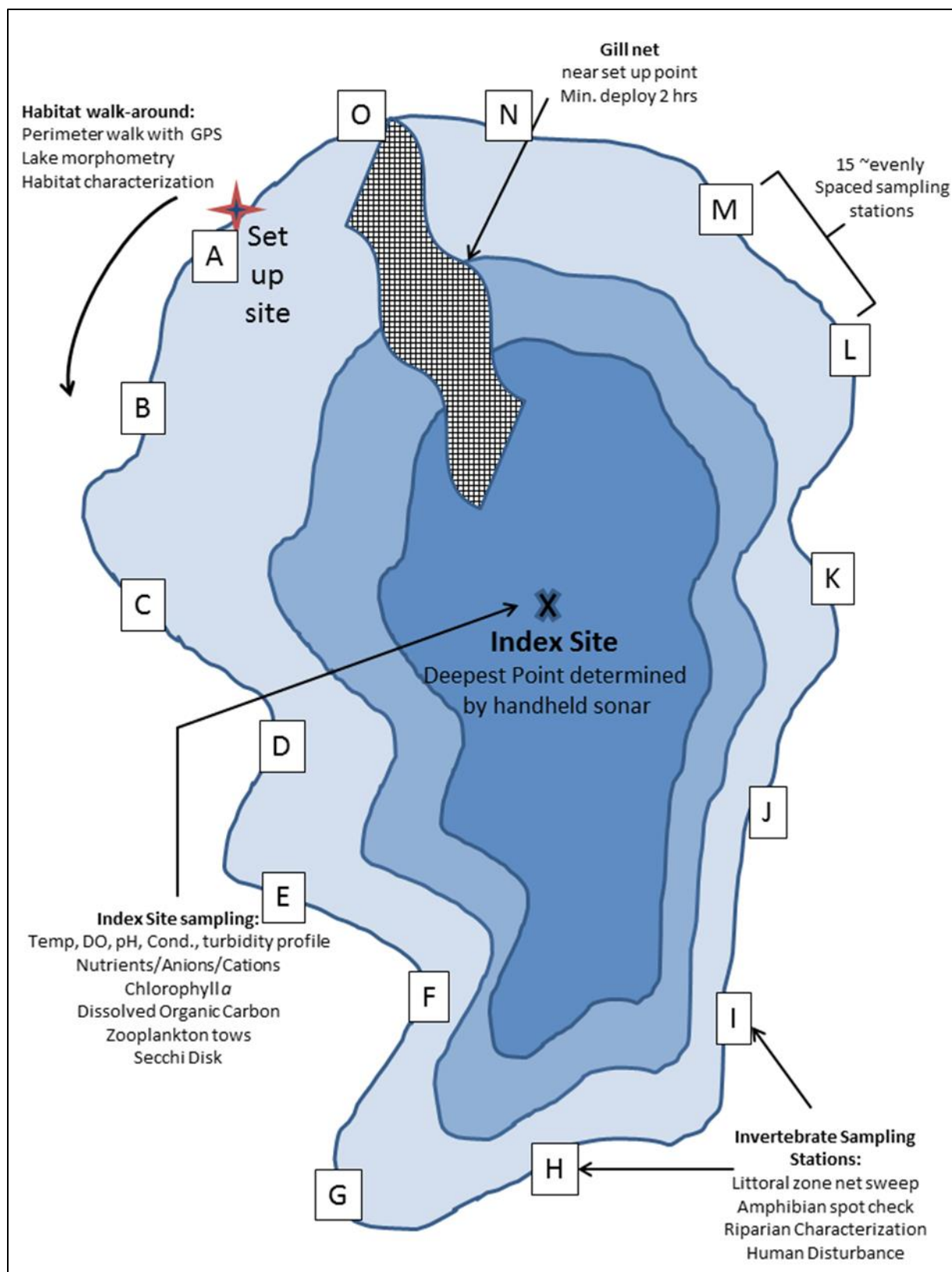


Figure 1. Layout schematic of a pond-lake showing the location and type of sampling completed during each site visit.

Aquatic Communities

Three components (Zooplankton, Littoral Macroinvertebrates-Amphibians, Fish) of the pond or lake aquatic community are sampled at the three location types (Figure 1) around each pond and lake sampled.

Zooplankton

Zooplankton are collected from the deepest measured point of the lake using a 64- μ m mesh Wisconsin-style net with a 12.7 cm diameter opening using five replicate tows (Figure 2). In lakes >5 m deep, the tow is vertical, with the net being lowered 5 m prior to being lifted up through the water column. In lakes <5 m deep, the tow is horizontal, with the net being deployed 5 m away from the inflatable boat by tossing the net attached to a 5 m cord out and away from the boat before being pulled in. All individual tows are composited into a single vial, preserved in 90% ethanol, and sent to a contract taxonomy lab for enumeration and identification. (For this sampling year, the samples were sent to ZPs Taxonomy, LLC.).



Figure 2. Kirsten Underwood finishing horizontal zooplankton tow sampling at Lily Pond, Lake 10430.

Littoral Macroinvertebrates

Macroinvertebrates from the near-shore littoral zone are sampled at the 15 sampling stations using a 1 ft. (0.304 m) wide D-frame 500- μ m mesh net, by sweeping the net along a 1-m path in the dominant substrate at the station (Figure 3). After sweeping 1 m, the net is turned and the 1 m path is re-swept. The samples from all 15 stations are composited into a single sample, subject to field splitting to minimize sample volume. The sample is 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.).



Figure 3. Crew Leader Kirsten Underwood sampling littoral zone macroinvertebrates in Summit Lake (10793) (left) and Lily Pond (10430) (right).

During collection of the macroinvertebrate samples, and during the lake walk-around, a visual encounter survey and targeted search for amphibians is also conducted, and species and abundances recorded in the GPS unit.

Fish

Fish are sampled with a 42 m long, 1 m deep monofilament gill net with 3 panels: 1) 25-m mesh X 6 m length; 2) 35 mm X 12 m length; and 3) 50 mm X 24 m length. The net is deployed perpendicular from the shore out toward the deeper part of the pond or lake (Figure 4), with the 25-mm panel being closet to the shore. The net is deployed from a small inflatable boat and kept in the water for a minimum of two hours, but can be left out longer as crew sampling dictates as long as no substantial fish numbers are accumulating in the net.

Zooplankton and Macroinvertebrate reporting

For both zooplankton and littoral zone macroinvertebrates, biodiversity is summarized as taxonomic richness for certain taxonomic categories; for example, zooplankton is summarized for richness in Cladoceran and Copepoda among other categories. In summing the richness, the count is the number of distinct taxa within that category. Due to taxonomic ambiguity, the taxa contributing to the count may be at the species, genus, family, or higher level of taxonomic resolution. This ambiguity is generally due to damaged or immature specimens, or unavailability of adequate taxonomic references.

Two additional metrics are provided: Shannon Diversity and Evenness. In brief, Shannon Diversity (or Shannon-Weaver Index) is a diversity measure based on the sum of the individual proportion of a taxa multiplied by the natural log of the proportion. It incorporates the concept of abundance and the number of species into a fuller measure of biodiversity. Evenness is a ratio of observed Shannon Diversity to a situation where the abundance is spread equally among species (e.g., Evenness of 1.0

indicates no one taxa is more abundant than the other; and the closer the Evenness to 0, the more a single or a few taxa dominate the sample numerically). Full details on these metrics are provided in the full protocol (Dinger et al. 2012).



Figure 4. Deployment of gill net at Lily Pond (10430). Project lead Eric Dinger in boat, Crew Member Eric Scott feeding out net.

Physical Habitat and Lake Morphometrics

The habitat of the lake is measured during a walk-around the lake perimeter, staying as close to the shoreline as possible. During the walk-around, a GPS unit (Trimble XH or similar) is used to record a detailed GIS (Geographic Information System) feature delineating the shoreline. When the crew member performing the walk-around observes a change in substrate at the water-shore interface, the substrate type GIS segment is recorded along with the feature, denoting the various substrate types present (boulders, bedrock, cobble, detritus, emergent macrophytes, submergent macrophytes, gravel, sand, fines, or woody debris). The crew member then estimates the percent occurrence of each substrate category for the segment (e.g., a specific segment might be composed of 80% bedrock, 15% gravel, and 5% woody debris). The segment length and percent of substrate type can then be used in a weighted average of overall lake shoreline substrate.

The recorded lake perimeter segments are combined in ArcGIS 10.2 to calculate an overall perimeter and lake area. These are then used to calculate Shoreline Development, the ratio of the actual shoreline to that of a circumference of a perfect circle of the same surface area. A perfectly round lake will approach 1, whereas a lake with a complex shoreline will have higher numbers of shoreline development. This metric is a reflection of the possibility of increased development of littoral communities, proportional to lake size.

Results

Lassen Volcanic National Park

Sampling occurred in Lassen Volcanic National Park from 17 July 2013 to 29 August 2013. A total of 30 probabilistically chosen ponds and lakes, and one judgment lake (Lake Helen) were visited. Three of the 30 ponds and lakes were found to be dry (Table 1, Figure 5) resulting in a total of 27 ponds and lakes sampled (Figures 6 and 7). Time constraints precluded visiting additional sites to make up for the dry lakes. In future years (i.e., 2016 onward) these lakes will be replaced with oversample lakes from the GRTS draw. Basic parameters for the 27 sampled ponds and lakes and the one judgment lake are presented in Table 2.

Table 1. Location of three dry lakes encountered in Lassen Volcanic National Park. They were not sampled. Coordinates are in NAD1983 datum, Zone 10N.

Site Code	Lake Name	UTM Coordinates		Date Visited
		X	Y	
11373	Dream Lake	635035	4478004	20150822
10469	Unnamed	637379	4487738	20150815
10454	Crags Lake	624474	4487894	20150725

The 27 probabilistically chosen ponds and lakes were mostly shallow, with an average depth of 2.6 m and a median depth of 1.6 m. The average surface area was 1.61 hectares, with a range of 0.04 to 12.14 hectares. In general, the common notion of a pond is associated with smaller surface areas, whereas a mountain lake is commonly associated with larger surface areas (Figure 8).

The average Shoreline Development Index for the 27 ponds and lakes sampled was 1.24 (note that the closer the index is to 1 the more the lake outline approaches a perfect circle).



Figure 5. Photos of the three dry lakes encountered during sampling in Lassen Volcanic National Park: Crags Lake (10454, top), Dream Lake (11373, middle), and Unnamed (10469, bottom).

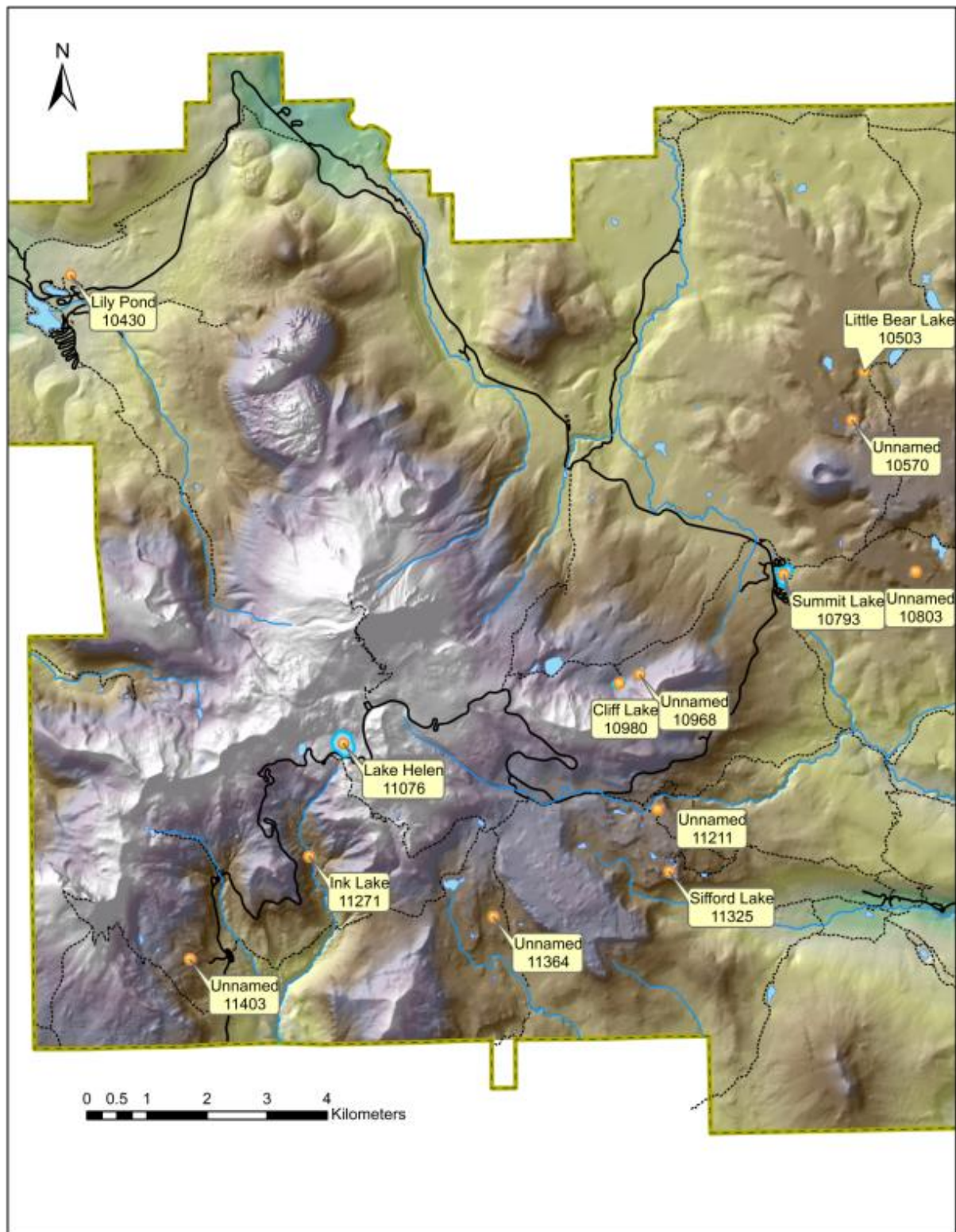


Figure 6. Locations of ponds and lakes sampled in the western portion of Lassen Volcanic National Park, 2013. Lake Helen (11076) is the judgment site.

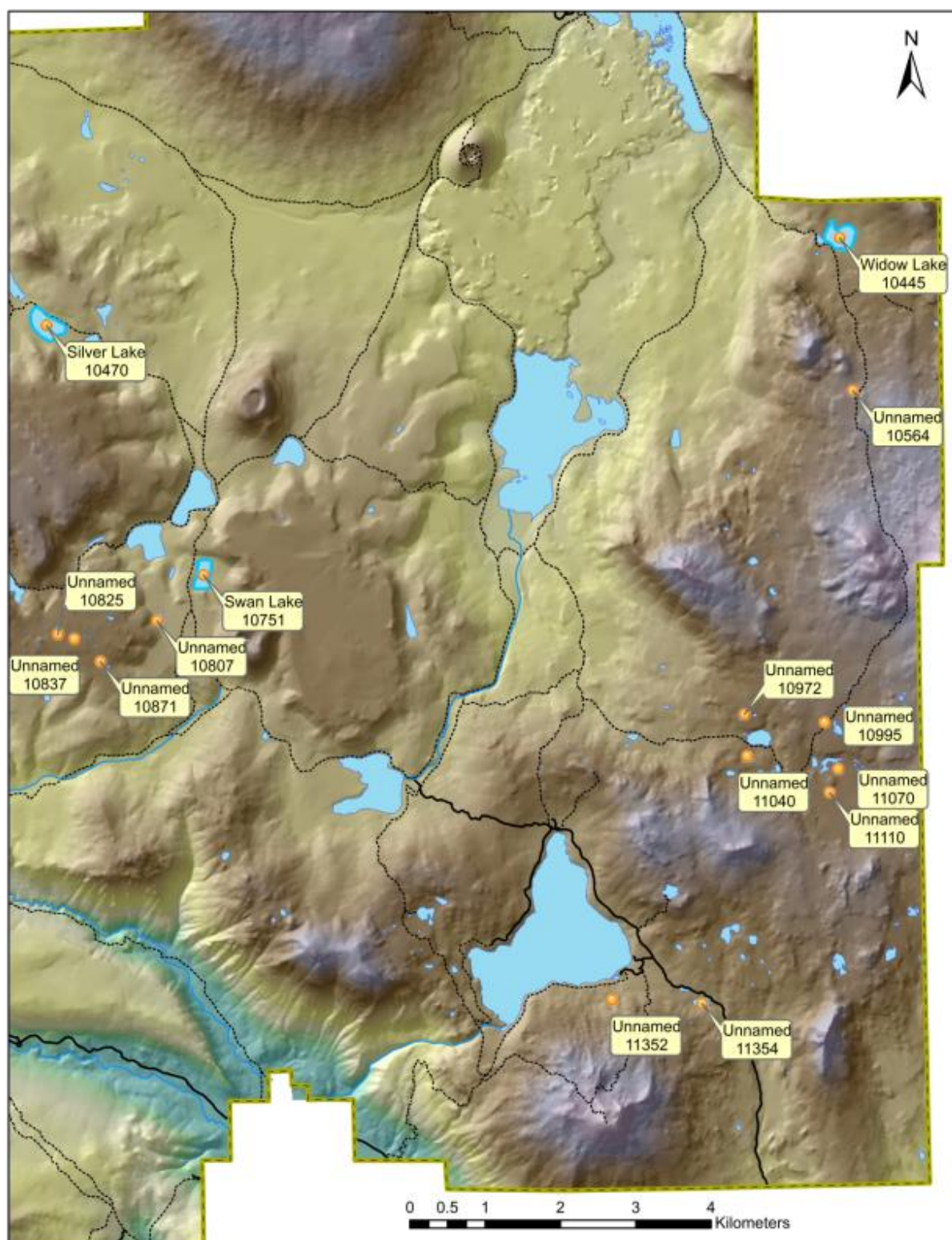


Figure 7. Locations of ponds and lakes sampled in the eastern portion of Lassen Volcanic National, 2013.

Table 2. Morphometric and location data for ponds and lakes sampled at Lassen Volcanic National Park, 2013. Note that the single Judgment site (Lake Helen) is not included in summary statistics.

