



Vegetation Community Monitoring

2016 Results From Crater Lake National Park and Oregon Caves National Monument

Natural Resource Data Series NPS/KLMN/NRDS—2018/1178



ON THE COVER

Image of ORCA plot 3

Photo by Amy Rachkowski, KLMN Crew Lead

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Abstract

During the 2016 field season, the Klamath Inventory and Monitoring Network implemented the sixth season of its vegetation monitoring protocol (Odion et al. 2011) at Crater Lake National Park (Crater Lake) and Oregon Caves National Monument (Oregon Caves). The vegetation monitoring plots are 20 x 50 m (0.1 ha) and are partitioned into one of three sampling frames: matrix (upland), riparian (within 10 m of a perennial stream), and high elevation (above a predetermined elevation, generally near tree line). Once every three years we measure vegetation composition, structure, and function at two of the six network parks (all parks are visited once every three years). The protocol was initiated in 2011 when we established sites at Lava Beds National Monument and Redwood National and State Parks (Smith and Sarr 2013); those sites were revisited and remeasured in 2014 (Smith 2015). In 2012 we established sites at Whiskeytown National Recreation Area and Lassen Volcanic National Park (Smith and Sarr 2014b) and revisited those sites in 2015. In 2013 we established sites at Oregon Caves National Monument and Crater Lake National Park (Smith and Sarr 2014a); we revisited those sites in 2016.

This report summarizes the data collected in 2016 from Crater Lake and Oregon Caves. At Crater Lake we revisited 24 matrix, 20 riparian, and 20 high elevation sites. Two matrix sites were not revisited due to safety concerns. At Oregon Caves we revisited all 10 sites established in 2013. For vegetation composition, we report on species richness and non-native species presence. Structural data metrics include: live and dead trees/ha, live and dead tree basal area, tree height and height to crown, woody debris, substrate cover percentages, litter and duff depths, and vegetation cover by height strata. For vegetation function, we report on tree species regeneration: most abundant tree by size class and trees/ha by size class.

Introduction

The development of the Klamath Inventory and Monitoring Network (Klamath Network) vital signs monitoring has emphasized the importance of documenting status and trends in the composition, structure, and function of ecosystems. Vegetation is a foundation for terrestrial ecosystem composition, structure, and function. Vegetation also ranked among the highest potential vital signs for monitoring in the Network's vital signs selection process. The reasons are simply that vegetation dominates biomass and energy pathways and defines the habitat for most other forms of life. Changes in vegetation composition, structure, and function will therefore have a profound effect on ecosystems. Monitoring vegetation change is thus imperative to detecting and understanding status and trends in park ecosystem vital signs, the overriding goal of National Park Service (NPS) Inventory and Monitoring. Natural processes that have shaped vegetation inside and outside parks have been directly affected by a variety of land use activities, fire suppression/management, plus climate/atmospheric changes and many other anthropogenic factors. Vegetation sampling can help document changes in species composition, structure, and function that occur as a result of these processes.

In 2011, we began monitoring vegetation following the Klamath Network vegetation monitoring protocol (Odion et al. 2011) and established sites at Lava Beds National Monument, and Redwood National and State Parks (Smith and Sarr 2013), and we revisited those sites in 2014 (Smith 2015). In 2012, we established sites at Whiskeytown National Recreation Area and Lassen Volcanic National Park (Smith and Sarr 2014b). In 2013, we established sites at Oregon Caves National Monument and Crater Lake National Park (Smith and Sarr 2014a). Once every three years, we measure vegetation composition, structure, and function on selected sampling frames in six network parks.

The main objective for the Fiscal Year 2016 field season was to collect data from the 26 matrix, 20 riparian, and 20 high elevation plots at Crater Lake and 10 matrix sites at Oregon Caves.

Annual reports such as this one are intended for park staff and partners and summarize the data collected that season on the status of vegetation composition, structure, and function. The analyses and data summaries are selected to convey basic descriptive information in an easily interpreted format. More complex analyses and syntheses will be conducted every third year (beginning in 2014 for all six parks sampled from 2011 to 2013) as outlined in the vegetation monitoring protocol (Odion et al. 2011).

Methods

Complete methods for site selection, data collection, data management, and analysis are described in Odion et al. (2011), which provides detailed guidance for sampling in each park. This summary of methods is an overview to provide context for this report.

Site Selection

For safety and logistical reasons, we constrained the monitoring sampling frames to exclude areas with slopes greater than 30 degrees and locations less than 100 m, or more than 1 km, from a road or trail. An exception occurred at Whiskeytown National Recreation Area: due to safety issues regarding illegal cannabis cultivation in the park, all sites (except high elevation) were <150 m from a road or trail. Across all parks, three types of sampling frames were recognized: 1) riparian (areas within 10 m horizontally of a perennial stream), 2) high elevation (elevations above a specific elevation threshold in each park), and 3) matrix (remaining upland areas).

Crater Lake has all three sample frames. Oregon Caves only has the matrix sampling frame. Where possible, we aimed to co-locate our plots with landbird monitoring sites (Stephens et al. 2010) and stream monitoring sites (Dinger et al. 2013).

Training and Logistics

One NPS crew lead (GS-7) began work on May 16th: A. Rachkowski. On May 30th, one GS-7 Crew Leader (G.J. Johnson) and two GS-5 Biological Science Technicians (K. Hosken and A. Goodwin) began work. Hosken quit and was replaced on July 11th by L. Caverly.

Rachkowski was hired early to assist with Vegetation Mapping work. Initial training for the entire crew occurred during the week of May 30th. The initial in-office training included a review of the protocol and standard operating procedures, as well as safety and job hazard analysis discussions. Field procedure training occurred at a nearby green space. During the second work week, we made a site visit to Oregon Caves for species familiarization and hands-on instruction about protocol procedures. After training as a group for two work weeks, the crew began site sampling at Oregon Caves. After finishing at Oregon Caves, we conducted two days of training at Crater Lake for species familiarization. The Project Lead (Sean Smith) conducted one-on-one training with Caverly at Crater Lake. Crews worked a field schedule of eight 10-hour days; an eight-day work week is referred to hereafter as a hitch.

Field Sampling

A 20 × 50 m (0.1 ha) plot was used for sampling matrix sites (Figure 1); a 10 × 100 m or two 10 × 50 m plots were used for riparian sites, and riparian plot shape depended on the sinuosity of the stream channel (Figure 2). The 10 m wide riparian plots were used to avoid going too far into the upland habitat type, and the varying plot angles allowed us to capture more of the streamside vegetation. Site reference diagrams were drawn in the field for all riparian sites.

