



Monitoring Vegetation Composition, Structure, and Function in Oregon Caves National Monument and Crater Lake National Park

Fiscal Year 2013 Annual Report

Natural Resource Data Series NPS/KLMN/NRDS—2014/728



ON THE COVER

Sampling at: **Upper:** Oregon Caves Matrix Site; **Lower Left:** Crater Lake High Elevation Site; **Lower Right:** *Collomia mazama* from Crater Lake

Photograph by: Upper, Katelyn Detweiler; Lower Left, Ellery Watson; Lower, Right Sean B. Smith

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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.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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

This report describes the results of the third year of implementing the Klamath Network's Vegetation Monitoring Protocol. At Oregon Caves National Monument, we monumented and collected data from 10 matrix sites. At Crater Lake National Park, we monumented and collected data from 26 matrix, 20 riparian, and 20 high elevation sites. Data from these sites are summarized in this report in a format that provides a template for future annual vegetation monitoring data summary reports.

Introduction

In 2013, the Klamath Network Inventory and Monitoring Program (KLMN) implemented the third season of its vegetation monitoring protocol (Odion et al. 2011) at Oregon Caves National Monument (ORCA, or Oregon Caves) and Crater Lake National Park (CRLA, or Crater Lake). The protocol measures vegetation composition, structure, and function on selected sampling frames in each of the six parks of the network every three years. The previous two seasons we established sites at Lava Beds National Monument (2011), Redwood National and State Parks (2011), Whiskeytown National Recreation Area (2012), and Lassen Volcanic National Park (2012).

The main objectives for the Fiscal Year (FY) 2013 field season were to monument and collect data from 20 matrix and 20 riparian sites at Oregon Caves and 30 matrix, 20 riparian, and 20 high elevation sites at Crater Lake (Odion et al. 2011). After the 2011 season, when we met 80% of our goals to monument and collect data from sites, we realized the goals for monumenting and reading plots as planned in the Vegetation Monitoring Protocol (Odion et al. 2011) were very likely going to be too high to consistently meet. Entering into the 2013 season we therefore set a minimum sampling effort of 10 matrix sites at Oregon Caves and 20 matrix, 20 riparian, and 10 high elevation sites at Crater Lake.

Results are presented here in the format the KLMN proposes to use for future annual reporting of the vegetation monitoring. Annual reports are intended for park staff and partners and will summarize the work completed in a given field season and the status of vegetation composition, structure, and function based on the data collected. 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) 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 methods summary is an abbreviated overview to provide context for this report.

Site Selection

The monitoring sampling frame used was constrained for safety and logistical reasons 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. Across all parks, three types of sampling frames were recognized: 1) Riparian (areas within 20 m horizontally of a perennial stream), 2) High Elevation (elevations above a specific elevation threshold in each park), and 3) Matrix (remaining areas).

Oregon Caves had only the matrix sampling frame. The Vegetation Monitoring Protocol (Odion et al. 2011) identified two sampling frames at Oregon Caves (matrix and riparian), but since the proposed expansion area had not happened prior to FY 2013, the park did not have a sufficient riparian environment to sample. Should the expansion happen we will explore the possibility of sampling more matrix site and riparian sites within the expansion. We chose to establish plots only in the matrix sampling frame at Oregon Caves. At Crater Lake, the park landscape was divided into matrix, riparian, and high elevation sampling frames. For each sampling frame, we set target sample sizes following the Vegetation Monitoring Protocol (Odion et al. 2011), which were 30 matrix, 26 riparian, and 20 high elevation plots at Crater Lake. Where possible, we aimed to co-locate our plots with Landbird Monitoring sites (Stevens et al. 2011), Stream Monitoring sites (Dinger et al. 2013, and Whitebark Pine Monitoring sites (McKinney et al. 2012).

Training and Logistics

Three National Park Service (NPS) crew members began work on June 17th to assist the Crew Lead with site sampling. In addition to the four NPS positions, one Southern Oregon University (SOU) alumna and one SOU student intern were hired through a cooperative agreement to assist with sampling, also beginning June 17th. Initial training occurred during the first work week. Training consisted of protocol and Standard Operating Procedure (SOP) review, safety and Job Hazard Analysis (JHA) discussions in the office, and field procedures training 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 of protocol procedures. After training as a group for two work weeks, we split into two groups, and sampling was conducted by three-person crews. Crews worked a field schedule of eight 10-hour days; an eight day work week is referred to hereafter as a hitch.

Field Sampling

Sampling at Oregon Caves occurred between June 25th and July 5th. Sampling at Crater Lake occurred between July 15th and Sept 14th. A 20 x 50 m plot was used for sampling matrix sites (Figure 1); a 10 x 100 m or two 10 x 50 m plots was used for riparian sites, and plot shape depended on the sinuosity of the stream channel (Figures 2a and b). The 10 m wide riparian plots were used to avoid going too far into the upland habitat type, and the varying plot angles (plots were not strictly linear) allowed us to capture more of the streamside vegetation. Site diagrams were drawn in the field

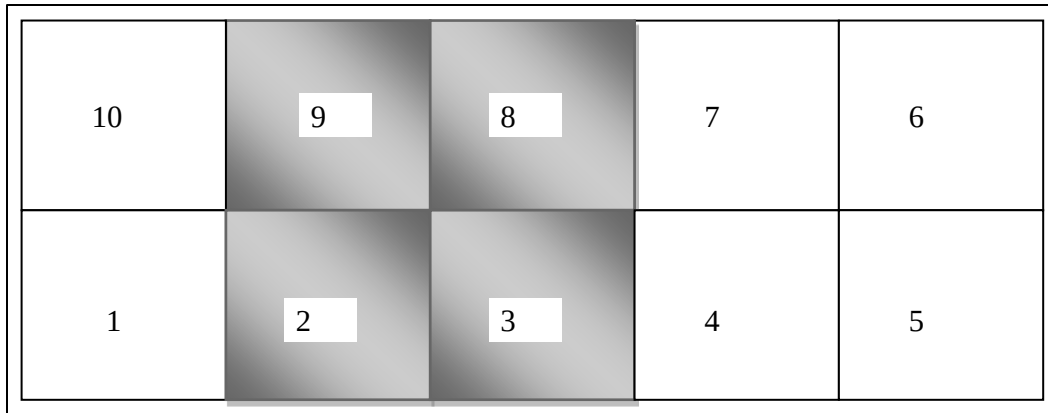


Figure 1. The 20 x 50 m matrix and high elevation site layout. Each numbered square is 10 x 10 m. Shaded squares are the four intensive modules.

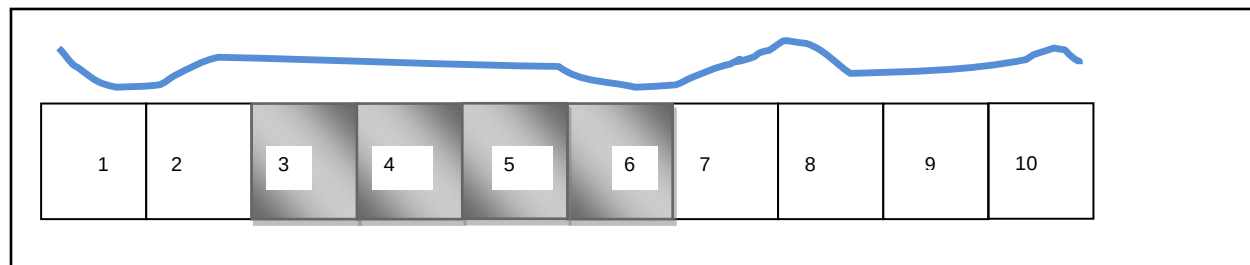


Figure 2a. Ten x 100 m riparian plot layout. Each numbered square is a 10 x10 m module. Shaded squares are the four intensive modules.

