



Monitoring Vegetation Composition, Structure, and Function in Lava Beds National Monument and Redwood National and State Parks

Fiscal Year 2014 Annual Report

Natural Resource Report NPS/KLMN/NRR—2015/1011



ON THE COVER

Sampling at Lava Beds National Monument

Photograph by Rebecca Manion, KLMN Biotechnician

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Abstract

This report describes the results of the fourth year of implementing the Klamath Network's vegetation monitoring protocol. This was the first year of resampling plots established in 2011. At Lava Beds National Monument, we collected data from 29 of 30 matrix sites (i.e., not associated with specific vegetation), excluding the one site due to fire. At Redwood National and State Parks, we collected data from 24 of 26 matrix and 18 of 21 riparian sites. We did not sample the two matrix sites due to lack of time and the three riparian sites due to vegetation phenology or disturbance issues.

Overall, we observed lower species richness in 2014 than in 2011. Drought could be a factor driving the lower species richness we observed in 2014. We observed within-park patterns that seemed to differ with respect to plant life-history. The two separate patterns of change between 2011 and 2014 were: 1) fewer annuals at Lava Beds; 2) fewer herbaceous and graminoid perennials, as well as more unknown (or unidentifiable) species, at Redwood.

Introduction

In 2014, the Klamath Inventory and Monitoring Network of the National Park Service (KLMN) implemented the fourth season of its vegetation monitoring protocol (Odion et al. 2011) at Lava Beds National Monument (LABE, or Lava Beds) and Redwood National and State Parks (RNSP, or Redwood). This season was the first resampling of sites since 2011, the year that we monumented sites and collected initial data (Smith and Sarr 2013). Once every three years we are scheduled to measure vegetation composition, structure, and function on selected sampling frames in each of the network's six parks. 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).

The main objective for the Fiscal Year 2014 field season was to collect data from the 30 matrix sites (i.e., not associated with a specific vegetation) at Lava Beds and 26 matrix and 21 riparian sites at Redwood that were established during the 2011 season.

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 abbreviated 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. At Lava Beds, lava flows were also avoided due to safety concerns. 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).

Lava Beds has only the matrix sampling frame. At Redwood, we divided the park landscape into matrix and riparian sampling frames. 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

Four National Park Service (NPS) crew members began work on May 19: two GS-7 Crew Leaders (L. Leonard, J. Paget-Seekins) and two GS-5 Biological Science Technicians (R. Manion, R. Steel).

Initial training occurred during the first work week. Office training included a review of protocol and standard operating procedures, as well as safety and job hazard analysis discussions. Field procedures training occurred at a nearby green space. During the second work week, we made a site visit to Lava Beds for species familiarization and hands-on instruction about protocol procedures. After training as a group for two work weeks, we split into two two-person crews to sample the Lava Beds sites. After finishing Lava Beds, we conducted two days of training at Redwood for species familiarization. The Project Lead (Sean Smith) assisted with site sampling periodically throughout the season, especially at Redwood. 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 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.

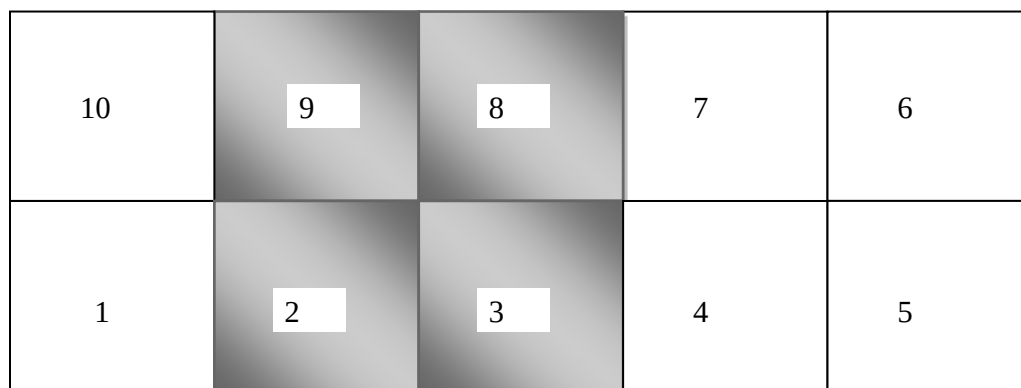


Figure 1. The 20 × 50 m matrix and high elevation site plot layout. Each numbered square is 10 × 10 m. Shaded squares are the four intensive modules.

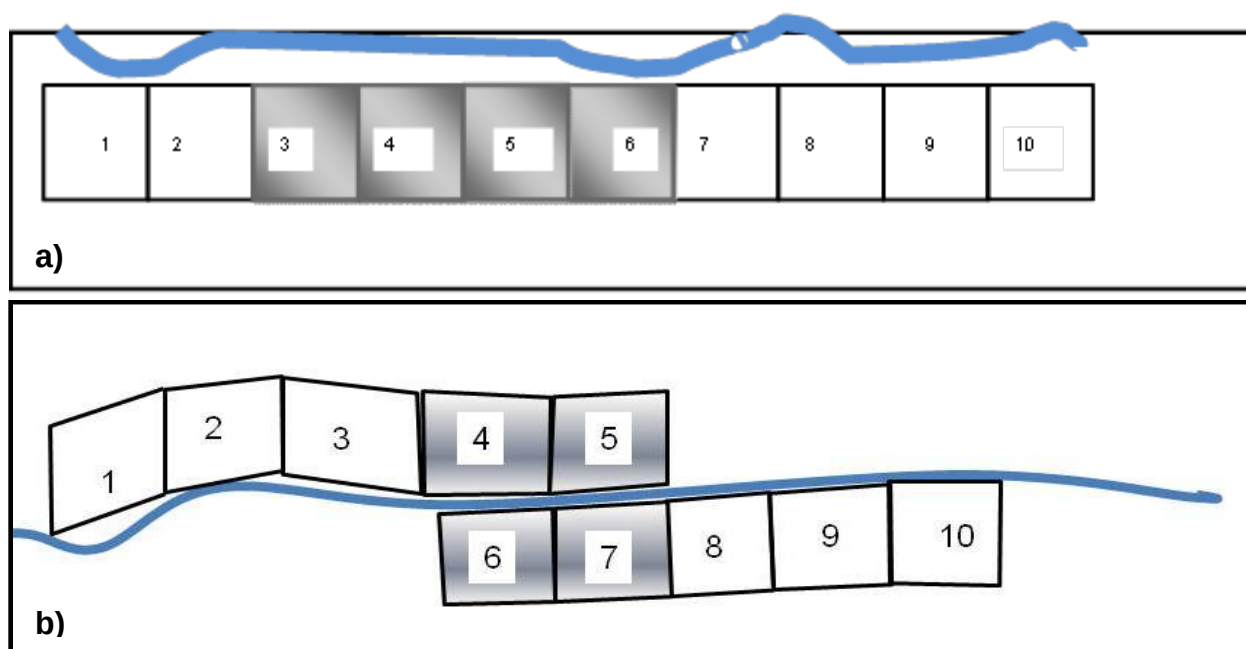


Figure 2. Riparian site plots in one 10 × 100 m layout (a) or two 10 × 50 m layouts (b). Each numbered square is 10 × 10 m and shaded squares are the four intensive modules.

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. Microtopography
5. Macrotopography

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) (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) (1000-hr sound; 1000-hr rotten)
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). We collected field data on tablet computers, 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 were finalized at the end of the field season by the Project Lead.

We performed general data summaries to provide descriptive statistics of the park vegetation. These included measures of central tendency (mean, median) and variance (range, standard deviation) for selected parameters. To compare species richness between sampling years, we performed paired t-tests of species richness for all, perennial, and annual species within parks using R version 3.0.3. To explore potential relationships with precipitation, we used PRISM climate data (PRISM 2015) to calculate the total precipitation at each site for the months preceding the field season (Oct–May). 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.

Due to database constraints, the vascular plant taxonomy used in the study is a combination of The Jepson Manual, 1st edition (Hickman 1993), The Jepson Manual, 2nd edition (Baldwin et al. 2012), and the United States Department of Agriculture (USDA) Plants Database (USDA, NRCS 2014).

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

Results

After the initial 2011 field season at Lava Beds and Redwood, we realized that the number of sample sites articulated in our original goals (Odion et al. 2011) was too ambitious. See Smith and Sarr (2013) for a summary of the 2011 field season. For 2014, our goal was to resample all sites monumented in 2011, with similar timing. Sampling windows at Lava Beds were May 28 to July 10, 2011, and May 28 to July 1, 2014. Sampling windows at Redwood were June 6 to September 27, 2011, and July 5 to October 3, 2014. Our 2014 sampling, for the most part, went smoothly. One of the Crew Leads suffered a knee injury while working at Redwood. The Project Lead filled in while the employee recovered. However, this injury did cause some loss of productivity.