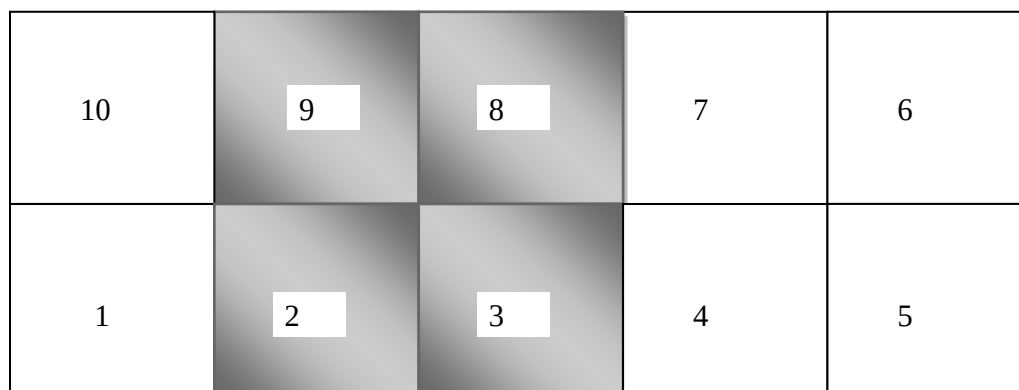


Figure 1. The 20 × 50 m matrix and high elevation site plot layout. Each numbered square is 10 × 10 m. Shaded squares are the four intensive modules.

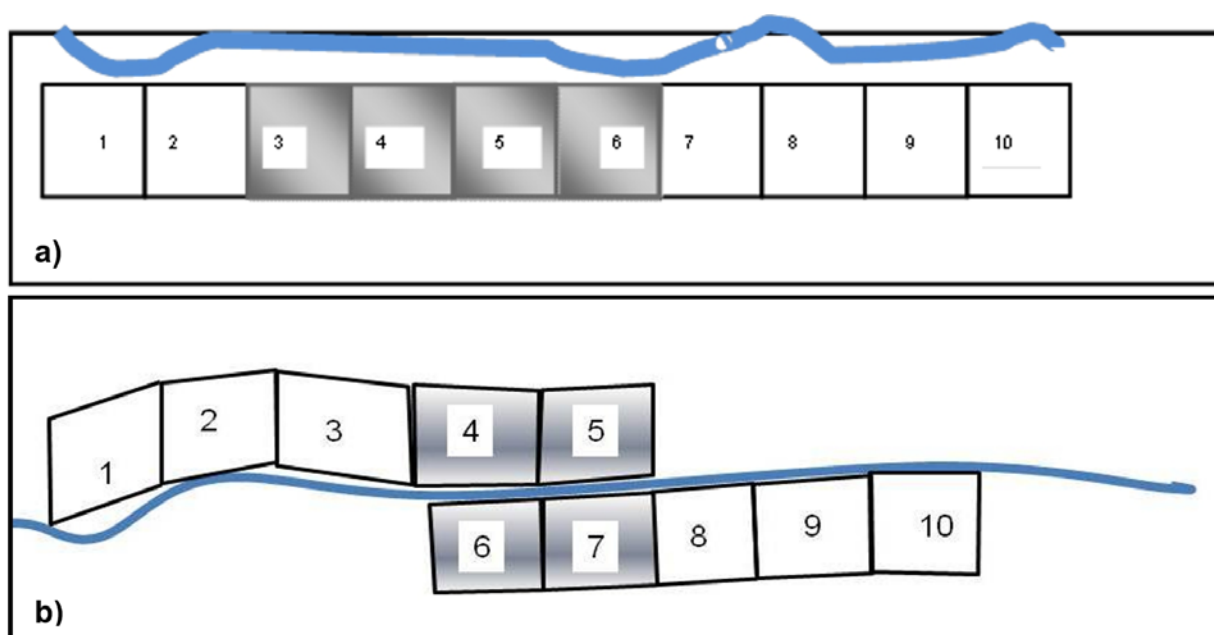


Figure 2. Riparian site plots in (a) one 10 × 100 m layout or (b) two 10 × 50 m layouts. Each numbered square is 10 × 10 m and shaded squares are the four intensive modules.

Each plot (total area 0.1 ha), regardless of sampling frame, consisted of ten 10 × 10 m modules, four of which were sampled intensively for species and substrate percent cover, and seedling and sapling counts. Standard Operating Procedures 6–9 of the Vegetation Monitoring protocol (Odion et al. 2011) provide details on the measurements of the following parameters sampled in each plot:

1. Slope
2. Aspect
3. Elevation
4. Micro topography
5. Macro topography

6. Vascular plant cover by species and height strata (Stratum 1 = (<0.75 m), Stratum 2 = (0.75–2.5 m), Stratum 3 = (2.6–5 m), and Stratum 4 = (>5 m)
7. Ground cover
8. Tree seedlings
9. Tree saplings by size class
10. Small trees by size class
11. Live trees (diameter at breast height [dbh], canopy position, and condition)
12. Dead trees (dbh, decay class)
13. Fine wood (<7.6 cm diameter), defined by time lag classes: how many hours would it would take for 2/3 of the dead fuel to respond to atmospheric moisture. In other words, how long for it to dry out. (1-hr = 0–0.62 cm; 10-hr = 0.63–2.54 cm; 100-hr = 2.55–7.6 cm)
14. Coarse wood (>7.6 cm in diameter, size, and decay class), also defined by lag classes (1000-hr sound; 1000-hr rotten)
15. Litter and duff (depth/thickness)

Data Management, Analysis, and Presentation

Data management followed the procedures outlined in Standard Operating Procedure 12 of the Vegetation Monitoring protocol (Odion et al. 2011). We collected field data on tablet computers, with nightly and weekly downloads to a secure thumb drive or computer. Verification of specimens and validation of data occurred throughout the field season and were finalized at the end of the field season by the Project Lead.

We performed general data summaries to provide descriptive statistics of the vegetation. These included measures of central tendency (mean, median) and variance (range, standard deviation) for selected parameters. Data are presented in tabular form, and where suitable, in a user-friendly graphical format to aid in the visualization of data distribution or geographic variation across the sampling frame. Depending on data collected during future monitoring of the parks, annual reports may show different statistics but will use the same general families of analysis and similar tables and illustrations.

The vascular plant taxonomy used in the study follows the United States Department of Agriculture (USDA) Plants Database (USDA, NRCS 2016).

Woody debris (tons/acre) was calculated using FFI (FEAT/FIREMON Integrated Database; Lutes et al. 2009) fuel constants.

Results

Sampling began at Oregon Caves on June 17th and ended on June 29th, 2016. Sampling occurred at Crater Lake from July 1st to Sept 30th, 2016. Despite one employee quitting and conducting a mid-season critical needs hire, our 2016 sampling went smoothly.

Here we summarize selected data most relevant to our monitoring objectives.

Crater Lake

At Crater Lake, we resampled 24 matrix, 20 riparian, and 20 high elevation sites (Figure 3). We did not sample two matrix sites, due to safety concerns regarding the National Creek Fire from 2015. We will revisit these matrix sites not sampled this year in 2019.

