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Sierra Nevada Network White Pine Monitoring

2021 Annual Report

Natural Resource Data Series NPS/SIEN/NRDS—2024/1405

ON THE COVER
Whitebark pine (*Pinus albicaulis*), west of Knapsack Pass, Kings Canyon National Park, California
PHOTO: K. Ward, Yosemite National Park

Sierra Nevada Network White Pine Monitoring

2021 Annual Report

Natural Resource Data Series NPS/SIEN/NRDS—2024/1405

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Executive Summary

Five-needle white pines (Family Pinaceae, Genus *Pinus*, Subgenus *Strobus*), and in particular whitebark pine (*Pinus albicaulis*), limber pine (*P. flexilis*), and foxtail pine (*P. balfouriana*) are foundation species in upper subalpine and treeline forests of several National Park Service Pacific West Region parks, including Sequoia and Kings Canyon National Parks (SEKI) and Yosemite National Park (YOSE). The Sierra Nevada Network Inventory & Monitoring Program, in collaboration with the Klamath Network, Upper Columbia Basin Network, and Mojave Desert Network have implemented a joint long-term monitoring protocol to assess the current status and future trends in high elevation white pine communities. Key demographic parameters within white pine forest communities will be estimated by monitoring individual trees within permanent plots through time.

This report documents the results of the 2021 field season, which was the eighth year of monitoring in Sequoia and Kings Canyon National Parks (SEKI) and Yosemite National Park (YOSE). The 2021 goal was to complete the third full re-measure of the second of three rotating panels (Panel 2) for each species-park population: YOSE-whitebark pine, SEKI-whitebark pine, and SEKI-foxtail pine. Each panel consists of 12 permanent 50 x 50 m (2,500 m^2) plots that were randomly selected for each of the three populations. The full sampling array thus includes a total of 36 whitebark pine plots in YOSE, 36 whitebark pine plots in SEKI, and 36 foxtail pine plots in SEKI. Data from plot surveys will be used to characterize white pine forest community dynamics in SEKI and YOSE, including changes in tree species composition, forest structure, forest health, and demographics.

The first full measure of all Panel 2 plots was completed over two years in 2013-2014, then a full remeasure of both parks' whitebark pine Panel 2 was conducted in 2016, with 10 of 12 SEKI-foxtail plots sampled that year. A third remeasure of all Panel 2 plots was not possible in 2021 because a smaller crew size was necessary during the COVID-19 pandemic.

In total, the crew visited 37 sites, and sampled 31, during the 2021 field season. One plot in the YOSE whitebark pine frame was uninstalled before reading and one plot in the SEKI whitebark pine frame was uninstalled after reading, both for safety concerns. Four plots were not visited due to lack of capacity with the reduced crew size: one in each of the YOSE and SEKI whitebark frames, and three in the SEKI foxtail frame. A plot from Panel 3 in each of the parks' whitebark frames was measured, for a total of 11 plots measured in each whitebark pine frame. Nine plots were measured in the SEKI foxtail pine frame. Within the 31 plots completed, a total of 5,728 trees was measured. Species composition, forest structure, and factors affecting tree health and reproduction, including incidence and severity of white pine blister rust (*Cronartium ribicola*) infection, mountain pine beetle (*Dendroctonus ponderosae*) infestation, dwarf mistletoe (*Arceuthobium spp*.) infection, canopy kill, female cone production and regeneration were recorded. During the 2021 field season, crews continued to count the total number of mature cones per tree for whitebark and foxtail pine, use crown condition codes to assess crown health, and tag individual seedlings to be tracked through time. All three of these procedures started in 2017 and are to be evaluated by each of the three

participating networks over several years, to determine whether they should become permanent changes to the monitoring protocol.

In YOSE, 11 whitebark pine plots were re-measured, from Panels 2 and 3. A total of 2,810 trees were sampled, which included 586 live whitebark pine trees and 2,097 other live conifers. An additional 127 trees (including 17 whitebark pine) were recorded as dead. The forest crew noted little sign of white pine blister rust (WPBR) in Yosemite in 2021, and just a single inactive canker was observed on one whitebark pine in Panel 3, Plot 42, near Dana Meadows. This infection was new to plot 42, and it expands the total number of plots where white pine blister rust has been documented in Yosemite to six. The crew also noted little mountain pine beetle activity, documenting beetle galleries on 15 lodgepole pines in three Panel 2 plots. Dwarf mistletoe was not observed. The average number of live whitebark pine trees per plot was 53 (SD = 56). This was a low cone crop year for whitebark pine, with two percent of live whitebark pine trees producing female cones. Cone-bearing trees averaged 2 (SD = 1) cones per tree. Whitebark pine seedling density averaged 90 (SD = 157) seedlings per hectare. The largest number of whitebark pine seedlings found in a plot was four, and three of the eleven plots contained whitebark seedlings.

In SEKI, 10 of 12 Panel 2, and one Panel 3, whitebark pine plots were re-measured. Within these plots, 1,246 live whitebark pine, 30 live foxtail pine, and 861 other live conifers were sampled. WPBR was infrequently documented in the SEKI whitebark frame as well, with indicators of infection in Plot 31 near Window Creek and Plot 44 near Upper State Lake. These were the first infections documented in these plots, bringing the number of plots where WPBR has been documented in the SEKI whitebark panel to nine. Although WPBR was documented in Plot 27 near Charlotte Dome in 2016, it was not documented this year because putative cankers showing three signs of infection in 2016 showed only two or fewer signs in 2021. Mountain pine beetle activity was observed in one live lodgepole pine and two recently dead whitebark pine, within three plots in the SEKI whitebark sample frame. An exception to the low levels of mountain pine beetle activity was outside Plot 31 in the Window Creek area, where the forest crew noted many recently dead whitebark pine with signs of beetle activity. Dwarf mistletoe was not encountered. The average number of live whitebark pine trees per plot was 113 (SD = 86). Less than one percent of live whitebark pine trees produced female cones, each producing on average 2 (SD = 1) cones. Whitebark seedling regeneration averaged 303 (SD = 319) seedlings per hectare. The largest number of whitebark seedlings found in a plot was eight, and eight of the 11 plots contained whitebark seedlings.