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

Lava Beds

At Lava Beds, we sampled 29 matrix sites (Figure 3). We did not sample one site due to a fire. The Caldwell Fire was a lightning caused fire that started on July 1, 2014. This fire was close in proximity to the only LABE plot we had not yet revisited in 2014—a plot we were scheduled to visit on July 2, 2014. For safety reasons we were advised not to attempt a site visit. We will revisit this site in 2017.

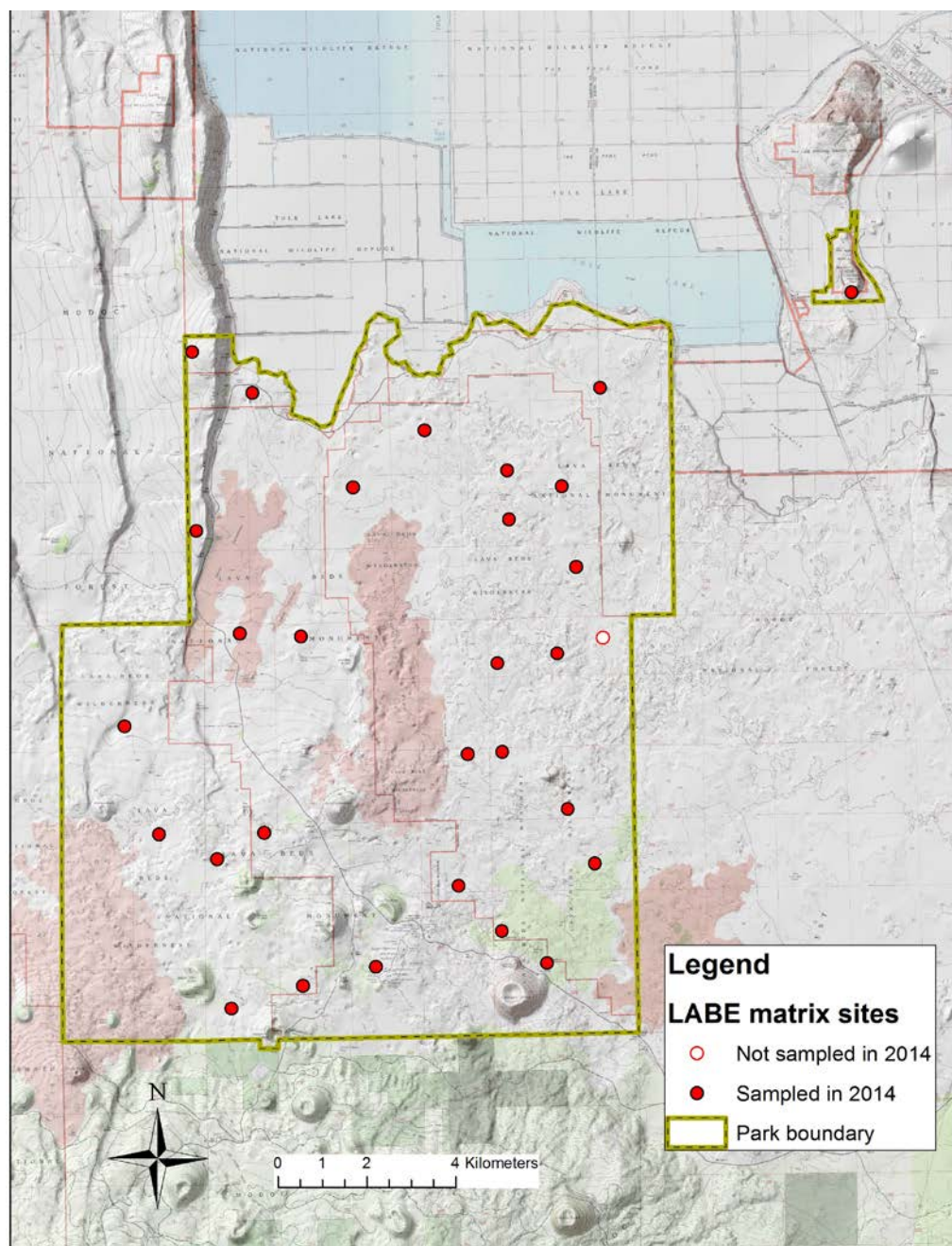


Figure 3. Location of vegetation monitoring sites at Lava Beds National Monument in 2014. Dark pink areas are lava flows, which were avoided.

Redwood

At Redwood, we resampled 24 matrix and 18 riparian sites (Figures 4 and 5, representing the northern and southern portions of the parks, respectively). Two matrix sites were not visited due to lack of time. We visited but did not collect data at three riparian sites. One site along lower Redwood Creek was visited on September 12 and vegetation was too dry to sample (species identification would have been very difficult). We will revisit this site in 2017 and make an effort to visit it earlier in the season. A second site along Mill Creek has become so thick with blackberry (*Rubus armeniacus*) that the crew could not find all the monumenting rebar; two modules in that site have become eroded and are now >50% water. We will, most likely, not revisit this site. We attempted to access the third site, on Little Lost Man Creek, but a landslide made the last 50 m impassable. This site could possibly be accessed from a different approach, but we did not have time for such reconnaissance. We will attempt to revisit and establish a reliable approach in 2017.

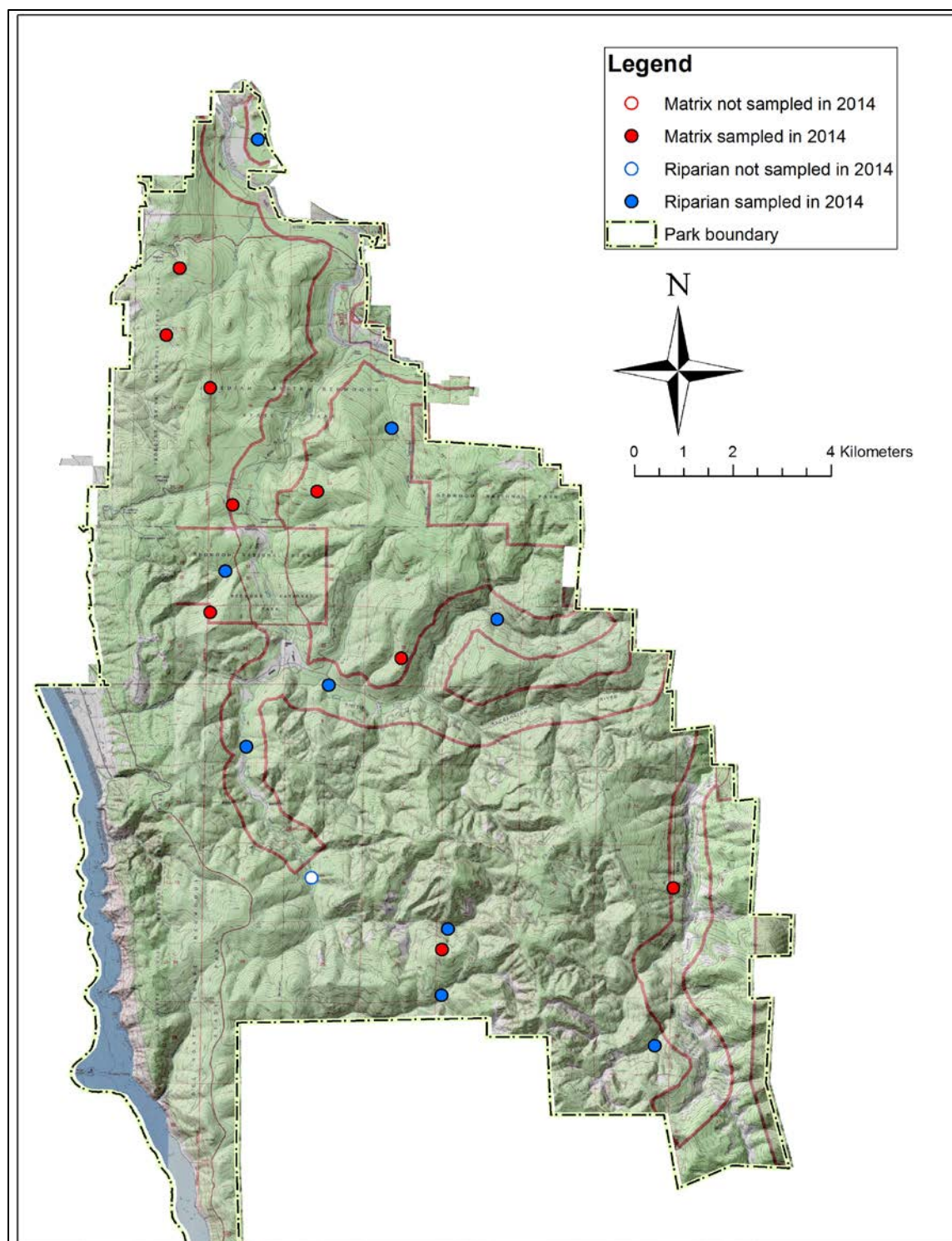


Figure 4. Location of vegetation monitoring sites in the northern portion of Redwood National and State Parks in 2014.