Oregon Caves

At Oregon Caves, we resampled all 10 matrix sites (Figure 4).

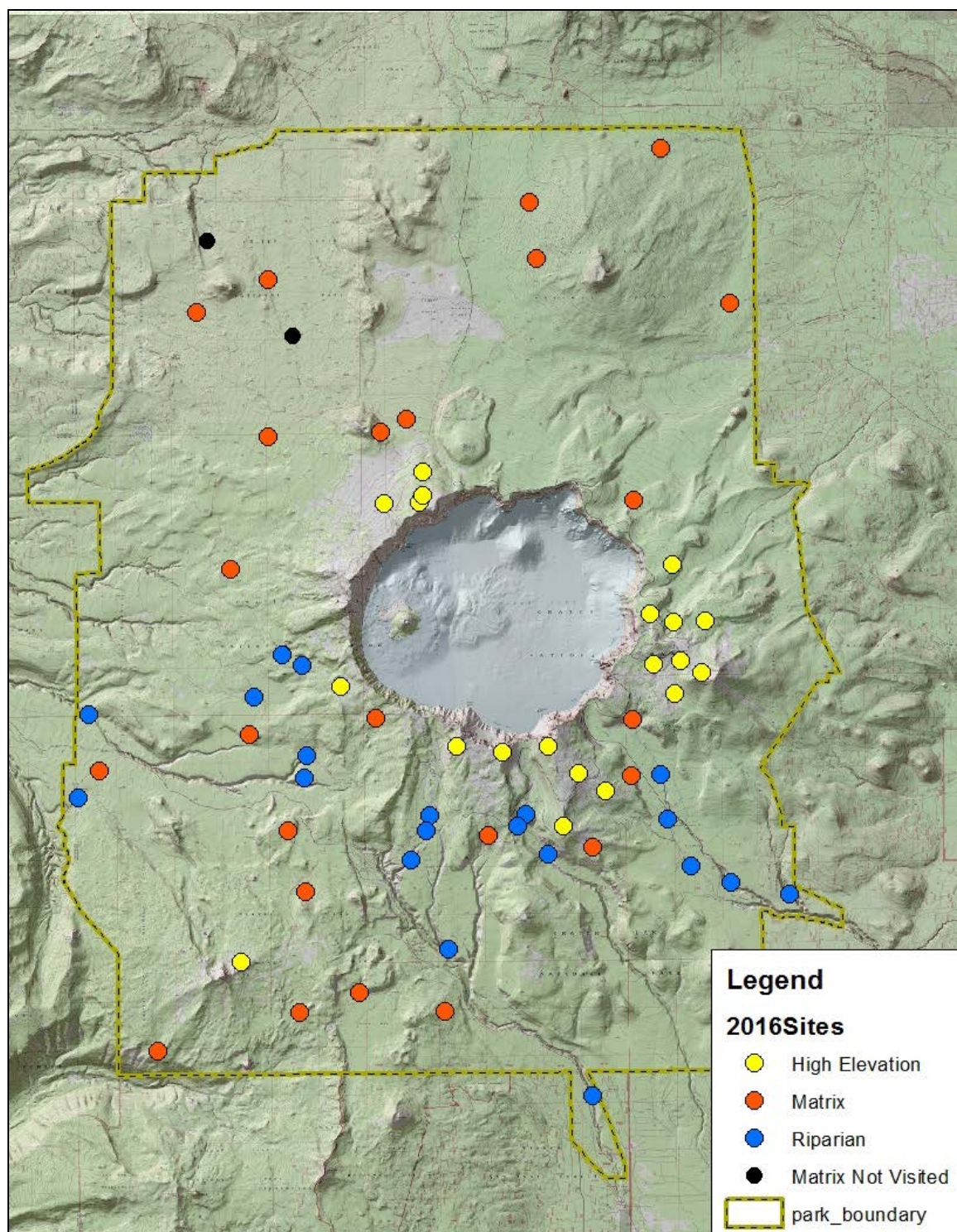


Figure 3. Location of vegetation monitoring sites at Crater Lake National Park in 2016.

