



Whitebark Pine Monitoring at Crater Lake and Lassen Volcanic National Parks

Fiscal Years 2012–2014 Project Report

Natural Resource Report NPS/KLMN/NRR—2015/1052



ON THE COVER

Dead and dying whitebark pine near Dutton Ridge in Crater Lake National Park, 2012.
Photograph by: Erik Jules

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Abstract

This report describes the results of a three year project to establish whitebark pine (*Pinus albicaulis*) monitoring plots in Crater Lake National Park (CRLA) and Lassen Volcanic National Park (LAVO). The project is a collaboration between scientists from the NPS Klamath Inventory and Monitoring Network and the Principal Investigator, Erik Jules of Humboldt State University and his students. This project implements methodology outlined by McKinney et al. (2012) for five-needle pines found on National Park Service land in the western United States. Here we present data and observations from the first three years of monitoring (2012, 2013, and 2014). Thirty plots have now been established and monumented in each of the two parks, and all trees have been identified and tagged with unique identification numbers. Whitebark pines were assessed for blister rust and other insect and pathogen damage. On average, white pine blister rust has infected 51% of whitebark pine in CRLA plots and 54% in the LAVO plots. Of the whitebark pine trees for which cause of death could be determined, beetles were the primary cause of whitebark pine mortality in CRLA and LAVO; nevertheless, cause of death often could not be determined.

In addition, 202 increment cores were collected in CRLA in 2013 in an effort to reconstruct the history of mortality in the park using dendrochronological techniques. Preparation of the cores and crossdating are ongoing and the results are pending.

Introduction

Whitebark pine (*Pinus albicaulis*) is best known for its stunted, twisted appearance near treeline, where it is a classic feature of the American West, familiar to anyone who has spent time in subalpine habitat. Rivaling the better-known bristlecone pine (*P. longaeva*), whitebark pine has a much larger range than other subalpine conifers and is found from the southern Sierra Nevada to British Columbia and the northern Rockies (Tomback et al. 2001). Besides its inherent beauty, whitebark pine serves several key ecosystem functions, including modulating springtime snowmelt (thereby increasing water availability in summer) and producing large seed crops critical to, for example, Clark's Nutcrackers (*Nucifraga columbiana*; Tomback 1982) and grizzly bears (*Ursus arctos horribilis*; Mattson et al. 2001).

Unfortunately, whitebark pines are being affected by three of the most pressing threats that contemporary resource managers face: exotic pathogens, fire suppression, and climate change. White pine blister rust (*Cronartium ribicola*), an exotic fungus introduced a century ago, has begun to cause increasingly widespread mortality of whitebark pine over the past few decades (Murray 2005). In addition, fire suppression has allowed other conifer species to move higher in elevation, increasingly competing with whitebark pine (Ellison et al. 2005). And finally, the effects of a warming climate are predicted to increase stress on montane plants, though they are largely unstudied for whitebark pine (Warwell et al. 2007).

The purpose of this project is to implement the first three years of the Pacific West Region five-needle pine protocol (McKinney et al. 2012) for monitoring tree species composition, characteristics, and regeneration in Crater Lake National Park (CRLA) and Lassen Volcanic National Park (LAVO), where whitebark pines inhabit the treeline environment. The project is a collaboration between scientists from the National Park Service (NPS) Klamath Inventory and Monitoring Network (KLMN) and the Principal Investigator, Erik Jules of Humboldt State University (HSU) and his students. This project will form the foundation of a long-term whitebark pine monitoring program at CRLA and LAVO and follows the methodology outlined by McKinney et al. (2012) for five-needle pines found in NPS lands in the western United States. McKinney et al. (2012) places emphasis on blister rust infection rates and demographics of *P. albicaulis*, *P. balfouriana* (foxtail pine), and *P. flexilis* (limber pine).

Previous work at CRLA was conducted by Dr. Michael Murray, the park's terrestrial ecologist at the time (Murray 2010). Murray noted that mortality rates approached 1% per year in established reference stands, primarily caused by mountain pine beetles (*Dendroctonus ponderosae*). These results were echoed in the pilot study conducted by the KLMN in 2009, reported in Smith et al. (2011). Whitebark pines are known to occur at LAVO, but no monitoring or research has been previously conducted.

Methods

Over the course of three years, 30 long-term whitebark pine monitoring plots (10 per year) were established at CRLA and LAVO (Appendix A). Plot design and sampling follow the NPS Pacific West Region five-needle pine protocol (McKinney et al. 2012), which employs a 50×50 m plot to track tree demographics and infestation rates. Data in this report are from the first three years of monitoring the 60 total plots—30 in each park—from 2012 to 2014.

Each field season began in the second week of July with a 2.5-day training in CRLA of four field assistants. The field assistants in 2012 were April Sahara (HSU graduate student), David McClean (HSU undergraduate), Rachael Patton (HSU undergraduate), and Kasey Graue (Southern Oregon University undergraduate). Rachael and Kasey implemented the CRLA plots, while April and David implemented the LAVO plots. The field assistants in 2013 included Jenell Jackson (HSU graduate student), David McClean, Rachael Patton, and Kelsey Guest (HSU undergraduate). Jenell and David implemented the CRLA plots, and Kelsey and Rachael implemented the LAVO plots. Finally, the field assistants for the 2014 field season included Jenell Jackson, David McLean, Rachael Patton, and Emily DeStigter (HSU alumni). Rachael and Emily established plots in CRLA and Jenell and David established plots in LAVO.

The sampling points for all three field seasons (2012, 2013, and 2014) were generated using the Generalized Random Tesselated Stratified (GRTS) algorithm in GIS. In addition, an oversample of points was also drawn using the GRTS algorithm to support any eventual site rejections. The sampling frame excluded slopes greater than 30 degrees, and locations <100 m or >1 km from a road or trail. Sites were rejected if (1) no whitebark pines were present, or (2) they would result in unsafe working conditions (e.g., terrain that was too steep to work on). The points generated by the GIS became the southwest corner of the 50×50 m plots if one or more whitebark pine trees >1.37 m in height were found within the plot boundary. If there were no whitebark pine individuals in a plot, an offset procedure was employed. We would select a direction at random and walk at that azimuth for a distance of 50 m from the original coordinates. This location was considered the new southwest corner. If the second plot did not contain whitebark pine, then a new random direction was determined and we would walk 50 m from the last offset coordinates. If the second offset procedure did not generate a usable plot, a new point was used from the oversample described above.