Type	Site Code	Lake Name	UTM Coordinates		Date Sampled	Max Depth (m)	Area			Circumference (m)	Shoreline Development
			X	Y			Square meters	Hectare	Acre		
Judgment	11076	Lake Helen	626236	4480167	7/30/2013	33.8	110580	11.06	26.73	1225	1.04
Probabilistic Sites	10430	Lily Pond	621727	4488696	7/17/2013	2	1066	0.11	0.26	125	1.08
	10793	Summit Lake	633740	4483689	7/18/2013	2.5	56475	5.65	13.65	1056	1.25
	11211	Unnamed	631503	4479775	7/19/2013	1.7	2354	0.24	0.57	195	1.14
	11403	Unnamed	623737	4477245	7/22/2013	1.4	1066	0.11	0.26	125	1.08
	11271	Ink Lake	625701	4478951	7/23/2013	4.4	1116	0.11	0.27	164	1.39
	11364	Unnamed	628796	4477957	7/24/2013	1.4	3556	0.36	0.86	235	1.11
	10968	Unnamed	631208	4482017	7/31/2013	0.9	907	0.09	0.22	126	1.18
	10980	Cliff Lake	630950	4481835	7/31/2013	3.5	22574	2.26	5.46	660	1.24
	11352	Unnamed	644147	4478664	8/1/2013	1.1	995	0.10	0.24	130	1.16
	11354	Unnamed	645400	4478642	8/1/2013	0.4	2408	0.24	0.58	197	1.13
	11325	Sifford Lake "5"	631704	4478731	8/2/2013	2.6	907	0.09	0.22	132	1.23
	10803	Unnamed	635833	4483749	8/6/2013	1.1	2239	0.22	0.54	293	1.75
	10825	Unnamed	636765	4483551	8/6/2013	0.6	739	0.07	0.18	148	1.54
	10837	Unnamed	637001	4483458	8/7/2013	0.6	878	0.09	0.21	120	1.14
	10807	Unnamed	638099	4483714	8/8/2013	0.6	2903	0.29	0.70	312	1.63
	10871	Unnamed	637356	4483127	8/8/2013	0.4	432	0.04	0.10	82	1.12
	10751	Swan Lake	638814	4484449	8/9/2013	6.7	71416	7.14	17.26	1170	1.24
	10503	Little Bear Lake	635016	4487006	8/13/2013	3.3	17561	1.76	4.24	508	1.08
	10470	Silver Lake	636718	4487686	8/14/2013	15	121447	12.14	29.35	1462	1.18
	10570	Unnamed	634761	4486264	8/16/2013	1.7	1754	0.18	0.42	190	1.28
	10445	Widow Lake	647070	4488641	8/19/2013	10.3	107519	10.75	25.99	1458	1.25
	10564	Unnamed	647286	4486741	8/20/2013	0.9	1883	0.19	0.46	200	1.30
	11040	Unnamed	645980	4481876	8/21/2013	2.6	5783	0.58	1.40	332	1.23
	10972	Unnamed	645898	4482453	8/27/2013	1.3	1241	0.12	0.30	142	1.14
	11070	Unnamed	647139	4481750	8/28/2013	1.8	3453	0.35	0.83	233	1.12
	11110	Unnamed	647009	4481384	8/28/2013	0.8	1267	0.13	0.31	140	1.11
	10995	Unnamed	646961	4482353	8/29/2013	1.6	1856	0.19	0.45	224	1.47
Average						2.6	16141	1.61	3.90	376	1.24
SD						3.3	33101	3.31	8.00	412	0.17
Median						1.6	1883	0.19	0.46	197	1.18
Range						0.4 - 15	432 - 121447	0.04 - 12.14	0.10 - 29.35	82 - 1461	1.08 - 1.75



Figure 8. Examples of the variety of Lassen Volcanic National Park ponds and lakes. Widow Lake (10445) – Top, the second largest areal lake sampled; Bottom, Unnamed pond (10564), one of the smaller areal lakes.

Physical substrate

Physical habitat characteristics for the Lassen Volcanic National Park ponds and lakes are presented in Table 3. Secchi Disk clarity is included in this table as a physical measurement, although it is a direct measurement of water clarity. At the majority of sites, the disk was visible through the water column to the bottom, resulting in a reading of NA (not applicable). In these cases, direct readings of turbidity are a better measure of water clarity than the Secchi Disk depth (see Water Quality, below).

The dominant substrate type at most ponds and lakes was fine sediment, although emergent vegetation, detritus, and woody debris were also common substrates. Lake Helen (11076), Unnamed (10968), and Little Bear Lake (10503) stand out as having higher prevalence of coarse substrate than other sites (e.g., boulders, cobbles, and gravel).

Table 3. Physical substrate composition and Secchi Disk depths for ponds and lakes sampled in Lassen Volcanic National Park, 2013.

Type	Site Code	Lake Name	Date Sampled	Secchi Disk Depth (m)	Bedrock	Boulder	Cobble	Gravel	Sand	Fines	Woody Debris	Emergent Vegetation	Submergent Vegetation	Detritus
Judgment	11076	Lake Helen	7/30/2013	NA	0%	12%	31%	34%	21%	0%	0%	0%	0%	0%
Probabilistic Sites	10430	Lily Pond	7/17/2013	0.95	0%	0%	0%	0%	0%	17%	8%	73%	1%	0%
	10793	Summit Lake	7/18/2013	NA	0%	1%	0%	3%	16%	42%	11%	8%	1%	16%
	11211	Unnamed	7/19/2013	NA	0%	0%	10%	3%	0%	43%	11%	10%	4%	19%
	11403	Unnamed	7/22/2013	NA	0%	0%	0%	0%	0%	34%	33%	6%	8%	20%
	11271	Ink Lake	7/23/2013	1.00	0%	0%	0%	0%	0%	5%	5%	90%	0%	0%
	11364	Unnamed	7/24/2013	NA	0%	0%	0%	0%	0%	37%	12%	46%	0%	6%
	10968	Unnamed	7/31/2013	NA	0%	29%	30%	14%	4%	0%	9%	0%	0%	14%
	10980	Cliff Lake	7/31/2013	NA	1%	6%	4%	3%	3%	50%	23%	4%	0%	6%
	11352	Unnamed	8/1/2013	NA	0%	0%	0%	0%	0%	60%	15%	16%	3%	5%
	11354	Unnamed	8/1/2013	NA	0%	3%	7%	0%	0%	77%	0%	0%	13%	0%
	11325	Sifford Lake "5"	8/2/2013	NA	0%	0%	6%	7%	0%	44%	4%	11%	6%	23%
	10803	Unnamed	8/6/2013	NA	0%	4%	0%	0%	0%	52%	15%	18%	8%	5%
	10825	Unnamed	8/6/2013	NA	0%	1%	0%	0%	0%	40%	12%	13%	0%	35%
	10837	Unnamed	8/7/2013	NA	0%	2%	0%	0%	0%	55%	12%	22%	0%	5%
	10807	Unnamed	8/8/2013	NA	0%	6%	0%	0%	0%	52%	5%	14%	2%	22%
	10871	Unnamed	8/8/2013	NA	0%	0%	0%	0%	0%	60%	0%	40%	0%	0%
	10751	Swan Lake	8/9/2013	NA	0%	5%	1%	11%	33%	14%	17%	5%	0%	14%
	10503	Little Bear Lake	8/13/2013	NA	0%	10%	11%	0%	38%	21%	4%	0%	0%	16%
	10470	Silver Lake	8/14/2013	6.90	0%	1%	6%	5%	36%	14%	23%	0%	0%	14%
	10570	Unnamed	8/16/2013	NA	0%	0%	0%	0%	0%	63%	8%	14%	1%	13%
	10445	Widow Lake	8/19/2013	5.63	0%	2%	7%	4%	31%	32%	8%	6%	2%	7%
	10564	Unnamed	8/20/2013	NA	0%	0%	4%	0%	0%	35%	3%	0%	17%	41%
	11040	Unnamed	8/21/2013	NA	0%	1%	1%	0%	0%	58%	17%	10%	8%	5%
	10972	Unnamed	8/27/2013	NA	0%	0%	2%	0%	0%	60%	7%	0%	0%	30%
	11070	Unnamed	8/28/2013	NA	0%	1%	2%	0%	0%	39%	12%	38%	5%	3%
	11110	Unnamed	8/28/2013	NA	0%	0%	3%	0%	0%	79%	10%	8%	0%	0%
	10995	Unnamed	8/29/2013	NA	0%	1%	0%	0%	0%	40%	27%	18%	4%	9%
Average					0%	3%	3%	2%	6%	42%	11%	17%	3%	12%
SD					0%	6%	6%	4%	13%	20%	8%	22%	4%	11%
Median					0%	1%	1%	0%	0%	42%	11%	10%	1%	9%
Range					0 - 1%	0 - 29%	0 - 30%	0 - 14%	0 - 38%	0 - 79%	0 - 33%	0 - 90%	0 - 17%	0 - 41%

Water Chemistry

Water chemistry samples, taken either at the mid-point of shallow ponds (<2 m) or at the near surface and near bottom of deeper lakes, are presented in Table 4.

Because samples are time sensitive, and must be kept on ice (or refrigerated for Dissolved Organic Carbon samples) until immediately before shipping, samples were stored at a housing unit in the Mineral housing quarters for Lassen Volcanic National Park. During the government shutdown from 1 October 1 to 17 October 2013, network staff was unable to access these samples. During this time period, the Lassen Volcanic National Park staff still active were shutting down the units to prevent winter-time damage, and power to the housing unit was shut-off. This resulted in defrosting of the refrigerator and loss of sample integrity. This included four samples of nutrients and anions-cations from the last four ponds sampled in the park, and all samples of Dissolved Organic Carbon collected during the season. These values are not included in park wide averages, medians, or variability (Standard Deviation and Range) of Table 4.

Water Quality

Water quality data, based on *in situ* real-time measurements taken with a probe, are presented in Table 5. The values are the site-specific averages for the depth profile measured, with deeper lakes having more measurements than shallower lakes. Even with this difference in number of measurements, the averages are still the best method for conveying the typical conditions in each lake, representing an integrated depth assessment.

Two ponds and lakes stand out as being different from other ponds and lakes Lassen Volcanic National Park – Ink Lake (11271) and Unnamed 11403 when examining water chemistry and water quality. Both are high in anions and cations, especially SO_4^{2-} (Sulfate, Table 3), and are high in specific conductivity. Both of these lakes occur in the southwest part of the park, in the area of Little Hot Springs Valley, Bumpass Hell, and Sulphur Works areas.

Zooplankton

Zooplankton summary metrics are provided in Table 6. A full listing of zooplankton taxa is presented in Appendix A. The average number of taxa at the probabilistically chosen sites was 13.2, with a minimum of 6 (at Unnamed sites 11364 and 10968) and a maximum of 23 (Lily Pond, 10430). The judgment site, Lake Helen, had three collected taxa. Most of the average taxonomic richness was in Cladoceran diversity.

Littoral Zone Macroinvertebrates

Macroinvertebrate metrics are presented in Table 7, with a complete list of taxa collected available in Appendix B. The highest taxonomic richness was at Lily Pond (10430), a small pond with large amounts of submergent and emergent vegetation. The lowest taxonomic richness was at Unnamed pond 10837. Chironomidae (common name: midges) made up most of the diversity with an average taxonomic richness of 9.19 across the probabilistic choose sites, with a maximum richness of 18 at Swan Lake (10751).

Table 4. Water Chemistry results for ponds and lakes of Lassen Volcanic NP, 2013. Values in grey shading were compromised during storage and not included in park-wide averages (see text for details). Values marked with a * are below the quantifiable limit of the analytical technique, but are still included in the park wide averages.

Type	Site Code	Lake Name	Date	Depth	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Dissolved Organic Carbon (mg/L)
Judgment	11076	Lake Helen	7/30/2013	Shallow	0.04	*0.002	0.12	0.06	0.15	0.1	0.34	0.04	0.63
				Deep	0.06	0.005	0.2	0.19	0.21	0.09	0.47	0.05	0.5
Probabilistic Sites	10430	Lily Pond	7/17/2013	Shallow	0.28	0.097	0.16	*0.01	9.35	2.64	5.77	4.13	3.24
	10793	Summit Lake	7/18/2013	Shallow	0.24	0.011	0.26	*0.01	1.49	0.53	2.52	0.63	2.44
				Deep	0.25	0.01	0.56	0.02	1.76	0.53	2.62	0.64	2.39
	11211	Unnamed	7/19/2013	Shallow	0.44	0.038	0.32	*0.01	0.24	0.08	0.23	0.07	4.03
	11403	Unnamed	7/22/2013	Shallow	0.03	*0.001	0.44	32.73	7.35	1.35	30.56	1.62	0.35
	11271	Ink Lake	7/23/2013	Shallow	0.16	0.015	0.86	29.57	4.32	0.26	39.55	3.52	0.87
				Deep	0.15	0.018	0.29	28.4	3.7	0.27	38.84	3.34	0.54
	11364	Unnamed	7/24/2013	Shallow	0.45	0.018	0.22	0.05	0.62	0.12	0.77	0.16	4.43
	10968	Unnamed	7/31/2013	Shallow	0.17	0.015	0.17	0.02	0.23	0.12	0.72	0.12	1.97
	10980	Cliff Lake	7/31/2013	Shallow	0.12	0.018	0.32	0.24	2.42	0.58	8.54	4.9	0.58
				Deep	0.11	0.021	0.28	0.25	2.42	0.6	8.53	4.92	0.52
	11352	Unnamed	8/1/2013	Shallow	0.67	0.046	0.25	*0.01	0.09	0.47	0.41	0.21	6.69
	11354	Unnamed	8/1/2013	Shallow	0.39	0.025	0.29	*0.01	0.67	0.2	0.77	0.3	2.84
	11325	Sifford Lake "5"	8/2/2013	Shallow	0.33	0.016	0.11	*0.01	0.14	0.21	0.2	0.11	3.87
				Deep	0.37	0.016	0.21	*0.01	0.19	0.21	0.22	0.11	4.03
	10803	Unnamed	8/6/2013	Shallow	0.67	0.042	0.42	0.03	0.3	0.17	0.52	0.43	6.35
	10825	Unnamed	8/6/2013	Shallow	0.72	0.045	0.23	0.05	0.16	0.39	0.35	0.39	6.81
	10837	Unnamed	8/7/2013	Shallow	0.84	0.043	0.21	0.02	0.15	0.37	0.33	0.5	7.84
	10871	Unnamed	8/7/2013	Shallow	1.48	0.086	0.35	*0.00	0.17	0.52	0.63	0.75	15.54
	10807	Unnamed	8/8/2013	Shallow	0.56	0.028	0.16	*0.01	0.17	0.16	0.3	0.48	4.89
	10751	Swan Lake	8/9/2013	Shallow	0.14	0.007	0.17	0.05	0.14	0.17	0.17	0.23	1.42
				Deep	0.13	0.007	0.16	0.05	0.13	0.15	0.16	0.22	1.34
	10503	Little Bear Lake	8/13/2013	Shallow	0.25	0.011	0.33	0.06	0.38	0.39	0.52	0.34	2.25
				Deep	0.23	0.01	0.26	0.05	0.32	0.37	0.53	0.34	2.22
	10470	Silver Lake	8/14/2013	Shallow	0.14	0.004	0.23	0.05	0.36	0.33	0.58	0.38	1.68
				Deep	0.13	0.004	0.23	0.05	0.35	0.32	0.59	0.37	1.63
	10570	Unnamed	8/16/2013	Shallow	0.47	0.025	0.27	*0.00	0.34	0.2	0.41	0.28	5.18
	10445	Widow Lake	8/19/2013	Shallow	0.26	0.007	0.41	*0.00	1.06	0.83	2.15	0.98	2.84
				Deep	0.34	0.013	0.52	*0.01	1.12	0.87	2.43	1.07	2.43
	10564	Unnamed	8/20/2013	Shallow	0.64	0.026	0.22	*0.00	0.2	0.33	0.39	0.71	6.2

Table 4, continued. Water Chemistry results for ponds and lakes of Lassen Volcanic NP, 2013. Values in grey shading were compromised during storage and not included in park-wide averages (see text for details). Values marked with a * are below the quantifiable limit of the analytical technique, but are still included in the park wide averages.

Type	Site Code	Lake Name	Date	Depth	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Dissolved Organic Carbon (mg/L)
Probabilistic Sites, cont.	11040	Unnamed	8/21/2013	Shallow	0.32	0.007	0.26	*0.01	0.46	0.21	0.44	0.71	3.46
				Deep	0.31	0.008	0.39	*0.01	0.51	0.25	0.45	0.72	3.51
	10972	Unnamed	8/27/2013	Shallow	0.43	0.018	1.4	*0.01	1.48	0.2	0.34	0.74	5.48
	11070	Unnamed	8/28/2013	Shallow	0.4	0.013	0.38	*0.00	0.38	0.17	0.26	0.43	4.02
	10995	Unnamed	8/29/2013	Shallow	0.53	0.031	0.21	*0.00	0.21	0.16	0.54	0.56	5.9
	11110	Unnamed	8/29/2013	Shallow	0.69	0.036	0.19	*0.00	0.16	0.06	0.31	0.49	5.22
				Average	0.37	0.023	0.30	3.06	1.29	0.44	4.73	1.05	
				SD	0.29	0.022	0.15	9.23	2.14	0.48	10.63	1.42	
				Median	0.30	0.016	0.26	0.02	0.36	0.33	0.56	0.46	
				Range	0.03 - 1.48	0.001 - 0.097	0.11 - 0.86	0.00 - 32.73	0.09 - 9.35	0.08 - 2.64	0.16 - 39.55	0.07 - 4.95	

Table 5. Averaged water quality profiles for ponds and lakes of Lassen Volcanic National Park, 2013.