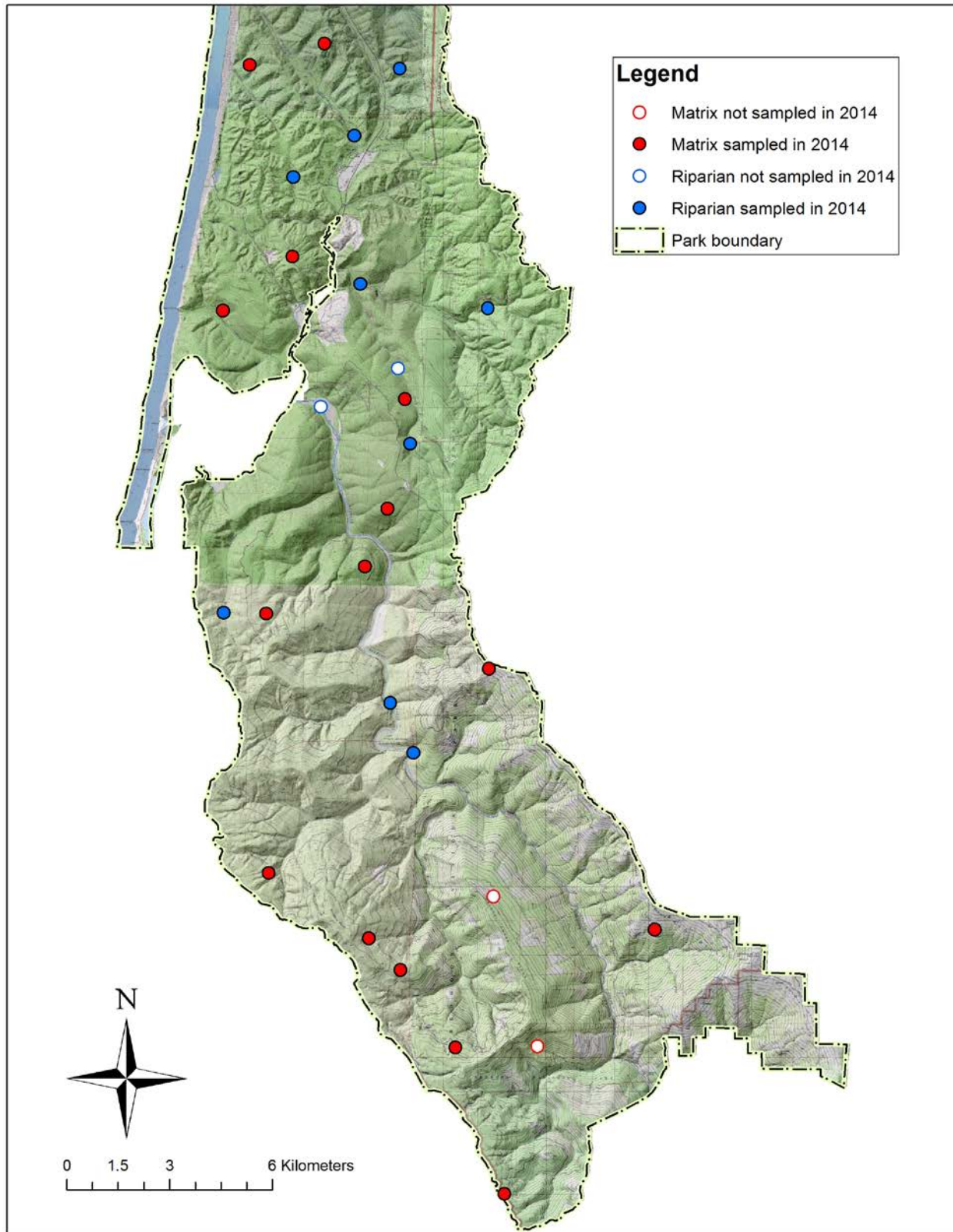


Figure 5. Location of vegetation monitoring sites in the southern portion of Redwood National and State Parks in 2014.

Vegetation Composition

Lava Beds

Vascular plant species richness for the 0.1 ha sampling plot at Lava Beds ranged from 11 to 46 species for matrix plots (Figure 6, Table 1), with an average species richness of 28. For all matrix plots, 115 species were recorded, although the total was 131 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. *Bromus tectorum*, *Poa secunda*, *Chrysothamnus nauseosus*, and *Artemisia tridentata* topped the list of the most frequently occurring species (Table 2). Ten nonnative species were observed. Nonnative species by site ranged from 2 to 36% (Figure 6). Figure 7 shows the composition of basal area by tree species at each site. At two sites, crews did not measure *Cercocarpus ledifolius* trees that were measured in 2011; tags were missing or not seen, and crews mistakenly thought the trees were classified as shrubs. Crews were notified of the error, but time did not permit a revisit to measure the trees.

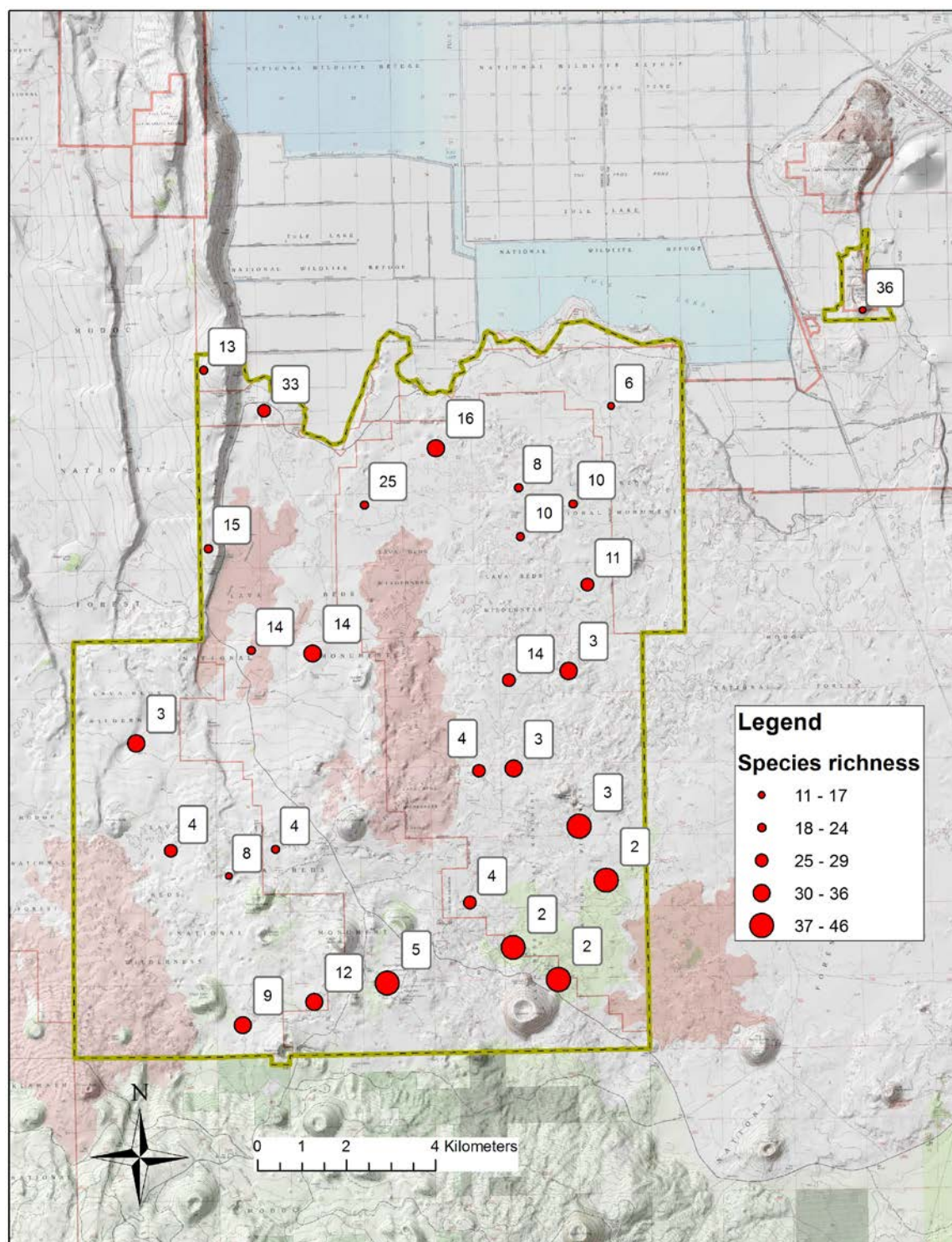


Figure 6. Vascular plant species richness for matrix sampling frame sites at Lava Beds in 2014. Numbers next to sites indicate the percentage of nonnative species present.