Each 50×50 m plot consisted of five 10×50 m subplots and nine regeneration plots (each 3×3 m) (Figure 1). Within the entire 50×50 m plot, all trees >1.37 m in height were identified to species and tagged with a unique ID. The diameter at breast height (DBH) and height of each tree were recorded. In addition, white pine blister rust was assessed for all five-needle pines. The upper, middle, and bottom thirds of each tree were assessed separately and assigned to one of three conditions: (1) absent—no sign of rust infection, (2) active cankers (aeciospores present), or (3) no active cankers, but with the presence of three of the following six indicators of infection—rodent chewing, flagging, swelling, roughened bark, oozing sap, or old aecia. For all pines, mountain pine beetle activity was recorded if pitch tubes, frass, and/or J-shaped galleries were found. Appendix B summarizes the conditions, including some not mentioned here, that were recorded for each tree (see also McKinney

et al. 2012 for details). Dead trees >1.37 m in height were tagged with unique IDs also. Seedlings (trees <1.37 m in height) were counted by species and height class in the nine regeneration plots and all whitebark pine seedlings were tagged with an ID tag. In the 2013 and 2014 field seasons, crew members returned to all plots in both parks to implement recommendations resulting from the previous field seasons.

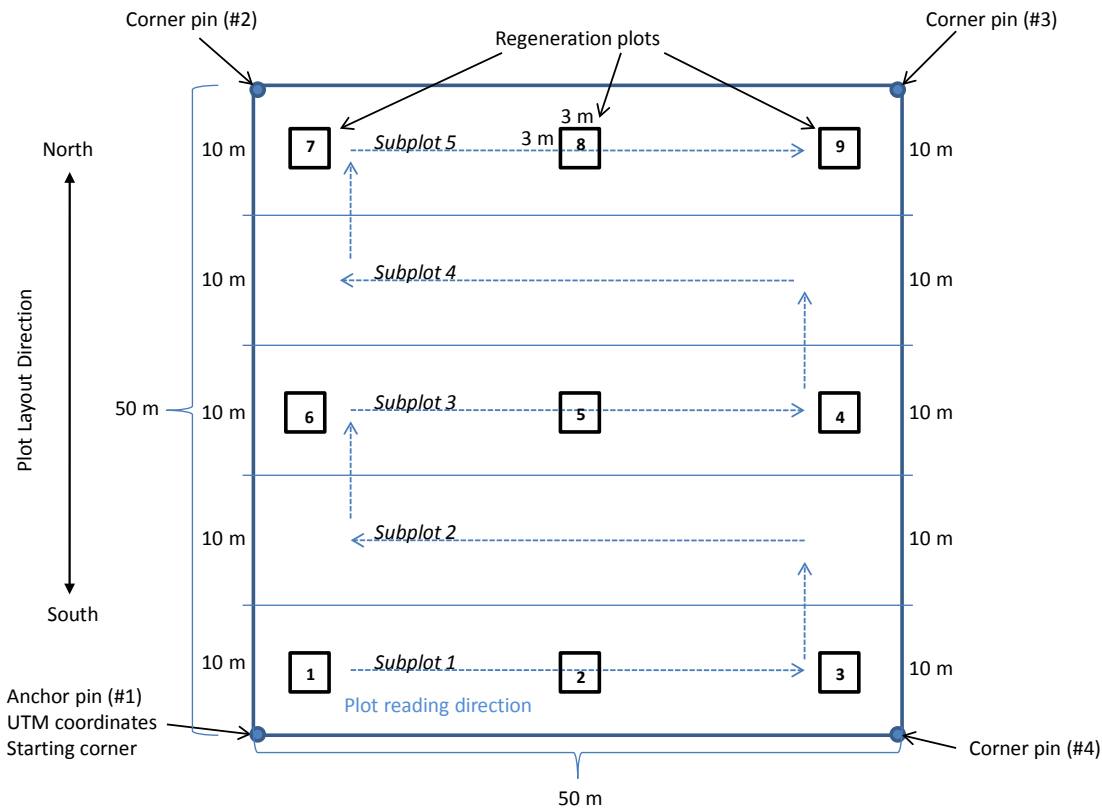


Figure 1. Layout of 50 × 50 m plot for monitoring whitebark pine.

In addition to implementing the KLMN whitebark pine monitoring, HSU will also generate a history of whitebark pine mortality in CRLA over the past century using dendrochronology techniques. To accomplish this, increment cores were taken from 15 dead whitebark pine trees in 2012 as part of a pilot project. Two or three cores were extracted from each tree to ensure a high probability of successful crossdating. In addition, previously collected cores from living whitebark pines were acquired from CRLA for use in the pilot dendrochronology study. These cores were previously mounted in standard wooden mounts, and had been stored in the Natural Resources Building in CRLA. The cores had been part of a fire ecology study conducted by Siderius and Murray (2005).

In 2013, increment cores were extracted from 100 dead whitebark pine trees as a follow-up to the pilot study performed in 2012. Plots from the last two sampling panels were used as a reference for coring five dead whitebark pines, and trees were used both inside and outside existing plots. Two to three cores were extracted from each tree. In 2013 cores were prepped and visually counted, and in

2014 we began crossdating cores. As of the publication date of this report, we are currently finishing crossdating and analysis of these cores.

Data management

Except for the tree increment core side-study, data management followed procedures outlined in Standard Operating Procedure 1.0 of McKinney et al. (2012). Field data were collected on tablet computers and backed up nightly on a memory stick. During the 2013 field season the PC tablet used by the LAVO crew was not operational for the last 2.5 plots and these data were instead recorded by hand and entered into the database after the field season had ended. Data were checked for accuracy at HSU after the field season and all errors were either corrected or removed. The coordinates of the SW corner were not recorded for plot #22, plot #23, and plot #34 in LAVO. Therefore the coordinates used to generate maps regarding these points use the original coordinates generated by the GRTS algorithm. A detailed record of all changes was created and archived at both HSU and KLMN. Summary statistics for the 60 plots established from 2012 to 2014 were created in both tabular and graphical form.

We documented all changes to elevation, plot coordinates, and site tags according to the recommendations made in the 2012 and 2013 whitebark pine monitoring reports. Crew members also returned to sites where we had “flagged” trees as having possible measurement errors prior to the start of the 2014 field season. This “flagging” was a process performed during the 2012 and 2013 data QA/QC process in which trees with dbh:height ratios that fell outside of a 99% prediction interval were “flagged” as possible measurement errors. We remeasured the heights and DBHs of all trees in all plots. The summary statistics in this report reflect the addition of these remeasurements and thus differ from those in the 2012 and 2013 whitebark pine monitoring reports. These changes have been documented in the KLMN Five Needle Pine Monitoring Protocol database.

Results

Over the course of three years (2012–2014), 30 monitoring plots were successfully established in both CRLA (Figure 2) and LAVO (Figure 3).

Due to safety concerns or a lack of whitebark pine, some sites were rejected and replaced by GRTS oversample sites. See Appendix C for site characteristics at CRLA, and Appendix D for site characteristics at LAVO.

Tree Species Composition and Characteristics

We documented a variety of characteristics for all trees and tree seedlings, by species, in monitoring plots established between 2012 and 2014 in CRLA and LAVO.