Type	Site Code	Lake Name	Date Sampled	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)	Oxidation-Reduction Potential (mV)	Specific Conductivity (µS/cm)	Temperature (°C)	pH
Judgment	11076	Lake Helen	7/30/2013	126.8	10.3	0.0	119.2	3.6	12.0	6.62
	10430	Lily Pond	7/17/2013	61.8	5.2	121.6	-15.0	105.8	13.4	6.88
	10793	Summit Lake	7/18/2013	102.2	7.3	14.9	73.0	22.0	20.3	7.49
	11211	Unnamed	7/19/2013	89.5	6.2	12.1	133.0	2.8	20.6	4.91
	11403	Unnamed	7/22/2013	122.0	10.5	0.7	140.3	242.0	10.9	5.42
	11271	Ink Lake	7/23/2013	91.2	7.4	0.0	84.1	255.3	13.3	7.14
	11364	Unnamed	7/24/2013	87.3	6.0	3.7	90.7	7.0	21.0	6.72
	10968	Unnamed	7/31/2013	98.6	6.7	0.1	132.3	5.0	20.9	6.78
	10980	Cliff Lake	7/31/2013	102.1	8.0	126.7	281.9	93.6	14.4	8.80
	11352	Unnamed	8/1/2013	85.3	6.1	2.8	143.7	5.7	19.4	5.24
	11354	Unnamed	8/1/2013	108.9	7.8	0.0	213.0	9.0	19.4	7.35
	11325	Sifford Lake "5"	8/2/2013	99.6	7.1	1.2	335.5	5.3	18.7	5.54
	10803	Unnamed	8/6/2013	74.1	5.7	5.9	165.0	7.3	15.6	5.78
	10825	Unnamed	8/6/2013	96.0	7.0	1.0	154.0	7.0	18.4	5.86
	10837	Unnamed	8/7/2013	93.1	6.9	2.4	180.5	7.0	17.7	5.78
	10807	Unnamed	8/8/2013	95.9	7.2	0.1	165.0	6.0	17.6	6.08
	10871	Unnamed	8/8/2013	74.2	5.8	2.9	188.0	10.0	15.0	5.59
	10751	Swan Lake	8/9/2013	108.0	7.7	0.0	170.6	4.0	20.0	6.47
	10503	Little Bear Lake	8/13/2013	120.3	8.7	0.0	156.3	8.0	19.2	6.97
	10470	Silver Lake	8/14/2013	116.6	8.3	0.0	165.6	9.0	20.0	7.04
	10570	Unnamed	8/16/2013	96.6	7.0	44.3	153.8	6.0	18.4	6.57
	10445	Widow Lake	8/19/2013	94.4	6.8	1.0	122.5	26.4	19.5	8.71
	10564	Unnamed	8/20/2013	82.7	5.8	2.7	134.7	9.0	19.7	6.27
	11040	Unnamed	8/21/2013	104.5	7.3	19.2	315.6	16.0	20.2	7.12
	10972	Unnamed	8/27/2013	86.3	6.5	14.4	121.0	9.0	16.4	7.13
	11070	Unnamed	8/28/2013	97.6	7.3	2.4	93.8	5.8	17.0	6.64
	11110	Unnamed	8/28/2013	75.0	5.7	1.6	114.5	6.0	15.9	6.10
	10995	Unnamed	8/29/2013	83.1	6.3	1.2	138.0	8.0	16.1	6.13
Probabilistic Sites	Average			94.3	7.0	14.2	153.8	33.3	17.7	7.68
	SD			14.4	1.1	33.1	71.9	66.9	2.7	0.9
	Median			95.9	7.0	2.4	143.7	8.0	18.4	6.6
	Range			61.8 - 122.0	5.2 - 10.5	0 - 126.7	-350.5	2.8 - 255.3	10.9 - 21.0	4.9 - 8.8

Table 6. Zooplankton metrics for ponds and lakes sampled at Lassen Volcanic National Park, 2013. Other richness includes aquatic mites and insect larvae.

Type	Site Code	Lake Name	Date Sampled	Taxa richness	Cladoceran richness	Calanoida richness	Rotifer richness	Cyclopoida richness	Other richness	Shannon Diversity	Evenness
Judgment	11076	Lake Helen	7/30/2013	3	2	0	0	0	1	1.10	1.00
	10430	Lily Pond	7/17/2013	23	8	0	1	4	10	1.66	0.53
	10793	Summit Lake	7/18/2013	17	5	4	3	3	2	1.95	0.69
	11211	Unnamed	7/19/2013	12	5	2	2	1	2	0.93	0.37
	11403	Unnamed	7/22/2013	8	3	2	0	0	3	1.35	0.65
	11271	Ink Lake	7/23/2013	11	6	0	0	3	2	1.04	0.43
	11364	Unnamed	7/24/2013	6	2	2	1	0	1	1.03	0.58
	10968	Unnamed	7/31/2013	6	1	3	0	1	1	0.31	0.17
	10980	Cliff Lake	7/31/2013	7	3	3	0	1	0	0.64	0.33
	11352	Unnamed	8/1/2013	17	7	2	5	2	1	1.22	0.43
	11354	Unnamed	8/1/2013	8	3	3	1	0	1	0.72	0.34
	11325	Sifford Lake "5"	8/2/2013	16	6	4	2	1	3	1.20	0.43
	10803	Unnamed	8/6/2013	20	7	2	3	3	5	1.72	0.57
	10825	Unnamed	8/6/2013	14	7	2	1	0	4	1.78	0.67
	10837	Unnamed	8/7/2013	17	8	2	4	0	3	1.62	0.57
	10807	Unnamed	8/8/2013	21	8	2	3	3	5	1.92	0.63
	10871	Unnamed	8/8/2013	15	6	2	2	2	3	1.77	0.65
	10751	Swan Lake	8/9/2013	11	4	3	2	2	0	1.61	0.67
	10503	Little Bear Lake	8/13/2013	8	4	3	1	0	0	1.14	0.55
	10470	Silver Lake	8/14/2013	11	3	5	2	1	0	1.55	0.64
	10570	Unnamed	8/16/2013	14	6	3	2	1	2	0.15	0.06
	10445	Widow Lake	8/19/2013	11	6	2	1	1	1	0.69	0.29
	10564	Unnamed	8/20/2013	15	8	2	1	2	2	1.94	0.72
	11040	Unnamed	8/21/2013	12	4	2	0	3	3	1.30	0.52
	10972	Unnamed	8/27/2013	14	8	2	2	2	0	1.66	0.63
	11070	Unnamed	8/28/2013	15	5	2	1	3	4	1.69	0.62
	11110	Unnamed	8/28/2013	14	7	2	3	0	2	1.95	0.74
	10995	Unnamed	8/29/2013	14	6	2	2	2	2	0.60	0.23
	Average			13.2	5.4	2.3	1.7	1.5	2.3	1.30	0.51
	SD			4.4	2.0	1.0	1.3	1.2	2.1	0.53	0.18
	Median			14.0	6.0	2.0	2.0	1.0	2.0	1.35	0.57
	Range			6 - 23	1 - 8	0 - 5	0 - 5	0 - 4	0 - 10	0.15 - 1.95	0.05 - 0.74

Table 7. Macroinvertebrates collected in pond and lake littoral zones in Lassen Volcanic National Park, 2013.

Type	Site Code	Lake Name	Date Sampled	Total Taxa Richness	Ephemeroptera Richness	Trichoptera Richness	Odonata Richness	Coleoptera Richness	Diptera Richness (non-Chironomidae)	Chironomidae Richness	Shannon Diversity	Evenness
Judgment	11076	Lake Helen	7/30/2013	9	0	1	0	2	0	4	2.24	0.94
Probabilistic Sites	10430	Lily Pond	7/17/2013	45	1	0	0	7	6	13	2.44	0.63
	10793	Summit Lake	7/18/2013	28	1	3	2	0	1	14	1.78	0.53
	11211	Unnamed	7/19/2013	29	0	3	3	3	0	13	2.35	0.68
	11403	Unnamed	7/22/2013	14	0	1	0	1	0	8	1.60	0.61
	11271	Ink Lake	7/23/2013	23	2	0	0	1	2	9	2.27	0.72
	11364	Unnamed	7/24/2013	22	0	1	1	1	2	8	2.22	0.72
	10968	Unnamed	7/31/2013	9	1	1	0	2	0	4	2.11	0.88
	10980	Cliff Lake	7/31/2013	27	0	1	1	1	0	11	2.22	0.64
	11352	Unnamed	8/1/2013	9	1	1	0	4	1	1	1.86	0.85
	11354	Unnamed	8/1/2013	20	0	2	1	0	1	9	1.53	0.50
	11325	Sifford Lake "5"	8/2/2013	25	1	4	2	2	1	9	2.29	0.70
	10803	Unnamed	8/6/2013	5	0	1	0	1	0	1	0.29	0.18
	10825	Unnamed	8/6/2013	42	0	2	4	4	1	12	2.64	0.70
	10837	Unnamed	8/7/2013	3	0	1	0	0	0	1	0.80	0.72
	10807	Unnamed	8/8/2013	21	0	0	1	4	0	11	1.23	0.40
	10871	Unnamed	8/8/2013	27	0	2	3	2	1	10	2.41	0.71
	10751	Swan Lake	8/9/2013	44	1	4	3	3	1	18	2.63	0.69
	10503	Little Bear Lake	8/13/2013	33	1	4	2	2	3	12	2.70	0.75
	10470	Silver Lake	8/14/2013	44	2	4	2	5	3	15	2.84	0.75
	10570	Unnamed	8/16/2013	19	0	1	2	2	2	6	1.58	0.53
	10445	Widow Lake	8/19/2013	36	3	5	3	0	3	13	2.43	0.67
	10564	Unnamed	8/20/2013	7	0	1	0	0	1	3	1.19	0.61
	11040	Unnamed	8/21/2013	22	1	2	2	1	3	7	2.33	0.74
	10972	Unnamed	8/27/2013	23	0	1	2	2	1	9	2.19	0.70
	11070	Unnamed	8/28/2013	28	1	3	2	1	3	11	2.15	0.65
	11110	Unnamed	8/28/2013	18	0	2	0	1	2	6	2.15	0.74
	10995	Unnamed	8/29/2013	25	1	1	1	0	0	14	2.22	0.68
Average				24	0.63	1.89	1.37	1.85	1.41	9.19	2.02	0.66
SD				11.77	0.79	1.40	1.21	1.75	1.42	4.48	0.60	0.14
Median				23	0	1	1	1	1	9	2.22	0.69
Range				3 - 45	0 - 3	0 - 5	0 - 4	0 - 7	0 - 6	1 - 18	0.29 - 2.84	0.18 - 0.88

Vertebrates

Only four vertebrate species were collected or observed using gill nets and visual encounter surveys (Table 8). Long-toed Salamanders (*Ambystoma macrodactylum*) were seen at seven sites, and most abundant at Unnamed pond 11354. Western Toads (*Anaxyrus boreas*) were observed only at Cliff Lake (10980), although in large numbers. Pacific Tree Frogs (*Pseudacris regilla*) were the most common and widespread at 21 of the 27 probabilistic sites. Gill netting only captured one fish species, Golden Shiners (*Notemigonus crysoleucas*), at Widow Lake (10445). Golden Shiners are an exotic minnow introduced from eastern North America, and spread around the state of California in the 1950s as a bait fish (Moyle, 2002). Although no trout were caught in the gill net, an unidentified trout carcass was observed at Summit Lake (10793) during the habitat walk-around.

Table 8. Number of vertebrates encountered at Lassen Volcanic National Park sampling sites during gill netting and visual encounter surveys, 2013. Blanks indicate none encountered.

Type	Site Code	Lake Name	Date Sampled	Long-toed Salamander (<i>Ambystoma macrodactylum</i>)	Western Toad (<i>Anaxyrus boreas</i>)	Pacific Tree Frog (<i>Pseudacris regilla</i>)	Golden Shiner (<i>Notemigonus crysoleucas</i>)
Judgment	11076	Lake Helen	7/30/2013				
	10430	Lily Pond	7/17/2013				
Probabilistic Sites	10793	Summit Lake	7/18/2013			1	
	11211	Unnamed	7/19/2013			4	
	11403	Unnamed	7/22/2013			2	
	11271	Ink Lake	7/23/2013			2	
	11364	Unnamed	7/24/2013				
	10968	Unnamed	7/31/2013				
	10980	Cliff Lake	7/31/2013		363	520	
	11352	Unnamed	8/1/2013	6		6	
	11354	Unnamed	8/1/2013	46		779	
	11325	Sifford Lake"5"	8/2/2013			3	
	10803	Unnamed	8/6/2013	5		222	
	10825	Unnamed	8/6/2013	1			
	10837	Unnamed	8/7/2013	1		2	
	10807	Unnamed	8/8/2013	1		1	
	10871	Unnamed	8/8/2013			6	
	10751	Swan Lake	8/9/2013			3	
	10503	Little Bear Lake	8/13/2013			1	
	10470	Silver Lake	8/14/2013				
	10570	Unnamed	8/16/2013			13	
	10445	Widow Lake	8/19/2013			4	21
	10564	Unnamed	8/20/2013			4	
	11040	Unnamed	8/21/2013	1		19	
	10972	Unnamed	8/27/2013			2	
	11070	Unnamed	8/28/2013			3	
	11110	Unnamed	8/28/2013			9	
	10995	Unnamed	8/29/2013				

Crater Lake National Park

Sampling occurred in Crater Lake National Park from 4 September 2013 to 9 September 2013. A total of six mountain ponds and lakes were found to be potentially perennial from site visits in 2008 (25 visited) and 2013 (16 visited). Some of the sites visited in 2013 may have contained water, but were not characteristic of ponds or lakes and were more typical of a wetland with a portion of open water (e.g., Figure 9, CRLAWQL02 [UTM coordinates: 561013, 4760592]). Many of the sites visited in 2008 were deemed to be unsuitable and were not re-visited in 2013 (e.g., Figure 10). All of the six sites sampled comprise the known population of perennial lentic habitats in Crater Lake National Park outside of the caldera sampleable under this protocol (see Appendix G for map and listing of sites visited).



Figure 9. Unnamed site CRLAWQL02, unsuitable for lake-pond sampling. Crew leader Kirsten Underwood recording visit notes.



Figure 10. Dry site at Crater Lake during 2008 pilot study. Crew member Gwen Meyer at right (October 29th, 2008; UTM: 560487, 4767102).

The six ponds sampled were mostly shallow (maximum depth was 1.8 m at CRLAWQL04, Spruce Lake) and located in the southwest portion of the park (except for Spruce Lake; Figure 11). Table 9 presents basic morphometric and location data for the six ponds sampled. The average surface area was 0.20 hectares, with the largest being Spruce Lake at 0.51 hectares. Spruce Lake, despite the name, is more representative of a pond than a lake (see Figure 12 for examples of sampled Crater Lake National Park lentic habitats).

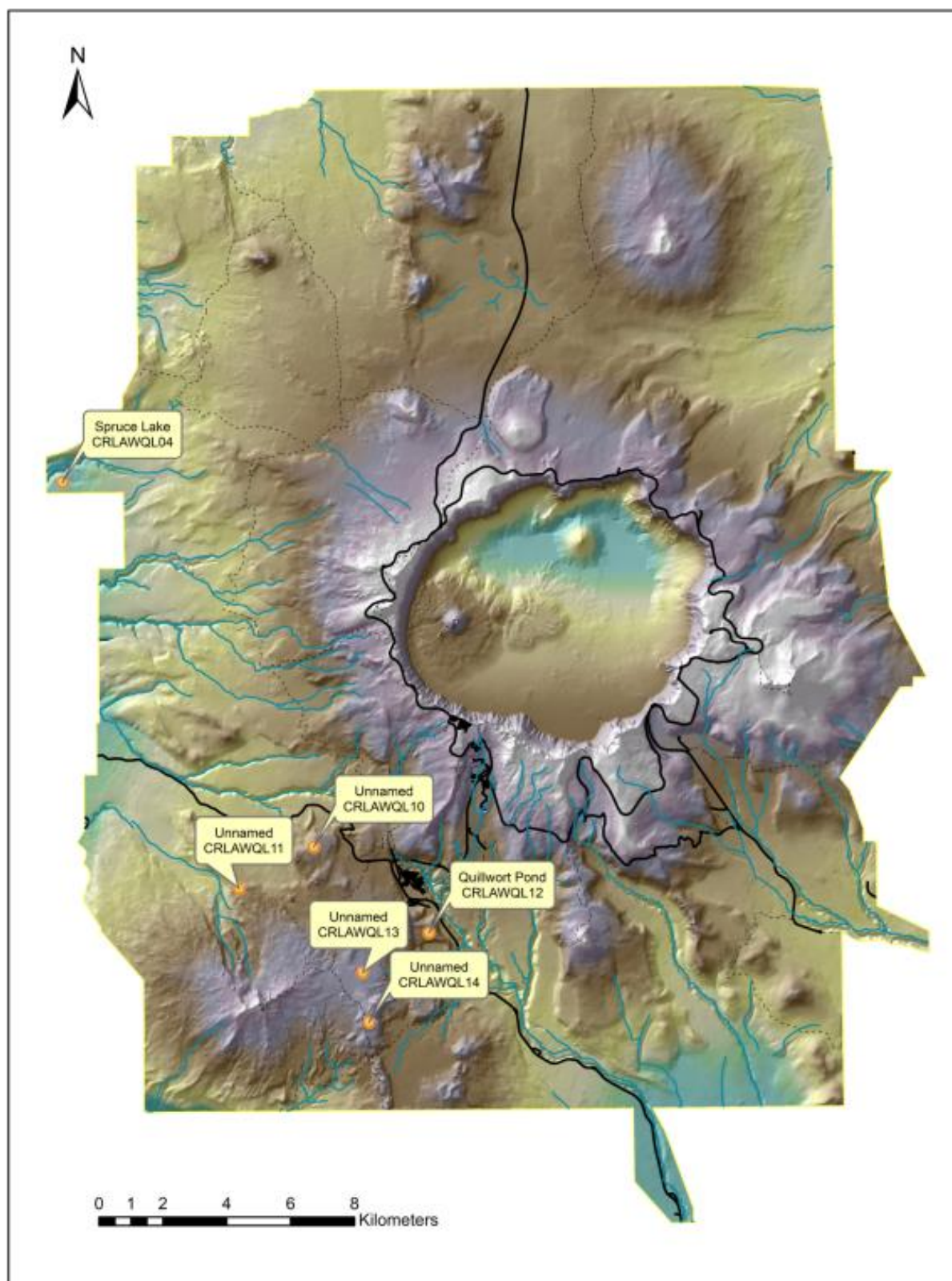


Figure 11. Locations of ponds sampled in Crater Lake National Park, 2013. Sites represent all known, potentially perennial lentic habitats for the park outside of the caldera.

Table 9. Morphometric and location data for ponds sampled in Crater Lake National Park, 2013. Note that all six sites comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	UTM Coordinate		Date Sampled	Max Depth (m)	Area			Circumference (m)	Shoreline Development
		X	Y			Square meters	Hectare	Acre		
CRLAWQL04	Spruce Lake	557283	4758703	9/4/2013	1.8	5135	0.51	1.24	440	1.73
CRLAWQL10	Unnamed	565230	4747315	9/7/2013	0.5	658	0.07	0.16	105	1.16
CRLAWQL11	Unnamed	562885	4746009	9/7/2013	0.4	179	0.02	0.04	59	1.25
CRLAWQL13	Unnamed	566744	4743376	9/8/2013	0.5	843	0.08	0.20	137	1.33
CRLAWQL14	Unnamed	566953	4741818	9/8/2013	0.6	2133	0.21	0.52	289	1.77
CRLAWQL12	Quillwort Pond	568837	4744618	9/9/2013	0.9	2888	0.29	0.70	227	1.19
Average					0.8	1973	0.20	0.48	210	1.41
SD					0.5	1849	0.18	0.45	140	0.27
Median					0.6	1488	0.15	0.36	182	1.29
Range					0.4 - 1.8	178 - 5135	0.02 - 0.51	0.04 - 1.24	59 - 440	1.16 - 1.77



Figure 12. Three characteristic ponds sampled in Crater Lake National Park, 2013. Left: CRLAWQL11; Center: CRLAWQL10, Right: CRLAWQL13.