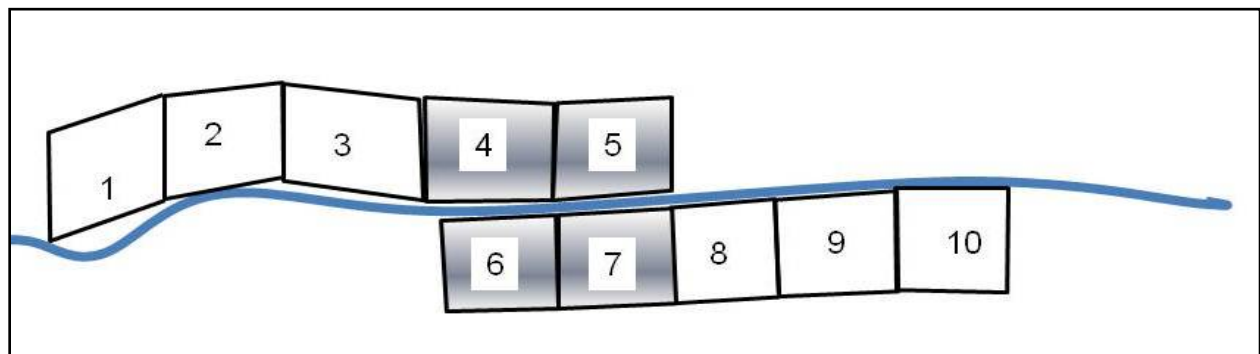


Figure 2b. Ten x 50 m riparian site layout. Each numbered square is 10 x10 m. Shaded squares are the four intensive modules.

for all riparian sites. Each plot (total area 0.1ha), regardless of sampling frame, consisted of ten 10 x 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, which are sampled in each plot:

1. Slope
2. Aspect

3. Elevation
4. Microtopography
5. Macrotopography
6. Vascular plant cover by species and height strata (Stratum 1 = (<0.75m), 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)
14. Coarse wood (>7.6 cm in diameter, size and decay class)
15. Litter and duff: (depth/thickness)

Data Management, Analysis, and Presentation

All data management followed the procedures outlined in Standard Operating Procedure 12 of the Vegetation Monitoring Protocol (Odion et al. 2011). Field data were collected on tablet computers in the field, with nightly and weekly downloads to a secure thumb drive or computer, respectively. Verification of specimens and validation of data occurred throughout the field season and was finalized at the end of the field season, led by the field Crew Lead (Sean Smith).

General data summaries were conducted to provide descriptive statistics of the park vegetation. These included measures of central tendency (mean, median) and variance (range, standard deviation) for each selected parameter. 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. A procedure for producing bubble maps was created for use in the future. Depending on data collected in 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.

Due to database constraints, the vascular plant taxonomy used in the study is a combination of The Jepson Manual 1st edition (Hickman et al. 1993) and United States Department of Agriculture (USDA) Plants Database (USDA, NRCS 2012).

Woody debris tons/acre was calculated using FFI (FEAT/FIREMON Integrated Database; Lutes et al. 2009) fuel constants. We did not calculate weighted averages.

Results and Discussion

We realized after the 2011 field season of sampling at Lava Beds and Redwoods, the original goals of number of sites to monument set out in Odion et al. (2011) were too ambitious. We adjusted our goals for 2012, while sampling at Whiskeytown and Lassen, and nearly met them despite complications (Smith and Sarr 2014). For 2013, we knew we would probably again not meet the Odion et al. (2011) goals but set tentative goals of 10 matrix sites at Oregon Caves, and 20 matrix, 20 riparian, and 10 high elevation site at Crater Lake. Our 2013 sampling went smoothly, and we met our minimum goals at Oregon Caves and exceeded them at Crater Lake.

Here we summarize selected data most relevant to our monitoring objectives. The Appendix provides a more comprehensive summary of the environmental data collected at each site.

Oregon Caves

At Oregon Caves, we established 10 matrix sites. No site co-location was possible. Figure 3 shows site locations.

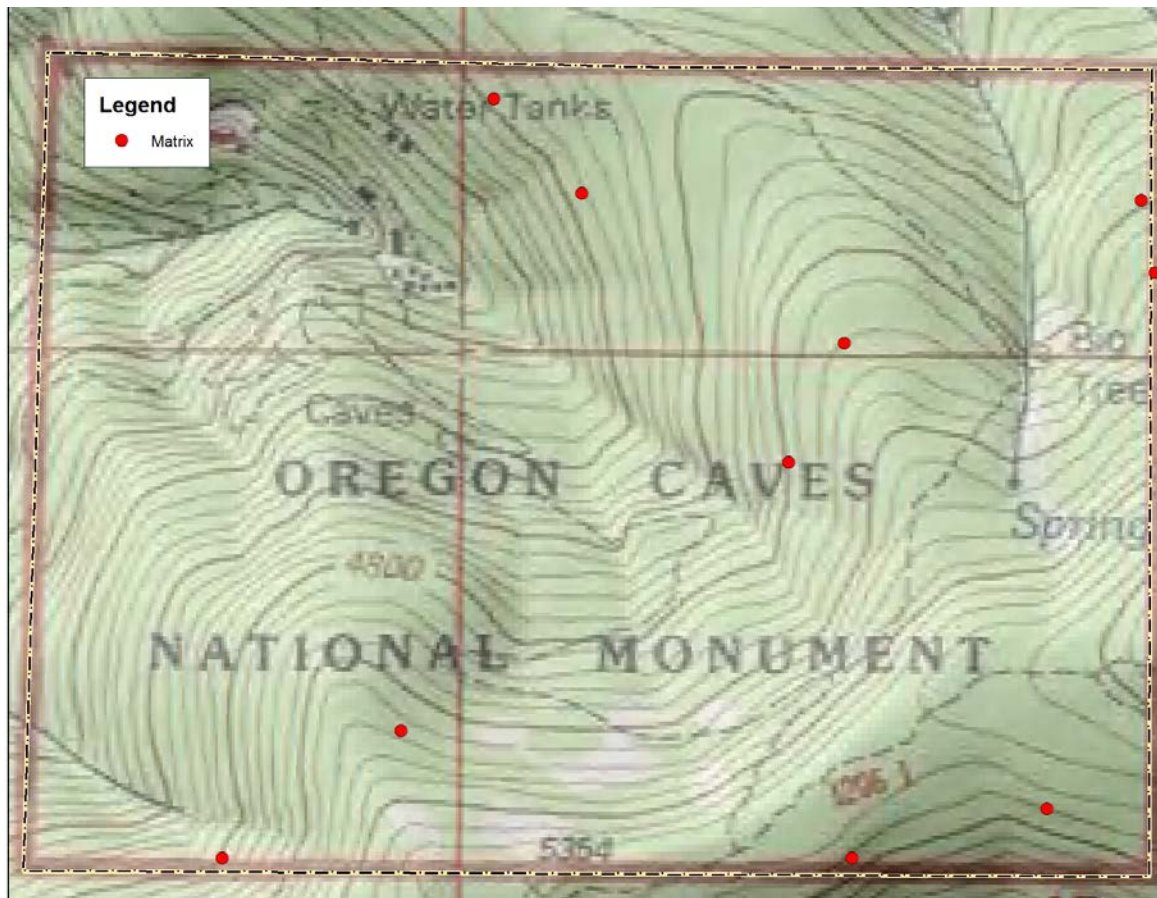


Figure 3. Location of 2013 Vegetation Monitoring plots at Oregon Caves National Monument.

Crater Lake

At Crater Lake, we established 26 matrix sites, 15 co-located with Landbird Monitoring sites; (Stevens et al. 2011) 20 riparian sites, 17 co-located with Stream Monitoring sites (Dinger et al. 2013; and 20 high elevation sites, 10 co-located with Whitebark Pine Monitoring sites (McKinney et al. 2012). Figure 4 shows the site locations.