Crater Lake National Park

A total of 3637 live trees >1.37 m in height were found across the 30 CRLA plots, of which 952 were whitebark pine, 2344 were mountain hemlock (*Tsuga mertensiana*), 259 were lodgepole pine (*Pinus contorta* var. *murrayana*), 73 were red fir (*Abies magnifica*), three were Englemann spruce (*Picea engelmannii*), two were western white pine (*Pinus monticola*), and four were subalpine fir (*Abies lasiocarpa*); Figure 4 (top graph). Whitebark pine represented 11% of the total basal area in the thirty plots, while mountain hemlock represented 82%, lodgepole pine 6%, and red fir represented 1% (Figure 5). Note that basal area measurements are not precise because a few trees either had missing or erroneous DBH values (~16 trees) and were not included in the basal area estimates.

A total of 34 whitebark pine seedlings were found in the 30 CRLA plots (Table 1). Seedlings are only assessed in regeneration plots, and these cover 81 m² in each 50 × 50 m plot (Figure 1). Based on the plots, therefore, we estimate an average of 173 seedlings per hectare in CRLA.

Lassen Volcanic National Park

In LAVO, a total of 4647 live trees >1.37 m in height were found across the 30 plots, of which 657 were whitebark pine, 3944 were mountain hemlock, 43 were red fir, one was a lodgepole pine, one was a western white pine, and one individual could not be identified; Figure 4 (bottom graph). Whitebark pine represented 16% of the total basal area in the 30 LAVO plots, while mountain hemlock represented 83% and red fir represented 1% (Figure 6). As with the CRLA data, DBH measurements for a few trees (20) were removed due to suspect values or because we were unable to identify the species (plot 09), and were therefore not included in the basal area estimates. Six whitebark pine seedlings were found in the 30 LAVO plots (Table 2). Once again, seedlings are only assessed in regeneration plots, and these cover 81 m² in each 50 × 50 m plot (Figure 1). This equates to an average of 25 seedlings per hectare in LAVO.

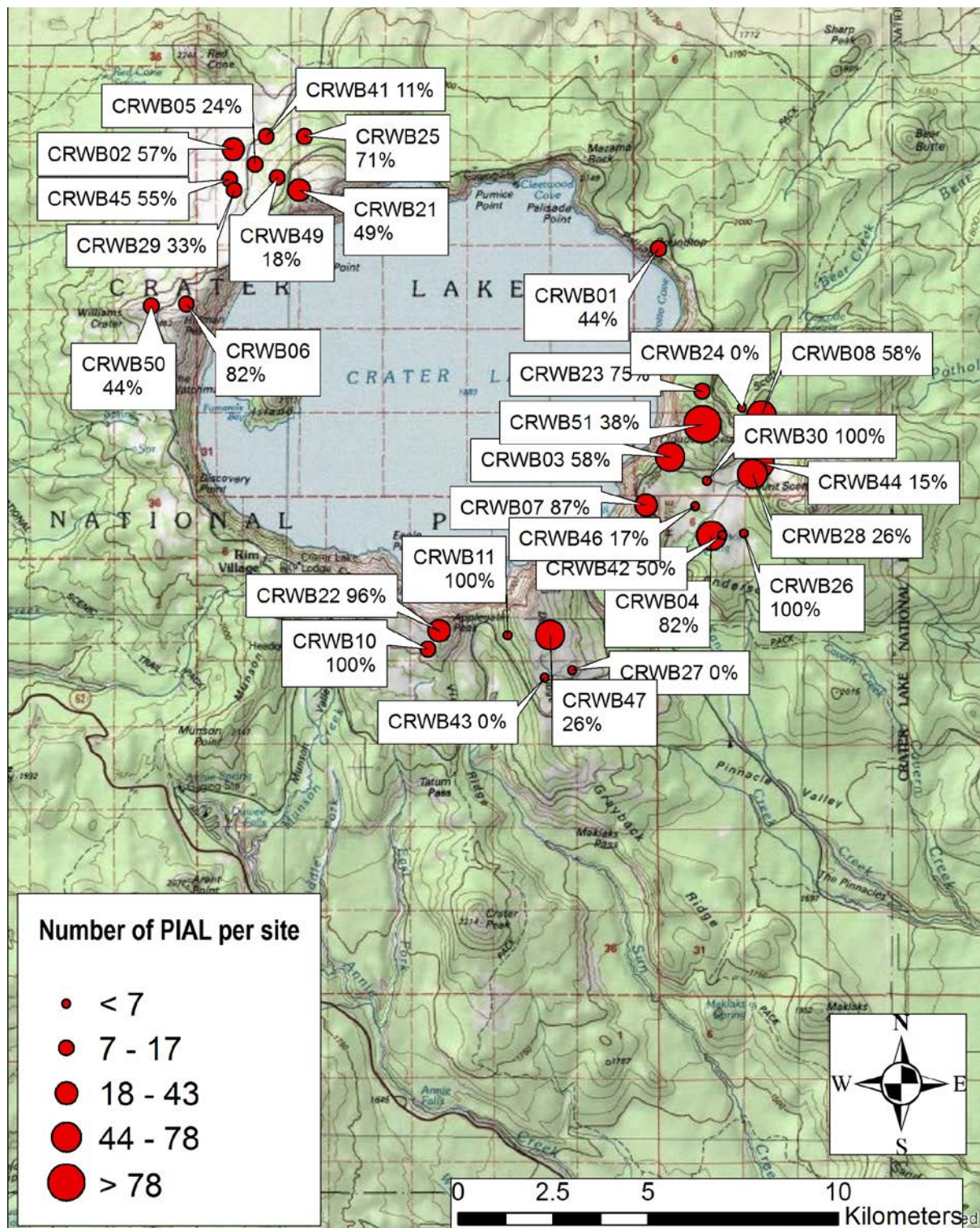


Figure 2. CRLA whitebark pine sites from 2012, 2013, and 2014. Dot sizing shows whitebark pine (PIAL) site locations and number of whitebark pine. Labels indicate site number and percentage of whitebark pine infected.