Table 1. Vascular plant species richness (SR) minimum, maximum, mean, and sample frame total from the 2014 vegetation monitoring plots at Lava Beds (LBE) and Redwood National and State Parks (RNSP).

Park	Sample Frame	SR Min	SR Max	SR Mean	Sample Frame Total
LBE	Matrix	11	46	28	131
RNSP	Matrix	13	40	23	130
RNSP	Riparian	26	72	43	157

Table 2. Most frequently occurring understory vascular plant species at Lava Beds matrix sites. Number indicates frequency (% of plots where species occurred). Note that * indicates an invasive species.

Herbs	% plots	Herbs	% plots
<i>Bromus tectorum</i> *	100	<i>Penstemon deustus</i>	55
<i>Poa secunda</i>	93	<i>Phacelia linearis</i>	55
<i>Elymus elymoides</i>	90	<i>Chaenactis douglasii</i>	52
<i>Pseudoroegneria spicata</i> ssp. <i>spicata</i>	79	Shrubs	
<i>Achnatherum thurberianum</i>	79	<i>Chrysothamnus nauseosus</i> ssp. <i>consimilis</i>	93
<i>Crepis acuminata</i>	66	<i>Artemisia tridentata</i>	93
<i>Phacelia heterophylla</i>	66	<i>Purshia tridentata</i>	72
<i>Leptodactylon pungens</i>	59	<i>Ribes velutinum</i>	72
<i>Cryptantha</i> sp.	59	<i>Chrysothamnus viscidiflorus</i>	62
<i>Arabis sparsiflora</i>	59	<i>Ribes cereum</i>	55

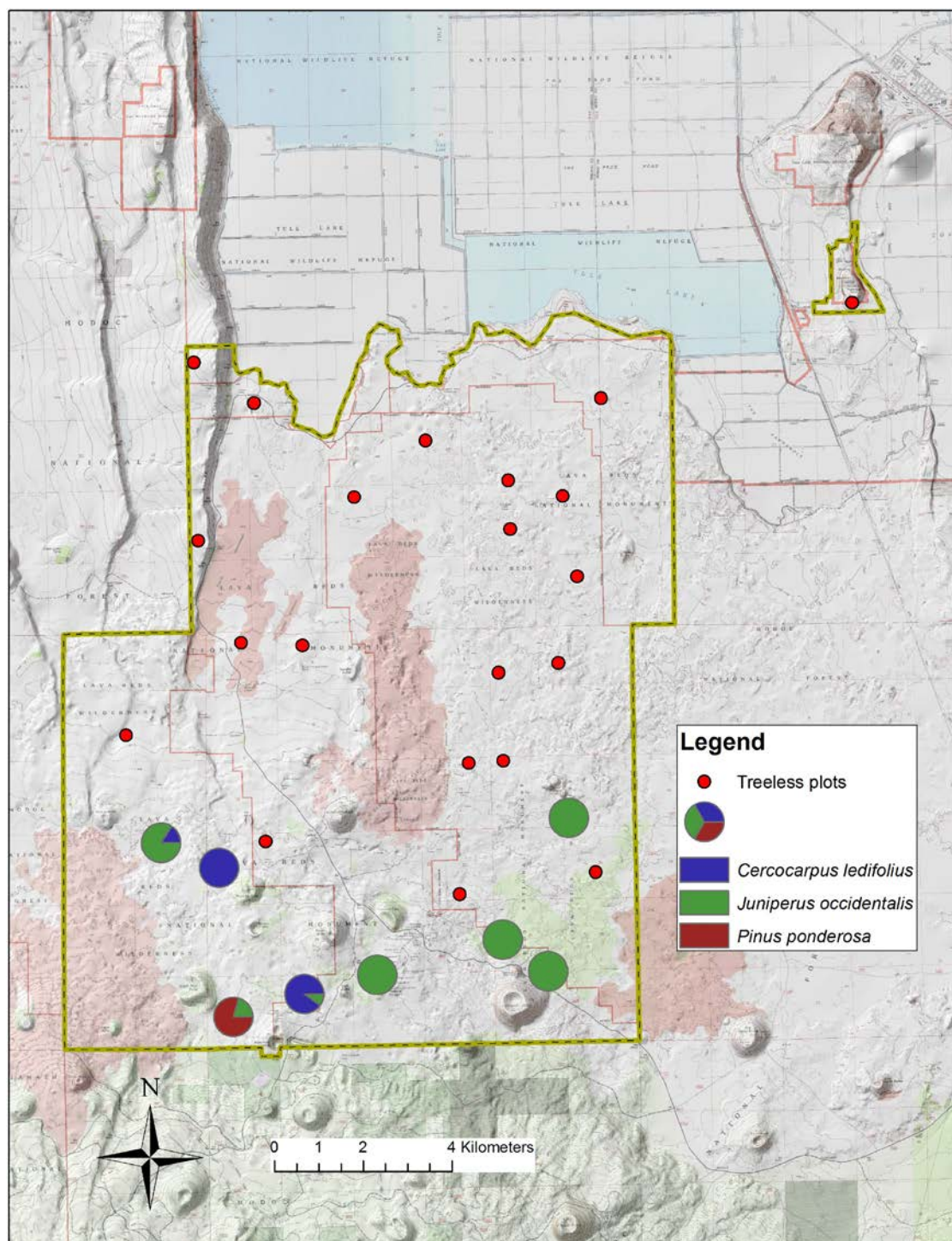


Figure 7. Individual tree species (>15 cm dbh) basal area composition at Lava Beds matrix sites in 2014.

Redwood

Vascular plant species richness in the Redwood matrix sampling frame ranged from 13 to 40 species per 0.1 ha sampling plot (Figures 8 and 9, representing the Redwood north and south sites, respectively; Table 1). Across all matrix plots sampled, we observed 107 species, although the total was 130 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 26 to 72 species, with 137 species observed (157 when including unknowns). At matrix sites, *Polystichum munitum*, *Gaultheria shallon*, and *Vaccinium ovatum* topped the list of the most frequently occurring understory species (Table 3). At riparian sites, *Polystichum munitum*, *Tolmiea menziesii*, *Athyrium filix-femina*, *Oxalis oregana*, and *Rubus spectabilis* topped the list of the most frequently occurring understory species (Table 4).

Nonnative species composition ranged from 0 to 58% in matrix sites and from 0 to 30% in riparian sites (Figures 8, 9). We observed 29 nonnative species in the matrix sampling frame and 25 in the riparian frame. Tree basal area composition by site is shown in Figures 10 (Redwood north) and 11 (Redwood south). Two nonnative species were observed that we did not observe in 2011: reed fescue (*Festuca arundinacea*) was observed at three sites, and English ivy (*Hedera helix*) was not observed at a site but was observed while traveling off trail to three sites.