Nine of the 12 SEKI foxtail Panel 3 plots were remeasured. Within these plots, 413 live foxtail pine, 67 live whitebark pine, and 402 other live conifers were sampled. Ninety-two dead or recently dead trees were also documented, 65 of which were foxtail pine. No signs of blister rust infection, mistletoe, or mountain pine beetle were observed in the foxtail plots sampled. The average number of foxtail pine trees per plot was 46 (SD = 33). Fifty-four percent of the foxtail pine trees produced female cones, averaging 14 (SD =15) cones/tree. Only one foxtail pine seedling was recorded within the 9 foxtail pine plots, resulting in an estimated 14 (SD = 41) seedlings per hectare. Eight whitebark pine seedlings were also found within two plots.

Acknowledgments

Funding for this project was provided through the National Park Service Inventory and Monitoring Division. Park staff (Monica Buhler, Devils Postpile National Monument and Vicky Hartman, Yosemite National Park) also provided valuable logistical support to field operations in 2021. The initial high-elevation white pine monitoring annual report (Stucki et al. 2012) on which this document is based was developed by Devin Stucki, Tom Rodhouse, and Shawn McKinney. This work would not have been possible without the amazing contributions of our dedicated field crew: Sean Auclair (lead) and Emma Kahle.

Background and Objectives

Many western North American coniferous forests are currently facing unprecedented health challenges, including upsurges of native pests and pathogens, invasive exotic species, and altered disturbance regimes. Increased atmospheric warming, carbon dioxide concentration, and nitrogen deposition, as well as changes in precipitation patterns (i.e., timing, magnitude, and type) portend additional short- and long-term changes in high elevation forest ecosystem processes. Each factor alone can alter forest structure, function, and species composition, and additive or synergistic effects are likely if multiple agents act jointly. How forest ecosystems will respond to modern perturbations is uncertain. However, the magnitude of change in structure, composition, and key ecological processes will likely be exceptional. Indeed, increased tree mortality rates over the last several decades have recently been documented across a broad range of latitude and forest types in western North America (van Mantgem et al. 2009), which may have important consequences for forest stand dynamics and ecosystem functions.

Five-needle white pines (Family Pinaceae, Genus *Pinus*, Subgenus *Strobus*), and in particular whitebark pine (*Pinus albicaulis*), limber pine (*P. flexilis*), and foxtail pine (*P. balfouriana*) are foundational species (Tomback and Achuff 2010) in upper subalpine and treeline forests of several National Park Service (NPS) Pacific West Region parks, including Sequoia and Kings Canyon National Parks (SEKI) and Yosemite National Park (YOSE) (Figure 1). Ongoing declines of foundation tree species pose an especially compelling problem because these species provide fundamental structure to ecosystems and are therefore irreplaceable (Ellison et al. 2005). If a foundation tree species is lost from these systems, it will likely lead to a cascade of secondary losses, shifts in biological diversity, and ultimately affect the functioning and stability of the community (Ebenman and Jonsson 2005).