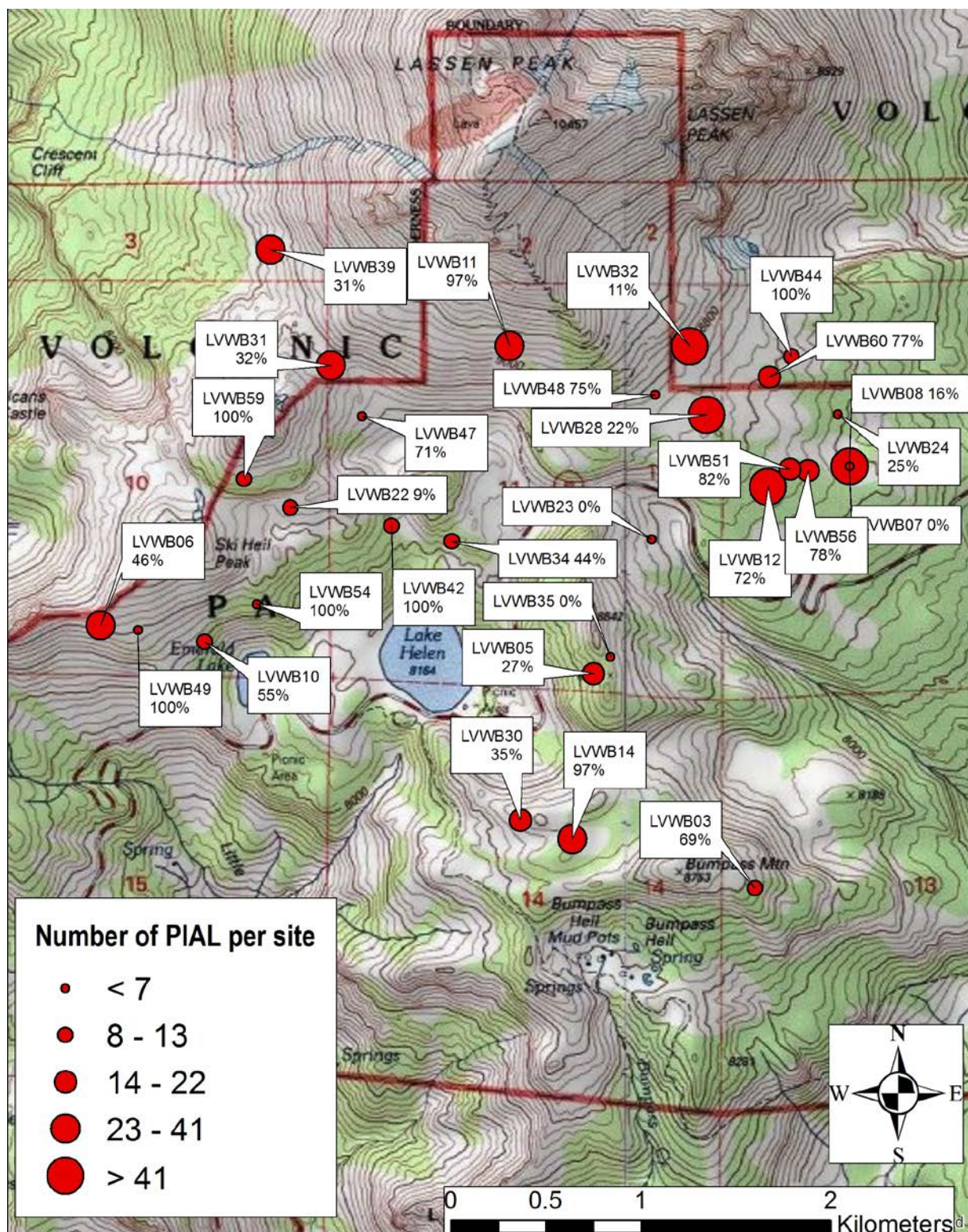


Figure 3. LAVO whitebark pine sites from 2012, 2013, and 2014. Dot sizing shows whitebark pine (PIAL) site locations and number of whitebark pine. Labels indicate site number and percentage of whitebark pine infected.

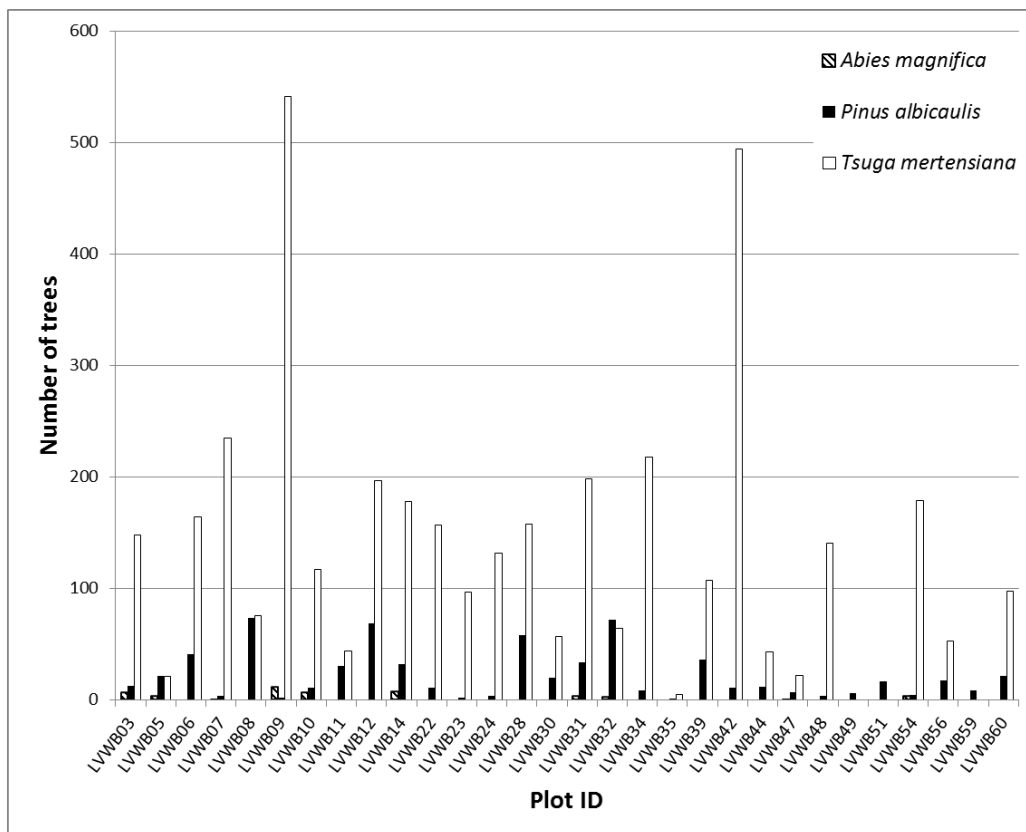
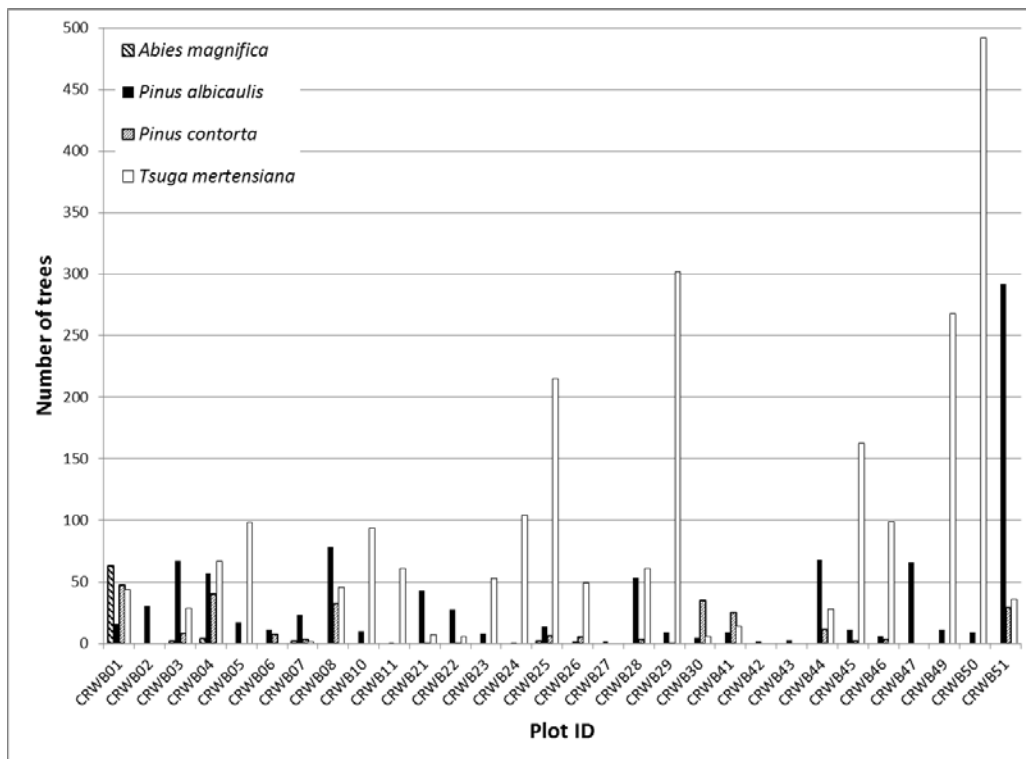