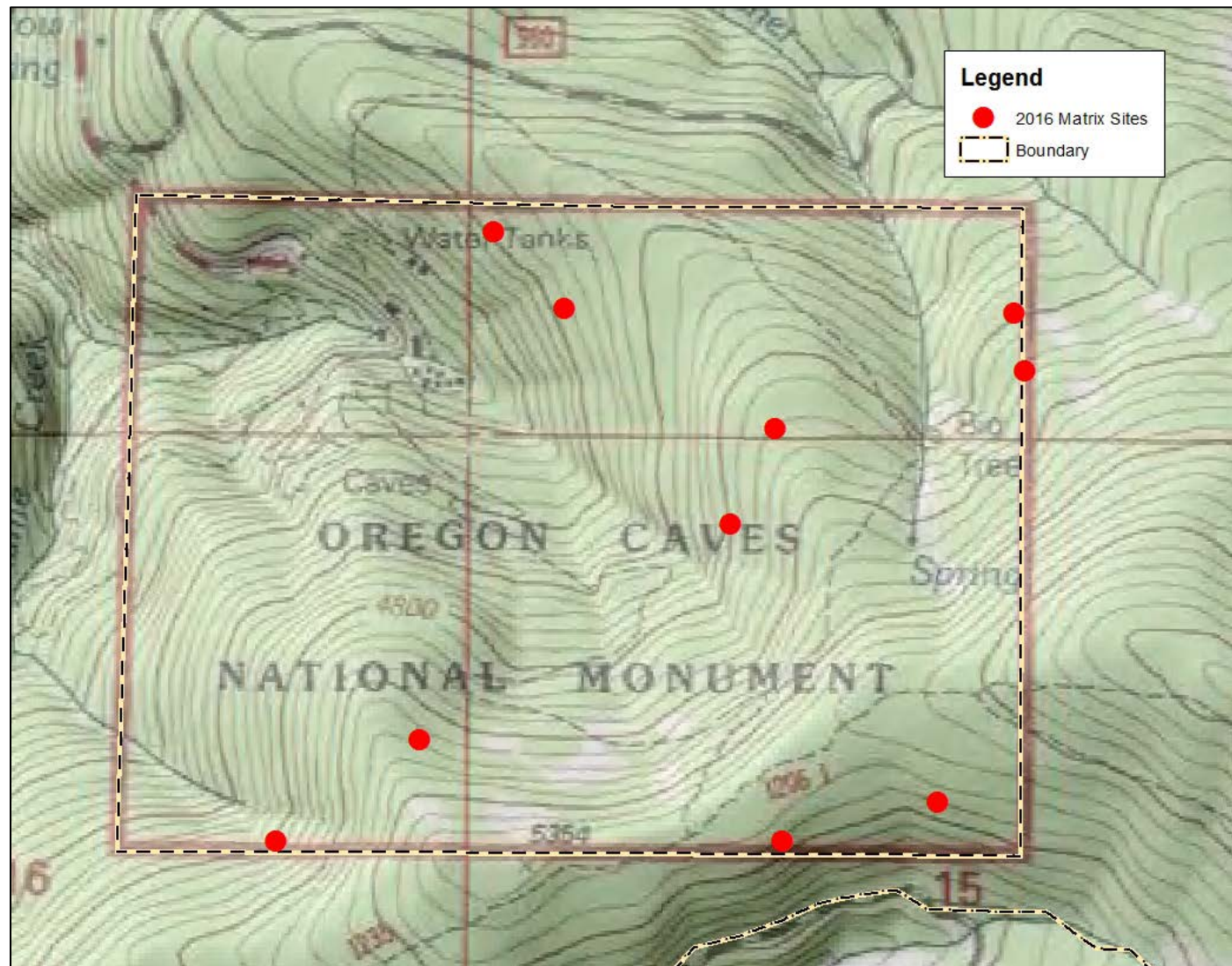


Figure 4. Location of vegetation monitoring sites at Oregon Caves National Monument in 2016.

Vegetation Composition

Oregon Caves

Vascular plant species richness for matrix plots at Oregon Caves ranged from 38 to 62 species (Table 1, Figure 5), with an average species richness of 53. For all matrix plots, 103 species were recorded, although the total was 126 when including unknowns. We define unknowns as any plant encountered in a sampling plot that cannot be identified to the species level; names are recorded to the finest taxonomic resolution possible: genus, family, lifeform, etc. The most frequently occurring herbaceous and shrub species by sample frame are shown in Table 2. Figure 6 shows the composition of tree basal area by tree species at each site.

Only one non-native species, bull thistle (*Cirsium vulgare*), was observed in the matrix sample frame. Non-native species by site ranged from 0 to 2% (Figure 5).

Table 1. Vascular plant species richness (SR) range, mean (standard deviation in parenthesis), and sample frame total from the 2016 vegetation monitoring plots at Oregon Caves.

Sample Frame	SR Range	SR Mean	Species Total
Matrix	38 - 62	53.1 (7.1)	126

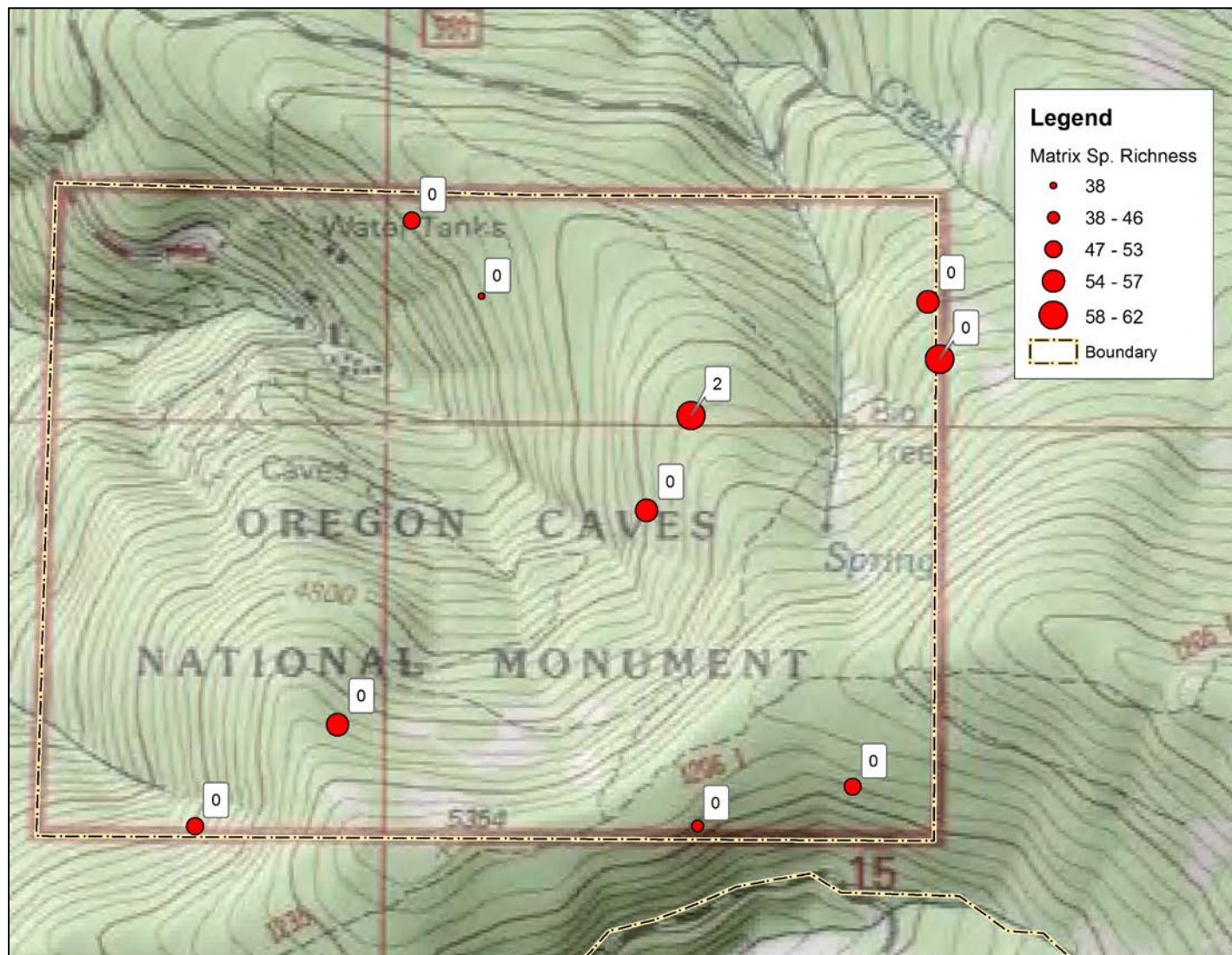


Figure 5. Vascular plant species richness for sites at Oregon Caves in 2016. Numbers next to sites indicate the percentage of non-native species present, no number shown for sites with no non-native species present.

Table 2. Most frequently occurring understory vascular plant species at Oregon Caves matrix sites. Number indicates frequency (% of plots where species occurred).