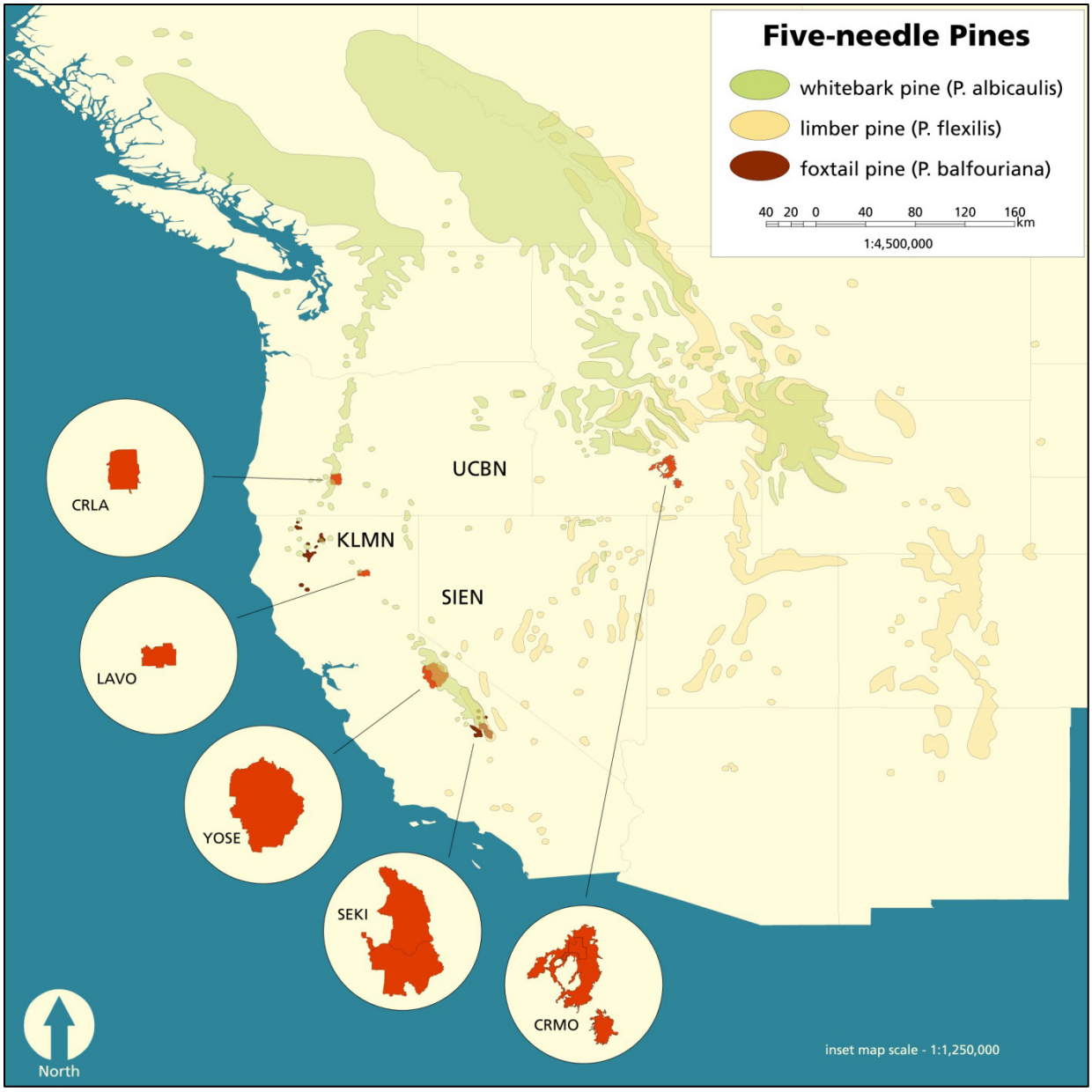

Figure 1. Distribution of whitebark pine, limber pine, and foxtail pine (from Little 1971) and locations of three Pacific West Region networks and associated parks. Sampling also occurs at Great Basin National Park, within the Mojave Desert Network, which is not shown in this figure.

Whitebark Pine

Whitebark pine occurs across a broad geographic range, occurring on both the west and the more arid east side of the Sierra Nevada crest and reaching its southern limit in central California in the Mount Whitney vicinity. Throughout its range, whitebark pine can occur in the montane, upper subalpine, and treeline zones (Arno and Hoff 1990). It often occurs as the only tree species on the coldest and driest sites near treeline (Figure 2) and as a seral species on protected, slightly lower sites more favorable to its shade-tolerant competitors (Arno and Weaver 1990).

Figure 2. Whitebark pine krummholz with cones, Kings Canyon National Park, August 8, 2021. (NPS/ SIEN Forest Crew, 2021).

In the Pacific West Region (PWR), whitebark pine is scattered across tens of thousands of hectares in the high elevations of SEKI and YOSE (Figure 1). White pine blister rust (*Cronartium ribicola*) infections on whitebark pine decrease from north to south in the PWR, resembling the trend seen in the Rocky Mountains. White pine blister rust (WPBR) is relatively rare in high elevation forests of SEKI and YOSE when compared to northern portions of the PWR (e.g., North Cascades). Mountain pine beetles (*Dendroctonus ponderosae*) are currently abundant in the northern Cascades, but also decrease with latitude (Gibson et al. 2008) in the PWR.

Whitebark pine acts as a foundation species in high-elevation forest communities by regulating ecosystem processes, community composition and dynamics, and by influencing regional biodiversity (Ellison et al. 2005, Tomback and Kendall 2001). Whitebark pine plays a role in initiating community development after fire, influencing snowmelt and stream flow, and preventing soil erosion at high elevations (Tomback et al. 2001, Farnes 1990). The large, wingless seeds of whitebark pine are high in fats and carbohydrates and provide an important food source for many granivorous birds and mammals (Tomback and Kendall 2001). Whitebark pine is a coevolved

mutualist with Clark's nutcracker (*Nucifraga columbiana*) and is dependent upon nutcrackers for dispersal of its seeds (Tomback 1982, McKinney et al. 2009).

Foxtail Pine

Foxtail pine is endemic to two distinct areas in California, the Klamath Mountains in the northwest part of the state and the southern Sierra Nevada (Figure 1). Research on community and population dynamics is lacking for foxtail pine compared to whitebark pine. Foxtail pine occurs in four different forest types: 1) stands dominated by foxtail pine, 2) stands with foxtail pine and whitebark pine, 3) stands with foxtail pine and red fir (*Abies magnifica*), and 4) stands with foxtail pine, red fir, and western white pine (*P. monticola*) (Eckert and Sawyer 2002). Foxtail and whitebark pine overlap in some portions of their southern Sierra Nevada distribution, however, south of the Kings-Kern divide, foxtail pine is the major (sometimes exclusive) subalpine and treeline tree species (e.g., >3,000 m). Foxtail pine provides important habitat and food resources for birds and mammals, and influences snowmelt and soil erosion (Figure 3).

Figure 3. Foxtail pine in the Lower Kern, Sequoia National Park (NPS/SIEN Forest Crew, 2021).

The southern population of foxtail, subspecies *austrina*, provides important data for dendrochronological research on paleoclimate (Lloyd 1997) as a consequence of its great longevity

(> 2,000 years) and slow growth. In fact, five-needle pines, in general, have proven valuable in enhancing our understanding of past climates through dendrochronological investigations (e.g., Kipfmueller and Salzer 2010, Woodhouse et al. 2011).