Physical Substrate

Physical habitat characteristics for the Crater Lake National Park ponds are presented in Table 10. Secchi Disk depth is included in this table as a physical measurement, although it is a direct measurement of water clarity which is affected by sediments and algal growth. In four of the six sites, the disk was visible through the water column to the bottom of the pond, resulting in a reading of NA (not applicable). In these cases, direct readings of turbidity are a better measure of water clarity (see Water Quality, below).

The physical substrate of the sites was characteristic of late successional ponds, with fine sediments the most dominant substrate type (e.g., an average of 47% and as high as 90% in CRLAWQL11). There were no coarse substrates observed (gravel or larger) at the six sites.

Water Chemistry

The six sampled sites in Crater Lake National Park were shallow (<2 m), so only a single sample was collected for each site at the midpoint of the water column (Table 11). At two sites, CRLAWQL11 and CRLAWQL13, the water was so turbid that filtering the samples for anions and cations was not possible. Both of these sites were characterized by high Total Nitrogen and Total Phosphorous concentrations; for example, the Total Nitrogen concentration at CRLAWQL11 was almost 32 times higher than at Spruce Lake.

Water Quality

Water quality data, based on *in situ* real-time measurements taken with a probe, are presented in Table 12. The values are the site-specific averages for the depth profile measured, with deeper lakes having more measurements than shallower lakes. Even with this difference in number of measurements, the averages are still the best method for conveying the typical conditions in each site, representing an integrated depth assessment. These ponds are also so shallow that many of them have depth profiles of only three readings; one at the surface, one at the 0.5 m depth, and one reading just above the pond bottom.

Zooplankton

Zooplankton summary metrics are provided in Table 13. A full listing of zooplankton taxa collected is presented in Appendix C. The average number of taxa at each site was 14.3, with the highest number of taxa ($n = 20$) at CRLAWQL11, and the least ($n = 7$) at CRLAWQL14. Cladocerans made up most of the taxonomic richness, with an average of 5.2 taxa per site. Other taxa collected in zooplankton tows (i.e., mostly aquatic mites and insect larvae) were also high on average, with 4.3 taxa per site.

Littoral Zone Macroinvertebrates

Macroinvertebrate metrics are presented in Table 14, with a full list of taxa collected presented in Appendix D. The highest taxonomic richness ($n = 29$ taxa) was at Spruce Lake (CRLAWQL04), whereas the lowest richness was at CRLAWQL11 ($n = 8$ taxa). At Spruce Lake, Chironomidae ($n = 13$ taxa) accounted for most of the macroinvertebrate diversity. Spruce Lake was also the only site where mayflies of the genus *Callibaetis* (Ephemeroptera,) were collected.

Table 10. Physical substrate composition and Secchi Disk depths for ponds sampled in Crater Lake National Park, 2013. Note that all six sites comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	Date Sampled	Secchi Disk Depth	Bedrock	Boulder	Cobble	Gravel	Sand	Fines	Woody Debris	Emergent Vegetation	Submergent Vegetation	Detritus
CRLAWQL04	Spruce Lake	9/4/2013	NA	0%	0%	0%	0%	0.0%	55%	6%	31%	4%	4%
CRLAWQL10	Unnamed	9/7/2013	NA	0%	0%	0%	0%	0.0%	77%	6%	13%	4%	0%
CRLAWQL11	Unnamed	9/7/2013	NA	0%	0%	0%	0%	0.0%	90%	9%	0%	0%	1%
CRLAWQL13	Unnamed	9/8/2013	0.03	0%	0%	0%	0%	0.7%	88%	8%	0%	0%	3%
CRLAWQL14	Unnamed	9/8/2013	0.28	0%	0%	0%	0%	0.0%	84%	8%	1%	0%	8%
CRLAWQL12	Quillwort Pond	9/9/2013	NA	0%	0%	0%	0%	0.0%	47%	8%	19%	26%	0%
Average				0%	0%	0%	0%	0.1%	74%	7%	11%	6%	3%
SD				0%	0%	0%	0%	0.3%	18%	1%	13%	10%	3%
Median				0%	0%	0%	0%	0.0%	80%	8%	7%	2%	2%
Range				NA	NA	NA	NA	0 - 0.7%	47 - 90%	6 - 9%	0 - 31%	0 - 26%	0 - 8%

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Table 11. Water chemistry results for the ponds of Crater Lake National Park, 2013. All samples were taken at the mid-point of the water column. NA indicates that the water was too turbid to filter in the field. Values marked with an asterisk (*) are below the quantifiable limit of the analytical technique, but are still included in the park wide averages. Note that all six sites comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	Date	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Dissolved Organic Carbon (mg/L)
CRLAWQL04	Spruce Lake	9/4/2013	0.44	0.018	0.50	*0.01	4.31	2.54	3.10	0.93	3.29
CRLAWQL10	Unnamed	9/7/2013	1.74	0.185	0.67	0.02	0.16	0.62	0.50	0.10	10.67
CRLAWQL11	Unnamed	9/7/2013	14.01	3.487	NA	NA	NA	NA	NA	NA	NA
CRLAWQL13	Unnamed	9/8/2013	6.35	1.617	NA	NA	NA	NA	NA	NA	8.46
CRLAWQL14	Unnamed	9/8/2013	2.14	0.517	1.04	*0.01	0.30	0.63	0.48	0.08	14.55
CRLAWQL12	Quillwort Pond	9/9/2013	0.51	0.034	0.57	*0.01	0.12	0.08	0.34	0.08	4.61
Average			4.20	0.976	0.70	0.013	1.22	0.97	1.11	0.30	8.32
SD			5.27	1.368	0.24	0.005	2.06	1.08	1.33	0.42	4.57
Median			1.94	0.351	0.62	0.01	0.23	0.63	0.49	0.09	8.46
Range			0.44 - 14.01	0.018 - 3.487	0.5 - 1.04	0.01 - 0.02	0.12 - 4.31	0.08 - 2.54	0.34 - 3.1	0.08 - 0.93	3.29 - 14.55

Table 12. Averaged water quality probe profiles for ponds of Crater Lake National Park, 2013. Note that all six sites comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	Date Sampled	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)	Oxidation-Reduction Potential (mV)	Specific Conductivity (μS/cm)	Temperature (°C)	pH
CRLAWQL04	Spruce Lake	9/4/2013	93.5	8.0	1.5	150.8	47.3	14.3	7.48
CRLAWQL10	Unnamed	9/7/2013	83.7	6.1	196.0	98.0	7.0	19.5	5.56
CRLAWQL11	Unnamed	9/7/2013	69.5	6.0	649.5	128.5	17.0	12.2	6.35
CRLAWQL13	Unnamed	9/8/2013	75.2	6.4	274.3	108.5	8.0	12.0	5.76
CRLAWQL14	Unnamed	9/8/2013	64.3	5.3	1.6	106.0	9.0	13.3	5.75
CRLAWQL12	Quillwort Pond	9/9/2013	83.7	6.5	0.0	90.0	8.0	16.5	5.37
Average			78.3	6.4	187.1	113.6	16.0	14.6	6.0
SD			10.7	0.9	255.1	22.3	15.7	2.9	0.78
Median			79.4	6.2	98.8	107.3	8.5	13.8	5.8
Range			64.3 - 93.5	5.3 - 8.0	0 - 649.5	90.0 - 150.8	7.0 - 47.3	12.0 - 19.5	5.4 - 7.5

Table 13. Zooplankton metrics for ponds sampled in Crater Lake National Park, 2013. Other richness includes aquatic mites and insect larvae. Note that all six sites comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	Date Sampled	Taxa richness	Cladoceran richness	Calanoida richness	Rotifer richness	Cyclopoida richness	Other richness	Shannon Diversity	Evenness
CRLAWQL04	Spruce Lake	9/4/2013	18	7	2	2	2	5	0.88	0.31
CRLAWQL10	Unnamed	9/7/2013	14	5	2	1	3	3	1.19	0.45
CRLAWQL11	Unnamed	9/7/2013	20	6	2	1	3	8	2.21	0.74
CRLAWQL13	Unnamed	9/8/2013	17	6	2	0	3	6	1.27	0.45
CRLAWQL14	Unnamed	9/8/2013	7	3	1	0	2	1	0.49	0.25
CRLAWQL12	Quillwort Pond	9/9/2013	10	4	2	1	0	3	0.43	0.19
Average			14.3	5.2	1.8	0.8	2.2	4.3	1.08	0.40
SD			5.0	1.5	0.4	0.8	1.2	2.5	0.65	0.20
Median			15.5	5.5	2.0	1.0	2.5	4.0	1.03	0.38
Range			7 - 20	3 - 7	1 - 2	0 - 2	0 - 3	1 - 8	0.43 - 2.21	0.19 - 0.74

Table 14. Macroinvertebrates collected from ponds in Crater Lake National Park, 2013. Note that all six habitats comprise the known population of perennial lentic habitats in the park outside of the caldera (excluding one unsampleable under this protocol).

Site Code	Lake Name	Date Sampled	Total Taxa Richness	Ephemeroptera Richness	Trichoptera Richness	Odonata Richness	Coleoptera Richness	Diptera Richness (non-Chironomidae)	Chironomidae Richness	Shannon Diversity	Evenness
CRLAWQL04	Spruce Lake	9/4/2013	29	1	1	2	1	2	13	2.54	0.75
CRLAWQL10	Unnamed	9/7/2013	9	0	0	0	0	0	6	1.32	0.60
CRLAWQL11	Unnamed	9/7/2013	8	0	0	1	1	0	5	1.27	0.61
CRLAWQL13	Unnamed	9/8/2013	9	0	1	0	1	0	6	1.16	0.53
CRLAWQL14	Unnamed	9/8/2013	13	0	0	1	0	1	8	1.81	0.71
CRLAWQL12	Quillwort Pond	9/9/2013	18	0	1	1	0	3	9	1.37	0.47
Average			14.3	0.2	0.5	0.8	0.5	1.0	7.8	1.58	0.61
SD			8.1	0.4	0.5	0.8	0.5	1.3	2.9	0.52	0.10
Median			11	0	0.5	1	0.5	0.5	7	1.34	0.61
Range			8 - 29	0 - 1	0 - 1	0 - 2	0 - 1	0 - 3	5 - 13	1.16 - 2.54	0.47 - 0.75

Vertebrates

Four amphibian species were recorded during visual encounter surveys (Table 15). Most ponds were too shallow for the deployment of gill nets, and no visible signs of fish were observed at any of the ponds. Individuals of the salamander genus *Ambystoma* spp. were the most numerous and widespread of the amphibians observed; two species are believed to occur in the park, *A. macrodactylum* and *A. gracile*, but distinguishing larval forms of these species is difficult. Observation of the Cascades Frog (*Rana cascadae*) during visual encounter surveys is notable because this species has been extirpated from Lassen Volcanic National Park but is still present in Crater Lake National Park (Figure 13).

Table 15. Number of vertebrates encountered at Crater Lake National Park sampling sites during visual encounter surveys, 2013. Blanks indicate none encountered.

Site Code	Lake Name	Date Sampled	Unknown Salamander (<i>Ambystoma</i> spp.)	Rough-skinned Newt (<i>Tarichia granulosa</i>)	Pacific Tree Frog (<i>Pseudacris regilla</i>)	Cascades Frog (<i>Rana cascadae</i>)
CRLAWQL04	Spruce Lake	9/4/2013	3	2		5
CRLAWQL10	Unnamed	9/7/2013	1			
CRLAWQL11	Unnamed	9/7/2013	1		5	
CRLAWQL13	Unnamed	9/8/2013	180			
CRLAWQL14	Unnamed	9/8/2013				
CRLAWQL12	Quillwort Pond	9/9/2013			1	2

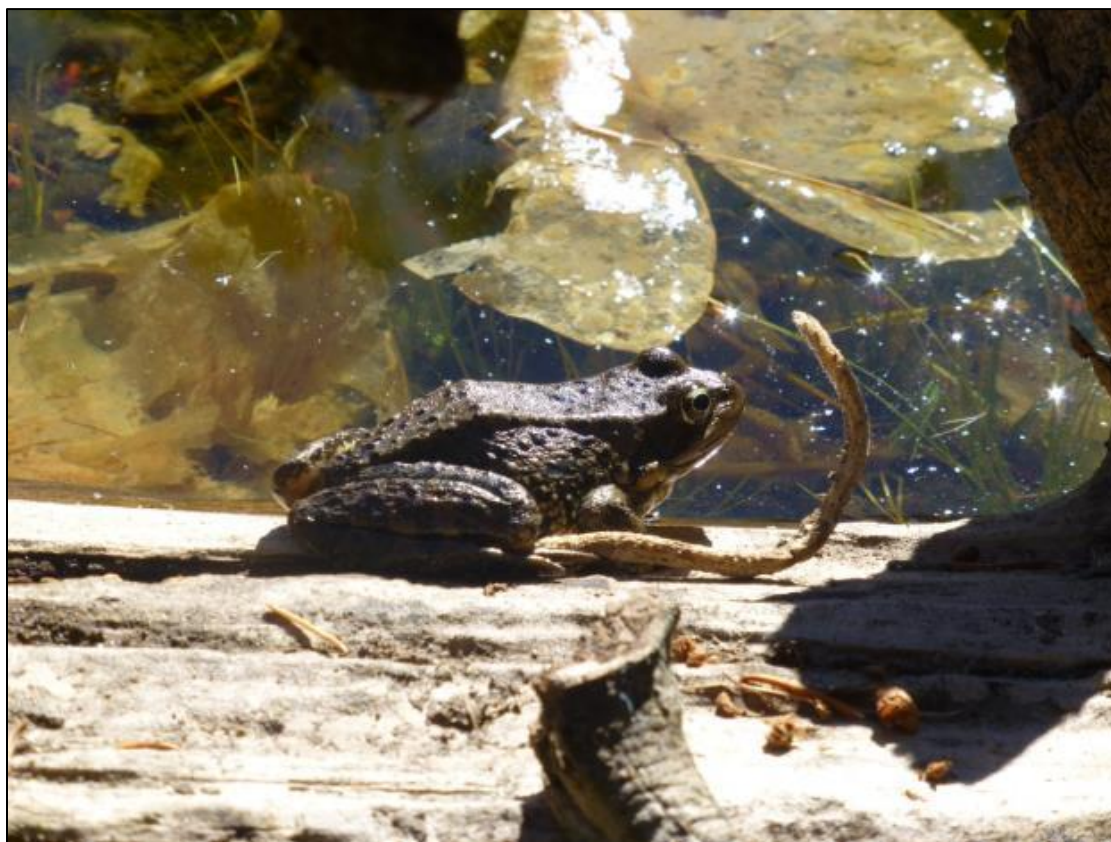


Figure 13. Cascades Frog, *Rana cascadae*, at Quillwort Pond (CRLAWQL12).

Redwood National Park

Sampling in Redwood National Park occurred on 17-18 September 2013, at the single judgment site, Freshwater Lagoon (Table 16, Figure 14). The size of the lagoon (approximately 7 times as big as the largest lake in Lassen Volcanic National Park), in addition to the copious amounts of vegetation, necessitated that the sampling occur over two days.

Physical Substrate

The physical habitat comprising Freshwater Lagoon was largely emergent vegetation (38%), fine sediment (26%), and sand (24%) (Table 17). The dominance of emergent vegetation is clear in Figure 15. Secchi Disk clarity was included in this table as a physical measurement, although it is a direct measurement of water clarity.

Water Chemistry

Water chemistry samples, taken at both 0.5 m below the water surface and at 0.5 m above the lagoon bottom, are presented in Table 18.

Water Quality

Water quality data, based on *in situ* real-time measurements taken with a probe, are presented in Table 19. The values represent a single average for each parameter and are the averages for the depth profile of Freshwater Lagoon.

Zooplankton and Littoral Zone Macroinvertebrates

Zooplankton summary metrics are provided in Table 20, and littoral zone macroinvertebrate metrics in Table 21. Littoral zone macroinvertebrates included two introduced exotic species, the Chinese mystery snail (*Bellamya chinensis*; synonym *Cipangopaludina chinensis*) and the Asian clam (*Corbicula fluminea*). Both have been introduced from Asia as a culinary food source in the late 1800s and early 1900s. All zooplankton and macroinvertebrate taxa collected are listed in Appendixes E and F.

Table 16. Morphometric and location data for Freshwater Lagoon sampled in Redwood National Park, 2013.