Figure 4. Number of trees for each species found in 30 monitoring plots in CRLA (top) and LAVO (bottom), 2012–2014. Species with fewer than five trees are not shown.

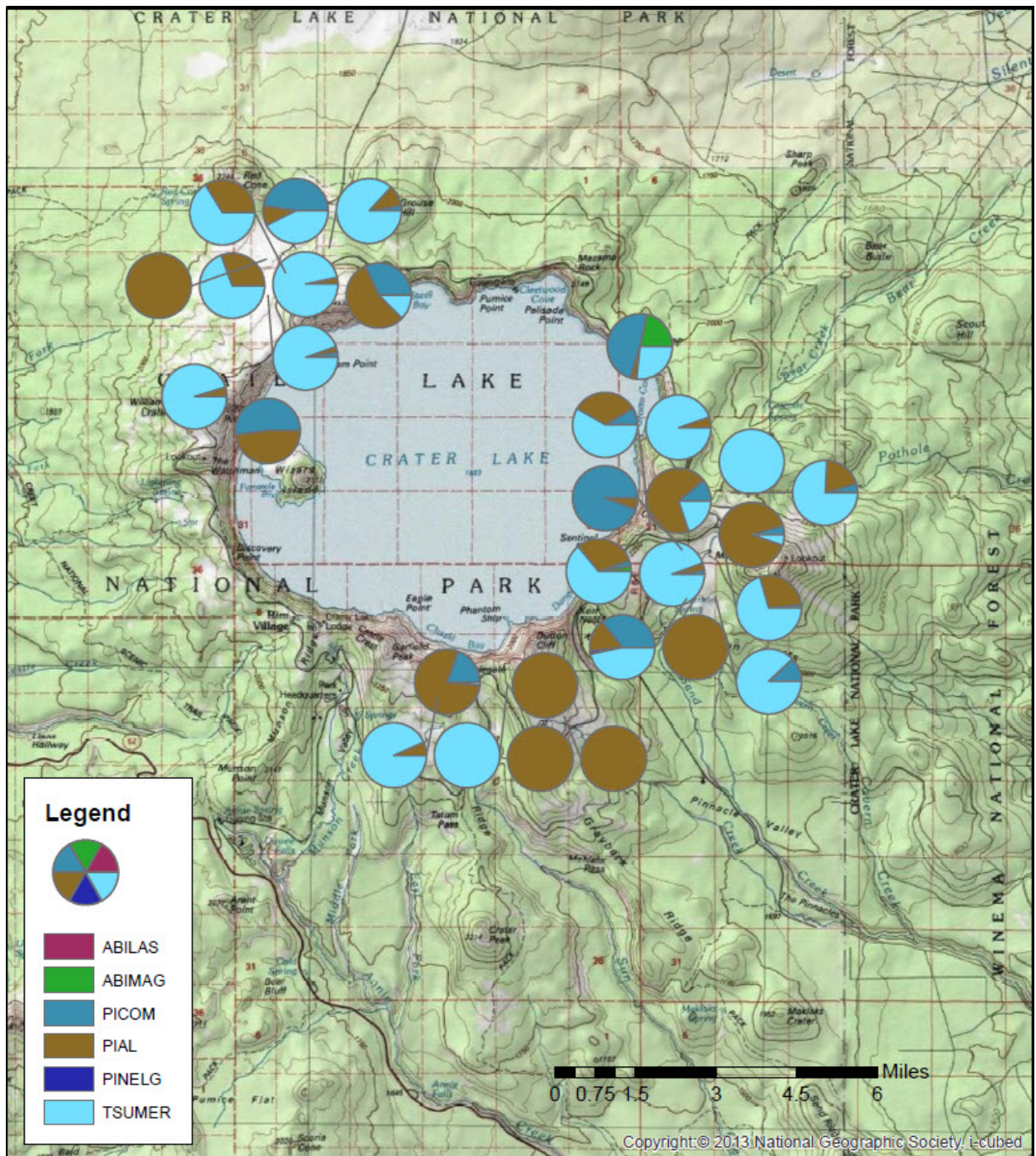


Figure 5. Relative proportion of basal area by species at monitoring sites in CRLA, 2012–2014. ABIMAG = *Abies magnifica*; PIAL = *Pinus albicaulis*; PICOM = *Pinus contorta* var. *murrayana*; TSUMER = *Tsuga mertensiana*; ABILAS = *Abies lasiocarpa*; PICENG = *Picea engelmannii*. At sites where trees from one species make up a very small percentage of the basal area, the species percentage is not visible in the pie chart.

Table. 1. Summary statistics for 30 whitebark pine monitoring plots established in CRLA in 2012, 2013, and 2014.