Vegetation Type	Species	% Plots
Herb	<i>Achlys triphylla</i>	100
	<i>Prosartes hookeri</i>	100
	<i>Phlox adsurgens</i>	100
	<i>Goodyera oblongifolia</i>	100
	<i>Galium triflorum</i>	100
	<i>Trientalis borealis</i> ssp. <i>latifolia</i>	100
	<i>Hieracium albiflorum</i>	100
	<i>Fragaria vesca</i>	90
	<i>Asyneuma prenanthoides</i>	90
	<i>Adenocaulon bicolor</i>	90
	<i>Asarum marmoratum</i>	90
	<i>Trillium ovatum</i>	90
	<i>Vancouveria hexandra</i>	90
Shrub	<i>Rosa gymnocarpa</i>	100
	<i>Symphoricarpos mollis</i>	90

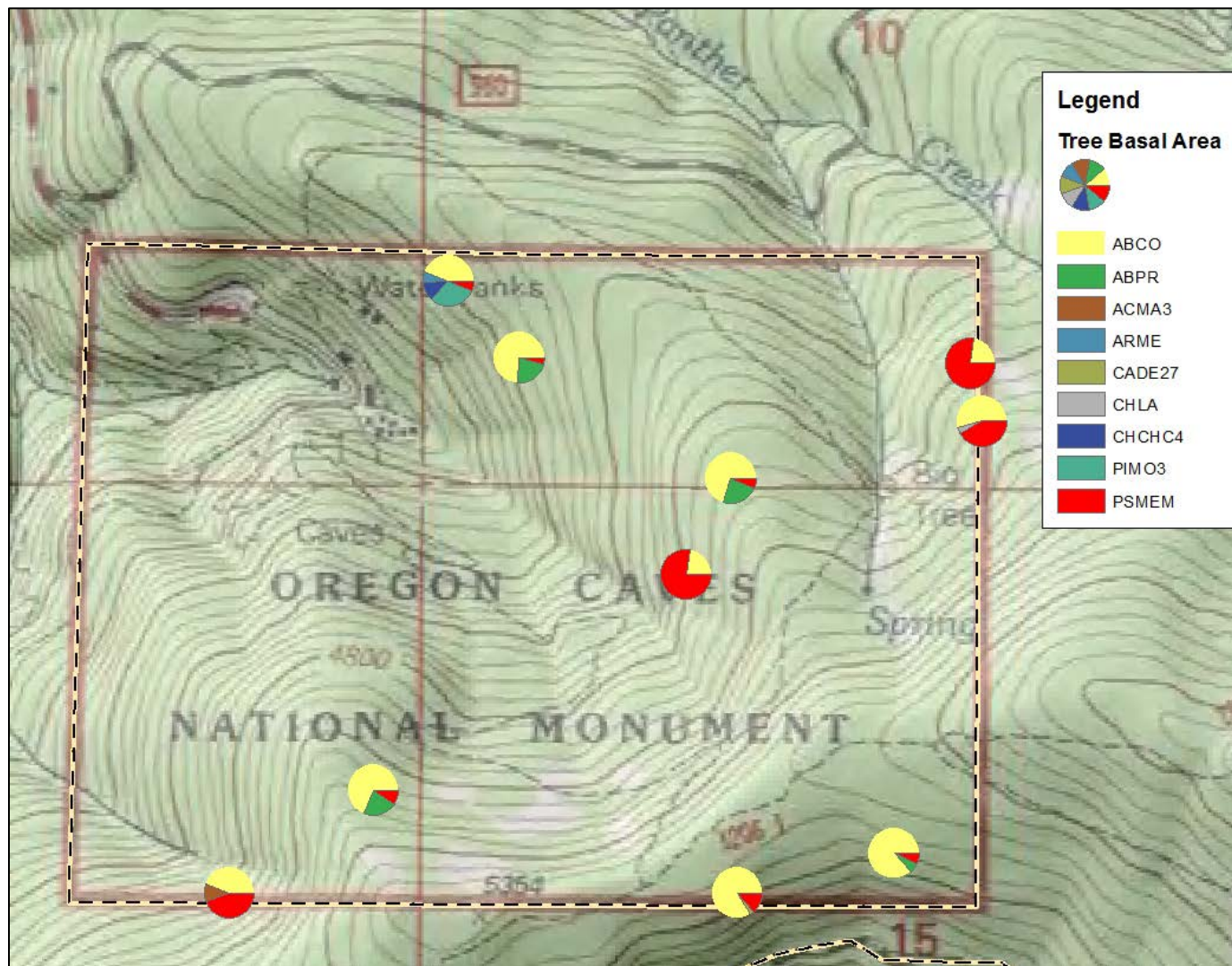


Figure 6. Individual tree species (>15 cm dbh) basal area composition at Oregon Caves sites in 2016.

Crater Lake

Vascular plant species richness in the Crater Lake matrix sampling frame ranged from six to 39 species per 0.1 ha sampling plot (Table 3, Figure 7). Across all matrix plots sampled, we observed 80 species, although the total was 92 when including unknowns. We define unknowns as any plant encountered in a sampling plot that cannot be identified to the species level; names are recorded to the finest taxonomic resolution possible: genus, family, lifeform, etc. In the riparian sampling frame, species richness at the plot level ranged from 59 to 91 species, with 236 species observed (265 including unknowns). High elevation sites had the lowest species richness, with a range of five to 26 species per plot, with 57 species observed (63 including unknowns). The most common herbaceous and shrub species by sample frame are shown in Tables 4, 5, and 6. Tree basal area composition by site is shown in Figure 8.

Non-native species composition ranged from 0 to 15% in matrix sites, 0 to 4% in riparian sites; no non-native species were observed in the high elevation sites (Figure 7). We observed a total of six non-native species. From all sample frames, the most frequently occurring non-native species was common dandelion (*Taraxacum officinale*), present at five sites.

Table 3. Vascular plant species richness (SR) range, mean (standard deviation in parenthesis), and sample frame total from the 2016 vegetation monitoring plots at Crater Lake.

Sample Frame	SR Range	SR Mean	Species Total
Alpine	5 - 26	17 (6.1)	63
Matrix	6 - 39	14 (7.5)	92
Riparian	59 - 91	75 (9.6)	265