Site Code	Lake Name	UTM Coordinate		Date Sampled	Max Depth (m)	Area			Circumference (m)	Shoreline Development
		X	Y			Square meters	Hectare	Acre		
REDW Lagoon	Freshwater Lagoon	408293	4569528	9/17/2013	3.1	861955	86.20	208.34	5152	1.57

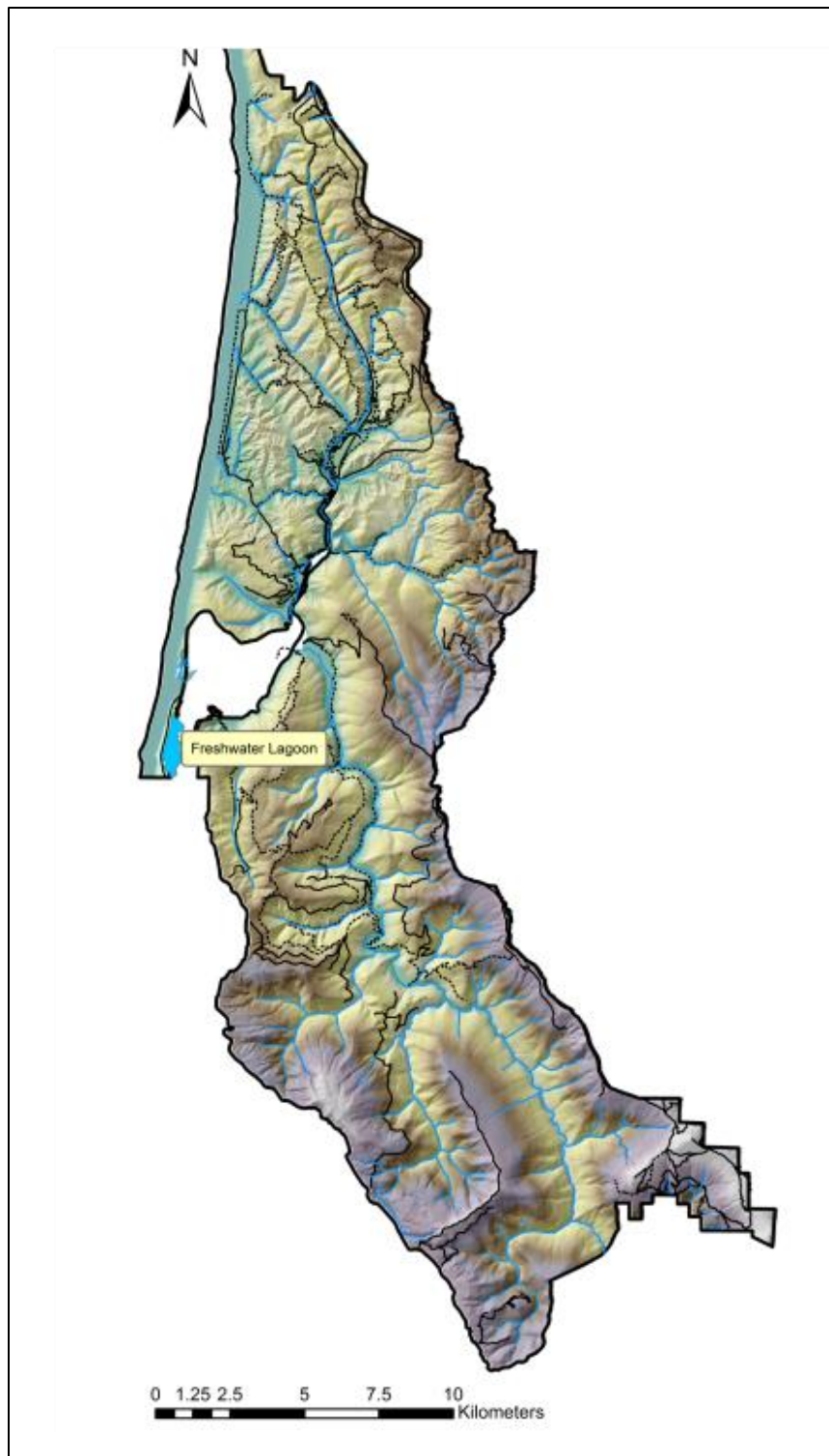


Figure 14. Location of Freshwater Lagoon in the southern portion of Redwood National Park, sampled in 2013.

Table 17. Physical substrate composition and Secchi Disk depth of Freshwater Lagoon sampled in Redwood National Park, 2013.

Site Code	Lake Name	Date Sampled	Secchi Disk Depth (m)	Bedrock	Boulder	Cobble	Gravel	Sand	Fines	Woody Debris	Emergent Vegetation	Submergent Vegetation	Detritus
REDW Lagoon	Freshwater Lagoon	9/17/2013	0.95	0%	0%	2%	5%	24%	26%	0%	38%	3%	1%

Table 18. Water chemistry results for Freshwater Lagoon sampled in Redwood National Park, 2013.

Site Code	Lake Name	Date	Depth	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Dissolved Organic Carbon (mg/L)
REDW Lagoon	Freshwater Lagoon	9/17/2013	Shallow	0.45	0.033	35.14	2.42	19.59	1.87	3.07	3.18	4.29
		9/17/2013	Deep	0.48	0.039	35.17	2.42	19.97	1.83	3.08	3.17	4.04

Table 19. Averaged water quality profile for Freshwater Lagoon, Redwood National Park, 2013.

Site Code	Lake Name	Date Sampled	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)	Oxidation-Reduction Potential (mV)	Specific Conductivity (µS/cm)	Temperature (°C)	pH
REDW Lagoon	Freshwater Lagoon	9/17/2013	96.9	8.7	0.82	132.8	165.0	20.6	6.67

Table 20. Zooplankton metrics for Freshwater Lagoon, Redwood National Park, 2013. Other richness includes aquatic mites and insect larvae.

Site Code	Lake Name	Date Sampled	Taxa richness	Cladoceran richness	Calanoida richness	Rotifer richness	Cyclopoida richness	Other richness	Shannon Diversity	Evenness
REDW Lagoon	Freshwater Lagoon	9/17/2013	17	7	4	3	1	2	0.7013	0.2475

Table 21. Littoral zone macroinvertebrate metrics for Freshwater Lagoon, Redwood National Park, 2013.

Site Code	Lake Name	Date Sampled	Total Taxa Richness	Ephemeroptera Richness	Trichoptera Richness	Odonata Richness	Coleoptera Richness	Diptera Richness (non-Chironomidae)	Chironomidae Richness	Shannon Diversity	Evenness
REDW Lagoon	Freshwater Lagoon	9/17/2013	24	0	0	3	1	2	3	1.614	0.4793



Figure 15. Freshwater Lagoon at Redwood National Park, showing abundance of inundated grasses along the shoreline. Freshwater Lagoon is large compared to the other sites sampled at Lassen Volcanic and Crater Lake National Parks.

Vertebrates

Two species of vertebrates were encountered in Freshwater Lagoon: *Oncorhynchus mykiss* (Rainbow Trout) were captured in gill nets, and Northern Red-Legged Frogs (*Rana aurora*) were observed during visual encounter surveys (Table 22, Figure 16). Many more fish species are known to be present in Freshwater Lagoon, which illustrates the need for more comprehensive sampling and the use of additional techniques (e.g., boat electrofishing and minnow traps) for sampling larger sites (which are not included in the Klamath Network mountain and ponds and lake sampling protocol). California Department of Game and Fish may inventory the fish populations on a regular basis.

Table 22. Number of vertebrates observed and collected at Freshwater Lagoon, Redwood National Park, 2013.

Site Code	Lake Name	Date Sampled	Northern Red-Legged Frog (<i>Rana aurora</i>)	Rainbow Trout (<i>Oncorhynchus mykiss</i>)
REDW Lagoon	Freshwater Lagoon	9/17/2013	8	12



Figure 16. Northern Red-Legged Frog at Freshwater Lagoon, Redwood National Park, 2013.

Discussion

In 2013, 27 probabilistically chosen lakes and one judgment lake (Lake Helen) were sampled in Lassen Volcanic National Park. In Crater Lake National Park, we sampled six ponds-lakes that comprise the known population of perennial lentic habitats outside of the Crater Lake caldera (outside of a single inaccessible site, see Appendix G). In Redwood National Park, Freshwater Lagoon was sampled as a judgment site. These sites will be resampled in 2016. The data collected in 2013 represent an initial baseline measurement of the physical habitat, water chemistry and quality, and aquatic communities of the sites sampled, and lays the groundwork for future Analysis and Synthesis Reports that will eventually include the analysis of trends of the measured lentic attributes.

Literature Cited

- Dinger, E. C., D. A. Sarr, S. R. Mohren, and R. L. Hoffman. 2012. Integrated aquatic community and water quality monitoring of mountain ponds and lakes in the Klamath Network. Natural Resource Report NPS/KLMN/NRR—2012/484. National Park Service, Fort Collins, Colorado.
- Dinger, E. C., D. A. Sarr, S. R. Mohren, C. E. Stanley, and K. M. Irvine. 2013. Integrated aquatic community and water quality monitoring of wadeable streams in the Klamath Network. Natural Resource Report NPS/KLMN/NRR—2013/669. National Park Service, Fort Collins, Colorado.
- Hoffman, R. L., T. J. Tyler, G. L. Larson, M. J. Adams, W. Wente, and S. Galvan. 2005. Sampling protocol for monitoring abiotic and biotic characteristics of mountain ponds and lakes: U.S. Geological Survey Techniques and Methods 2-A2. U.S. Geological Survey, Reston, Virginia.
- Knapp, R. A., C. P. Hawkins, J. Ladau, and J. G. McClory. 2005. Fauna of Yosemite National Park lakes has low resistance but high resilience to fish introduction. *Ecological Applications* **15**:835-847.
- Rosenberg, D. M., and V. H. Resh, editors. 1993. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York.
- Sarr, D. A., D. C. Odion, S. R. Mohren, E. E. Perry, R. L. Hoffman, L. K. Bridy, and A. A. Merton. 2007. Klamath Network vital signs monitoring plan. Natural Resource Report NPS/KLMN/NRR—2007/016. National Park Service, Fort Collins, Colorado.
- Stevens, D. L. Jr., and A. R. Olsen. 1999. Spatially restricted sampling over time for aquatic resources. *Journal of Agricultural, Biological and Environmental Statistics* **4**:415-428.
- Stevens, D. L. Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* **99**:262-278.
- USEPA. 2011. 2012 National lakes assessment. Field operations manual. EPA 841-B-11-003. U.S. Environmental Protection Agency, Washington, D.C.

Appendix A. Zooplankton Taxa of Lassen Volcanic National Park

Table A1. List of taxa collected at Lassen Volcanic National Park, 2013. The Category and Taxon are the values reported by the taxonomic contractor – CLA = Cladoceran, OLI = Oligochaete, INS = Insect, ROT = Rotifer, CYC = Cyclopoida, CAL = Calanoida, PRT = Protista, CNI = Cnidarian, NEM = Nemata, OST = Ostracod, ARC = Arachnid. ITIS.gov Taxon is the current taxa name using the Integrated Taxonomic Information System, and may vary from the contractor reported value. TSN = Taxonomic Serial Number. Total Accumulated Density is across all samples (including QA/QC samples) and is presented as a measure of relative abundance across taxa. Note that Sites (for No. of Sites and % of Sites) includes QA/QC repeat sites.

Category	Taxon	ITIS.gov Taxon	TSN	Total Accumulated Density (per m3)	No. of Sites	Percent of Sites
CLA	<i>Alona costata</i>	<i>Alona costata</i>	83983	129806	14	48.3%
CLA	<i>Alona leei</i>	<i>Disparalona leei</i>	84100	1263	1	3.4%
OLI	aquatic oligochaete	Oligochaeta	68422	3158	2	6.9%
CLA	<i>Bosmina longirostris</i>	<i>Bosmina longirostris</i>	83938	4705851	18	62.1%
CLA	<i>Camptocercus rectirostris</i>	<i>Camptocercus rectirostris</i>	84057	2526	1	3.4%
CLA	<i>Ceriodaphnia dubia</i>	<i>Ceriodaphnia dubia</i>	83912	2319453	9	31.0%
CLA	<i>Ceriodaphnia pulchella</i>	<i>Ceriodaphnia pulchella</i>	83908	2305078	3	10.3%
INS	<i>Chaoborus</i> larvae	<i>Chaoborus</i> sp.	125904	249138	10	34.5%
INS	chironomid larvae	Chironomidae	127917	674314	18	62.1%
CLA	<i>Chydorus sphaericus</i>	<i>Chydorus sphaericus</i>	83993	5619014	26	89.7%
CLA	Cladoceran unknown	Cladocera	83832	5052	1	3.4%
ROT	<i>Collotheca mutabilis</i>	<i>Collotheca mutabilis</i>	59435	10104	1	3.4%
ROT	<i>Conochilus unicornis</i>	<i>Conochilus unicornis</i>	59419	97377009	18	62.1%
CYC&CAL	copepod nauplii	Copepoda	85257	643665	17	58.6%
CAL	copepodid, Calanoida	Calanoida	85258	3657811	1	3.4%
CYC	copepodid, Cyclopoida	Cyclopoida	88530	410809	12	41.4%
CLA	<i>Daphnia ambigua</i>	<i>Daphnia ambigua</i>	83888	50389	2	6.9%
CLA	<i>Daphnia mendotae</i>	<i>Daphnia galeata mendotae</i>	83877	40418	1	3.4%
CLA	<i>Daphnia pulex</i>	<i>Daphnia pulex</i>	83874	619238	15	51.7%
CLA	<i>Daphnia rosea</i>	<i>Daphnia rosea</i>	83891	670683	4	13.8%
CLA	<i>Diaphanosoma brachyurum</i>	<i>Diaphanosoma brachyurum</i>	83838	17967738	19	65.5%
CAL	<i>Diaptomus (L.) siciloides</i>	<i>Diaptomus siciloides</i>	85793	1495459	3	10.3%
CAL	<i>Diaptomus (L.) signicauda</i>	<i>Diaptomus signicauda</i>	85824	4954969	10	34.5%
CAL	<i>Diaptomus (L.) tyrrelli</i>	<i>Diaptomus tyrrelli</i>	85802	1381432	8	27.6%
PRT	<i>Diffugia</i> sp.	<i>Diffugia</i> sp.	43948	113650	11	37.9%
CAL	<i>Epischura nevadensis</i>	<i>Epischura nevadensis</i>	85857	115055	6	20.7%
CAL	epischurid copepodites	<i>Epischura</i> spp.	85856	100794	5	17.2%
CLA	<i>Eurycercus lamellatus</i>	<i>Eurycercus lamellatus</i>	84017	2105	1	3.4%
VER	Fish egg	Actinopterygii	161061	20209	1	3.4%
VER	Fish fry	Actinopterygii	161061	316	1	3.4%
HAR	harpacticoid copepod	Harpacticoida	86110	5052	1	3.4%
CAL	<i>Hesperodiaptomus eiseni occidentalis</i> (a.k.a. <i>H. arcticus</i>)	<i>Hesperodiaptomus arcticus</i>	666938	466197	5	17.2%
CLA	<i>Holopedium gibberum</i>	<i>Holopedium gibberum</i>	83957	3436857	10	34.5%
CNI	<i>Hydra</i>	<i>Hydra</i>	50845	80836	1	3.4%
CLA	<i>Ilyocryptus acutifrons</i>	<i>Ilyocryptus acutifrons</i>	84137	1263	1	3.4%
ROT	<i>Kellicottia bostonensis</i>	<i>Kellicottia bostoniensis</i>	58487	164829	2	6.9%
ROT	<i>Keratella cochlearis</i> var. <i>cochlearis</i>	<i>Keratella cochlearis cochlearis</i>	58362	205805	10	34.5%

Category	Taxon	ITIS.gov Taxon	TSN	Total Accumulated Density (per m3)	No. of Sites	Percent of Sites
ROT	<i>Keratella hiemalis</i>	<i>Keratella hiemalis</i>	58378	789	1	3.4%
ROT	<i>Keratella taurocephala</i>	<i>Keratella taurocephala</i>	58381	386495	7	24.1%
CAL	<i>Leptodiaptomus</i> sp.	<i>Leptodiaptomus</i> sp.	85838	3631	3	10.3%
CYC	<i>Macrocyclus albidus</i>	<i>Macrocyclus albidus</i>	88738	52417	5	17.2%
CLA	<i>Macrothrix (Echinisco) rosea</i>	<i>Macrothrix rosea</i>	84119	45470	3	10.3%
CLA	<i>Macrothrix laticornis</i>	<i>Macrothrix laticornis</i>	84121	389021	7	24.1%
INS	mayfly larvae	Ephemeroptera	100502	17683	2	6.9%
CYC	<i>Microcyclus varicans</i>	<i>Microcyclus varicans</i>	88758	129834	10	34.5%
ROT	<i>Monostyla bulla</i>	<i>Monostyla bulla</i>	58748	2526	1	3.4%
INS	mosquito larvae	Culicidae	125930	7578	2	6.9%
NEM	nematode	Nematoda	59490	7578	1	3.4%
INS	odonate larvae	Odonata	101593	2526	1	3.4%
OST	Ostracoda (seed shrimp)	Ostracoda	84195	20209	2	6.9%
CLA	<i>Pleuroxus</i> sp.	<i>Pleuroxus</i> sp.	84044	10894	2	6.9%
ROT	<i>Ploesoma truncatum</i>	<i>Ploesoma truncatum</i>	59283	15157	2	6.9%
ROT	<i>Polyarthra vulgaris</i>	<i>Polyarthra vulgaris</i>	59277	40418	3	10.3%
CLA	<i>Scapholeberis armata</i>	<i>Scapholeberis armata</i>	83928	2184455	15	51.7%
CLA	<i>Sida crystallina</i>	<i>Sida crystallina</i>	83863	6315	2	6.9%
CLA	<i>Simocephalus serrulatus</i>	<i>Simocephalus serrulatus</i>	83901	2526	1	3.4%
CLA	<i>Simocephalus vetulus</i>	<i>Simocephalus vetulus</i>	83902	30313	1	3.4%
CAL	small sp. copepodid, Calanoida	Calanoida	85258	12623444	24	82.8%
ROT	<i>Synchaeta</i> sp.	<i>Synchaeta</i> sp.	59255	40418	2	6.9%
INS	water boatman	Corixidae	103364	947	2	6.9%
ARC	water mite	Trombidiformes	82769	47365	10	34.5%