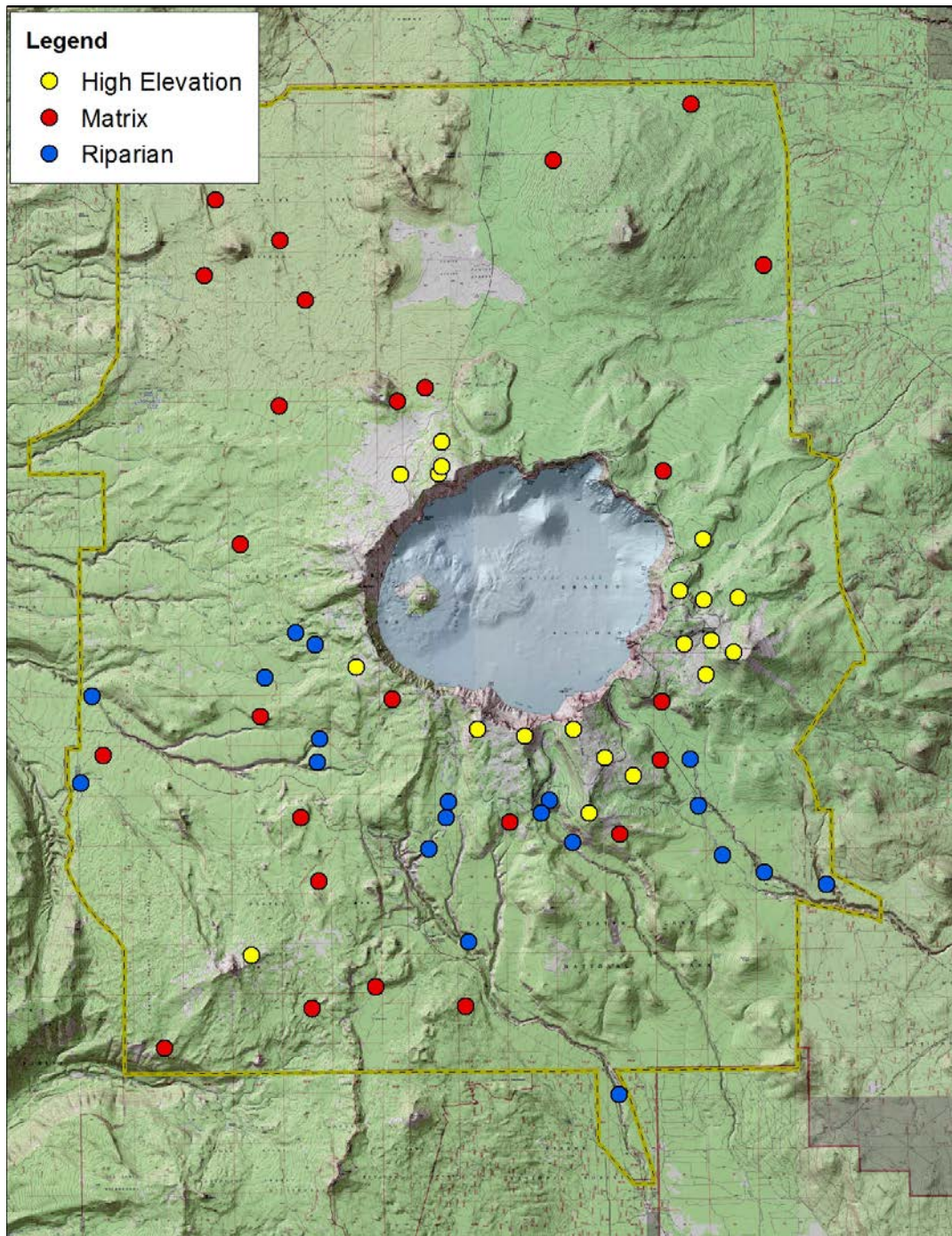


Figure 4. Location of 2013 Vegetation Monitoring sites at Crater Lake National Park.

Vegetation Composition

Oregon Caves

Vascular plant species richness for the 0.1 ha sampling plot at Oregon Caves ranged from 46 to 62 species for matrix plots. (Figure 5, Table1). For all matrix plots, 113 species were recorded (135 including unknowns). The most frequently occurring understory species are shown in Table 2. No non-native species were observed. Tree species composition at Oregon Caves consisted of nine species. Both white fir (*Abies concolor*) and Douglas fir (*Pseudotsuga menziesi*) occurred in all plots. Figure 6 shows tree basal area composition percentage by site.

One new genus was observed at Oregon Caves. A species of *Woodsia* was collected but could not be identified confidently to species.

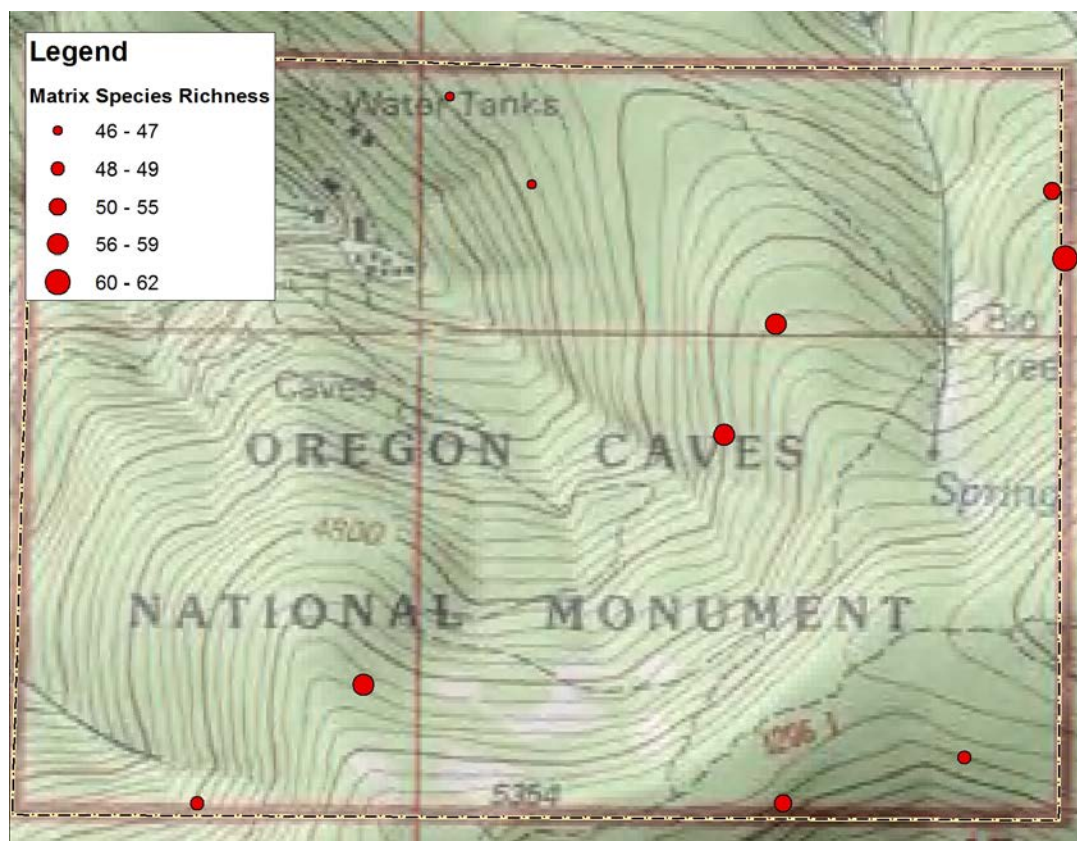


Figure 5. Oregon Caves species richness of matrix sampling frame sites.

Table 1. Species richness (SR) minimum, maximum, mean, and sample frame total from the 2013 Vegetation Monitoring plots.

Park	Sample frame	SR Min	SR Max	SR Mean	Sample Frame Total
ORCA	Matrix	46	62	54	135
CRLA	High Elevation	5	28	18	72
CRLA	Matrix	7	36	14	87
CRLA	Riparian	52	89	72	293

Table 2. Most frequently occurring understory species at Oregon Caves matrix sites. Number indicates constancy (% of plots species occurred in).