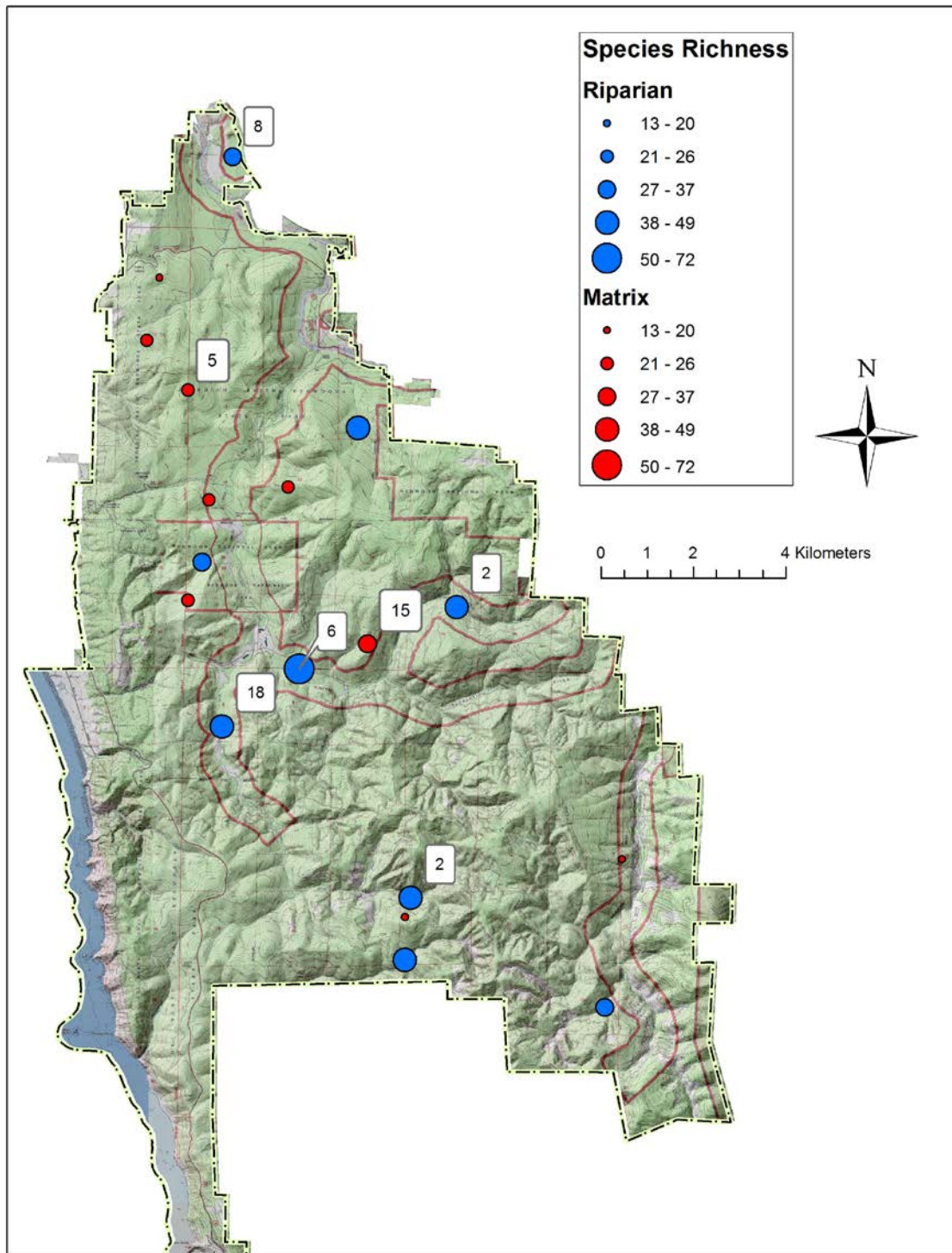


Figure 8. Redwood north site vascular plant species richness from each sampling frame in 2014. White labels show percentage of species that are nonnative. Sites without nonnative species are not labeled.

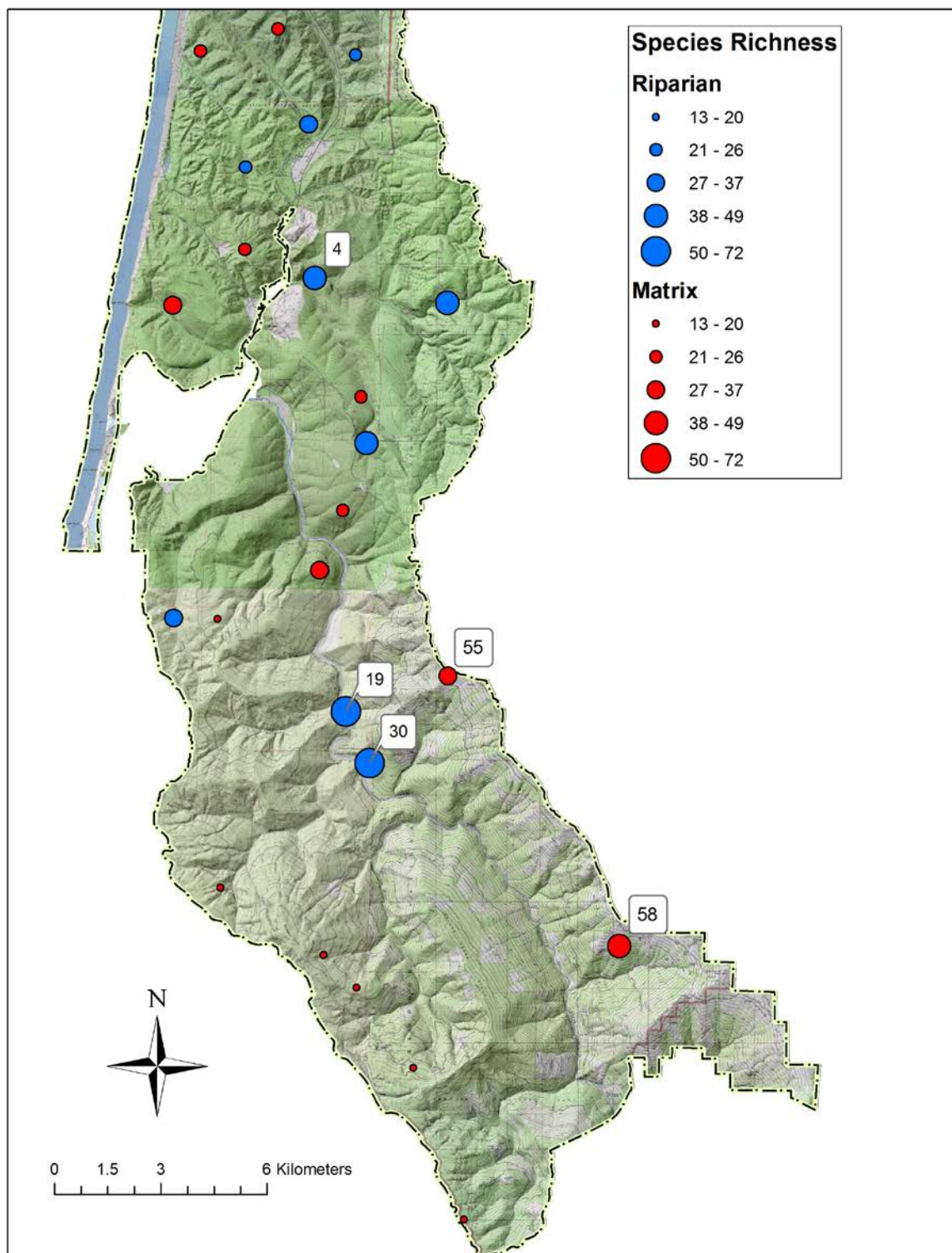


Figure 9. Redwood south site vascular plant species richness from each sampling frame in 2014. White labels show percentage of species that are nonnative. Sites without nonnative species are not labeled.

Table 3. Most frequently occurring understory species at Redwood matrix sites. Number indicates frequency (% of plots where species occurred).

Herbs	% plots	Herbs	% plots
<i>Polystichum munitum</i>	81	<i>Pteridium aquilinum</i> var. <i>pubescens</i>	46
<i>Viola sempervirens</i>	73	Shrubs	
<i>Blechnum spicant</i>	62	<i>Gaultheria shallon</i>	85
<i>Trillium ovatum</i>	62	<i>Vaccinium ovatum</i>	85
<i>Galium triflorum</i>	50	<i>Vaccinium parvifolium</i>	77
<i>Oxalis oregana</i>	50	<i>Rhododendron macrophyllum</i>	54
<i>Prosartes hookeri</i>	46		

Table 4. Most frequently occurring understory species at Redwood riparian sites. Number indicates frequency (% of plots where species occurred).

Herb	% plots	Herb	% plots
<i>Polystichum munitum</i>	100	<i>Galium triflorum</i>	67
<i>Tolmiea menziesii</i>	100	Unknown grass	67
<i>Athyrium filix-femina</i>	94	Shrub	
<i>Oxalis oregana</i>	94	<i>Rubus spectabilis</i>	94
<i>Blechnum spicant</i>	89	<i>Ribes bracteosum</i>	89
<i>Mimulus dentatus</i>	89	<i>Vaccinium parvifolium</i>	89
<i>Stachys rigida</i> var. <i>rigida</i>	83	<i>Gaultheria shallon</i>	67
<i>Carex leptopoda</i>	78	<i>Vaccinium ovatum</i>	67
<i>Dryopteris expansa</i>	72		