Appendix B. Littoral Zone Macroinvertebrates of Lassen Volcanic National Park

Table B-1. Taxonomic units of littoral zone benthic macroinvertebrates encountered in Lassen Volcanic National Park, 2013. TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy. 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.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Ablabesmyia</i>	128079	390	17	58.6%
Diptera	Chironomidae	<i>Acampocladius dentolatus</i>	128461	2	1	3.4%
Acari		Acari	733321	1	1	3.4%
Coleoptera	Dytiscidae	<i>Acilius abbreviatus</i>	112080	6	5	17.2%
Odonata	Aeshnidae	Aeshnidae	101596	62	15	51.7%
Coleoptera	Dytiscidae	<i>Agabus</i>	111966	15	7	24.1%
Trichoptera	Phryganeidae	<i>Agrypnia</i>	115882	473	17	58.6%
Diptera	Chironomidae	<i>Apedilum</i>	206655	93	1	3.4%
Trombidiformes	Arrenuridae	<i>Arrenurus</i>	82864	54	7	24.1%
Anostraca	Artemiidae	<i>Artemia franciscana</i>	83692	1	1	3.4%
Diptera	Ceratopogonidae	<i>Atrichopogon</i>	127113	1	1	3.4%
Coleoptera	Hydrophilidae	<i>Berosus</i>	112812	1	1	3.4%
Diptera	Ceratopogonidae	<i>Bezzia / Palpomyia</i>	NA	37	6	20.7%
Diptera	Ptychopteridae	<i>Bittacomorpha</i>	125765	2	1	3.4%
Ephemeroptera	Caenidae	<i>Caenis</i>	101478	230	2	6.9%
Ephemeroptera	Baetidae	<i>Callibaetis</i>	100903	224	13	44.8%
Diptera	Ceratopogonidae	Ceratopogonidae	127076	4	1	3.4%
Diptera	Ceratopogonidae	Ceratopogoninae	127338	21	9	31.0%
Diptera	Chironomidae	<i>Chaetocladius</i>	128520	2	1	3.4%
Diptera	Chaoboridae	<i>Chaoborus</i>	125904	16	3	10.3%
Diptera	Chironomidae	Chironomini	129229	14	3	10.3%
Diptera	Chironomidae	<i>Chironomus</i>	129254	366	15	51.7%
Diplostraca		Cladocera	83832	369	10	34.5%
Diptera	Chironomidae	<i>Cladopelma</i>	129350	108	9	31.0%
Diptera	Chironomidae	<i>Clinotanytus</i>	127996	4	1	3.4%
Odonata	Coenagrionidae	Coenagrionidae	102077	24	10	34.5%
Copepoda		Copepoda	85257	126	10	34.5%
Coleoptera	Dytiscidae	<i>Coptotomus longulus</i>	112373	6	2	6.9%
Odonata	Corduliidae	Corduliidae	102020	30	12	41.4%
Hemiptera	Corixidae	Corixidae	103364	35	18	62.1%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	63	17	58.6%
Diptera	Chironomidae	<i>Cricotopus</i>	128575	131	3	10.3%
Diptera	Chironomidae	<i>Cryptochironomus</i>	129368	6	4	13.8%
Diptera	Ceratopogonidae	<i>Dasyhelea</i>	127278	148	6	20.7%
Trichoptera	Limnephilidae	<i>Desmona</i>	116023	39	3	10.3%
Coleoptera	Dytiscidae	<i>Desmopachria convexa</i>	112148	1	1	3.4%
Diptera	Chironomidae	<i>Dicrotendipes</i>	129428	242	13	44.8%
Diptera	Dolichopodidae	Dolichopodidae	136824	1	1	3.4%
Coleoptera	Dytiscidae	Dytiscidae	111963	15	7	24.1%
Haplotaenidia	Enchytraeidae	<i>Enchytraeus</i>	68531	46	15	51.7%
Diptera	Chironomidae	<i>Endochironomus</i>	129470	4	2	6.9%
Coleoptera	Hydrophilidae	<i>Enochrus</i>	112973	1	1	3.4%
Arhynchobdellida	Erpobdellidae	<i>Erpobdella</i>	69444	16	4	13.8%
Trombidiformes	Oxidae	<i>Frontipoda</i>	83240	14	7	24.1%

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Hemiptera	Gerridae	Gerridae	103801	8	6	20.7%
Rhynchobdellida	Glossiphoniidae	<i>Glossiphonia</i>	69380	4	2	6.9%
Trichoptera	Sericostomatidae	<i>Gumaga</i>	117003	141	4	13.8%
Basommatophora	Planorbidae	<i>Gyraulus</i>	76592	64	1	3.4%
Basommatophora	Planorbidae	<i>Gyraulus circumstriatus</i>	76593	1	1	3.4%
Coleoptera	Gyrinidae	Gyrinidae	112653	1	1	3.4%
Rhynchobdellida	Glossiphoniidae	<i>Helobdella</i>	69396	532	19	65.5%
Hemiptera	Corixidae	<i>Hesperocorixa vulgaris</i>	103450	1	1	3.4%
Trichoptera	Calamoceratidae	<i>Heteroplectron californicum</i>	116538	56	3	10.3%
Diptera	Chironomidae	<i>Heterotrissocladius Marcidus</i> Gr.	NA	182	6	20.7%
Amphipoda	Hyalellidae	<i>Hyalella</i>	94025	95	3	10.3%
Coleoptera	Hydrochidae	<i>Hydrochus</i>	113166	1	1	3.4%
Trombidiformes	Hydrodromidae	<i>Hydrodroma</i>	83225	8	4	13.8%
Coleoptera	Hydrophilidae	Hydrophilidae	112811	2	1	3.4%
Coleoptera	Dytiscidae	Hydroporinae	678402	15	5	17.2%
Coleoptera	Dytiscidae	Hydroporini	728229	2	2	6.9%
Coleoptera	Dytiscidae	<i>Hydroporus</i>	112390	3	2	6.9%
Trombidiformes	Hygrobatidae	<i>Hygrobatas</i>	83297	2	1	3.4%
Trombidiformes	Hygrobatidae	Hygrobatidae	83281	2	1	3.4%
Coleoptera	Dytiscidae	<i>Hygrotus</i>	112200	2	1	3.4%
Coleoptera	Dytiscidae	<i>Laccophilus maculosus</i>	112279	2	1	3.4%
Trombidiformes	Lebertiidae	<i>Lebertia</i>	83034	8	3	10.3%
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>	116794	5	1	3.4%
Trichoptera	Leptoceridae	Leptoceridae	116547	1	1	3.4%
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	101095	8	3	10.3%
Odonata	Lestidae	<i>Lestes</i>	102061	4	2	6.9%
Trichoptera	Limnephilidae	Limnephilidae	115933	6	4	13.8%
Trichoptera	Limnephilidae	Limnephilus	116069	14	6	20.7%
Trombidiformes	Limnesiidae	<i>Limnesia</i>	83051	12	4	13.8%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	9	5	17.2%
Coleoptera	Dytiscidae	<i>Liodessus</i>	112580	22	3	10.3%
Coleoptera	Dytiscidae	<i>Liodessus obscurellus</i>	728347	30	7	24.1%
Lumbriculida	Lumbriculidae	Lumbriculidae	68440	57	8	27.6%
Lumbriculida	Lumbriculidae	<i>Lumbriculus</i>	68441	28	5	17.2%
Haplotaxida	Enchytraeidae	<i>Mesenchytraeus</i>	68544	12	2	6.9%
Diptera	Chironomidae	<i>Microtendipes Pedellus</i> Gr.	NA	360	15	51.7%
Trichoptera	Leptoceridae	<i>Mystacides</i>	116598	240	7	24.1%
Haplotaxida	Naididae	Naididae	68854	6	5	17.2%
Haplotaxida	Naididae	<i>Nais</i>	68946	14	4	13.8%
Nemata		Nemata	563956	131	10	34.5%
Coleoptera	Dytiscidae	<i>Neoporus</i>	728252	9	1	3.4%
Diptera	Chironomidae	<i>Nilothauma</i>	129548	70	8	27.6%
Hemiptera	Notonectidae	<i>Notonecta</i>	103558	89	19	65.5%
Trichoptera	Leptoceridae	<i>Oecetis</i>	116607	47	9	31.0%
Sarcoptiformes		Oribatida	733326	3	2	6.9%
Diptera	Chironomidae	Orthocladiinae	128457	3	3	10.3%
Ostracoda		Ostracoda	84195	1	1	3.4%
Diptera	Chironomidae	<i>Pagastiella</i>	129561	40	4	13.8%
Diptera	Chironomidae	<i>Parachironomus</i>	129564	1	1	3.4%
Diptera	Chironomidae	<i>Paramerina</i>	128207	164	13	44.8%
Diptera	Chironomidae	<i>Paratanytarsus</i>	129935	49	10	34.5%
Basommatophora	Physidae	<i>Physa gyrina</i>	76678	87	1	3.4%
Trombidiformes	Pionidae	<i>Piona</i>	83350	2	1	3.4%

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	381	9	31.0%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	882	22	75.9%
Diptera	Ceratopogonidae	<i>Probezzia</i>	127729	76	10	34.5%
Diptera	Chironomidae	<i>Procladius</i>	128277	1956	27	93.1%
Diptera	Chironomidae	<i>Psectrocladius</i>	129018	413	19	65.5%
Diptera	Chironomidae	<i>Psectrotanypus</i>	128048	58	3	10.3%
Diptera	Chironomidae	<i>Pseudochironomus</i>	129851	16	4	13.8%
Diptera	Chironomidae	<i>Pseudosmittia</i>	129071	1	1	3.4%
Basommatophora	Lymnaeidae	<i>Radix auricularia</i>	76526	1	1	3.4%
Coleoptera	Scirtidae	Scirtidae	113924	1	1	3.4%
Megaloptera	Sialidae	<i>Sialis</i>	115002	243	16	55.2%
Hemiptera	Corixidae	<i>Sigara</i>	103369	4	3	10.3%
Odonata	Corduliidae	<i>Somatochlora</i>	101947	2	2	6.9%
Odonata	Corduliidae	<i>Somatochlora albicincta</i>	101952	3	1	3.4%
Veneroida	Sphaeriidae	Sphaeriidae	81389	426	9	31.0%
Diptera	Chironomidae	<i>Stenochironomus</i>	129746	1	1	3.4%
Coleoptera	Dytiscidae	<i>Stictotarsus</i>	568826	5	2	6.9%
Coleoptera	Dytiscidae	<i>Stictotarsus griseostriatus</i>	728483	1	1	3.4%
Coleoptera	Dytiscidae	<i>Stictotarsus striatellus</i>	568829	29	5	17.2%
Diptera	Tabanidae	Tabanidae	130934	4	3	10.3%
Diptera	Chironomidae	Tanypodinae	127994	12	8	27.6%
Diptera	Chironomidae	<i>Tanytarsus</i>	129978	727	18	62.1%
Diptera	Chironomidae	<i>Thienemanniella</i>	129182	1	1	3.4%
Diptera	Chironomidae	<i>Thienemannimyia</i> Gr.	NA	148	6	20.7%
Diptera	Tipulidae	<i>Tipula</i>	119037	8	1	3.4%
Hemiptera	Gerridae	<i>Trepobates</i>	103811	1	1	3.4%
Diptera	Chironomidae	<i>Tribelos</i>	129820	665	17	58.6%
Coleoptera	Hydrophilidae	<i>Tropisternus</i>	112938	1	1	3.4%
Coleoptera	Hydrophilidae	<i>Tropisternus lateralis</i>	112944	1	1	3.4%
Haplotaxida	Naididae	Tubificinae	NA	24	4	13.8%
Coleoptera	Dytiscidae	<i>Uvarus subtilis</i>	193571	2	1	3.4%
Diptera	Chironomidae	<i>Zavrelimyia</i>	128259	5	1	3.4%

Appendix C. Zooplankton Taxa of Crater Lake National Park

Table C-1. List of taxa collected at Crater Lake National Park, 2013. The Category and Taxon are the values reported by the taxonomic contractor – CLA = Cladoceran, OLI = Oligochaete, INS = Insect, ROT = Rotifer, CYC = Cyclopoida, CAL = Calanoida, PRT = Protista, CNI = Cnidarian, NEM = Nemata, OST = Ostracod, ARC = Arachnid. ITIS.gov Taxon is the current taxa name using the Integrated Taxonomic Information System, and may vary from the contractor reported value. TSN = Taxonomic Serial Number. Total Accumulated Density is across all samples (including QA/QC samples) and is presented as a measure of relative abundance across taxa. Note that Sites (for No. of Sites and % of Sites) includes QA/QC repeat sites.

Category	Taxon	ITIS.gov.Taxon	TSN	Total Accumulated Density (per m3)	No. of Sites	Percent of Sites
CLA	<i>Alona costata</i>	<i>Alona costata</i>	83983	31576	3	42.9%
CLA	<i>Alona guttata</i>	<i>Alona guttata</i>	83975	2526	1	14.3%
CLA	<i>Alona quadrangularis</i>	<i>Alona quadrangularis</i>	83980	632	1	14.3%
CLA	<i>Bosmina longirostris</i>	<i>Bosmina longirostris</i>	83938	23998	3	42.9%
INS	<i>Chaoborus</i> larvae	<i>Chaoborus</i> sp.	125904	64732	6	85.7%
INS	chironomid larvae	Chironomidae	127917	163250	6	85.7%
CLA	<i>Chydorus sphaericus</i>	<i>Chydorus sphaericus</i>	83993	152514	4	57.1%
ROT	<i>Conochilus unicornis</i>	<i>Conochilus unicornis</i>	59419	15358763	4	57.1%
CYC&CAL	copepod nauplii	Copepoda	85257	56522	4	57.1%
CAL	copepodid, Calanoida	Calanoida	85258	1581346	5	71.4%
CYC	copepodid, Cyclopoida	Cyclopoida	88530	63469	5	71.4%
CLA	<i>Daphnia pulex</i>	<i>Daphnia pulex</i>	83874	241244	5	71.4%
CLA	<i>Daphnia rosea</i>	<i>Daphnia rosea</i>	83891	1217586	2	28.6%
CLA	<i>Diaphanosoma brachyurum</i>	<i>Diaphanosoma brachyurum</i>	83838	90309	3	42.9%
CAL	<i>Diaptomus</i> (A.) <i>leptopus</i>	<i>Diaptomus leptopus</i>	85789	1759437	5	71.4%
CAL	<i>Diaptomus</i> (H.) <i>franciscanus</i>	<i>Diaptomus franciscanus</i>	85786	593636	1	14.3%
PRT	<i>Diffugia</i> sp.	<i>Diffugia</i> sp.	43948	17683	4	57.1%
CAL	<i>Epischura nevadensis</i>	<i>Epischura nevadensis</i>	85857	3473	1	14.3%
CAL	epischurid copepodites	<i>Epischura</i> spp.	85856	1579	1	14.3%
ROT	<i>Euchlanis calpidia</i>	<i>Euchlanis calpidia</i>	58591	272820	1	14.3%
CLA	<i>Eurycerus lamellatus</i>	<i>Eurycerus lamellatus</i>	84017	11683	2	28.6%
VER*	Fish fry*	Actinopterygii*	161061	316	1	14.3%
HAR	harpacticoid copepod	Harpacticoida	86110	2526	1	14.3%
CLA	<i>Holopedium gibberum</i>	<i>Holopedium gibberum</i>	83957	2526	1	14.3%
ROT	<i>Keratella hiemalis</i>	<i>Keratella hiemalis</i>	58378	316	1	14.3%
HIR	leech	Hirudinea	914192	316	1	14.3%
CLA	<i>Macrothrix laticornis</i>	<i>Macrothrix laticornis</i>	84121	32839	2	28.6%
INS	mayfly larvae	Ephemeroptera	100502	88730	3	42.9%
CYC	<i>Microcyclops varicans</i>	<i>Microcyclops varicans</i>	88758	52733	4	57.1%
INS	odonate larvae	Odonata	101593	2526	1	14.3%
OST	Ostracoda (seed shrimp)	Ostracoda	84195	54627	3	42.9%
CLA	<i>Scapholeberis armata</i>	<i>Scapholeberis armata</i>	83928	792883	5	71.4%
CLA	<i>Simocephalus serrulatus</i>	<i>Simocephalus serrulatus</i>	83901	3789	1	14.3%
CLA	<i>Simocephalus vetulus</i>	<i>Simocephalus vetulus</i>	83902	2526	1	14.3%
ARC	water mite	Trombidiformes	82769	6631	2	28.6%

*Note that fish do not occur in the Crater Lake National Park ponds, and so the identification by the contractor of “Fish fry” is probably an early vertebrate (frog or salamander) life stage.

Appendix D. Littoral Zone Macroinvertebrates of Crater Lake National Park

Table D-1. Taxonomic units of littoral zone benthic macroinvertebrates encountered in Lassen Volcanic National Park, 2013. TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy. 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.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Ablabesmyia</i>	128079	63	2	28.6%
Coleoptera	Dytiscidae	<i>Acilius abbreviatus</i>	112080	3	1	14.3%
Odonata	Aeshnidae	Aeshnidae	101596	2	1	14.3%
Trichoptera	Phryganeidae	<i>Agrypnia</i>	115882	6	2	28.6%
Trombidiformes	Arrenuridae	<i>Arrenurus</i>	82864	22	1	14.3%
Diptera	Ceratopogonidae	<i>Bezzia</i> / <i>Palpomyia</i>	NA	65	2	28.6%
Ephemeroptera	Baetidae	<i>Callibaetis</i>	100903	25	1	14.3%
Diptera	Chironomidae	<i>Chaetocladius</i>	128520	14	1	14.3%
Diptera	Chaoboridae	<i>Chaoborus</i>	125904	83	2	28.6%
Diptera	Chironomidae	<i>Chironomus</i>	129254	521	5	71.4%
Diptera	Tabanidae	<i>Chrysops</i>	131078	1	1	14.3%
Diplostraca		Cladocera	83832	150	4	57.1%
Diptera	Chironomidae	<i>Cladopelma</i>	129350	3	1	14.3%
Odonata	Coenagrionidae	Coenagrionidae	102077	6	1	14.3%
Copepoda		Copepoda	85257	2	2	28.6%
Odonata	Corduliidae	Corduliidae	102020	1	1	14.3%
Hemiptera	Corixidae	Corixidae	103364	4	3	42.9%
Diptera	Chironomidae	<i>Corynoneura</i>	128563	9	2	28.6%
Diptera	Chironomidae	<i>Cryptochironomus</i>	129368	18	3	42.9%
Diptera	Ceratopogonidae	<i>Dasyhelea</i>	127278	15	1	14.3%
Coleoptera	Dytiscidae	Dytiscidae	111963	1	1	14.3%
Haplotaaxida	Enchytraeidae	<i>Enchytraeus</i>	68531	1	1	14.3%
Diptera	Chironomidae	<i>Endochironomus</i>	129470	37	3	42.9%
Trombidiformes	Feltriidae	<i>Feltria</i>	83314	1	1	14.3%
Trombidiformes	Oxidae	<i>Frontipoda</i>	83240	81	3	42.9%
Diptera	Chironomidae	<i>Glyptotendipes</i>	129483	17	3	42.9%
Odonata	Libellulidae	Libellulidae	101797	18	2	28.6%
Trichoptera	Limnephilidae	Limnephilidae	115933	6	2	28.6%
Diptera	Chironomidae	<i>Limnophyes</i>	128776	2	1	14.3%
Coleoptera	Dytiscidae	<i>Liodessus obscurellus</i>	728347	1	1	14.3%
Diptera	Chironomidae	<i>Metriocnemus</i>	128821	2	1	14.3%
Diptera	Chironomidae	<i>Microtendipes Pedellus</i> Gr.	NA	447	5	71.4%
Haplotaaxida	Naididae	Naididae	68854	4	1	14.3%
Haplotaaxida	Naididae	<i>Nais</i>	68946	2	1	14.3%
Diptera	Chironomidae	<i>Nilothauma</i>	129548	1	1	14.3%
Hemiptera	Notonectidae	<i>Notonecta</i>	103558	3	3	42.9%
Diptera	Chironomidae	Orthocladinae	128457	19	1	14.3%
Ostracoda		Ostracoda	84195	199	1	14.3%
Diptera	Chironomidae	<i>Paramerina</i>	128207	3	1	14.3%
Diptera	Chironomidae	<i>Paratanytarsus</i>	129935	52	3	42.9%
Trombidiformes	Pionidae	<i>Piona</i>	83350	1	1	14.3%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	6	2	28.6%
Diptera	Chironomidae	<i>Polypedilum</i>	129657	20	1	14.3%
Diptera	Ceratopogonidae	<i>Probezzia</i>	127729	3	1	14.3%
Diptera	Chironomidae	<i>Procladius</i>	128277	981	7	100.0%

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Diptera	Chironomidae	<i>Psectrocladius</i>	129018	25	3	42.9%
Diptera	Chironomidae	<i>Tanytarsus</i>	129978	763	7	100.0%
Diptera	Chironomidae	<i>Tribelos</i>	129820	285	6	85.7%

Appendix E. Zooplankton Taxa of Redwood National Park

Table E-1. List of taxa collected at Redwood National Park, 2013. The Category and Taxon are the values reported by the taxonomic contractor – CLA = Cladoceran, OLI = Oligochaete, INS = Insect, ROT = Rotifer, CYC = Cyclopoida, CAL = Calanoida, PRT = Protista, CNI = Cnidarian, NEM = Nemata, OST = Ostracod, ARC = Arachnid. ITIS.gov Taxon is the current taxa name using the Integrated Taxonomic Information System, and may vary from the contractor reported value. TSN = Taxonomic Serial Number. Total Accumulated Density is the density at the single site, Freshwater Lagoon.