Objectives

At least four networks in the Pacific West Region identified white pine species as targets for long-term monitoring (Sarr et al. 2007, Mutch et al. 2008, Garrett et al. 2007, Hupp et al. 2018). Ecologists in three of these networks (Klamath Network [KLMN], SIEN, and Upper Columbia Basin Network [UCBN]) collaborated to devise a common set of monitoring objectives and procedures which are documented in our multi-network white pine monitoring protocol (McKinney et al. 2012a, 2012b). This protocol was later implemented in Great Basin National Park (GRBA) by the Mojave Desert Network (MOJN) in 2018 (Hupp et al. 2018). The anticipated impacts from WPBR, dwarf mistletoe, mountain pine beetle, and climate change on high-elevation pines were primary factors considered in developing the monitoring objectives. Key demographic parameters within white pine forest communities will be estimated by monitoring individual trees within permanent plots. Specific objectives of white pine monitoring are to detect status and trend in:

1) Trees species composition and structure
2) Tree species birth, death, and growth rates
3) Incidence of white pine blister rust and level of crown kill
4) Incidence of bark beetles
5) Incidence of dwarf mistletoe
6) Cone production of white pine species

Information gathered from this white pine monitoring project will be integral to providing a more comprehensive understanding of the populations within SIEN parks as well as providing for comparisons across broader geographic areas. It will also allow early detection of important changes in populations that may trigger management intervention.

Methods

This section summarizes the methods used for white pine monitoring in SIEN in 2021. A full description of methods and standard operating procedures may be found in the multi-network white pine monitoring protocol (McKinney et al. 2012a, 2012b). Specific deviations from the published methods or clarifications on how the methods were interpreted in the field during the 2021 field season are documented in Appendix 1.

Sampling Frame

The sample frames for each species-park population (SEKI-whitebark pine, SEKI-foxtail pine, and YOSE-whitebark pine) were based on the distribution of whitebark and foxtail pine as identified in the YOSE and SEKI vegetation maps (Figures 4 – 6). An ordered list of plot locations was generated using a randomized, spatially-balanced sampling design via the Generalized Random Tessellation Stratified (GRTS) algorithm (Stevens and Olsen 2004). Plots in the ordered list were assigned to one of three panels and each panel will be sampled on a rotating basis every three years (Appendix 2). Extra plot locations were drawn in the event that plots from the original sample draw were rejected (the oversample). Common reasons for rejection included 1) plots were on slopes too steep to be safely sampled (slopes $\geq$ 35 degrees), 2) sites were not accessible in a safe manner, and 3) sampling frame errors (i.e., plot did not contain the target vegetation type). Based on this sampling design, our scope of inference extends broadly across mapped stands of whitebark and foxtail pine on < 35-degree slopes within YOSE and SEKI.