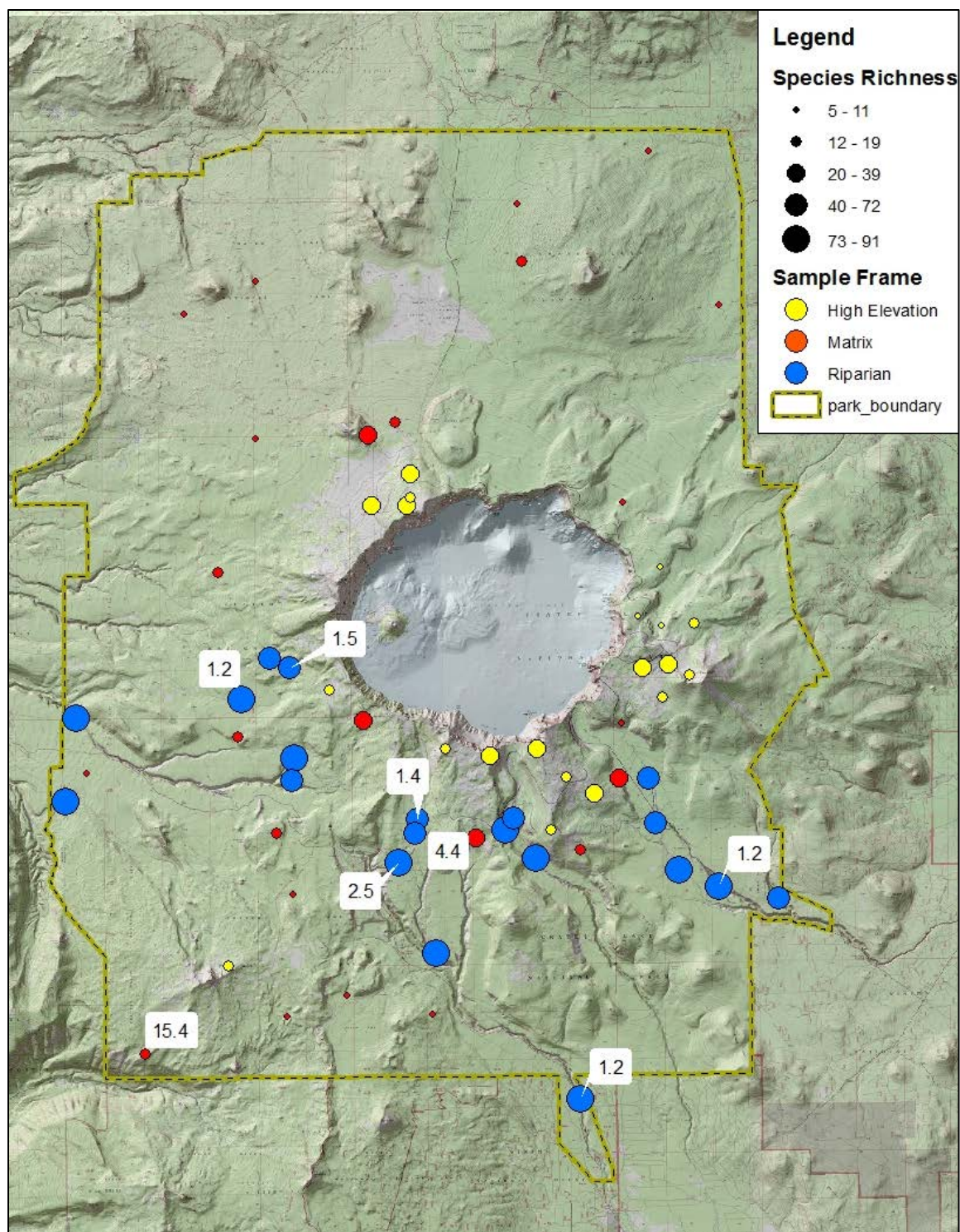


Figure 7. Vascular plant species richness for sites at Crater Lake from each sampling frame in 2016. White labels show percentage of species that are non-native. Sites without non-native species are not labeled.

Table 4. Most frequently occurring understory vascular plant species at Crater Lake matrix sites. Number indicates frequency (% of plots where species occurred).

Vegetation Type	Species	% Plots
Herb	<i>Carex inops</i> ssp. <i>inops</i>	92
	<i>Carex rossii</i>	54
	<i>Chimaphila umbellata</i>	46
	<i>Lupinus andersonii</i>	42
	<i>Achnatherum occidentale</i>	38
	<i>Chimaphila menziesii</i>	29
	<i>Cistanthe umbellata</i>	25
	<i>Luzula glabrata</i> var. <i>hitchcockii</i>	25
	<i>Orthilia secunda</i>	25
	<i>Allotropa virgata</i>	21
	<i>Arabis platysperma</i> var. <i>howellii</i>	21
	<i>Elymus elymoides</i>	21
	<i>Juncus parryi</i>	21
Shrub	<i>Arctostaphylos nevadensis</i>	38
	<i>Vaccinium scoparium</i>	29
	<i>Phlox diffusa</i>	21

Table 5. Most frequently occurring understory vascular plant species at Crater Lake riparian sites. Number indicates frequency (% of plots where species occurred).

Vegetation Type	Species	% Plots
Herb	<i>Aconitum columbianum</i>	100
	<i>Calamagrostis canadensis</i>	100
	<i>Senecio triangularis</i>	100
	<i>Carex neurophora</i>	95
	<i>Viola adunca</i>	95
	<i>Elymus glaucus</i>	90
	<i>Mimulus guttatus</i>	90
	<i>Mitella pentandra</i>	90
	<i>Viola glabella</i>	90

Table 5. Most frequently occurring understory vascular plant species at Crater Lake riparian sites. Number indicates frequency (% of plots where species occurred).

Vegetation Type	Species	% Plots
Herb (continued)	<i>Chamerion angustifolium</i> ssp. <i>circumvagum</i>	85
	<i>Osmorhiza berteroi</i>	85
	<i>Ranunculus gormanii</i>	85
	<i>Arnica mollis</i>	80
	<i>Cinna latifolia</i>	80
	<i>Epilobium hornemannii</i>	80
	<i>Ligusticum grayi</i>	80
	<i>Orthilia secunda</i>	80
	<i>Veronica wormskjoldii</i>	80

Table 6. Most frequently occurring understory vascular plant species at Crater Lake high elevation sites. Number indicates frequency (% of plots where species occurred).

Vegetation Type	Species	% Plots
Herb	<i>Eriogonum marifolium</i>	80
	<i>Polygonum davisiae</i>	80
	<i>Achnatherum occidentale</i>	75
	<i>Elymus elymoides</i>	70
	<i>Eriogonum pyrolifolium</i>	70
	<i>Cistanthe umbellata</i>	65
	<i>Lupinus lepidus</i>	65
	<i>Arabis platysperma</i> var. <i>howellii</i>	60
	<i>Luzula glabrata</i> var. <i>hitchcockii</i>	55
	<i>Arenaria pumicola</i>	50
	<i>Carex rossii</i>	50
Shrub	<i>Ericameria greenei</i>	55