Plot ID	Live PIAL (#)	Dead PIAL (#)	Dead PIAL (%)	PIAL infected (%)	Seedlings (#)
CRWB01	16	5	24	44	1
CRWB02	30	36	55	57	0
CRWB03	67	0	0	58	0
CRWB04	57	3	5	82	1
CRWB05	17	6	26	24	1
CRWB06	11	0	0	82	0
CRWB07	23	0	0	87	0
CRWB08	78	7	8	58	3
CRWB10	10	3	23	100	0
CRWB11	1	0	0	100	0
CRWB21	43	1	2	49	0
CRWB22	28	1	3	96	0
CRWB23	8	5	38	75	3
CRWB24	1	0	0	0	0
CRWB25	14	5	26	71	0
CRWB26	2	0	0	100	0
CRWB27	2	0	0	0	0
CRWB28	53	13	20	26	1
CRWB29	9	0	0	33	0
CRWB30	5	1	17	100	0
CRWB41	9	0	0	11	0
CRWB42	2	0	0	50	0
CRWB43	3	0	0	0	0
CRWB44	68	22	24	15	0
CRWB45	11	20	65	55	8
CRWB46	6	5	45	17	2
CRWB47	66	8	11	26	1
CRWB49	11	7	39	18	9
CRWB50	9	7	44	44	1
CRWB51	292	22	7	38	3

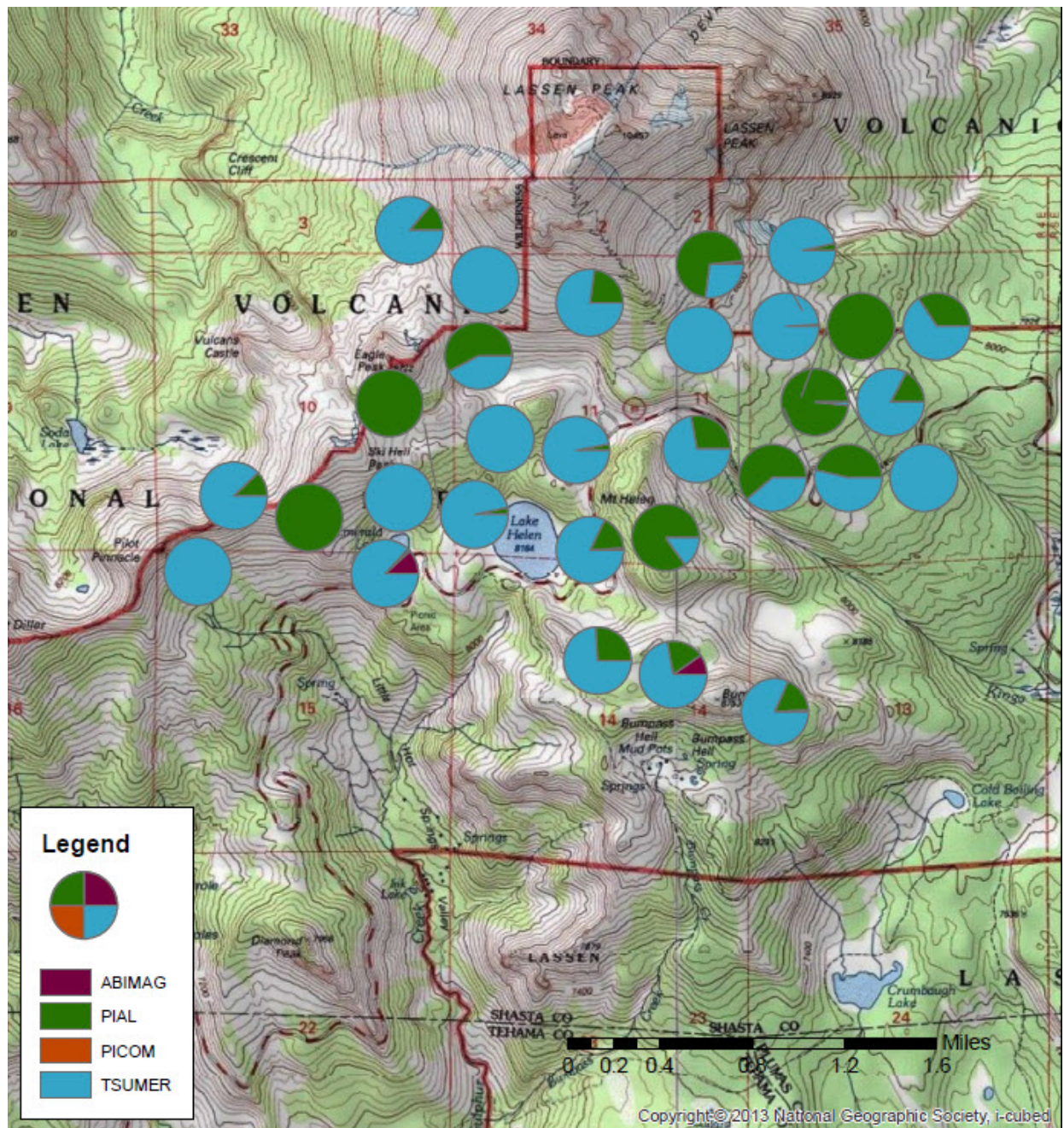


Figure 6. Relative proportion of basal area by species at monitoring sites in LAVO, 2012–2014. ABIMAG = *Abies magnifica*; PIAL = *Pinus albicaulis*; PICOM = *Pinus contorta* var. *murrayana*; and TSUMER = *Tsuga mertensiana*. At sites where trees from one species make up a very small percentage of the basal area, the species percentage is not visible in the pie chart.

Table 2. Summary statistics for 30 whitebark pine monitoring plots established in LAVO in 2012, 2013 and 2014.

Plot ID	Live PIAL(#)	Dead PIAL (#)	Dead PIAL (%)	PIAL infected (%)	Seedlings (#)
LVWB03	13	2	13	69	0
LVWB05	22	1	4	27	0
LVWB06	41	1	2	46	1
LVWB07	4	0	0	0	0
LVWB08	74	3	4	16	0
LVWB09	2	0	0	50	0
LVWB10	11	0	0	55	0
LVWB11	31	1	3	97	0
LVWB12	69	6	8	72	1
LVWB14	32	0	0	97	0
LVWB22	11	0	0	9	0
LVWB23	2	12	86	0	1
LVWB24	4	11	73	25	0
LVWB28	58	3	5	22	1
LVWB30	20	1	5	35	2
LVWB31	34	0	0	32	0
LVWB32	72	21	1	11	0
LVWB34	9	1	10	44	0
LVWB35	1	0	0	0	0
LVWB39	36	0	0	31	0
LVWB42	11	2	15	100	0
LVWB44	12	0	0	100	0
LVWB47	7	0	0	71	0
LVWB48	4	0	0	75	0
LVWB49	6	0	0	100	0
LVWB51	17	1	6	82	0
LVWB54	5	0	0	100	0
LVWB56	18	6	25	78	0
LVWB59	9	0	0	100	0
LVWB60	22	3	12	77	0

White Pine Blister Rust Infection

We documented white pine blister rust infection in whitebark pine trees, as well as other causes of mortality, in monitoring plots established between 2012 and 2014 in CRLA and LAVO.