Herbs		Herbs	
<i>Achlys triphylla</i>	100	<i>Maianthemum stellatum</i>	90
<i>Bromus orcuttianus</i>	100	<i>Phlox adsurgens</i>	90
<i>Fragaria virginiana</i>	100	<i>Prosartes hookeri</i>	90
<i>Galium triflorum</i>	100	<i>Trillium ovatum</i> ssp. <i>ovatum</i>	90
<i>Trientalis borealis</i> ssp. <i>latifolia</i>	100	<i>Vancouveria hexandra</i>	90
<i>Adenocaulon bicolor</i>	90	Shrubs	
<i>Anemone deltoidea</i>	90	<i>Rosa gymnocarpa</i>	100
<i>Asarum marmoratum</i>	90	<i>Corylus cornuta</i>	90
<i>Goodyera oblongifolia</i>	90	<i>Symphoricarpos mollis</i>	90
<i>Hieracium albiflorum</i>	90		

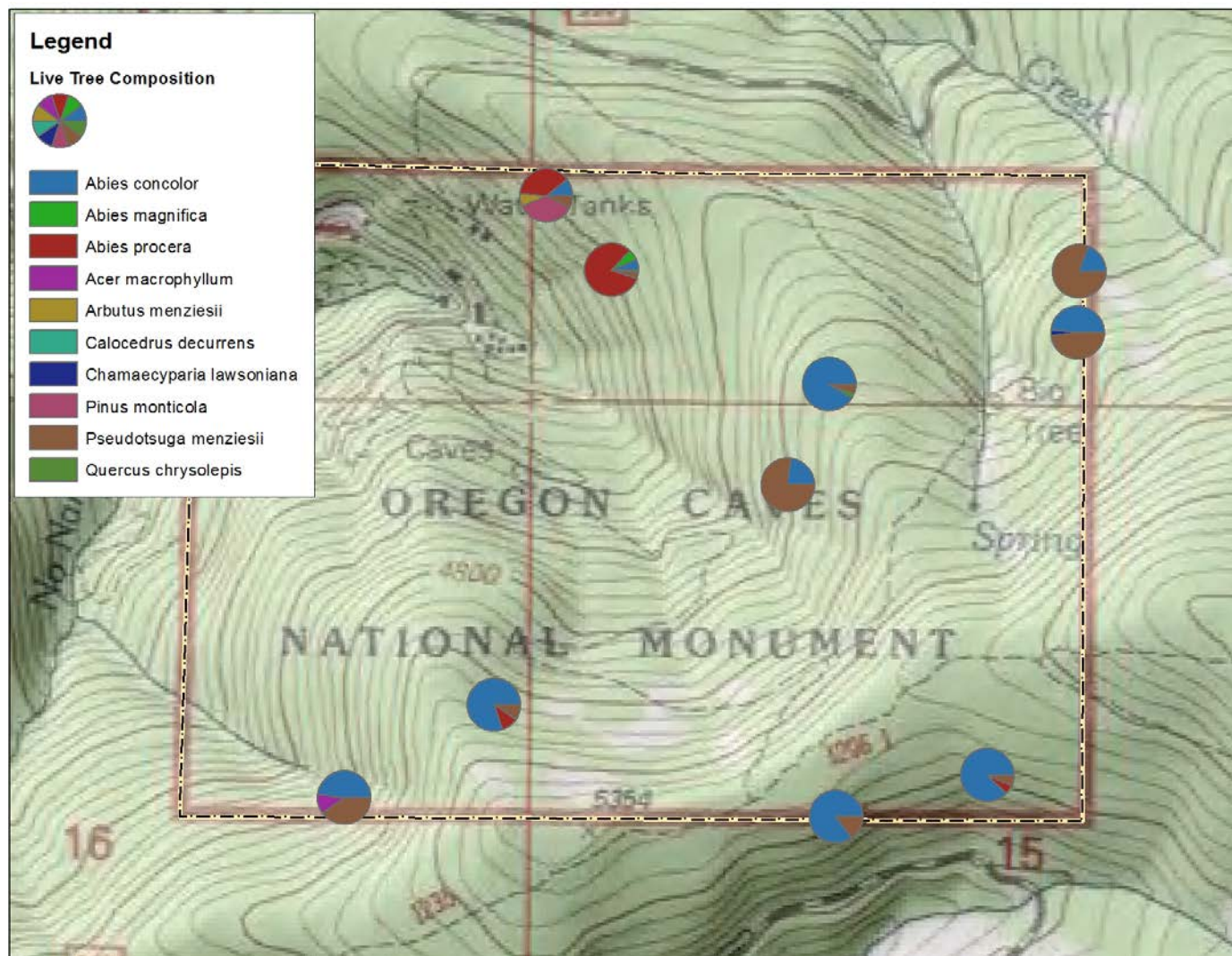


Figure 6. Individual tree species (>15cm dbh) basal area composition of Oregon Caves matrix sites.

Crater Lake

Species richness in the Crater Lake matrix sampling frame ranged from 7-36 species per 0.1 ha sampling plot (Figure 7, Table 1). Across all matrix plots sampled, 81 species (87 including unknowns) were observed. The riparian sampling frame proved to be very diverse; species richness at the plot level ranged from 52-89 species, with 250 species observed (293 including unknowns). Species richness in the high elevation frame ranged from 5-28, with 60 species observed (72 including unknowns). The most frequently occurring understory species for each sampling frame are shown in Tables 3, 4, and 5. Non-native species composition ranged from 0-11.1% in matrix sites, 0-3.8% in riparian sites, and 0% for all sites in the high elevation frame (Figure 7). We observed three non-native species in the matrix sampling frame and three in the riparian. Only dandelion (*Taraxacum officinale*) and bedstraw (*Gallium aparine*) were observed with notable frequency in the riparian sampling frame (each at six sites). Twelve tree species were observed; nine occurred in the matrix sampling frame, eight in the riparian frame, and four in the high elevation frame. Tree basal area composition by site is shown in Figure 8.

We had four confirmed new species at Crater Lake. One was a non native: *Cerastium fontanum*. We also observed three native species: *Botrychium pinnatum* (northern moonwort), *Carex praegracilis* (clustered field sedge), and *Conyza canadensis* (Canadian horseweed).