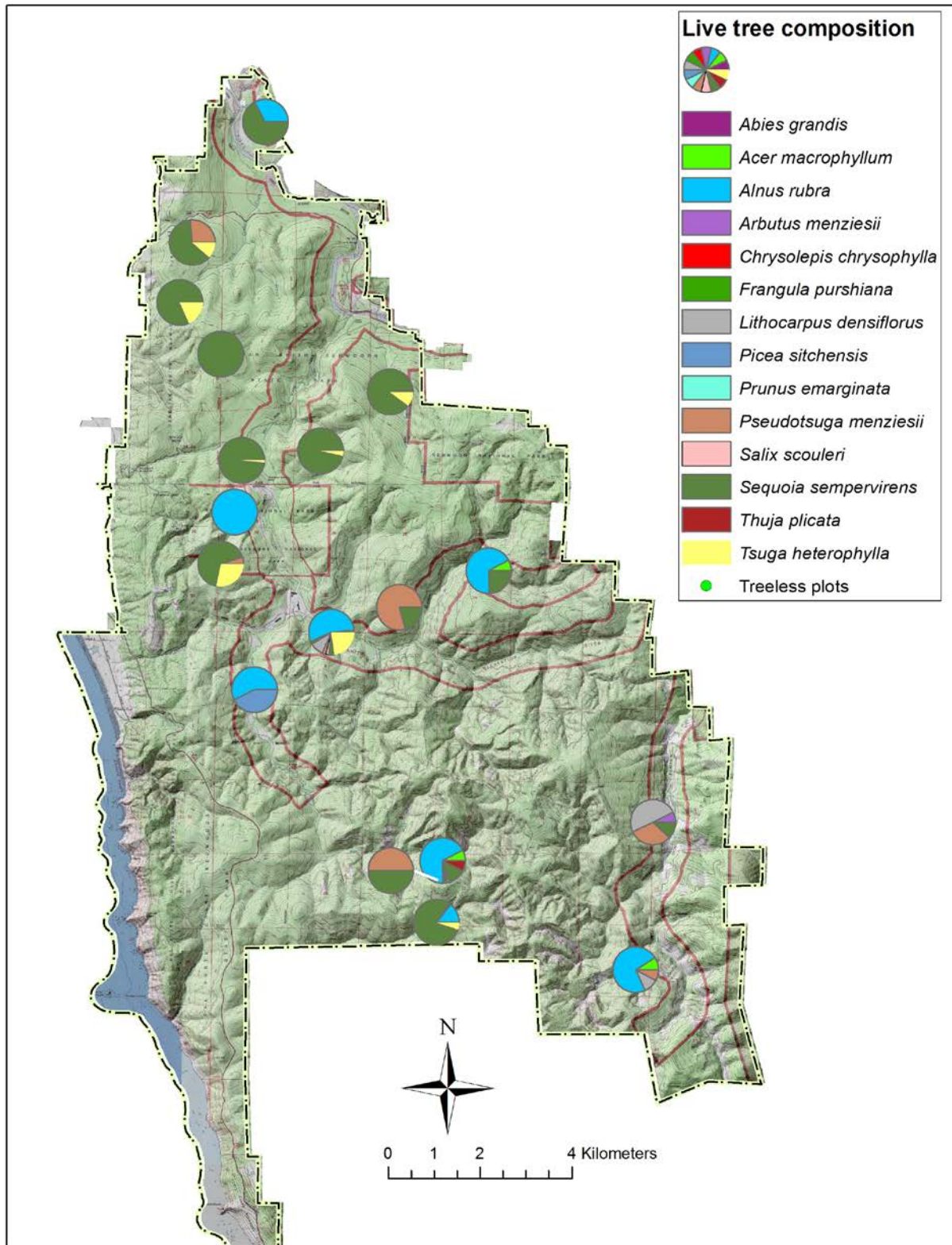


Figure 10. Individual tree (>15 cm dbh) species basal area composition of Redwood north sites in 2014.

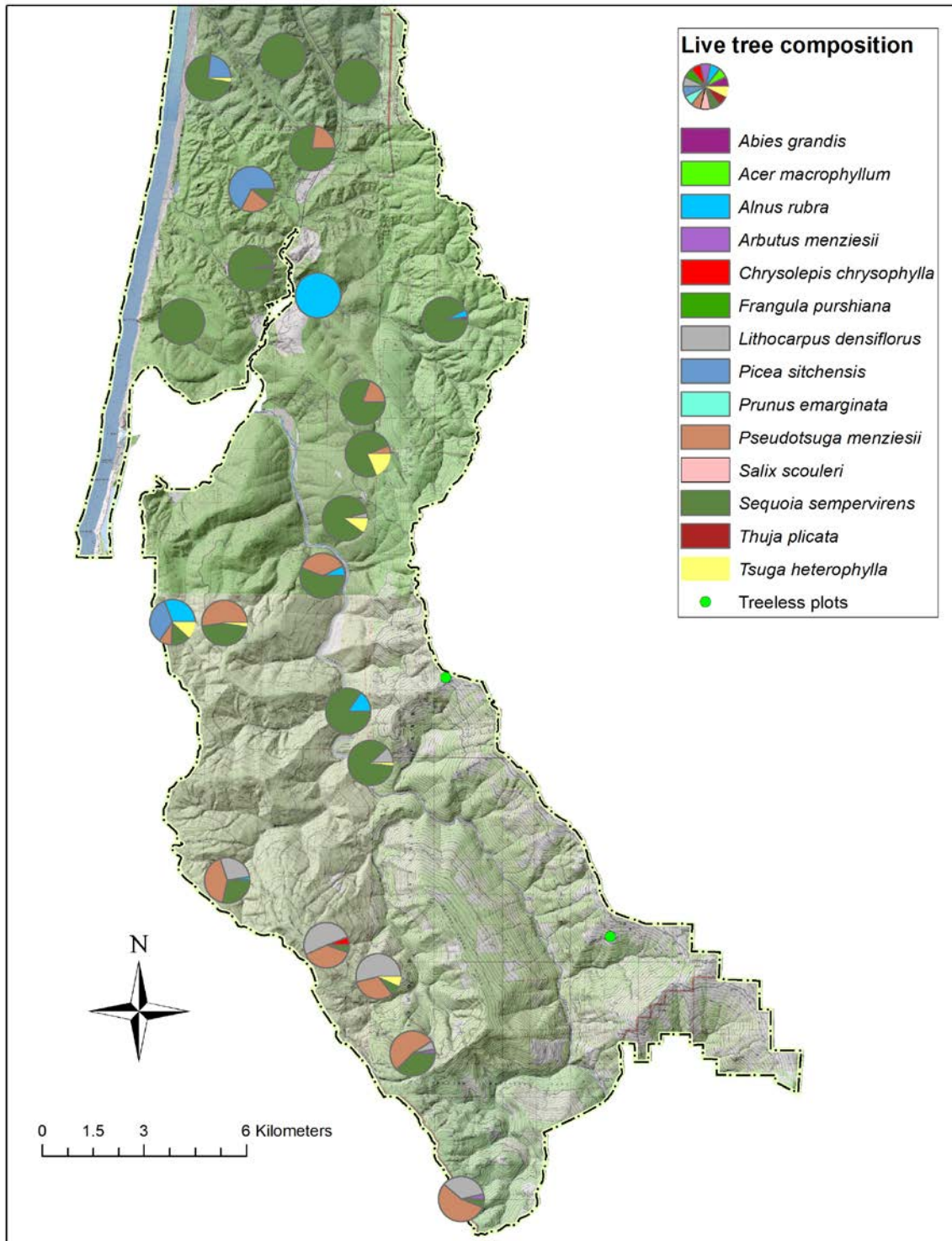


Figure 11. Individual tree (>15 cm dbh) species basal area composition of Redwood south sites in 2014.

Comparison of 2011 and 2014 Species Richness

While the intent of this report is mainly as a status update for the 2014 monitoring season, we present an interesting finding regarding differences in 2011 and 2014 species richness at both Lava Beds and Redwood plots.

At Lava Beds, vascular plant species richness was significantly lower in 2014 than in 2011 when all species were considered ($t(28) = 7.9$, $p < 0.001$), for annual species ($t(28) = 10.4$, $p < 0.001$), and for perennial species ($t(28) = 4.9$, $p < 0.001$) (Figure 12). In contrast, unknown species showed no difference in mean richness between 2011 and 2014 ($t(28) = 1.4$, $p = 0.19$). Annual species were most frequently present in 2011, but absent from 2014 sites. The top six species absent from 2014 were all annual, and, of the top 25 species absent from 2014, only seven were perennial herbaceous forbs. In contrast to the annual species, perennial graminoids and shrubs missing from 2014 plots were absent in relatively low percentages.