Crater Lake National Park

The incidence of infection of whitebark pine by white pine blister rust in CRLA ranged from 0.0% to 100%, and the average rate of infection among plots was 51% (Table 2; Figure 7). Figure 2 shows the percentage of whitebark pine infected by plot. Of the 952 live trees assessed, 443 showed signs of infection. Of the 177 dead trees that could be identified as whitebark pine in CRLA, 40 (23%) died from mountain pine beetle, 28 (16%) from blister rust, two (1%) from mistletoe, 40 (23%) from bark beetles other than mountain pine beetle, and 1 (1%) died from a broken stem. The remaining 66 trees (37%) died from unknown causes.

Lassen Volcanic National Park

In LAVO, the incidence of infection of whitebark pine by blister rust ranged from 0.0% to 100 %, and the average rate of infection among plots was 54% (Table 2; Figure 7). Figure 3 shows the percentage of whitebark pine infected by plot. Of the 657 live trees assessed; 316 showed signs of infection. Of the 75 dead trees that could be identified as whitebark pine in LAVO, three (4%) died from mountain pine beetle, eight (11%) from blister rust, 14 (19%) from bark beetles other than mountain pine beetle, and 50 (67%) died from unknown causes.

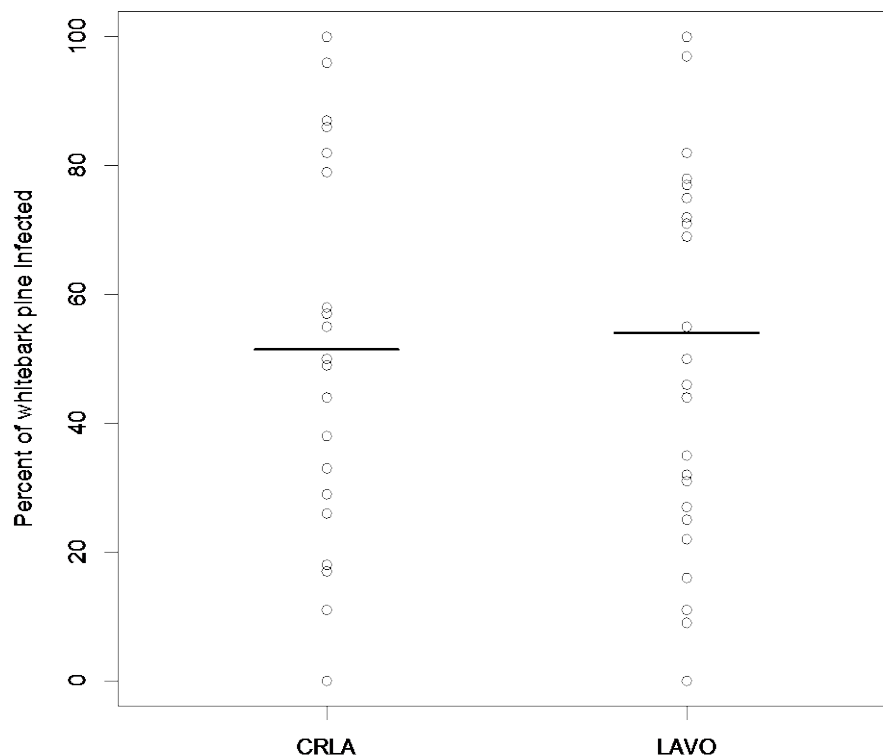


Figure 7. Percentage of whitebark pine individuals infected by white pine blister rust in 30 plots each in CRLA and LAVO in 2012, 2013, and 2014. Bars represent means.

Historical Mortality of Whitebark Pine in Crater Lake National Park

Reconstructing the historical mortality of whitebark pine in CRLA requires the collection and analysis of increment cores. The increment cores that were collected during the field season for the initial pilot study (summer of 2012) were mounted and sanded at HSU. All mounting, chronology building, and crossdating for the master chronology was completed in the spring of 2013 by April Sahara.

Increment cores that were collected during the summer of 2013 were mounted and sanded at HSU; however, we have yet to finish crossdating all of the cores at the time of this report. All crossdating and chronology building is currently ongoing and results are pending.

Discussion

The 2012, 2013, and 2014, whitebark pine monitoring in CRLA and LAVO was successfully implemented mostly as planned. The protocol (McKinney et al. 2012) was followed as planned with few errors made by the field crew. Furthermore, we revisited plots with incomplete observations and rectified almost all of these occurrences (see *Notes for future monitoring*, below). Within the allotted time, 30 plots in each park were successfully established, including training in the protocol and monumenting field sites. Increment cores from 15 whitebark pine trees were collected for the pilot study aimed at reconstructing mortality history in CRLA in 2012, and an additional 202 increment cores were collected from 100 dead whitebark pines in 2013 as a follow-up to the pilot study conducted in 2012.

The incidence of blister rust infection is slightly greater in LAVO (mean = 54% among plots; Table 2) than CRLA (mean = 51% among plots; Table 1) (see also Figure 7). The general impression through casual observation by field biologists before the beginning of this monitoring effort was that LAVO had low rates of infection, but our 30 plots suggest that LAVO is also experiencing comparable levels of whitepine blister rust infection. After the 2012 field season it appeared that LAVO was experiencing the beginning stages of infection of LAVO's whitebark pine, and the beginning of a larger mortality event; however, analysis from all field seasons shows that while 16% of the whitebark pine in CRLA plots were dead, 10% of the whitebark pine in the LAVO plots were also dead. Thus, it appears that LAVO whitebark pine may be experiencing an only slightly lagged stage of the blister rust epidemiology as compared to CRLA. It is important to note, however, that the cause of mortality for whitebark pine was often unknown (37% in CRLA and 67% in LAVO). Another complicating factor is that in CRLA most mortality has been due to mountain pine beetle (see below and Smith et al. 2011). Importantly, this difference between the two parks may also be confounded by the 20 snags in CRLA that could not be identified to species and would likely increase the true mortality rate of whitebark pine in CRLA.

Beetles appear to be the most important source of mortality for whitebark pine in the 30 CRLA monitoring plots we established. Of the 177 dead whitebark pine trees, 23% died from mountain pine beetle and 23% from bark beetles other than mountain pine beetle. Smith et al. (2011) found mountain pine beetle mortality to be 21%; however, they included other beetle mortality in the category *indeterminable*, which composed 54% of all mortality, and they did not evaluate it separately. Blister rust killed 16% of the whitebark pine in CRLA. In contrast, of the 75 dead whitebark pine found in the LAVO plots, only 4% died from mountain pine beetle, 19% from bark beetles other than mountain pine beetle, and 67% died of unknown causes. The remainder (11%) were killed by blister rust. Mountain pine beetles appear to be more important in CRLA, and our results agree with past studies (Murray 2010; Smith et al. 2011) in suggesting that they are the primary source of mortality in CRLA.

Notes for future monitoring:

Because the two crews working in CRLA and LAVO were trained together, and because of the easy communication among the crews and the PI, few mistakes were made during the 2012–2014 field seasons. Furthermore, we were able to retroactively correct or recheck mistakes made in previous years during the 2014 field season. Despite these efforts, there were a few issues that should be noted for future monitoring.