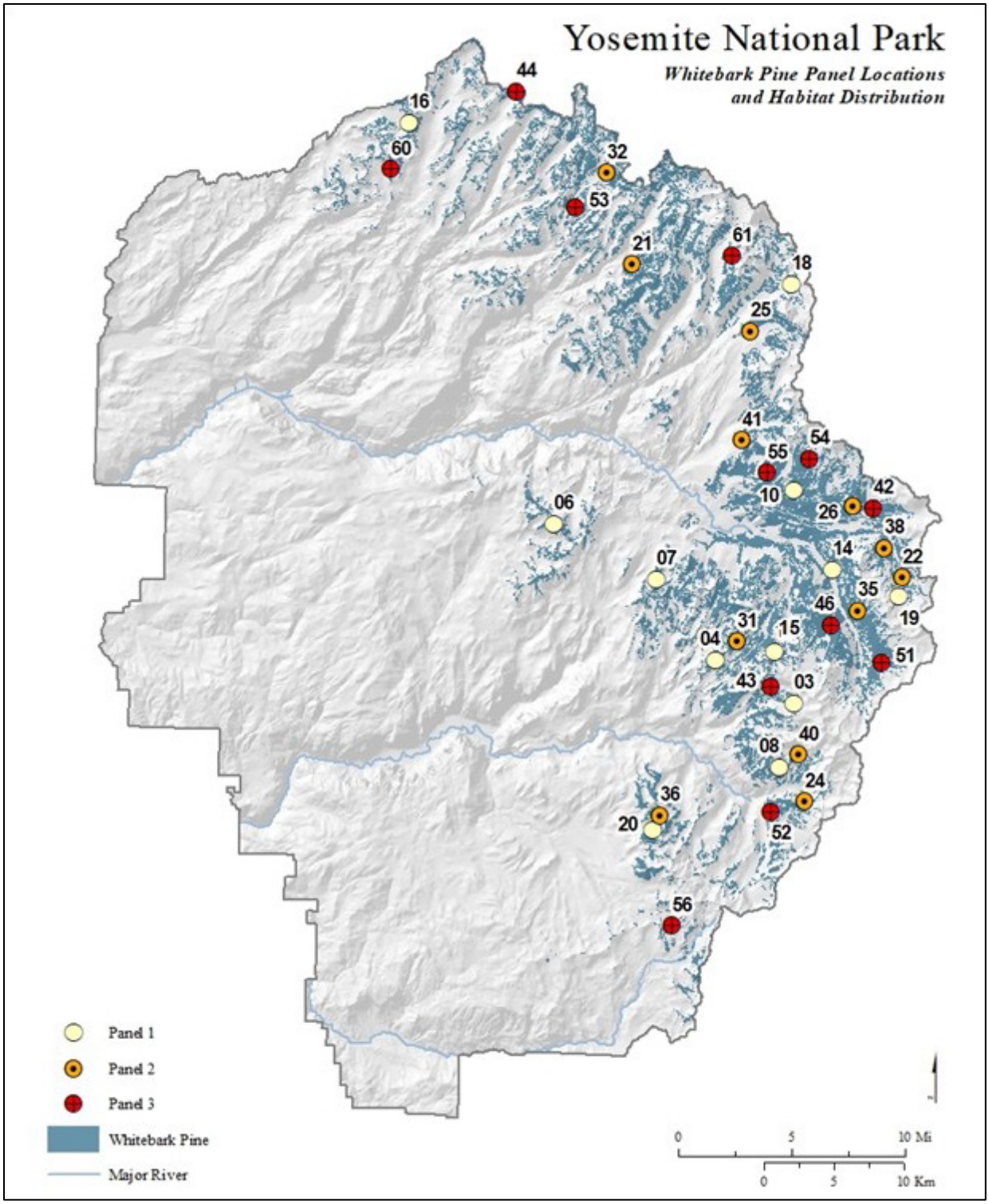

Figure 4. Whitebark pine sampling frame (blue shading) and GRTS-based plot locations for Yosemite National Park (colored dots). Plots are assigned to one of three panels (12 plots each), which are sampled every three years.

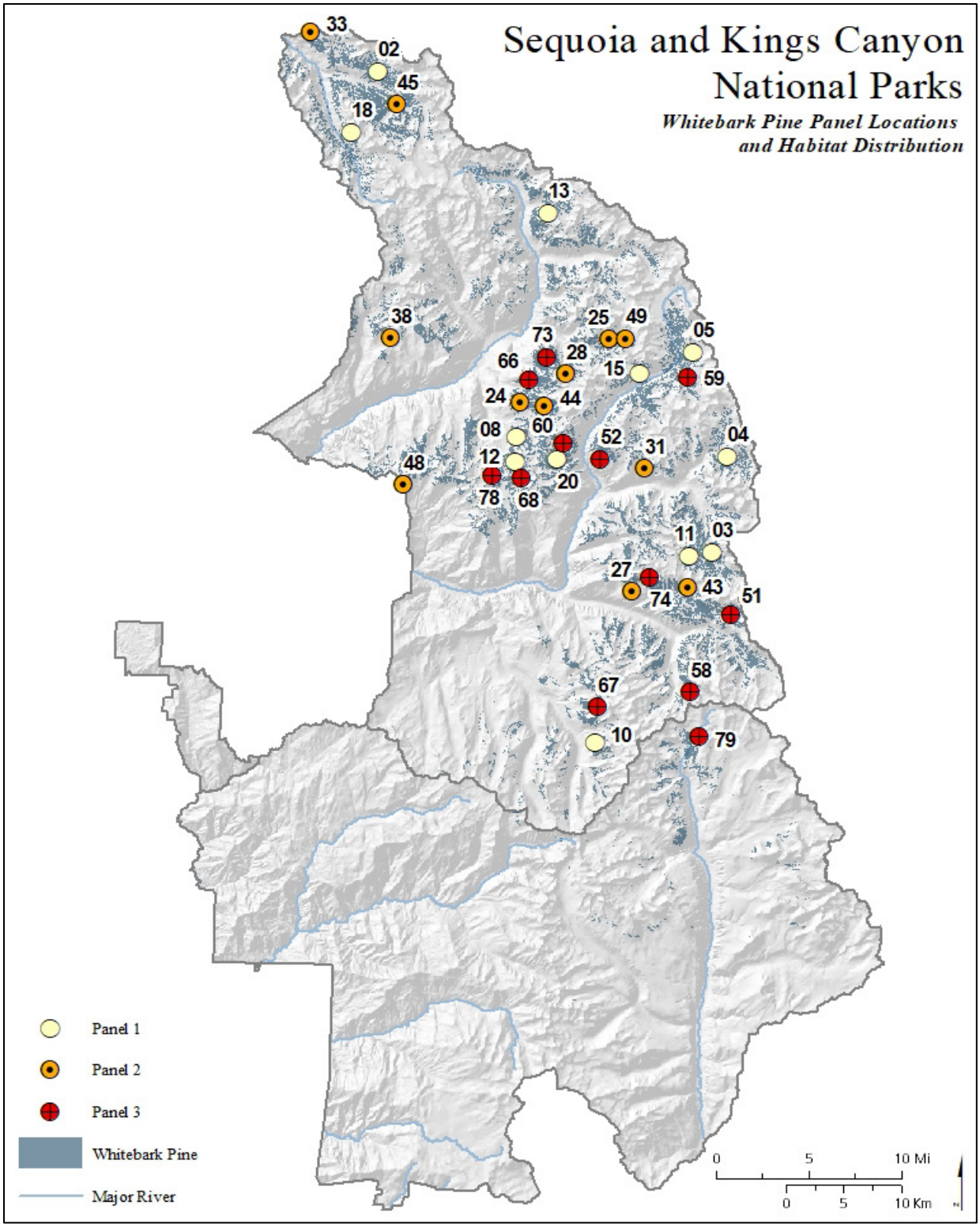

Figure 5. Whitebark pine sampling frame (blue shading) and GRTS-based plot locations for Sequoia and Kings Canyon National Parks (colored dots). Plots are assigned to one of three panels (12 plots each), which are sampled every three years.