Category	Taxon	ITIS.gov.Taxon	TSN	Total Accumulated Density (per m3)	No. of Sites	Percent of Sites
CLA	<i>Alona costata</i>	<i>Alona costata</i>	83983	789	1	100%
ROT	<i>Asplanchna priodonta</i>	<i>Asplanchna priodonta</i>	59240	678893	1	100%
CLA	<i>Bosmina luederi</i>	<i>Bosmina luederi</i>	684633	23682	1	100%
CLA	<i>Ceriodaphnia pulchella</i>	<i>Ceriodaphnia pulchella</i>	83908	11052	1	100%
ROT	<i>Conochilus unicornis</i>	<i>Conochilus unicornis</i>	59419	4737	1	100%
CYC&CAL	copepod nauplii	Copepoda	85257	1579	1	100%
CLA	<i>Daphnia ambigua</i>	<i>Daphnia ambigua</i>	83888	789	1	100%
CAL	<i>Diaptomus (L.) siciloides</i>	<i>Diaptomus siciloides</i>	85793	9473	1	100%
PRT	<i>Diffugia</i> sp.	<i>Diffugia</i> sp.	43948	1579	1	100%
CAL	<i>Epischura nevadensis</i>	<i>Epischura nevadensis</i>	85857	789	1	100%
CAL	epischurid copepodites	<i>Epischura</i> spp.	85856	789	1	100%
CLA	<i>Holopedium gibberum</i>	<i>Holopedium gibberum</i>	83957	8684	1	100%
CLA	<i>Pleuroxus striatus</i>	<i>Picripleuroxus striatus</i>	84049	789	1	100%
CLA	<i>Sida crystallina</i>	<i>Sida crystallina</i>	83863	789	1	100%
CAL	small sp. copepodid, Calanoida	Calanoida	85258	23682	1	100%
ROT	<i>Trichocerca cylindrica</i>	<i>Trichocerca cylindrica</i>	59076	20525	1	100%
ARC	water mite	Trombidiformes	82769	789	1	100%

Appendix F. Littoral Zone Macroinvertebrates of Redwood National Park

Table F-1. Taxonomic units of littoral zone benthic macroinvertebrates encountered Redwood National Park, 2013. TSN = Taxonomic Serial Number; see www.itis.gov for full taxonomy. 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.

Order (or higher)	Family	Taxon	TSN	Total No.	No. of Sites	Percent of Sites
Odonata	Aeshnidae	Aeshna	101603	1	1	100%
Trombidiformes	Arrenuridae	<i>Arrenurus</i>	82864	1	1	100%
Haplotaxida	Naididae	<i>Aulodrilus</i>	68679	9	1	100%
Architaenioglossa	Viviparidae	<i>Bellamyia chinensis</i>	NA	25	1	100%
Diptera	Ceratopogonidae	<i>Bezzia / Palpomyia</i>	NA	2	1	100%
Diplostraca		Cladocera	83832	26	1	100%
Odonata	Coenagrionidae	Coenagrionidae	102077	2	1	100%
Veneroida	Corbiculidae	<i>Corbicula</i>	81385	1	1	100%
Diptera	Ephydriidae	Ephydriidae	146893	2	1	100%
Coleoptera	Haliplidae	<i>Haliplus</i>	111858	7	1	100%
Coleoptera	Haliplidae	<i>Haliplus robertsi</i>	111865	2	1	100%
Amphipoda	Hyaellidae	<i>Hyaella</i>	94025	18	1	100%
Trombidiformes	Lebertiidae	Lebertiidae	83033	1	1	100%
Odonata	Libellulidae	Libellulidae	101797	1	1	100%
Lumbriculida	Lumbriculidae	<i>Lumbriculus</i>	68441	1	1	100%
Diptera	Chironomidae	<i>Microtendipes Pedellus</i> Gr.	NA	1	1	100%
Trombidiformes	Mideopsidae	<i>Mideopsis</i>	83479	1	1	100%
Veneroida	Pisidiidae	<i>Musculium</i>	81427	2	1	100%
Haplotaxida	Naididae	Naididae	68854	6	1	100%
Nemata		Nemata	563956	1	1	100%
Ostracoda		Ostracoda	84195	139	1	100%
Basommatophora	Physidae	<i>Physa gyrina</i>	76678	1	1	100%
Veneroida	Sphaeriidae	<i>Pisidium</i>	81400	5	1	100%
Diptera	Chironomidae	<i>Procladius</i>	128277	27	1	100%
Diptera	Chironomidae	<i>Psectrotanypus</i>	128048	1	1	100%
Megaloptera	Sialidae	<i>Sialis</i>	115002	1	1	100%
Veneroida	Sphaeriidae	Sphaeriidae	81389	332	1	100%
Odonata	Libellulidae	<i>Sympetrum</i>	101976	1	1	100%
Haplotaxida	Naididae	Tubificinae	NA	2	1	100%

Appendix G. Summary of Site Visits to CRLA Ponds

Ponds in Crater Lake National Park were visited in 2008 and 2013 to verify the presence of water (Figures G1-7). The visits in 2008 were made by a Pilot Project crew testing out methods used in advancing the development of the Mountain Ponds and Lake protocol (Dinger et al. 2012), and in October 2008 made a one week trip to perform a preliminary site visit to as many sites as possible. In 2013, the crew visited a total of 10 sites, sampling 6 of them. They did not visit sites that were determined in 2008 to be dry or almost dry; many of the sites had less than 0.5 meters of water, so that accessing the water column for sampling would be impossible without disturbing the water sample itself. A summary of visits and water status at time of visit is provided in Table G-1. A single site, CRLAWQL15 was not visited in either year, and access was deemed too difficult for safe access, although future years might reassess access.

Table G-1. Coordinates, water status, and visitation details for known ponds in Crater Lake National Park.

Lake Code	Coordinates		Year Visited	Water Status	2013 Sample Status
	X	Y			
CRLAWQL01	560707	4760666	2013	Dry	Sampled: No
CRLAWQL02	561013	4760592	2013	Dry	Sampled: No
CRLAWQL03	560723	4760152	2013	Dry	Sampled: No
CRLAWQL04	557367	4758730	2008	Yes	Sampled: Yes
CRLAWQL05	570543	4748624	2013	Artificial - Sewage	Sampled: No
CRLAWQL06	570551	4748562	2013	Artificial - Sewage	Sampled: No
CRLAWQL07	570494	4748493	2013	Artificial - Sewage	Sampled: No
CRLAWQL08	570596	4748414	2013	Artificial - Sewage	Sampled: No
CRLAWQL09	565154	4747317	2008	Dry	Sampled: No
CRLAWQL10	565230	4747318	2008	Yes	Sampled: Yes
CRLAWQL11	562885	4746009	2013	Yes	Sampled: Yes
CRLAWQL12	568837	4744618	2013	Yes	Sampled: Yes
CRLAWQL13	566744	4743376	2008	Yes	Sampled: Yes
CRLAWQL14	566953	4741818	2008	Yes	Sampled: Yes
CRLAWQL15	572217	4741668	Not Visited	Unknown	Sampled: No
CRLAWQL16	562424	4739698	2013	Dry	Sampled: No
CRLAWQL17	565344	4747418	2008	Dry	Sampled: No
CRLAWQL18	565158	4747320	2008	Almost Dry	Sampled: No
CRLAWQL19	565109	4747311	2008	Almost Dry	Sampled: No
CRLAWQL20	565501	4747155	2008	Dry	Sampled: No
CRLAWQL21	565496	4747184	2008	Dry	Sampled: No
CRLAWQL22	565576	4747130	2008	Dry	Sampled: No
CRLAWQL23	566439	4751179	2008	Mud	Sampled: No
CRLAWQL24	559613	4759715	2008	Almost Dry	Sampled: No
CRLAWQL25	565763	4747592	2008	Dry	Sampled: No
CRLAWQL26	565732	4747582	2008	Almost Dry	Sampled: No
CRLAWQL27	565591	4747450	2008	Dry	Sampled: No
CRLAWQL28	565515	4747443	2008	Dry	Sampled: No
CRLAWQL29	565541	4747358	2008	Dry	Sampled: No
CRLAWQL30	560487	4767102	2008	Dry	Sampled: No
CRLAWQL31	560425	4757949	2008	No Lake (springs only)	Sampled: No
CRLAWQL32	560151	4759679	2008	Almost Dry	Sampled: No
CRLAWQL33	560063	4759693	2008	Almost Dry	Sampled: No
CRLAWQL34	566697	4743396	2008	Almost Dry	Sampled: No
CRLAWQL35	568621	4745490	2008	Artificial - Sewage	Sampled: No

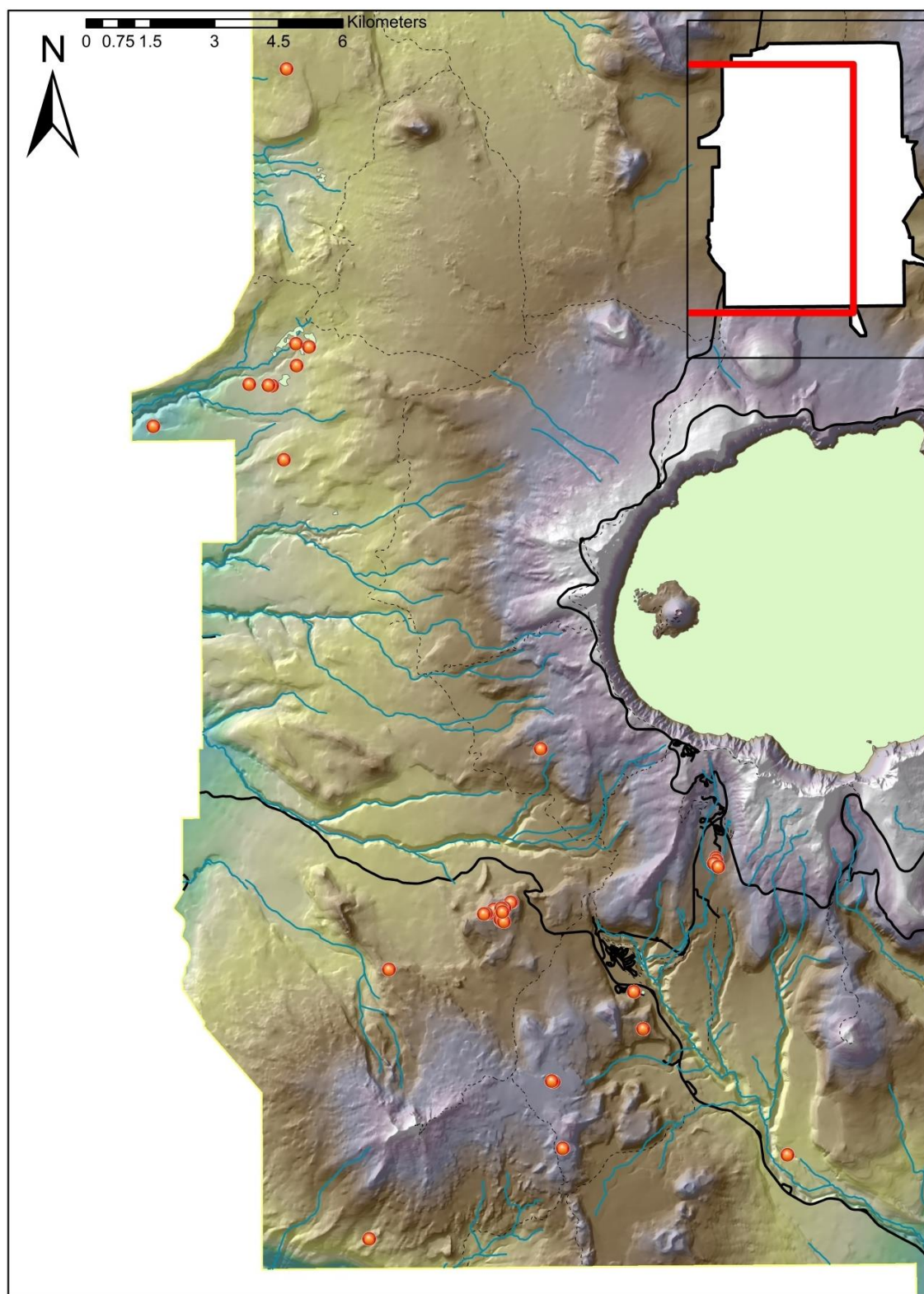


Figure G-1. Overview of locations of possible ponds for sampling in Crater Lake National Park. Red dots indicate locations of possible sites.

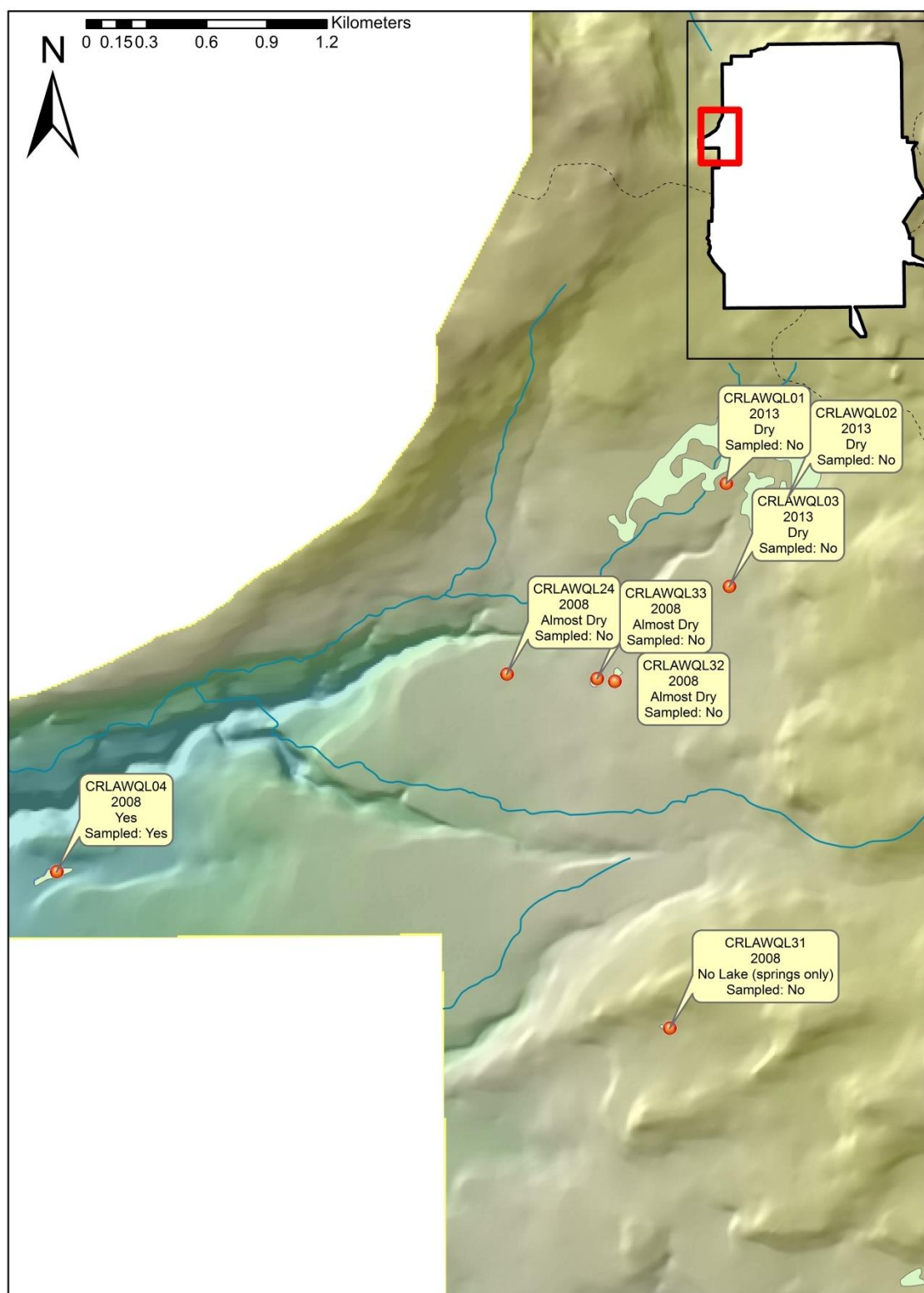


Figure G-2. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the northwest portion of Crater Lake National Park.