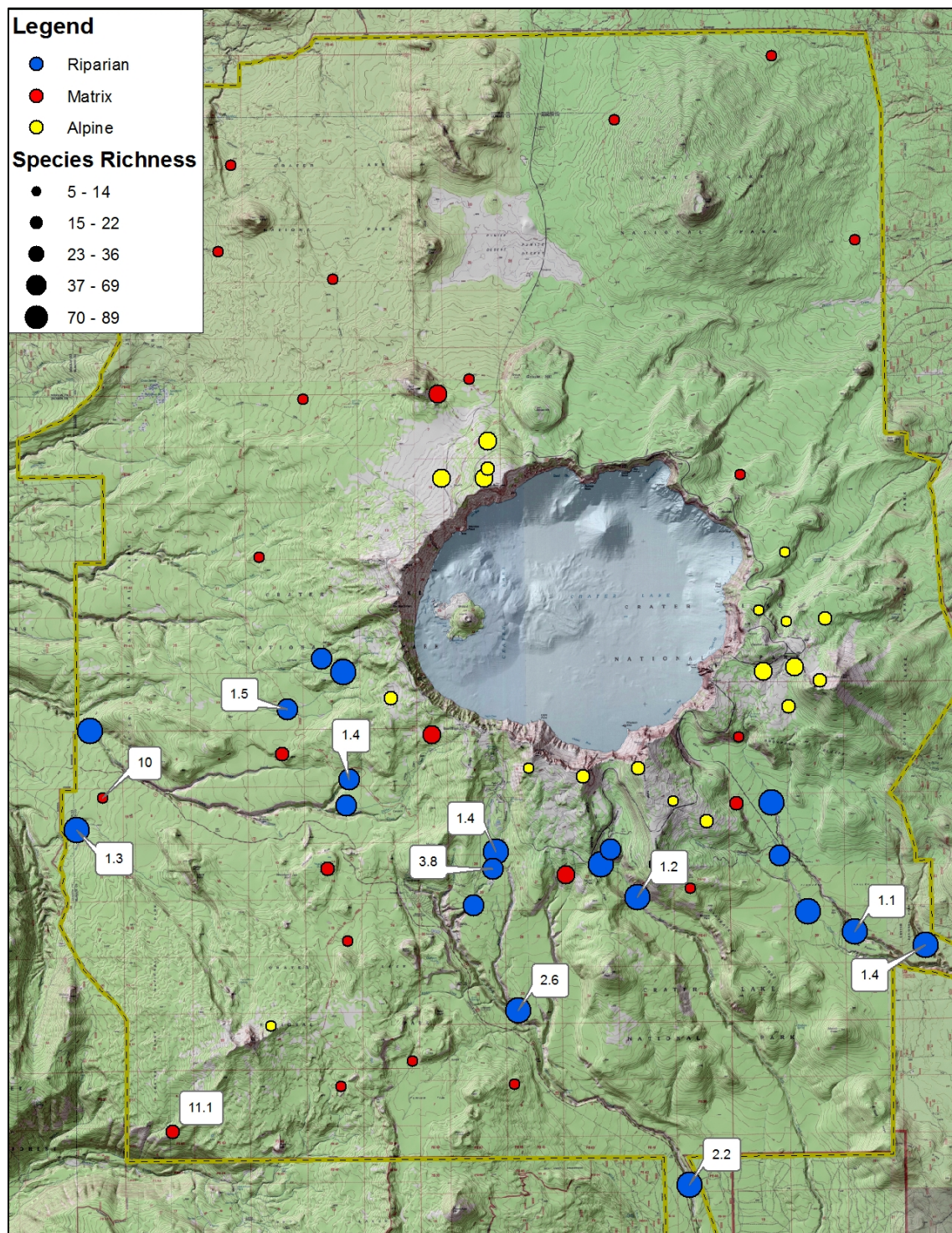


Figure 7. Crater Lake site species richness from each sampling frame. White labels show percentage of species that are non-native. Sites with no non-native species are not labeled.

Table 3. Most frequently occurring understory species at Crater Lake riparian sites. Number indicates constancy (% of plots species occurred in) (* indicates non-native species).

Herbs		Herbs	
<i>Calamagrostis canadensis</i>	100	<i>Osmorhiza berteroi</i>	80
<i>Mitella pentandra</i>	100	<i>Viola adunca</i>	80
<i>Senecio triangularis</i>	100	<i>Gallium trifolium</i>	75
<i>Aconitum columbianum</i>	95	<i>Ligusticum grayi</i>	75
<i>Carex neurophora</i>	95	<i>Ranunculus gormanii</i>	75
<i>Cinna latifolia</i>	95	<i>Stellaria calycantha</i>	75
<i>Elymus glaucus</i>	95	<i>Veronica womskjoldii</i>	75
<i>Viola glabella</i>	90	<i>Arnica mollis</i>	70
<i>Epilobium angustifolium</i>	85	<i>Chimaphila umbellata</i>	70
<i>Mimulus guttatus</i>	85	<i>Luzula parviflora</i>	70
<i>Orthilia segunda</i>	85	<i>Unknown Epilobium spp.</i>	70
<i>Carex inops ssp. inops</i>	80	Shrubs	
<i>Glyceria elata</i>	80	<i>Vaccinium membranaceum</i>	70

Table 4. Most frequently occurring understory species at Crater Lake high elevation sites. Number indicates constancy (% of plots species occurred in) (* indicates non-native species).

Herbs		Herbs	
<i>Polygonum newberryi</i>	80	<i>Lupinus lepidus</i>	65
<i>Achnatherum occidentale</i>	75	<i>Luzula hitchcockii</i>	60
<i>Eriogonum marifolium</i>	75	<i>Carex rossii</i>	55
<i>Elymus elymoides</i>	70	<i>Carex breweri</i>	50
<i>Boechera howellii</i>	65	<i>Juncus parryi</i>	50
<i>Ericameria greenei</i>	65	<i>Arenaria pumicola</i>	45
<i>Eriogonum pyrolifolium</i>	65	<i>Viola purpurea</i>	45

Table 5. Most frequently occurring understory species at Crater Lake matrix sites. Number indicates constancy (% of plots species occurred in).

Herbs		Herbs	
<i>Carex inops ssp. inops</i>	85	<i>Boechera howellii</i>	27
<i>Achnatherum occidentale</i>	54	<i>Chimaphila menziesii</i>	27
<i>Chimaphila umbellata</i>	54	<i>Elymus elymoides</i>	27
<i>Carex rossii</i>	50	<i>Juncus parryi</i>	27
<i>Lupinus andersonii</i>	42	<i>Phlox diffusa</i>	23
<i>Orthilia segunda</i>	38	Shrubs	
<i>Calyptridium umbellatum</i>	31	<i>Arctostaphylos nevadensis</i>	38
<i>Luzula hitchcockii</i>	31	<i>Vaccinium scoparium</i>	31

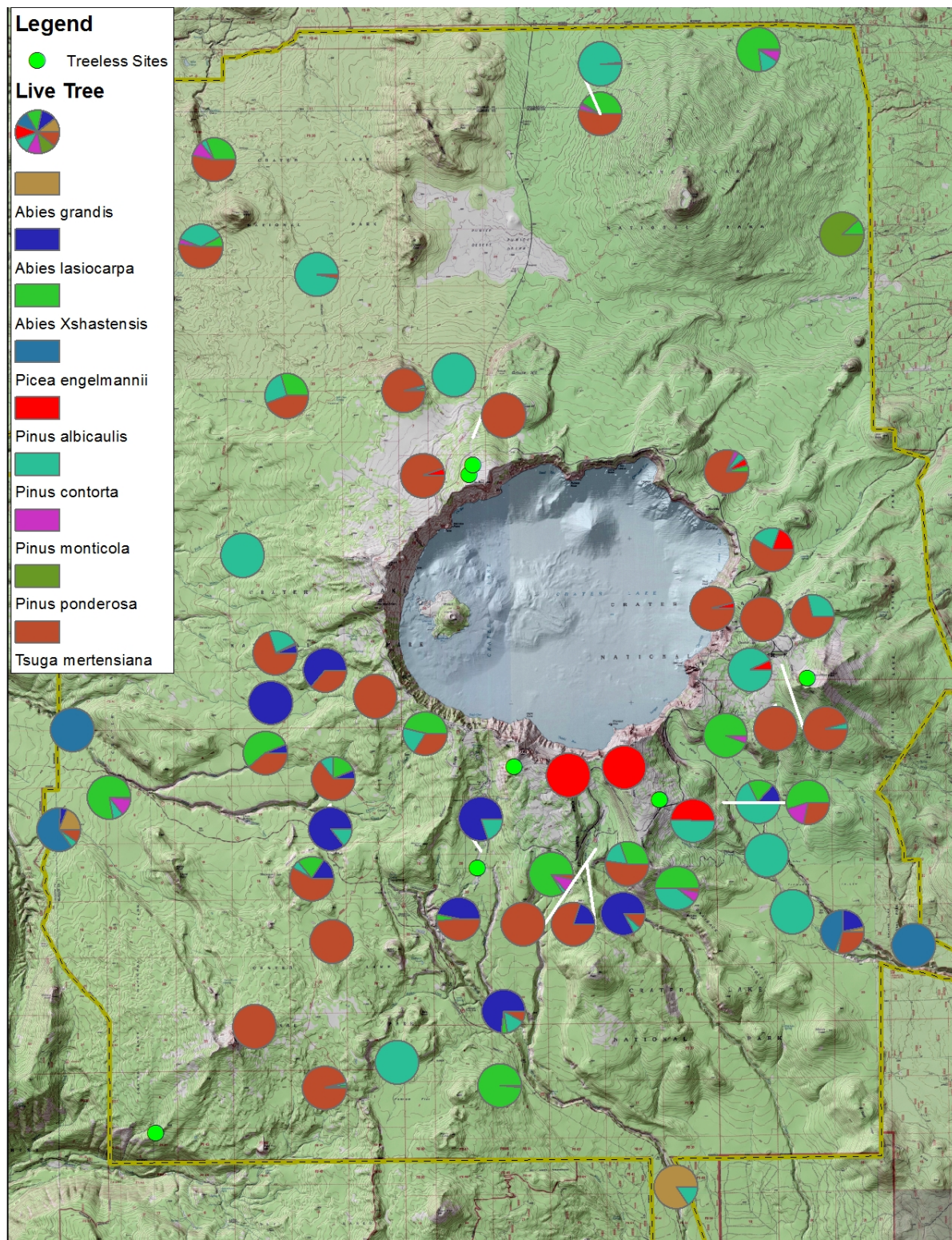


Figure 8. Individual tree (>15cm dbh) species basal area composition of Crater Lake sites. Three tree species are not shown in the map because they are not visible, due to small percentages of basal area: *Abies amabilis*, *Pseudotsuga menziesii*, and *Tsuga heterophylla*.