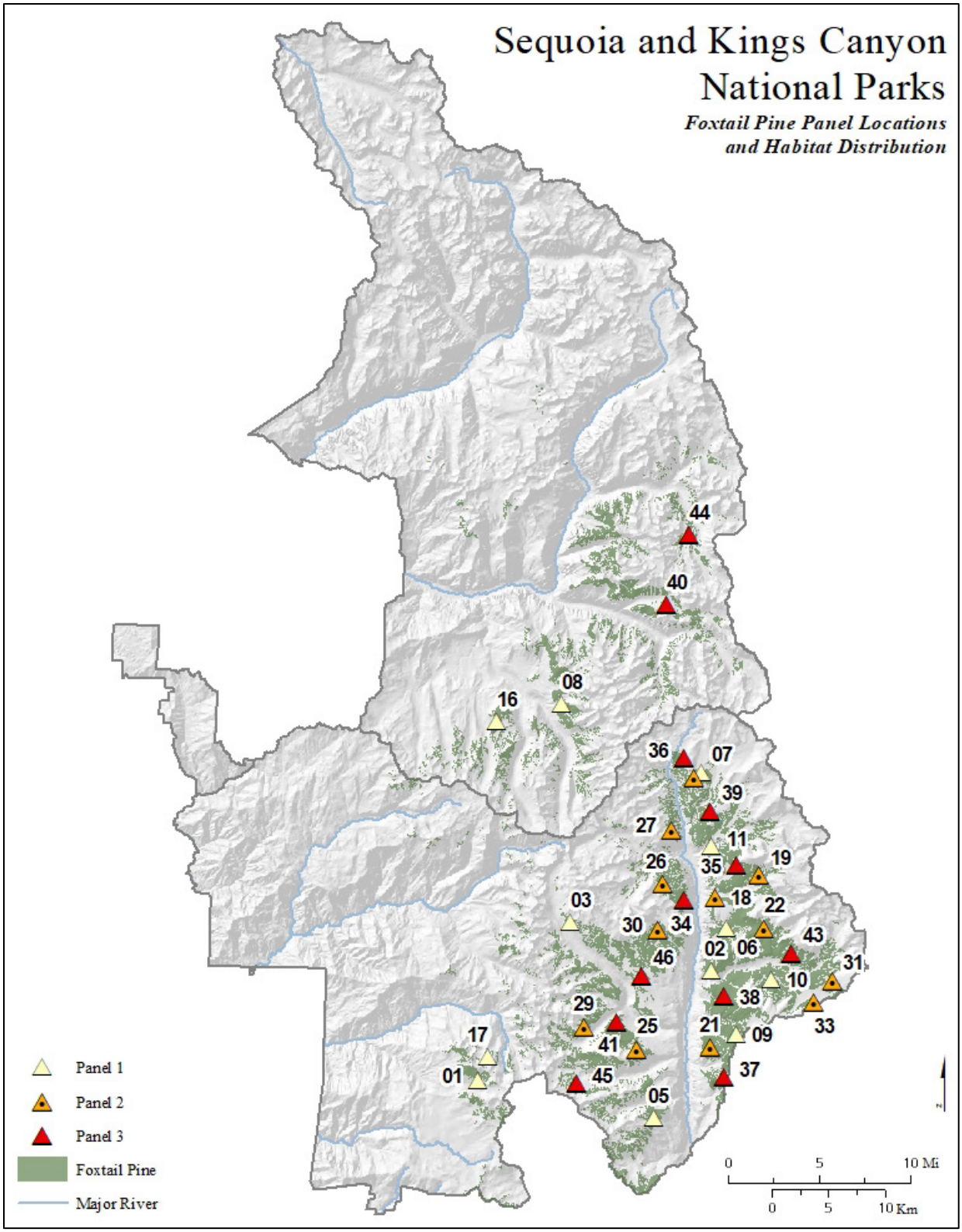

Figure 6. Foxtail pine sampling frame (green shading) and GRTS-based plot locations for Sequoia and Kings Canyon National Parks (colored dots). Plots are assigned to one of three panels (12 plots each), which are sampled every three years.

Frequency and Timing of Sampling

We adopted a three-year rotating panel design for re-surveying permanent plots in SEKI and YOSE (McDonald 2003). Sampling typically occurs between June and October and each plot is surveyed once per three-year rotation (Table 1). A total of 36 plots are monitored in each park (YOSE and SEKI) for each species, resulting in an overall total sampling effort of 72 plots in SEKI (36 whitebark and 36 foxtail) and 36 plots in YOSE (whitebark only).

Table 1. Revisit design for monitoring white pine species in the Sierra Nevada Network. This panel design is followed for each of the 3 species-park populations (YOSE-whitebark pine, SEKI-whitebark pine, and SEKI-foxtail pine) for a total SIEN *n* = 108 plots.

	Year [a]												
Panel	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
1 (n = 12)	x	–	–	–	x	–	–	–[b]	x	–	–	–	x
2 (n = 12)	–	–[b]	x	–	–	x	–	–	–	–[b]	x	–	–
3 (n = 12)	–	–	–	x	–	–	x	–	–	–	–	x	–

[a] An "x" indicates the years that the corresponding panel of monitoring plots was sampled. An "–" (or endash) indicates that the corresponding panel of monitoring plots was not sampled that year.

[b] Signifies the panels of monitoring plots originally planned to be sampled were not sampled those years.

Plot Layout

Quarter-hectare (50 x 50 m) macroplots consisting of five subplots are used to measure and track forest demographic parameters, disease, and insect occurrence, and the magnitude of their impact (Figure 7). The response design for this protocol is compatible with the *Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem* (GYWPMWG 2007) but differs in some respects, most notably, plot size. The 10 x 50 m plot size from the Yellowstone protocol has been increased to accommodate the often sparse or patchy distribution of white pines in our PWR parks and to adequately address forest demographic objectives. This design effectively represents five parallel 10 x 50 m subplots as used in the GYWPMWG and as proposed by the Whitebark Pine Ecosystem Foundation (Tomback et al. 2005).

A total of nine square regeneration plots (3 x 3 m) are established within each macroplot to measure seedling regeneration (Figure 7). Regeneration plots are located at each corner (4), at each midpoint between corners (4), and in the middle (1) of the macroplot. The current design was chosen because it provides a reasonable balance among sampling time constraints, observer accuracy and precision, and total area sampled.