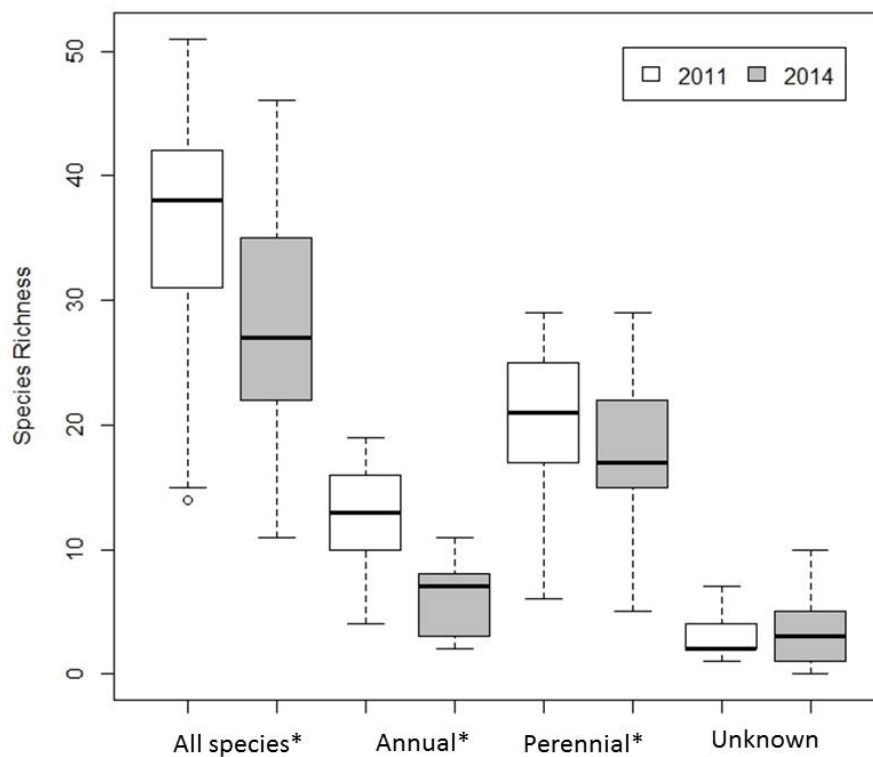


Figure 12. Change in vascular plant species richness between 2011 and 2014 at Lava Beds (0.1 ha plots) for all species and for annual, perennial, and unknown species. The horizontal lines within boxes are mean values. Bottom and top of boxes show 25th (first quartile) and 75th (third quartile) percentiles, respectively. Whiskers show maximum and minimum, except when outliers are present. Outliers are shown as hollow dots, and are 1.5 times below the first quartile and 1.5 times above the third quartile. (Note that 1.5 times the interquartile range of the data is roughly 2 standard deviations, and the interquartile range is the difference in the response variable between the first and third quartiles.) Categories followed by * show a significant difference between means.

At Redwood, contrasting species richness between 2011 and 2014 also showed a decrease in 2014 ($t(41) = 2.6$, $p = 0.01$). Differences for annual species richness were only marginally significant (Figure 13) ($t(41) = 2.1$, $p = 0.04$), with mean species richness lower in 2014. However, the difference in perennial species richness between 2011 and 2014 was highly significant ($t(41) = 3.7$, $p < 0.001$), with higher richness in 2011. In contrast, there was a lower mean value of unknowns in 2011, ($t(41) = 4.9$, $p < 0.001$). Species most frequently absent from 2014 sites that were present in 2011 were perennial forbs and graminoids. The most frequent category of species present in 2014 and absent from 2011 was the unknowns.

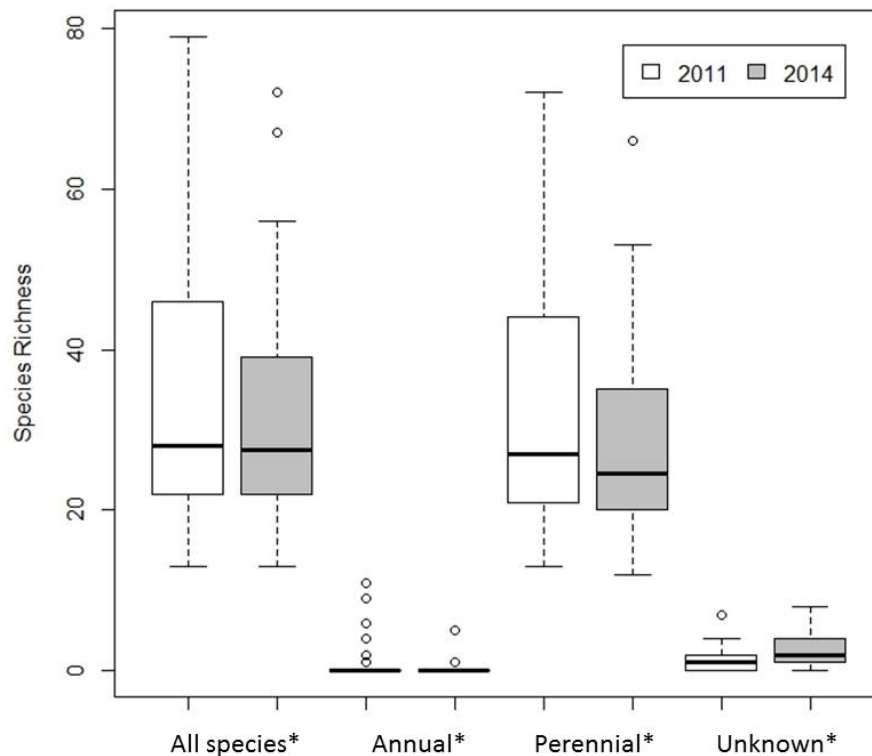


Figure 13. Change in vascular plant species richness between 2011 and 2014 at Redwoods 0.1 ha plots for all species and for annual, perennial, and unknown species. The horizontal lines within boxes are mean values. Bottom and top of boxes show 25th (first quartile) and 75th (third quartile) percentiles, respectively. Whiskers show maximum and minimum, except when outliers are present. Outliers are shown as hollow dots, and are 1.5 times below the first quartile and 1.5 times above the third quartile. (Note that 1.5 times the interquartile range of the data is roughly 2 standard deviations, and the interquartile range is the difference in the response variable between the first and third quartiles.) Categories followed by * show a significant difference between means.

Vegetation Structure

Lava Beds

The highest mean vegetation cover in the matrix sampling frame occurred in height stratum 1 (<0.75 m), at 25.6%; second highest was in height stratum 2 (0.75–2.5 m), at 14.7% (Table 5).

Table 5. Vegetation cover (%) by height stratum in the matrix sampling frame at Lava Beds. SD = standard deviation.

Frame	Height Stratum							
	<0.75 m				0.75–2.5 m			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	7.3	69.2	25.6	14.9	0.3	38.3	14.7	10.1
Frame	2.6–5 m				>5 m			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	0.0	21.3	2.4	5.4	0.0	27.1	1.6	5.3

Mean plot basal area for the matrix sampling frame was 1.2 m²/ha for live trees and 0.001 m²/ha for snags (Table 6). Eight of the 29 matrix plots had trees >15cm dbh. Mean tree density was 20 trees/ha (Table 7). Table 7 also shows tree height, height to crown, and maximum height. Snag density and mean heights are presented in Table 8. Woody debris lag class values were lowest in the 1000-hr rotten class and highest in the 1000-hr class for sound wood (Table 9). Tables 10 and 11 summarize ground substrate cover and litter depth.

Table 6. Live tree and snag basal area (BA) minimum, maximum, mean, and standard deviation for the matrix sampling frame at Lava Beds. Units are m²/ha.

Frame	Min Live Tree BA	Max Live Tree BA	Mean Live Tree BA	SD
Matrix	0.0	10.4	1.2	2.8
Frame	Min Snag BA	Max Snag BA	Mean Snag BA	SD
Matrix	0.000	0.029	0.001	0.005

Table 7. Mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m) at Lava Beds. Standard deviations are shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max Tree Height
Matrix	20 (28)	6 (2)	1 (1)	12

Table 8. Mean snag density (stems/ha) and height (m) at Lava Beds. Standard deviations are shown in parentheses. N/A = standard deviation not available because only one value was collected.

Frame	Mean Snag Density	Mean Snag Height
Matrix	0.33 (1.8)	4.6 (N/A)

Table 9. Mean woody debris time lag classes (tons per acre) at Lava Beds. Standard deviations are shown in parentheses (see page 4 #13 and #14 for lag class size criteria).

Frame	1-hr	10-hr	100-hr	1000-hr Rotten	1000-hr Sound
Matrix	0.24 (.23)	0.56 (0.48)	0.60 (0.69)	0.00 (0.00)	0.46 (1.28)

Table 10. Ground/substrate mean percent cover at Lava Beds. Standard deviations are shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
Matrix	27.9 (23.9)	3.7 (3.8)	0.9 (1.1)	36.0 (15.1)	29.9 (24.0)	0.0 (0)

Litter and duff mean depths were 0.7 and 0.0 cm, respectively (Table 11).

Table 11. Litter and duff minimum, maximum, and mean depth at Lava Beds. Units are cm, and standard deviations are shown in parentheses.

Frame	Litter Depth Mean	Litter Depth Min	Litter Depth Max	Duff Depth Mean	Duff Depth Min	Duff Depth Max
Matrix	0.7 (0.5)	0.1	2.6	0.0 (0.0)	0	0

Redwood

The highest overall mean value for vegetation cover was found in matrix height stratum 4 (>5 m), at 109.8% (Table 12). Mean percent vegetation cover in both the riparian and matrix sampling frames was highest in height stratum 4 (Table 12).

Table 12. Vegetation cover (%) by height stratum in matrix and riparian sampling frames at Redwood.