Vegetation Structure

Oregon Caves

The highest mean vegetation cover in the matrix sampling frame occurred in stratum 4 at 60.5%; second highest was in stratum 1 at 18.8% (Table 6.).

Table 6. Summary of vegetation cover (%) by stratum for Oregon Caves by sampling frame. SD = Standard Deviation.

Frame	Stratum 1 (< 0.75m)				Stratum 2 (0.75 – 2.5m)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	4.7	36.7	18.8	9.7	0.3	7.5	2.6	2.1
Frame	Stratum 3 (2.6 – 5m)				Stratum 4 (>5m)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	0.0	10.0	3.7	3.4	30.3	90.3	60.5	19.7

Mean plot basal area for the matrix sampling frame was 58.7 m²/ha for live trees and 0.9 m²/ha for snags. All ten matrix plots had trees >15cm dbh. Table 7 shows tree basal area summary. Tree density was (303 trees/ha) (Table 8). Also in Table 8 are tree height, height to crown, and maximum height. Snag density and mean heights are presented in Table 9. Woody debris lag class values were lowest in the 1hr class and highest in the 1000hr sound class (Table 10).

Table 7. Live tree and snag basal area (BA) minimum, maximum, mean, and standard deviation for sampling frames at Oregon Caves. Units are m²/ha.

Frame	Min BA	Max BA	Mean BA	SD
Matrix	29.25	75.77	58.73	16.12
Frame	Min Snag BA	Max Snag BA	Mean Snag BA	SD
Matrix	0.23	1.89	0.89	0.65

Table 8. Oregon Caves mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m). Standard deviations are shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max Tree Height
Matrix	303 (116)	24 (12)	12 (8)	59

Table 9. Oregon Caves mean snag density (stems/ha) and height (m). Standard deviations are shown in parentheses.

Frame	Mean Snag density	Mean Snag Height
Matrix	72 (37)	11 (8)

Table 10. Oregon Caves summary of mean woody debris time lag classes (tons per acre, standard deviations in parentheses).

Frame	1hr	10hr	100hr	1000hr Rotten	1000hr Sound
Matrix	0.90 (.43)	2.16 (1.25)	2.28 (0.98)	8.21 (6.86)	18.80 (12.95)

Mean shrub height was 0.5m for matrix sites.

Fine wood/litter dominated the ground cover. A ground cover summary is shown in Table 11.

Table 11. Oregon Caves ground cover/substrate mean percent cover. Standard deviations shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
Matrix	0.45 (0.54)	0.77 (1.14)	7.60 (4.93)	86.78 (6.72)	0.46 (0.93)	0.0 (0)

Litter and duff depths were similar, at 2.2 and 1.8 cm, respectively. Table 12 shows the litter and duff depth summary.

Table 12. Oregon Caves litter and duff minimum, maximum, and mean depth. Units are cm, standard deviations shown in parentheses.

Frame	Litter Depth Mean	Litter Depth Min	Litter Depth Max	Duff Depth Mean	Duff Depth Min	Duff Depth Max
Matrix	2.2 (0.7)	1.3	3.7	1.8 (1.0)	0.8	3.6

Crater Lake

Highest overall mean value for vegetation cover was found in riparian stratum 1 (38.2%) (Table 13). Mean vegetation percent cover in both the high elevation (20.9%) and matrix (27.8%) sampling frames was highest in stratum 4 (Table 13).

Table 13. Summary of vegetation cover (%) by stratum for Crater Lake by sampling frame.

Frame	Stratum 1 (<0.75m)				Stratum 2 (0.75 – 2.5m)			
	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.
High Elevation	0.2	57.2	9.0	12.1	0.0	13.8	1.3	3.2
Matrix	0.2	53.4	7.0	11.6	0.0	14.3	4.0	4.2
Riparian	14.9	70.0	38.5	19.9	0.1	19.6	6.2	4.8
Frame	Stratum 3 (2.6 – 5m)				Stratum 4 (>5m)			
	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.
High Elevation	0.0	12.0	1.8	3.0	0.0	66.8	14.5	19.1
Matrix	0.0	18.3	4.2	4.8	0.0	81.3	27.8	19.9
Riparian	0.0	41.5	6.6	9.2	0.0	68.0	20.9	16.6

Mean live tree basal area at Crater Lake was highest in the matrix (42.07 m²/ha), second highest in the riparian (28.8 m²/ha), and lowest in the high elevation (21.1 m²/ha) sampling frame. Snag basal area was much lower than live tree basal area (Table 14). One matrix, one riparian, and five high elevation plots lacked live trees >15cm dbh. Matrix site mean tree density (339 trees/ha) was higher than for both high elevation (123 trees/ha) and riparian (181 trees/ha) sites. Matrix site mean snag density (96 trees/ha) was highest, followed by riparian (84 trees/ha), and lastly high elevation (23 trees/ha) sites. Tree height and height to crown are shown in Table 15. Snag heights are presented in Table 16.

Table 14. 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 BA	Max BA	Mean BA	SD
High Elevation	0.00	79.14	21.06	25.04
Matrix	6.92	116.37	42.07	26.93
Riparian	0.00	80.58	28.79	21.98
Frame	Min Snag BA	Max Snag BA	Mean Snag BA	SD
High Elevation	0.03	2.37	1.06	0.82
Matrix	0.04	2.04	0.87	0.65
Riparian	0.03	3.66	1.28	1.21

Table 15. Crater Lake mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m). Standard deviations shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max Tree Height
High Elevation	123 (119)	16 (8)	5 (5)	39
Matrix	339 (235)	17 (8)	7 (5)	46
Riparian	181 (187)	18 (8)	7 (4)	45

Table 16. Crater Lake mean snag density (stems/ha) and height (m). Standard deviations shown in parentheses.

Frame	Mean Snag density	Mean Snag Height
High Elevation	23 (43)	9 (4)
Matrix	96 (92)	14 (7)
Riparian	84 (125)	16 (8)

Dead and down woody debris data are shown in Table 17. Both the matrix and riparian sites had the lowest value in the 1hr lag class and progressively increased up to the 1000hr sound class, which was the highest. High elevation sites had a similar pattern, except the highest value was in the 1000hr rotten class.

Table 17. Crater Lake summary of mean woody debris time lag classes (tons per acre, standard deviations in parentheses).

Frame	1hr	10hr	100hr	1000hr Rotten	1000hr Sound
High Elevation	0.17 (0.20)	0.27 (0.38)	0.65 (1.08)	2.19 (3.98)	1.72 (3.71)
Matrix	0.50 (0.29)	0.85 (0.69)	1.42 (1.47)	3.93 (8.13)	6.75 (9.43)
Riparian	0.37 (0.29)	1.07 (0.68)	1.63 (0.94)	3.52 (7.00)	10.66 (11.45)

Mean shrub heights were 0.5m for riparian sites, with a maximum of 2.8m. Both matrix and riparian sites had a mean shrub height of <0.05m.

Fine wood/litter was the dominant ground cover in both the matrix (83.2%) and riparian (75.8%) sampling frames. In the high elevation sampling frame, while bare soil was highest (46.3%), fine wood/litter (42.2%) was also a substantial component. The ground cover summary is presented in Table 18.

Table 18. Crater Lake ground cover/substrate mean percent cover. Standard deviations shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
High Elevation	46.3 (34.2)	0.5 (0.6)	3.0 (2.9)	42.2 (37.2)	11.6 (26.5)	0 (0)
Matrix	7.4 (23.6)	0.4 (0.8)	7.2 (7.7)	83.2 (22.7)	0.5 (.7)	0 (0)
Riparian	2.3 (4.5)	3.2 (4.3)	4.2 (2.3)	75.8 (19.5)	0.4 (.4)	3.0 (4.4)

Mean litter and duff depths were greatest for the riparian sampling frame. Table 19 shows the litter and duff depth summary.