- During the 2013 and 2014 field seasons, Trimbles were not used to monument plot corners in LAVO. Instead we used Garmin GPSmap 62st to monument plot corners. In 2013 Trimbles were not provided and in 2014 the field crew were unable to keep the Trimble operational. During the 2014 field season I returned to all plots to remonument them using a Trimble. I was unable to perform this in all locations for a number of reasons (weather or inadequate time). Plots that fell into this category included: #22, #24, #26, #27, and #28.
- During the 2013 and part of the 2014 field seasons, Trimbles were not used to monument plot corners in CRLA. Instead we used Garmin GPSmap 62st to monument plot corners. In 2013 Trimbles were not provided and in 2014 the field crew had issues with the Trimbles half way through plot installation and abandoned the Trimble for use of the Garmin. Plots that do not have plot corners monumented with the Trimble in CRLA include: #23, #28, #30, #32, #34, #35, #44, #51, #56 and #60.

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Appendix A: Sampling protocol for 30 whitebark pine monitoring plots established between 2012 and 2014 in CRLA and LAVO.

Each “x” represents a site visit to the sampling panel.

Panel	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
CRLA 1 (n = 10)	x			x			x		
CRLA 2 (n = 10)		x			x			x	
CRLA 3 (n = 10)			x			x			x
LAVO 1 (n = 10)	x			x			x		
LAVO 2 (n = 10)		x			x			x	
LAVO 3 (n = 10)			x			x			x

Appendix B: Data recorded for each tree found within 50 × 50 m plots established in CRLA and LAVO.

Methods follow McKinney et al. (2012).

Variable	Data Recorded
Species	Tree (nominal)
Diameter	Tree (cm)
Height	Tree (m)
Status	Tree (live or dead)
Crown kill	Each of three parts of a tree (%)
Active canker	Each of three parts of a tree (present/absent)
Inactive canker	Each of three parts of a tree (present/absent)
Rust infection	Tree (presence/absence of active or inactive canker)
Pine beetle	Tree (present/absent)
Dwarf mistletoe	Tree (present/absent)
Female cones	Tree (present/absent)
Seedlings	9 m ² plot; number of each of three size classes by species

Appendix C: Location information and site characteristics for whitebark pine monitoring plots established in CRLA in 2012, 2013, and 2014.

Oversample plots were used in cases where any of the original 10 plot locations did not contain whitebark pine, or where there were safety concerns.

Plot ID	Aspect (°)	Elevation (m)	Slope (°)	Eval Status	Eval Notes
CRWB01	120	2062	14	Established	
CRWB02	230	2074	4	Established	
CRWB03	200	2269	11	Established	
CRWB04	243	2166	6	Established	
CRWB05	284	2078	5	Established	
CRWB06	340	2334	9	Established	
CRWB07	115	2219	5	Established	
CRWB08	320	2253	4	Established	
CRWB09				Dropped	No WBP
CRWB10	250	2277	9	Established	
CRWB11	218	2262	12	Established	
CRWB21	302	2372	12	Established	
CRWB22	216	2410	19	Established	
CRWB23	64	2302	12	Established	
CRWB24	310	2211	14	Established	
CRWB25	333	2162	8	Established	
CRWB26	210	2205	2	Established	
CRWB27	117	2286	18	Established	
CRWB28	231	2294	8	Established	
CRWB29	313	2139	9	Established	
CRWB30	170	2265	6	Established	
CRWB41	145	2096	8	Established	
CRWB42	60	2481	9	Established	
CRWB43	10	2319	9	Established	
CRWB44	70	2481	27	Established	
CRWB45	140	2122	13	Established	
CRWB46	63	2481	24	Established	
CRWB47	167	2386	25	Established	
CRWB48				Dropped	Rejected for safety; too steep
CRWB49	90	2234	24	Established	
CRWB50	15	2318	26	Established	
CRWB51	130	2397	51	Established	

Appendix D: Location information and site characteristics for whitebark pine monitoring plots established in LAVO in 2012, 2013, and 2014.

Oversample plots were used in cases where any of the original 10 plot locations did not contain whitebark pine, or where there were safety concerns.

Plot ID	Aspect (°)	Elevation (m)	Slope (°)	Eval Status	Eval Notes
LVWB01				Dropped	No WBP
LVWB02				Dropped	Rejected for safety; proximity to fire
LVWB03	128	2595	14	Established	
LVWB04				Dropped	Rejected for safety; too steep
LVWB06	180	2627	15	Established	
LVWB06	256	2629	6	Established	
LVWB07	100	2539	11	Established	
LVWB08	336	2545	16	Established	
LVWB09	115	2502	5	Established	
LVWB10	186	2597	23	Established	
LVWB11	212	2752	25	Established	
LVWB12	170	2575	9	Established	
LVWB13				Dropped	Difficult plot access & WBP unlikely
LVWB14	184	2579	23	Established	
LVWB21				Dropped	Too steep; pumice slope
LVWB22	40		4	Established	
LVWB23	78	2815	14	Established	
LVWB24	120	2844	6	Established	
LVWB25				Dropped	Rejected for safety; too steep
LVWB26				Dropped	No WBP
LVWB27				Dropped	Rejected for safety; too steep
LVWB28	20	2904	5	Established	
LVWB29				Dropped	Rejected for safety; too steep
LVWB30	20	2977	23	Established	
LVWB31		2983		Established	
LVWB32	40	2940	16	Established	
LVWB33				Dropped	Rejected for safety; too steep
LVWB34	140	2983	24	Established	
LVWB35	120	2983	21	Established	
LVWB36				Dropped	Rejected for safety; too steep
LVWB37				Dropped	Rejected for safety; too steep
LVWB38				Dropped	Too steep; pumice slope
LVWB39	140	2983	25	Established	
LVWB41				Dropped	Rejected for safety; too steep
LVWB42	122	2576	19	Established	
LVWB43				Dropped	Rejected for safety; too steep
LVWB44	16	2610	23	Established	
LVWB45				Dropped	Rejected for safety: too steep; could not reach plot
LVWB46				Dropped	Rejected for safety; too steep
LVWB47	134	2628	6	Established	
LVWB48	126	2627	21	Established	

Plot ID	Aspect (°)	Elevation (m)	Slope (°)	Eval Status	Eval Notes
LVWB49	187	2635	18	Established	
LVWB50				Dropped	Rejected for safety; too steep
LVWB51	155	2603	15	Established	
LVWB52				Dropped	Rejected for safety; too steep
LVWB53				Dropped	NO WBP
LVWB54	213	2605	24	Established	
LVWB55				Dropped	Rejected for safety; too steep
LVWB56	63	2577	14	Established	
LVWB57				Dropped	Rejected for safety; could not reach plot
LVWB58				Dropped	Rejected for safety: too steep No WBP
LVWB59	125	2715	23	Established	
LVWB60	110	2612	26	Established	

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