Height Stratum								
<0.75 m					0.75–2.5 m			
Frame	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	4.2	55.5	19.4	13.4	15.3	90.1	46.5	22.8
Riparian	6.0	66.6	28.2	15.6	13.1	96.8	55.4	17.9
2.6–5 m					>5 m			
Frame	Min	Max	Mean	SD	Min	Max	Mean	SD
Matrix	0.0	69.3	29.3	19.2	0.0	194.0	109.8	45.3
Riparian	3.8	43.3	21.4	13.6	51.3	152.0	103.2	26.7

Mean live tree basal area at Redwood was highest in the matrix sampling frame (120.2 m²/ha) (Table 13). Two matrix plots lacked live trees >15cm dbh, and all riparian sites had trees >15cm dbh. Matrix site mean tree density (388 trees/ha) was higher than for riparian (347 trees/ha) sites (Table 14). Matrix site mean snag density (43 trees/ha) was higher than for riparian sites (29 trees/ha)(Table 15). Dead and down woody debris data are shown in Table 16. Both the matrix and riparian sites had the lowest value in the 1-hr lag class and progressively increased up to the 1000-hr class. Mean shrub heights were 2.0 m each for riparian and matrix sites, with a maximum of 3.3 m for both sample frames. Fine wood/litter was the dominant ground cover in both the matrix (81.3%) and riparian (72.9%) sampling frames (Table 17).

Table 13. Live tree and snag basal area (BA) minimum, maximum, mean, and standard deviation (SD) for sampling frames at Redwood. Units are m²/ha.

Frame	Min BA	Max BA	Mean BA	SD
Matrix	0.0	296.0	120.2	93.3
Riparian	15.4	219.9	81.3	56.5
Frame	Min Snag BA	Max Snag BA	Mean Snag BA	SD
Matrix	0.0	32.5	3.6	7.6
Riparian	0.02	7.4	1.1	1.9

Table 14. Mean live tree density (stems/ha), height (m), height to crown (m), and maximum tree height (m) at Redwood. Standard deviations are shown in parentheses.

Frame	Mean Tree Density	Mean Tree Height	Mean Height to Crown	Max Tree Height
Matrix	388 (346)	23 (11)	13 (6)	83
Riparian	347 (242)	25 (11)	12(6)	92

Table 15. Mean snag density (stems/ha) and height (m) at Redwood. Standard deviations are shown in parentheses.

Frame	Mean Snag Density	Mean Snag Height
Matrix	43 (42)	11 (9)
Riparian	29 (44)	8 (7)

Table 16. Summary of mean woody debris time-lag classes (tons per acre) at Redwood. Standard deviations are shown in parentheses.(See the descriptions for parameters #13 and #14 on page 4 for lag class size criteria.)

Frame	1-hr	10-hr	100-hr	1000-hr Rotten	1000-hr Sound
Matrix	0.55 (0.40)	1.76 (1.14)	2.37 (1.90)	42.31 (54.58)	38.99 (60.13)
Riparian	0.37 (0.25)	1.55 (0.81)	2.02 (1.40)	84.54 (139.97)	29.47 (53.20)

Table 17. Ground/substrate mean percent cover at Redwood. Standard deviations are shown in parentheses.

Frame	Bare Soil	Bryophytes	Coarse Wood	Fine Wood / Litter	Rock	Water
Matrix	0.9 (2.6)	8.9 (12.1)	4.8 (4.2)	81.3 (13.9)	0.4 (0.6)	0 (0)
Riparian	3.6 (4.1)	14.9 (16.5)	2.6 (1.7)	72.8 (16.5)	2.4 (.2.8)	2.4 (4.7)

Mean litter depth was greatest for the riparian sampling frame, while mean duff depth was greatest in the matrix sampling frame (Table 18).

Table 18. Litter and duff minimum, maximum, and mean at Redwood. Units are cm, and standard deviations are shown in parentheses.

Frame	Litter Depth Mean	Litter Depth Min	Litter Depth Max	Duff Depth Mean	Duff Depth Min	Duff Depth Max
Matrix	2.7 (1.2)	0.6	5.4	2.1 (1.8)	0	5.6
Riparian	3.7 (1.9)	0.7	8.8	1.5 (1.9)	0	5.9

Vegetation Function (Regeneration)

Lava Beds

In the matrix sampling frame at Lava Beds, *Cercocarpus ledifolius* was the most abundant regenerating tree in all size classes. Mean regeneration counts for all tree species combined are shown in Table 19.

Table 19. Regeneration by size class for all live tree species in the matrix sampling frame at Lava Beds. Units are trees/ha, and standard deviations are shown in parentheses.

≤15 cm Tall		>15 cm Tall			
Frame		<2.54 cm dbh	2.54 to 5 cm dbh	>5 to 10 cm dbh	>10 to <15 cm dbh
Matrix	328 (816)	534 (2593)	49 (159)	70 (234)	12 (39)

Redwood

At Redwood, the most abundant regenerating tree species in the matrix sampling frame for all classes except 2.54 to 5 cm dbh and >10 to <15 cm dbh was *Lithocarpus densiflorus* var. *densiflorus*. *Sequoia sempervirens* was the most abundant species in the 2.54 to 5 cm dbh class, and *Pseudotsuga menziesii* was most abundant in the >10 to <15 cm dbh class. In the riparian sampling frame, the most abundant species, from the smallest to largest size classes, were *Frangula purshiana*, *Thuja plicata*, *Frangula purshiana*, *Sequoia sempervirens*, and *Alnus rubra*. Mean regeneration counts for all tree species combined are shown in Table 20.

Table 20. Regeneration by size class for all live tree species in each sampling frame at Redwood. Units are trees/ha, and standard deviations are shown in parentheses.

≤15 cm Tall		>15 cm Tall			
Frame		<2.54 cm dbh	2.54 to 5 cm dbh	>5 to 10 cm dbh	>10 to <15 cm dbh
Matrix	542 (633)	1375 (2380)	203 (278)	208 (243)	101 (160)
Riparian	306 (450)	389 (595)	94 (127)	140 (124)	78 (108)

Discussion

Species Richness

Overall we observed lower species richness in 2014 than in 2011. Working in prairie vegetation, Tilman and El Haddi (1992) showed an average decrease in species richness of 37% as a result of drought. Drought could be a factor, along with detectability, driving the lower species richness we observed in 2014. Drought could prevent the germination of annuals, inhibit the growth of perennials, and cause both to become desiccated and less detectable, especially late in the season.

In 2014, precipitation at Lava Beds ranged from 162 to 273 mm; in 2011 it ranged from 295 to 493 mm. Thus, precipitation levels in 2014 were 52–57% of 2011 precipitation levels. At Redwood, 2014 precipitation values ranged from 760 to 1602 mm; 2011 sites ranged from 1541 to 2964 mm of precipitation. Thus 2014 precipitation values were 48–55% those of 2011. The lack of soil moisture available in 2014, and the lower species richness we found support the hypothesized mechanism whereby environmental variation or stress can limit biodiversity. This was also observed by Tilman and El Haddi (1992). This overall driver (lower precipitation) was consistent between parks, but as we might expect with such different vegetation zones, from the sagebrush steppe (Young et al. 2007) at Lava Beds to the coastal temperate forest (Sawyer 2007) at Redwood, within-park patterns seemed to differ with respect to life-history. The two separate patterns from 2011 and 2014 were 1) fewer annuals at Lava Beds, and 2) fewer herbaceous and graminoid perennials as well as more unknown (or unidentifiable) species at Redwood.

Nonnative Species

While not present at any of our sites, we did observe English Ivy (*Hedera helix*) while hiking to three plots. One infestation was near plot RW30, in Jedediah Smith Redwoods State Park, and near RW124 and RW08, both in Prairie Creek Redwoods State Park. All plants were small (<15 cm in height) and were pulled up. Time was not spent searching the area for more plants. Coordinates were taken at the infestations near RW124 and RW08. We did not observe this species in 2011.

We observed reed fescue (*Festuca arundinacea*) at three sites at Redwood. Two occurred along Redwood Creek (RW111 and RW163), and one from Mill Creek along Picnic Rd (RW173). Species cover at all sites was $\leq 1\%$. We did not remove any of these plants. We did not observe this species in 2011.

Logistics

Access to some sites at Redwood, in particular in the Mill Creek acquisition, could become problematic in future years. Little road maintenance is done in the Mill Creek acquisition, and while we did not have any issues with site access in 2014, there were some places where we moved small downed logs or rocks from roads that we needed to drive. Larger downed trees would be beyond our ability to move and assistance from park staff would be needed to clear roads. Conversations with park staff regarding this topic have illuminated several issues. It would be best if we could coordinate with park staff well before the season to discuss our road access needs. It would be unlikely that a last minute request would result in a crew coming out to clear an obstacle, meaning we either would have to walk the road to the site or not do the site that year. While early coordination with park staff

would allow time to plan road obstruction removal, it would not ensure that the work would be done, as budget or personnel shortfalls could still be an issue. Another important point is that the Mill Creek acquisition is technically run by the California State Parks, and special permissions might be needed if NPS personnel were to perform road maintenance. Also, a permit will be needed to work in the California State Parks in 2017; this requirement is new as of 2015.

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