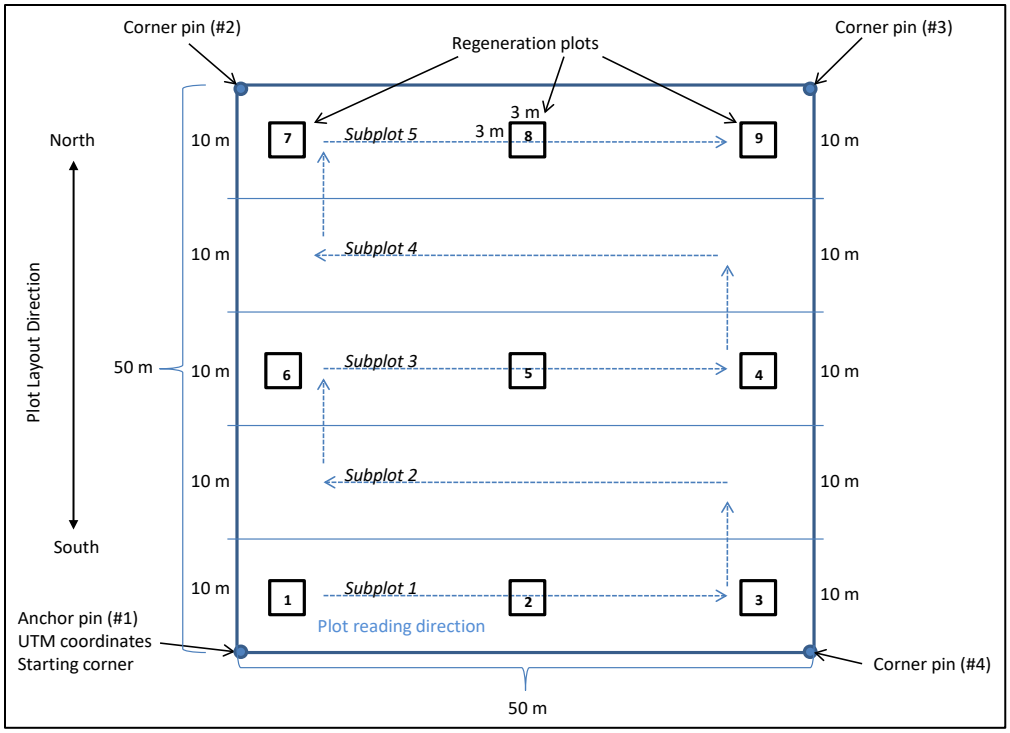

Figure 7. 50 x 50 m permanent plot layout used in SIEN white pine monitoring. Smaller regeneration plots are where seedlings are measured.

Plot Measurements

Table 2 describes variables measured, raw data collected, summarized values, and the monitoring objectives addressed. Detailed instructions on response design measurements are provided by McKinney et al. (2012a, 2012b) and only a general overview is presented here.

Table 2. Relationship among measured variables, data, and objectives for long-term monitoring of white pine communities in the Pacific West Region. p/a indicates presence/absence.

Variable	Raw Data	Summarized Data	Objectives Addressed
Species	Tree (nominal)	Trees per hectare (TPH); all spp., each spp., proportion of total by spp.	1. composition & structure
Diameter	Tree (cm)	Basal area (m^2/ha); all spp., each spp., proportion of total by spp. Mean diameter (cm) by spp. Diameter classes (5 cm); proportion and TPH by spp.	1. composition & structure 2. growth rate
Height	Tree (m)	Mean ht. (m); all spp. and by each spp. Height classes (3 m); proportion and TPH by spp.	1. composition & structure 2. growth rate
Status	Tree (live or dead)	Proportion live and dead; all spp and by each sp. TPH and proportion by 5 cm diameter classes in each condition; all spp and by each sp.	2. birth and death rates
Crown kill	Each of three parts of a tree (%)	Mean (%) individual white pine trees.	3. level of crown kill
Active canker	Each of three parts of a tree (p/a)	Proportion and TPH with active cankers by each white pine sp.	3. rust infection incidence
Inactive canker	Each of three parts of a tree (p/a)	Proportion and TPH with inactive cankers by each white pine sp.	3. rust infection incidence
Rust infection	Tree (p/a of active or inactive canker)	Proportion and TPH infected and healthy by each white pine sp. TPH by 5 cm diameter classes in each condition by each white pine sp.	3. rust infection incidence
Bark beetle	Tree (p/a)	Proportion and TPH with beetle sign; all spp and each sp.	4. incidence of bark beetle
Dwarf mistletoe	Tree (p/a)	Proportion and TPH with mistletoe sign; all spp and each sp.	5. incidence of dwarf mistletoe

Table 2 (continued). Relationship among measured variables, data, and objectives for long-term monitoring of white pine communities in the Pacific West Region. p/a indicates presence/absence.