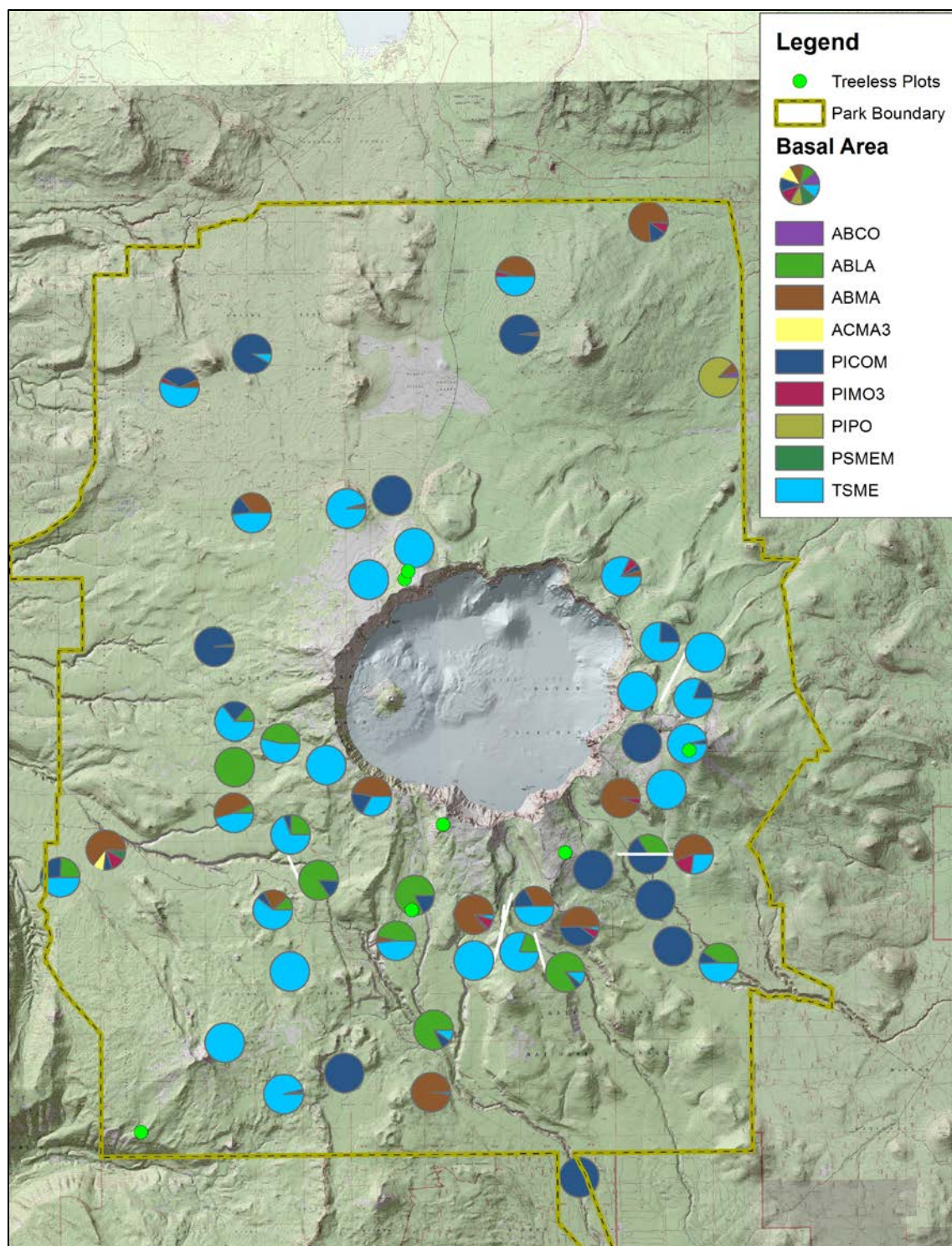


Figure 8. Individual tree (>15 cm dbh) species basal area composition of Crater Lake in 2016. White line indicated actual plot location, as basal area pie charts are off set to avoid overlap; treeless plots are not offset to avoid overlap.

Vegetation Structure

Oregon Caves

The highest mean vegetation cover in the Oregon Caves matrix sampling frame occurred in height stratum 4 (>5 m) (Table 7).

Table 7. Vegetation cover (%) by height stratum in the matrix sampling frame at Oregon Caves. SD = standard deviation.

Height Stratum	Min.	Max.	Mean	SD
<0.75 m	6.0	25.3	12.6	7.1
0.75-2.5 m	0.3	4.1	2.4	1.3
2.6-5 m	0.0	6.8	2.8	2.8
>5 m	23.0	110.3	68.5	22.2

Mean plot basal area for the matrix sampling frame was 60.2 m²/ha for live trees and 22.7 m²/ha for snags (Table 8). All matrix plots had trees >15cm dbh. Mean tree density was 310 trees/ha (Table 9). Table 9 also shows tree height, height to crown, and maximum height. Snag density and mean heights are shown in Table 10. Woody debris lag class values are presented in Table 11. Tables 12 and 13 summarize ground substrate cover and litter depth.

Table 8. Live tree and snag basal area (BA) minimum, maximum, mean, and standard deviation (SD) at Oregon Caves. Units are m²/ha.

Frame	Min. Live Tree BA	Max. Live Tree BA	Mean Live Tree BA	Live Tree BA SD	Min. Snag BA	Max. Snag BA	Mean Snag BA	Snag BA SD
Matrix	31.0	77.9	60.2	15.1	1.0	34.6	22.7	31.0

Table 9. Mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m) at Oregon Caves. Standard deviations are shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max. Tree Height
Matrix	310 (117.6)	24 (12)	9 (5)	61

Table 10. Mean snag density (stems/ha) and height (m) at Oregon Caves. Standard deviations are shown in parentheses.

Frame	Mean Snag Density	Mean Snag Height
Matrix	73 (28.7)	12 (10.6)

Table 11. Mean woody debris time lag classes (tons per acre) at Oregon Caves. Standard deviations are shown in parentheses (see page 4, #13 and #14 for lag class size criteria).

Frame	1-hr	10-hr	100-hr	10000-hr Rotten	1000-hr Sound
Matrix	0.89 (0.5)	1.5 (0.6)	3.9 (1.4)	9.4 (6.2)	15.7 (9.5)

Table 12. Ground/substrate mean percent cover at Oregon Caves. Standard deviations are shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
Matrix	0.1 (.2)	0.4 (.9)	6.1 (4.0)	91.2 (5.0)	0.2 (0.3)	0.0

Table 13. Litter and duff minimum, maximum, and mean depth at Oregon Caves. Units are cm, and standard deviations are shown in parentheses.

Frame	Mean Litter Depth	Min. Litter Depth	Max. Litter Depth	Mean Duff Depth	Min. Duff Depth	Max. Duff Depth
Matrix	3.3 (1.0)	1.9	4.9	4.0 (1.1)	2.3	6.4

Crater Lake

Mean percent vegetation values are shown in Table 14. The highest overall mean value for vegetation cover, 35.2 %, was found in riparian height stratum 1 (<0.75 m) (Table 14). Mean stratum cover was greatest in the matrix and high elevation frames in stratum 4 (>5 m).

Table 14. Vegetation cover (%) by height stratum in matrix and riparian sampling frames at Crater Lake. SD = standard deviation.