Table 19. Crater Lake litter and duff minimum, maximum, mean. Units are cm, standard deviations shown in parentheses.

Frame	Litter Depth Mean	Litter Depth Min	Litter Depth Max	Duff Depth Mean	Duff Depth Min	Duff Depth Max
High Elevation	0.5 (0.5)	0	1.6	0.6 (1.1)	0	3.8
Matrix	1.1 (0.6)	0	2.4	0.8 (0.9)	0	3.2
Riparian	1.4 (1.0)	0	4.0	1.2 (1.8)	0	6.0

Vegetation Function (Regeneration)

Oregon Caves

In the matrix sampling frame, *Abies* spp. seedlings (2250 trees/ha) was the most abundant regenerating tree species in the smallest size class, but with *Abies concolor* (1750 trees/ha) a close second. *Abies concolor* was the most abundant in all other size classes. Mean regeneration counts for all tree species combined are shown in Table 20.

Table 20. Oregon Caves regeneration by size class for all live tree species by sampling frame. Units are trees/ha, standard deviations shown in parentheses.

Frame	<15cm Tall	>15cm Tall- <2.54cm dbh	>15cm Tall >2.54 - <5cm dbh	>15cm Tall >5 - <10cm dbh	>15cm Tall >10 - <15cm dbh
Matrix	850 (1578)	100 (175)	93 (97)	98 (141)	65 (76)

Crater Lake

The most abundant regenerating tree species in the matrix sampling frame for all classes except >10cm - <15cm dbh was *Tsuga mertensiana*. *Pinus contorta* var *muryana* was the most abundant species in the >10cm - <15cm dbh class. In the riparian sampling frame *Tsuga mertensiana* was most abundant in the >15cm tall class, while *Abies lasiocarpa* was dominate in all other classes. High elevation sites had *Pinus albicaulis* as the dominant species in the <15cm tall and >10cm - <15cm dbh classes, while *Tsuga mertensiana* was dominant in the middle three size classes. Mean regeneration counts for all tree species combined are shown in Table 21.

Table 21. Crater Lake regeneration by size class for all live tree species by sampling frame. Units are trees/ha, standard deviations shown in parentheses.

Frame	<15cm Tall	>15cm Tall- <2.54cm dbh	>15cm Tall >2.54 - <5cm dbh	>15cm Tall >5 - <10cm dbh	>15cm Tall >10 - <15cm dbh
High Elevation	917 (1697)	667 (800)	143 (241)	82 (119)	20(33)
Matrix	4029 (4551)	3865 (4945)	376 (419)	268 (238)	135 (110)
Riparian	2950 (3058)	5413 (4281)	266 (249)	199 (150)	68 (67)

Phenological timing of sampling at both Oregon Caves and Crater Lake was good. Forty-one species were present at both Oregon Caves and Crater Lake. Species overlap during the 2012 season (Whiskeytown National Recreation Area and Lassen Volcanic National Park) was 71 species (Smith and Sarr 2014). During the 2011 field season, at Redwood National and State Parks and Lava Beds National Monument, only four species were present at both parks (Smith and Sarr 2013). Only one species was consistently observed among all six parks: *Achillea millefolium*.

No non-native species were observed at Oregon Caves. We did observe six non-native species at Crater Lake. Of these six non-natives (*Chenopodium album*, *Gallium aparine*, *Cerastium fontanum*, *Taraxacum officinale*, *Cirsium vulgare*, and *Senecio sylvaticus*), the latter three are on the KLMN Invasive Species Early Detection prioritization list (Odion et al 2010). *Cerastium fontanum* is not a prioritized invasive species at Crater Lake, or for the Klamath Network as a whole. This species is best classified as non-native, and is not considered to be invasive (Cal IPC) or noxious (USDA plants). Future monitoring efforts will detect if the population is growing or spreading. This is the second observation of the species in the park, the first being by Adamus and Bartlet (2008), but ours is the first voucher collection. Of the three prioritized invasive species, *Taraxacum officinale* was the most abundant, occurring at six sites but never with $>1\text{m}^2$ of cover at a site. This species has been noted as ‘control infeasible’ in the prioritization list and is not invasive. Both *Cirsium vulgare* and *Senecio sylvaticus* are on the Crater Lake prioritization list. These two species occurred at the same site, CRLA29, in the Red Blanket Canyon. Neither species was present with $>1\text{m}^2$ cover. This site showed signs of a recent fire (Figure 9).



Figure 9. Photo of site CRLA29 showing recent fire activity. Two invasive species were observed at this site, *Cirsium vulgare* and *Senecio sylvaticus*.

At Oregon Caves, we observed and collected a single specimen of *Woodsia* sp. This appears to be the first collection from the Monument. Available individuals were sparse, and we did not feel we could collect any more material than we did without impacting the population. The specimen is likely *W. oregana*, as abaxial leaf hairs were not present. But, with the limited material we could not positively identify the *Woodsia* to species. Future efforts could target the surrounding habitat to look for more individuals to collect.

We had four confirmed new species at Crater Lake, *Cerastium fontanum*, *Botrychium pinnatum*, *Carex praegracilis* and *Conyza canadensis*, mentioned above. We collected a voucher of *Cerastium fontanum*. We did not collect a physical specimen of the *Botrychium pinnatum* as we only observed one individual. We did, however, take a photo voucher. Peter Zika (personal communication, 2/12/2014) noted, through email correspondence, it looked like a scrawny *Botrychium pinnatum*. Both *Carex praegracilis* and *Conyza canadensis*, were confirmed by Dick xxx, the specimens were of poor quality and were destroyed during identification.

Not new to the park list but observed and collected this season were: *Trisetum wolfii* (last voucher was collected in 1937), *Stellaria borealis* (last voucher was collected in 1936) and *Stellaria umbellata* (last voucher was collected in 1929). All three of these species were observed by Adamus and Bartlet (2008) but were not vouchered.

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Appendix. Environmental Variables at Sites.

Table A.1. Site data and environmental parameters collected at Oregon Caves matrix vegetation plots in 2013.

Park	Site	Frame	Monument Date	Easting	Northing	Macro Position	Slope Shape	Elevation (m)	Avg Aspect (deg)	Avg Slope(deg)
ORCA	ORCA01	Matrix	6/25/13	466478	4660968	MACPOS 2	Undulating	1334	219	14
ORCA	ORCA02	Matrix	7/2/13	467413	4660821	MACPOS 3	Concave	1445	324	28
ORCA	ORCA03	Matrix	7/2/13	467434	4660717	MACPOS 2	Undulating	1507	321	18
ORCA	ORCA04	Matrix	7/4/13	466086	4659872	MACPOS 2	Undulating	1481	330	30
ORCA	ORCA05	Matrix	7/1/13	466904	4660443	MACPOS 3	Convex	1433	268	29
ORCA	ORCA06	Matrix	7/3/13	466996	4659872	MACPOS 2	Straight	1603	150	20
ORCA	ORCA07	Matrix	7/4/13	466344	4660056	MACPOS 3	Straight	1557	27	27
ORCA	ORCA08	Matrix	6/25/13	466605	4660831	MACPOS 2	Undulating	1333	236	28
ORCA	ORCA09	Matrix	7/5/13	466984	4660615	MACPOS 2	Undulating	1480	274	12
ORCA	ORCA10	Matrix	7/3/13	467277	4659943	MACPOS 2	Undulating	1590	210	21

Table A.2. Site data and environmental parameters collected at Crater Lake high elevation vegetation plots in 2013.