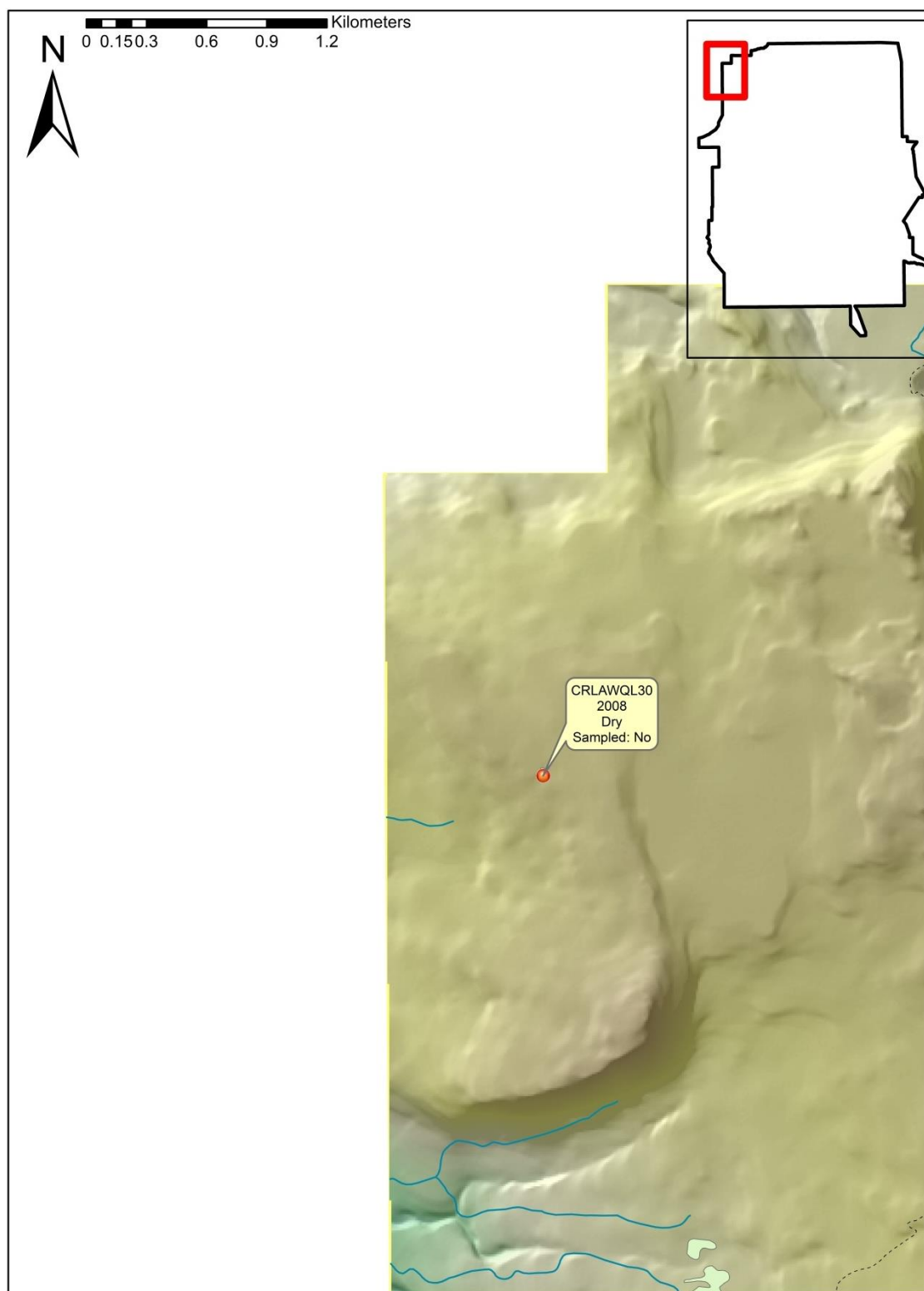


Figure G-3. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the far northwest portion of Crater Lake National Park

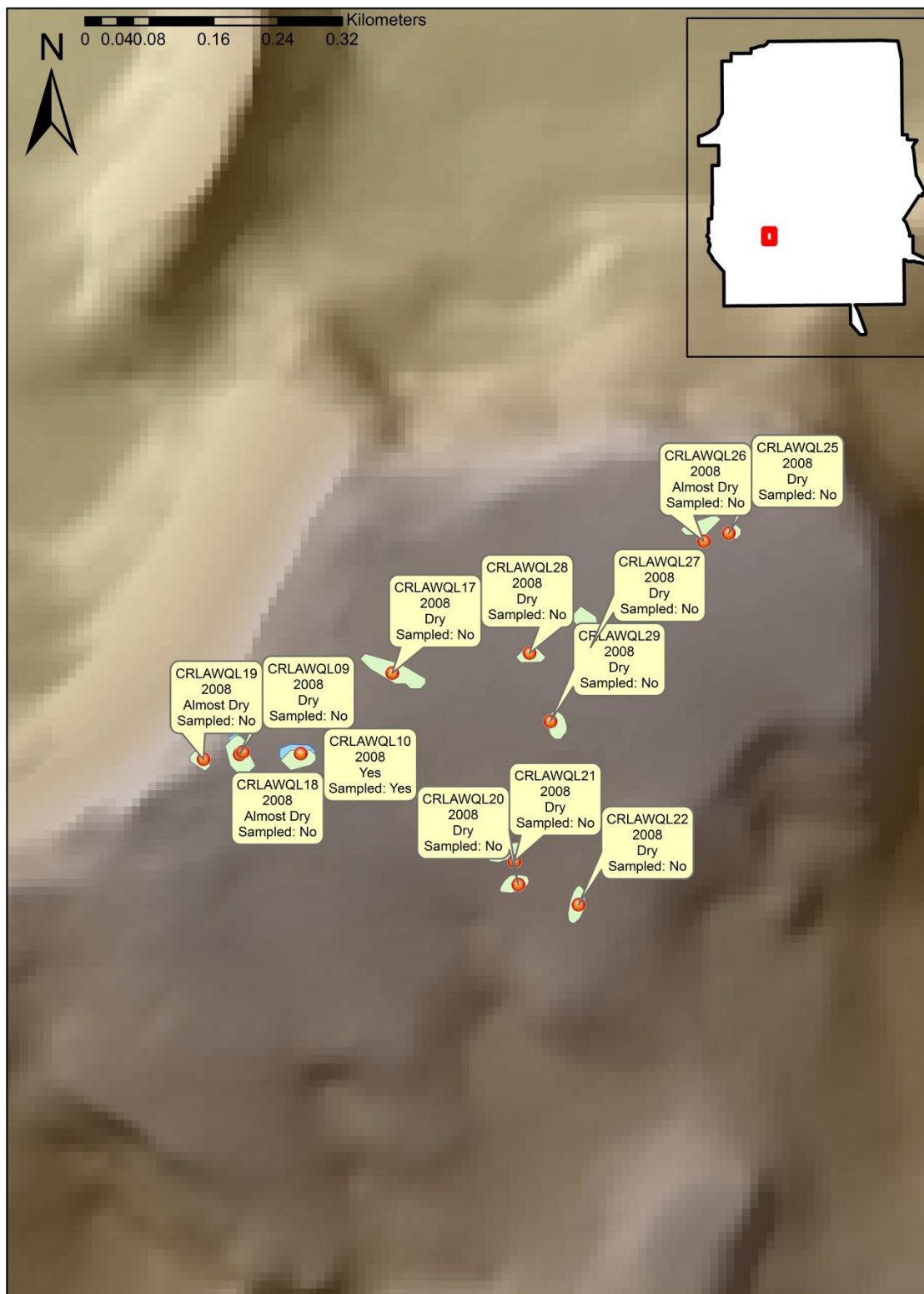


Figure G-4. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the Whitehorse Ponds area of Crater Lake National Park.

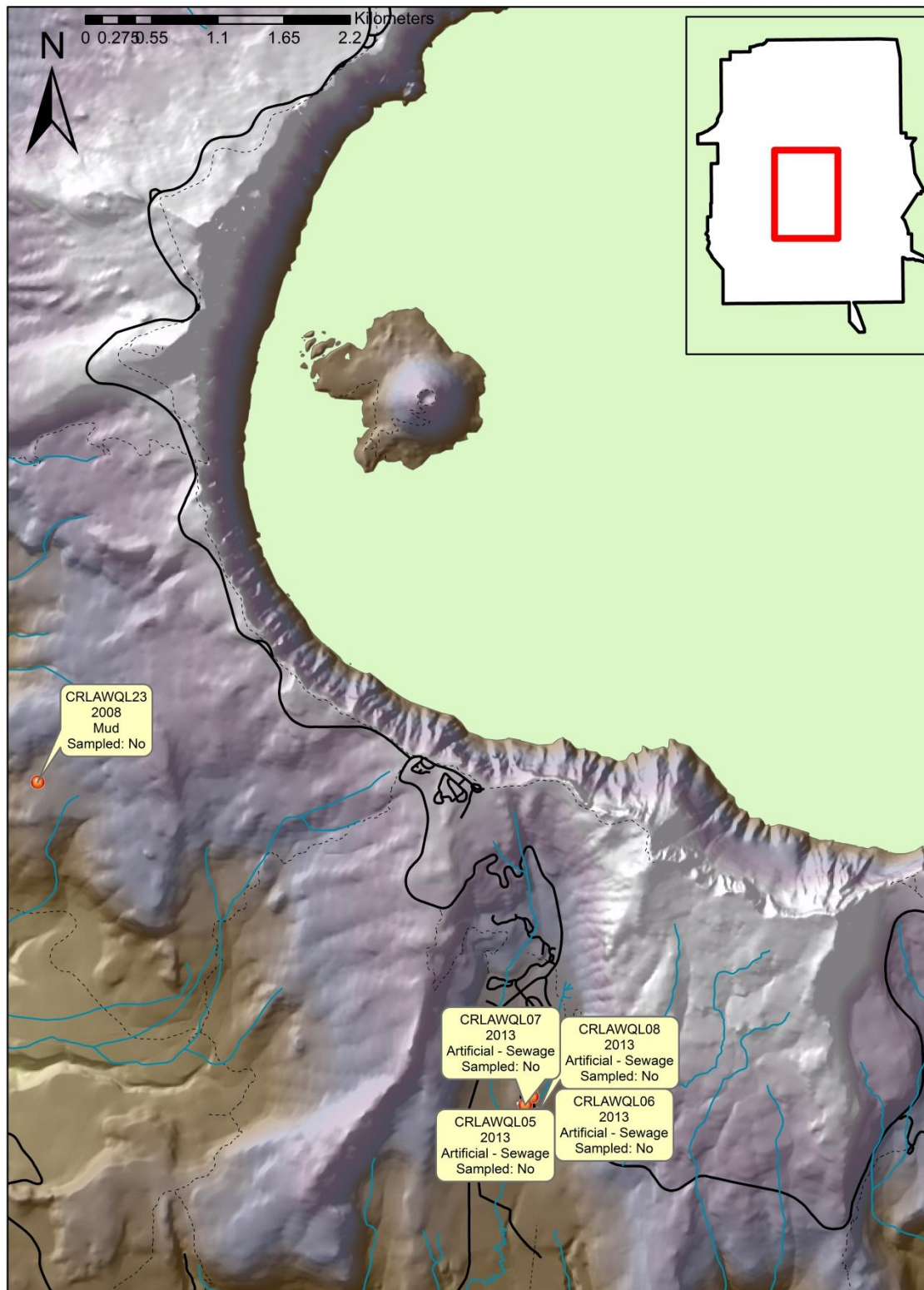


Figure G-5. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the central portion of Crater Lake National Park.

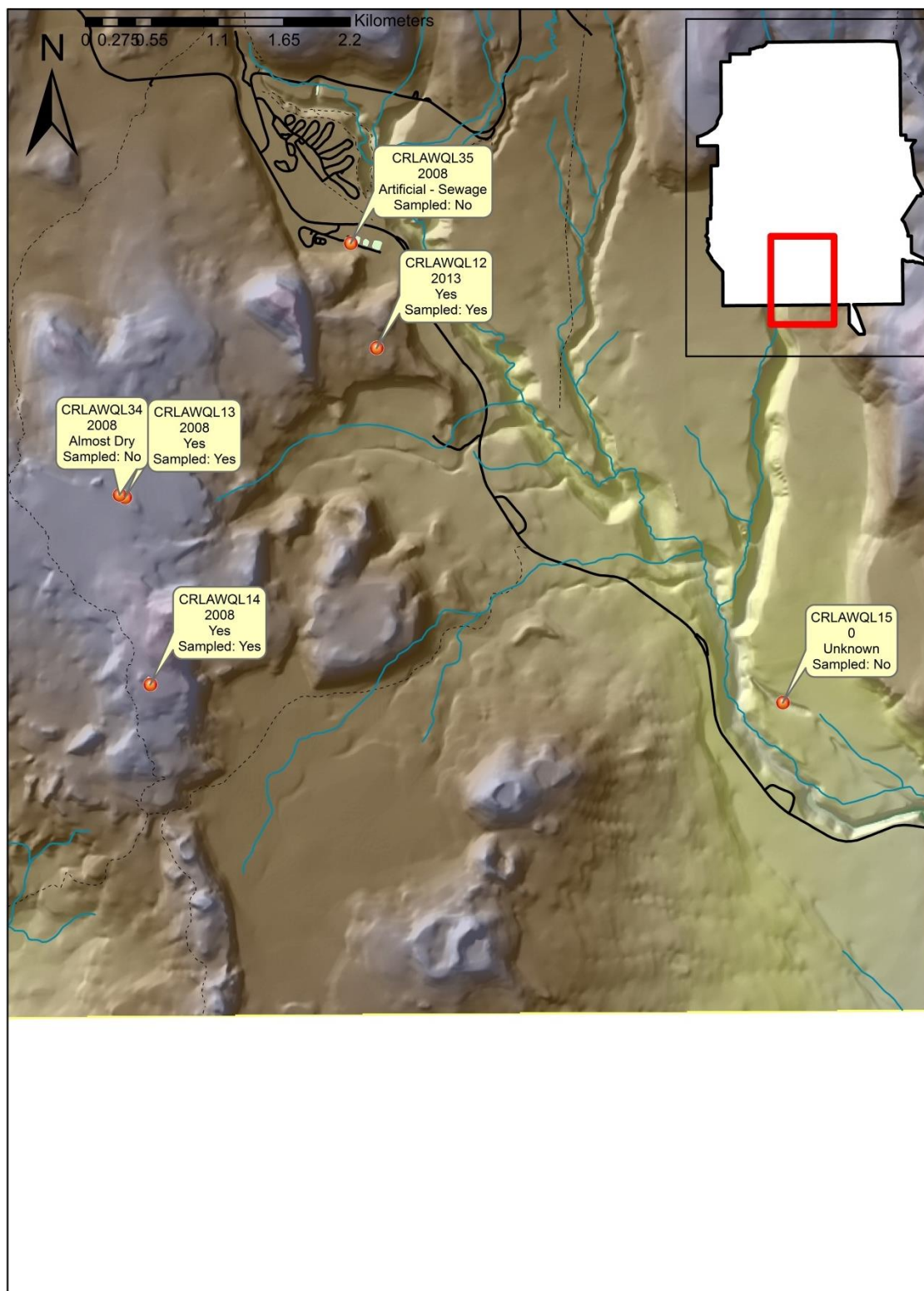


Figure G-6. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the southern portion of Crater Lake National Park.

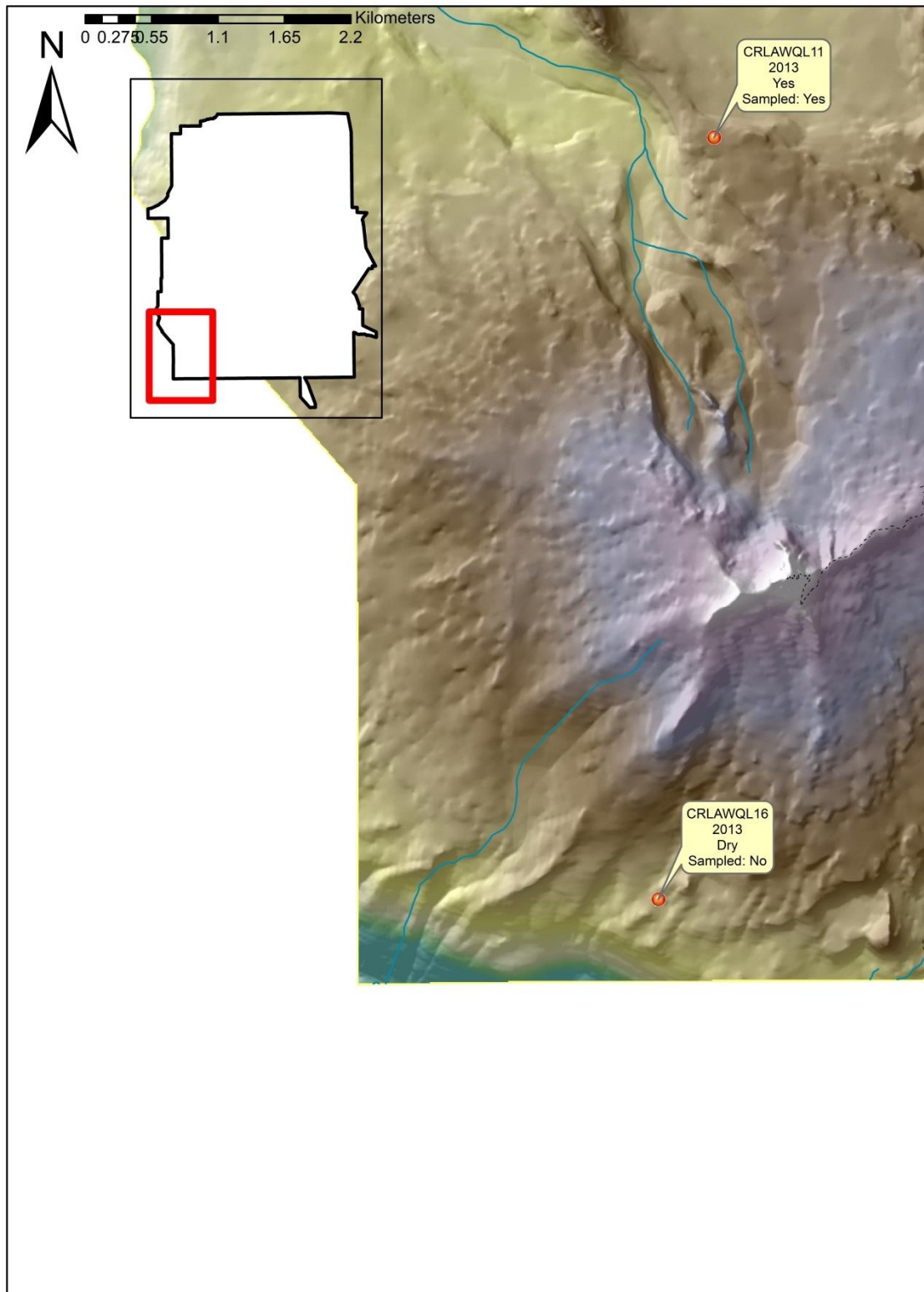


Figure G-7. Locations of sites visited in 2008 and 2013 to assess water status with site code, year visited, water status, and 2013 sampled status in the southwest portion of Crater Lake National Park.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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