Height Stratum	Frame	Min.	Max.	Mean	SD
<0.75 m	High Elevation	0.3	26.9	9.2	7.6
	Matrix	0.4	50.2	5.4	10.0
	Riparian	15.6	70.4	37.3	14.1
0.75-2.5 m	High Elevation	0.0	10.8	1.5	2.7
	Matrix	0.0	15.0	4.9	4.0
	Riparian	0.4	24.3	9.1	7.2
2.6-5 m	High Elevation	0.0	7.8	1.4	2.3
	Matrix	0.0	12.8	3.2	3.1
	Riparian	0.0	37.5	5.4	8.0
>5 m	High Elevation	0.0	86.3	16.6	23.2
	Matrix	0.0	82.8	31.7	21.9
	Riparian	0.0	50.3	21.3	15.2

Mean live tree basal area at Crater Lake was highest in the matrix sampling frame (40.8 m²/ha) (Table 15), and a mean snag basal area of 8.7 m²/ha. One matrix plot lacked live trees >15cm dbh. Matrix site mean tree density was 380 trees/ha (Table 16), and mean snag density was 125 trees/ha (Table 17). Riparian mean basal area was 28.8 m²/ha, while snag basal area had the highest overall value of 14.7 m²/ha (Table 15). Only one riparian site lacked trees >15 cm dbh. Mean tree density in the riparian frame was 268 tree/ha, and snags were the highest density of all three sample frames at 132 trees/ha. The high elevation sample frame had the lowest live tree basal area (21.2 m²/ha), and snag basal area (7.9 m²/ha). High elevation tree density was 122 trees/ha for live and 28 trees/ha for snags. Five high elevation site lacked trees >15 cm dbh. Dead and down woody debris data are shown in Table 18. Substrate cover and litter and duff are shown in Tables 19 and 20.

Table 15. Live tree and snag basal area (BA) minimum, maximum, mean, and standard deviation (SD) for sampling frames at Crater Lake. Units are m²/ha.

Frame	Min. Live Tree BA	Max. Live Tree BA	Mean Live Tree BA	Live Tree BA SD	Min. Snag MA	Max. Snag BA	Mean Snag BA	Snag BA SD
High Elevation	0.0	83.6	21.2	25.3	0.0	4.3	7.9	0.0
Matrix	0.0	104.0	40.8	26.3	0.0	12.7	8.7	0.0
Riparian	0.0	83.8	28.8	23.9	0.0	14.7	14.7	0.0

Table 16. Mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m) at Crater Lake. Standard deviations are shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max. Tree Height
High Elevation	122 (118.6)	16 (8)	4 (4)	39
Matrix	380 (206)	18 (23)	6 (5)	46
Riparian	267 (170)	18 (8)	4 (3)	44

Table 17. Mean snag density (stems/ha) and height (m) at Crater Lake. Standard deviations are shown in parentheses.

Frame	Mean Snag Density	Mean Snag Height
High Elevation	28 (48)	10 (4)
Matrix	125 (86)	13 (7)
Riparian	132 (135)	15 (8)

Table 18. Summary of mean woody debris time lag classes (tons per acre) at Crater Lake. Standard deviations are shown in parentheses. (see page 4, #13 and #14 for lag class size criteria).

Frame	1-hr	10-hr	100-hr	10000-hr Rotten	1000-hr Sound
High Elevation	0.19 (0.23)	0.33 (0.39)	0.59 (0.83)	2.28 (3.98)	2.01 (4.21)
Matrix	0.67 (0.44)	1.44 (0.82)	2.35 (1.69)	6.30 (6.91)	8.04 (8.31)
Riparian	0.45 (0.35)	1.44 (1.13)	1.89 (1.38)	8.58 (25.41)	17.18 (13.20)

Table 19. Ground/substrate mean percent cover at Crater Lake. Standard deviations are shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
High Elevation	42.5 (31.9)	1.0 (1.9)	2.9 (3.4)	44.1 (33.2)	9.6 (19.0)	0
Matrix	5.0 (19.4)	0.2 (0.4)	3.6 (2.2)	86.5 (19.4)	0.6 (0.6)	0
Riparian	4.3 (7.4)	3.4 (3.7)	4.5 (2.7)	71.7 (15.4)	0.7 (0.7)	1.1 (1.4)

Table 20. Litter and duff minimum, maximum, and mean at Crater Lake. Units are cm, and standard deviations are shown in parentheses.

Frame	Mean Litter Depth	Min Litter Depth	Max Litter Depth	Mean Duff Depth	Min Duff Depth	Max Duff Depth
High Elevation	0.9 (0.8)	0.0	2.7	0.5 (0.9)	0	3.5
Matrix	1.8 (0.8)	0.2	3.4	1.9 (1.1)	0	4.7
Riparian	1.6 (0.8)	0.3	3.4	1.9 (1.9)	0	8.1

Vegetation Function (Regeneration)

Oregon Caves

In the matrix sampling frame at Oregon Caves, California incense-cedar (*Calocedrus decurrens*) and a *Pinus* sp. were the most abundant regenerating tree species in the smallest size class. In all other classes, white fir (*Abies concolor*) was dominant. Mean regeneration counts for all tree size classes are shown in Table 21.

Table 21. Regeneration by size class for all live tree species in the matrix sampling frame at Oregon Caves. Units are trees/ha, and standard deviations are shown in parentheses.

Frame	≤15 cm Tall	>15 cm Tall			
		<2.54 cm dbh	2.54 to 5 cm dbh	>5 to 10 cm dbh	>10 to <15 cm dbh
Matrix	50 (105)	150 (242)	100 (111)	100 (135)	68 (88)

Crater Lake

At Crater Lake, the most abundant regenerating tree species in the high elevation sampling frame for all classes was mountain hemlock (*Tsuga mertensiana*). Within the matrix sampling frame, mountain hemlock had the highest density in three size classes except in the >15 cm tall and <2.54 cm dbh category, where red fir (*Abies magnifica*) dominated, and in the >10 to <15 cm dbh category, where Sierra lodgepole pine (*Pinus contorta* var. *murrayana*) dominated. For the riparian sample frame, subalpine fir (*Abies lasiocarpa*) had the highest density in all classes. Mean regeneration counts for all trees by size class are shown in Table 22.

Table 22. Regeneration by size class for all live tree species in each sampling frame at Crater Lake. Units are trees/ha, and standard deviations are shown in parentheses.

Frame	≤15 cm Tall	>15 cm Tall			
		<2.54 cm dbh	2.54 to 5 cm dbh	>5 to 10 cm dbh	>10 to <15 cm dbh
High Elevation	575 (859)	525 (730)	113 (213)	96 (169)	24 (47)
Matrix	3729 (3827)	3750 (5017)	305 (336)	290 (237)	133 (117)
Riparian	1438 (1699)	5663 (5032)	249 (172)	189 (137)	69 (77)

Summary

Overall the season was a success. We missed sampling only two sites at Crater Lake due to safety concerns relating to a fire from the previous season. If safety clearance is assured, we will revisit these sites in 2019.

Nonnative Species

Bull thistle was found at both parks. This is a species of concern, listed by the Oregon Department of Agriculture as a list B plant (ODA 2017) and on the Klamath Network early detection list (Odion et al. 2011). We will continue to monitor the abundance of this species. Other species detected at Crater Lake pose no immediate threat to native plant communities.

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