Park	Site	Frame	Monument Date	Easting	Northing	Macro Position	Slope Shape	Elevation (m)	Avg Aspect (deg)	Avg Slope (deg)
CRLA	CRLA221	Alpine	8/16/13	570140	4758399	MACPOS 2	Straight	2359	321	9
CRLA	CRLA222	Alpine	8/28/13	572944	4749929	MACPOS 2	Undulating	2397	219	15
CRLA	CRLA223	Alpine	8/14/13	577954	4754634	MACPOS 2	Straight	2297	53	12
CRLA	CRLA224	Alpine	8/31/13	578734	4754335	MACPOS 3	Undulating	2194	332	7
CRLA	CRLA225	Alpine	8/14/13	570246	4759447	MACPOS 2	Straight	2162	336	4
CRLA	CRLA226	Alpine	8/18/13	578792	4751919	MACPOS 3	Straight	2188	--	0
CRLA	CRLA227	Alpine	8/16/13	575523	4749221	MACPOS 2	Straight	2282	124	18
CRLA	CRLA228	Alpine	8/18/13	578966	4753036	MACPOS 2	Straight	2289	255	7
CRLA	CRLA229	Alpine	8/5/13	568925	4758381	MACPOS 2	Straight	2143	307	8
CRLA	CRLA230	Alpine	8/15/13	578085	4752911	MACPOS 2	Straight	2252	192	5
CRLA	CRLA231	Alpine	8/31/13	579829	4754409	MACPOS 2	Straight	2222	--	0
CRLA	CRLA232	Alpine	8/29/13	575020	4747432	MACPOS 3	Straight	2223	206	11
CRLA	CRLA233	Alpine	8/28/13	571415	4750161	MACPOS 2	Straight	2351	237	26
CRLA	CRLA234	Alpine	8/26/13	567492	4752155	MACPOS 2	Undulating	2079	21	3
CRLA	CRLA235	Alpine	9/12/13	578696	4756298	MACPOS 2	Straight	2081	32	7
CRLA	CRLA236	Alpine	8/27/13	576458	4748645	MACPOS 3	Undulating	2114	71	6
CRLA	CRLA237	Alpine	9/14/13	564088	4742842	MACPOS 2	Undulating	2072	280	18
CRLA	CRLA238	Alpine	9/10/13	570251	4758662	MACPOS 2	Undulating	2308	338	20
CRLA	CRLA239	Alpine	8/29/13	579687	4752654	MACPOS 2	Undulating	2422	356	15
CRLA	CRLA240	Alpine	8/27/13	574518	4750153	MACPOS 2	Straight	2425	217	5

Table A.3. Site data and environmental parameters collected at Crater Lake vegetation matrix plots in 2012.

Park	Site	Frame	Monument Date	Easting	Northing	Macro Position	Slope Shape	Elevation (m)	Avg Aspect (deg)	Avg Slope (deg)
CRLA	CRLA01	Matrix	7/18/13	566068	4741117	MACPOS 4	Straight	1935	242	6
CRLA	CRLA02	Matrix	7/17/13	568648	4751111	MACPOS 2	Straight	2054	245	3
CRLA	CRLA03	Matrix	8/15/13	565841	4764036	MACPOS 3	Straight	1804	--	0
CRLA	CRLA05	Matrix	7/16/13	568110	4741829	MACPOS 4	Straight	1867	93	2
CRLA	CRLA06	Matrix	7/20/13	565703	4747300	MACPOS 1	Straight	1945	207	5
CRLA	CRLA07	Matrix	8/15/13	564998	4760623	MACPOS 3	Straight	1856	--	0
CRLA	CRLA08	Matrix	7/21/13	577311	4749167	MACPOS 2	Convex	1955	33	21
CRLA	CRLA09	Matrix	7/17/13	559296	4749314	MACPOS 3	Straight	1559	348	3
CRLA	CRLA10	Matrix	7/31/13	580671	4765170	MACPOS 3	Straight	1622	32	3
CRLA	CRLA11	Matrix	7/30/13	562937	4767276	MACPOS 3	Straight	1694	20	2
CRLA	CRLA13	Matrix	8/18/13	564392	4750557	MACPOS 3	Straight	1823	75	3
CRLA	CRLA14	Matrix	7/19/13	573845	4768565	MACPOS 2	Straight	1917	170	4
CRLA	CRLA15	Matrix	8/14/13	562571	4764833	MACPOS 3	Undulating	1695	--	0
CRLA	CRLA17	Matrix	7/15/13	571011	4741184	MACPOS 1	Straight	1868	122	4
CRLA	CRLA18	Matrix	7/29/13	572457	4747135	MACPOS 3	Undulating	1980	120	13
CRLA	CRLA20	Matrix	7/19/13	573845	4768565	MACPOS 4	Undulating	1872	284	8
CRLA	CRLA22	Matrix	7/21/13	566273	4745237	MACPOS 3	Straight	1917	--	0
CRLA	CRLA24	Matrix	8/3/13	576011	4746750	MACPOS 1	Straight	2031	86	1
CRLA	CRLA26	Matrix	8/1/13	578315	4770382	MACPOS 3	Straight	1730	120	8
CRLA	CRLA27	Matrix	9/11/13	563743	4756137	MACPOS 3	Straight	1809	245	5
CRLA	CRLA28	Matrix	8/2/13	577376	4751052	MACPOS 2	Convex	2061	145	14
CRLA	CRLA29	Matrix	9/9/13	561286	4739834	MACPOS 2	Undulating	1786	326	12
CRLA	CRLA30	Matrix	8/4/13	577410	4758500	MACPOS 2	Convex	1974	344	21
CRLA	CRLA31	Matrix	8/13/13	565011	4765959	MACPOS 3	Straight	1744	--	0
CRLA	CRLA46	Matrix	8/30/13	568826	4760770	MACPOS 2	Convex	2049	22	12
CRLA	CRLA77	Matrix	8/16/13	569710	4761206	MACPOS 3	Straight	1958	--	0

Table A.4. Site data and environmental parameters collected at Crater Lake riparian vegetation plots in 2013. *Average aspect is problematic to report as sites are often either flat or the 10 x 50 m belts are on opposite sides of a stream, i.e. opposite aspects.

Park	Site	Frame	Monument Date	Easting	Northing	Macro Position	Slope Shape	Elevation (m)	Avg Aspect (deg)	Avg Slope (deg)
CRLA	CRLA101	Riparian	9/12/13	582688	4745133	MACPOS 5	Undulating	1615	--	25.5
CRLA	CRLA103	Riparian	9/10/13	574493	4746487	MACPOS 5	Concave	1773	--	6.5
CRLA	CRLA105	Riparian	7/16/13	579338	4746082	MACPOS 5	Concave	1734	--	15.25
CRLA	CRLA106	Riparian	7/17/13	569850	4746307	MACPOS 5	Undulating	1856	--	10.25
CRLA	CRLA107	Riparian	7/31/13	573726	4747838	MACPOS 5	Concave	1966	--	11.5
CRLA	CRLA108	Riparian	8/29/13	558568	4748398	MACPOS 5	Undulating	1508	--	11.75
CRLA	CRLA109	Riparian	7/30/13	578548	4747684	MACPOS 5	Straight	1824	--	0
CRLA	CRLA112	Riparian	8/2/13	558941	4751216	MACPOS 5	Straight	1457	--	1.75
CRLA	CRLA113	Riparian	8/27/13	575991	4738331	MACPOS 5	Convex	1382	--	13.75
CRLA	CRLA115	Riparian	7/20/13	565483	4753239	MACPOS 5	Convex	1899	--	11
CRLA	CRLA116	Riparian	8/13/13	564541	4751819	MACPOS 5	Undulating	1802	--	13.5
CRLA	CRLA117	Riparian	8/17/13	580681	4745524	MACPOS 5	Undulating	1665	--	10.75
CRLA	CRLA121	Riparian	7/18/13	578300	4749175	MACPOS 5	Concave	1850	--	20.75
CRLA	CRLA122	Riparian	8/28/13	571107	4743271	MACPOS 5	Concave	1648	--	0
CRLA	CRLA126	Riparian	8/12/13	570471	4747793	MACPOS 5	Convex	1896	--	7.75
CRLA	CRLA128	Riparian	8/3/13	566228	4749087	MACPOS 5	Concave	1804	--	9
CRLA	CRLA134	Riparian	8/17/13	570382	4747293	MACPOS 5	Straight	1874	--	2.25
CRLA	CRLA137	Riparian	8/29/13	573465	4747428	MACPOS 5	Concave	1886	--	10.5
CRLA	CRLA138	Riparian	9/11/13	566303	4749836	MACPOS 5	Concave	1797	--	23.5
CRLA	CRLA142	Riparian	9/14/13	566147	4752894	MACPOS 5	Undulating	1940	--	0

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