Variable	Raw Data	Summarized Data	Objectives Addressed
Female cones	Tree (p/a)	Proportion and TPH with cones by each white pine sp.	6. cone production
Seedlings	9 m^2 plot; number of each of three size classes by species	Mean (number per m^2); all spp and each sp for each size class.	1. composition & structure 2. birth rates

Each live tree at least 1.37 m tall is affixed with a uniquely numbered metal tag; its species is identified, and diameter at 1.37 m (breast height, DBH) and tree height are measured. Standing dead trees ≥5 cm DBH are also affixed with a metal tag and are recorded as either recently dead or dead. Recently dead trees have needles present (but no green needles) and dead trees have no needles present. For plots that are re-measured, recently dead trees are defined as those that were alive during the previous visit but are now dead and dead trees are those that were already dead. White pine blister rust infection is assessed for all living white pine trees. The bole and branches of white pine trees are each vertically divided into thirds (upper, middle, and bottom) and each third is assigned one of three rust condition classes: 1) absent–no sign of rust infection, 2) active cankers (aeciospores present), or 3) no active cankers, but with the presence of at least three of the following five indicators of infection: rodent chewing, flagging, swelling, roughened bark, and oozing sap. Mountain pine beetle occurrence is recorded for all pine trees using three indicators of beetle activity: pitch tubes, frass, and J-shaped galleries. The presence of galleries is only determined for recently dead and dead trees because bark has to be removed for this assessment (unless bark is already missing and galleries can be observed on the live tree). Current dwarf mistletoe infection is recorded for all living white pine trees by noting presence or absence of mistletoe for each third of a tree using the Hawksworth (1977) rating system. The level of canopy kill in live trees is determined by dividing the tree's canopy (all the main branches, encompassing all foliage and supporting twigs and side branches) into thirds and obtaining an ocular estimate of the percentage of each third of the canopy that is dead. Cone production is recorded based on whether female cones are present or absent on each live whitebark or foxtail pine tree. Starting in 2017 we also counted mature female cones on target species to assess cone abundance in addition to presence/absence. This was continued in 2021. Live seedlings are recorded by species and assigned to a height class in regeneration plots. Height classes are: 1) 20 to <50 cm, 2) 50 to <100 cm, and 3) 100 to <137 cm. Seedlings <20 cm are not measured. Beginning in 2017 all seedlings in the regeneration plots were tagged by using wire to attach a tag around the base of the stem. These seedlings will be individually tracked in the same way as the mature trees going forward.

2021 Sampling Logistics

A two-person crew was hired to establish or re-measure up to 36 plots within YOSE and SEKI during the 2021 field season. Crew size was reduced from three to two members to minimize risk of exposure to the COVID-19 virus. Training on safety, backcountry communication, and project-specific sampling methods was provided by SIEN staff in June. The SIEN Ecologist Jonny Nesmith, who had been the forest project lead since 2012, left in the spring 2021 and Monica Buhler, the natural resource manager at Devils Postpile, filled in for the summer as the forest project lead. In addition to the forest monitoring protocol, the crews also conducted fieldwork early in the season associated with a giant sequoia monitoring pilot project not discussed further in this report. Forest monitoring fieldwork occurred at YOSE from June through early August and at SEKI from June through early September. Detailed notes for each trip and route descriptions were recorded by the crews and will be used in future years to help guide planning. These documents are stored in the forest project folder on the SIEN network drive. For a complete list of plot status and location see Appendix 2.

Results

Yosemite

From June 10 to August 3, 14 plots were visited, and 11 sampled, throughout whitebark pine stands in Yosemite National Park (Figure 8). All sampled plots were from Panel 2, except for Panel 3 plot YOSE_PINALB_42 near Dana Meadows. This plot was sampled to replace Panel 2 plot YOSE_PINALB_31 near Booth Lake, which was uninstalled before collecting data because terrain was unsafe for long term monitoring. One Panel 2 plot (YOSE_PINALB_36) near Grey Peak/Mt. Clark was not visited due to reduced capacity with a two-person crew. Two plots were scouted for Panel 3, YOSE_PINALB_61 near Spiller Lake and YOSE_PINALB_62 near Potter Point, and both were found to be suitable for long term monitoring.

Summary statistics for the YOSE whitebark pine plots are provided in Table 3. The 11 completed plots contained a total of 2,810 trees: 586 live whitebark pine (13 recently dead, four dead), 1,305 live lodgepole pine (31 recently dead, 76 dead), 791 live mountain hemlock (*Tsuga mertensiana*) (three dead), and 1 live California red fir (*Abies magnifica*). The average number of live whitebark pine trees per plot (2,500 m^2) was 53 (SD = 56) with a range of 1 to 183 trees. In 2021, data were not collected on the prevalence of the krummholz growth form or the number of stems per clump as these data exist from the previous visit to these plots and have not changed.

The forest crew noted that there was little sign of white pine blister rust in 2021, with no active spores, few signs of rodent activity, and most flagging appearing to have occurred the previous season rather than the current one. The incidence of white pine blister rust infection across all 586 live whitebark pine trees was 0.17%. The average infection rate per plot was 0.5% (SD = 0.15) of live whitebark trees. WPBR was discovered on one whitebark pine tree within the Panel 3 plot YOSE_PINALB_42 near Dana Meadows. No aecia were observed, and one inactive bole canker in the middle third of the tree canopy was indicated by chewing, flagging and rough bark. This infection was new to plot 42, and it expands the total number of plots where WPBR has been observed in Yosemite to six. The forest crew also observed little mountain pine beetle activity, noting this was similar to observations from past seasons. Mountain pine beetle activity was documented in three plots on 15 trees (all lodgepole pine). No dwarf mistletoe was encountered.

This was a low cone-crop year, with only 2% of the 586 live whitebark pine trees producing female cones. Cone production varied among stands, with the percentage of cone bearing trees per plot ranging between 0 and 50% (the plot with 50% had just two live whitebark pine trees). The number of cones per tree for all 9 cone-bearing trees sampled averaged 2 (SD = 1, range 1-4) cones/tree, with the per-plot average ranging from 1-2 cones/cone-bearing tree. Whitebark pine seedling regeneration averaged 90 (SD = 157) seedlings per hectare. Lodgepole pine (14 seedlings) and mountain hemlock (15 seedlings) were also encountered in the regeneration plots.

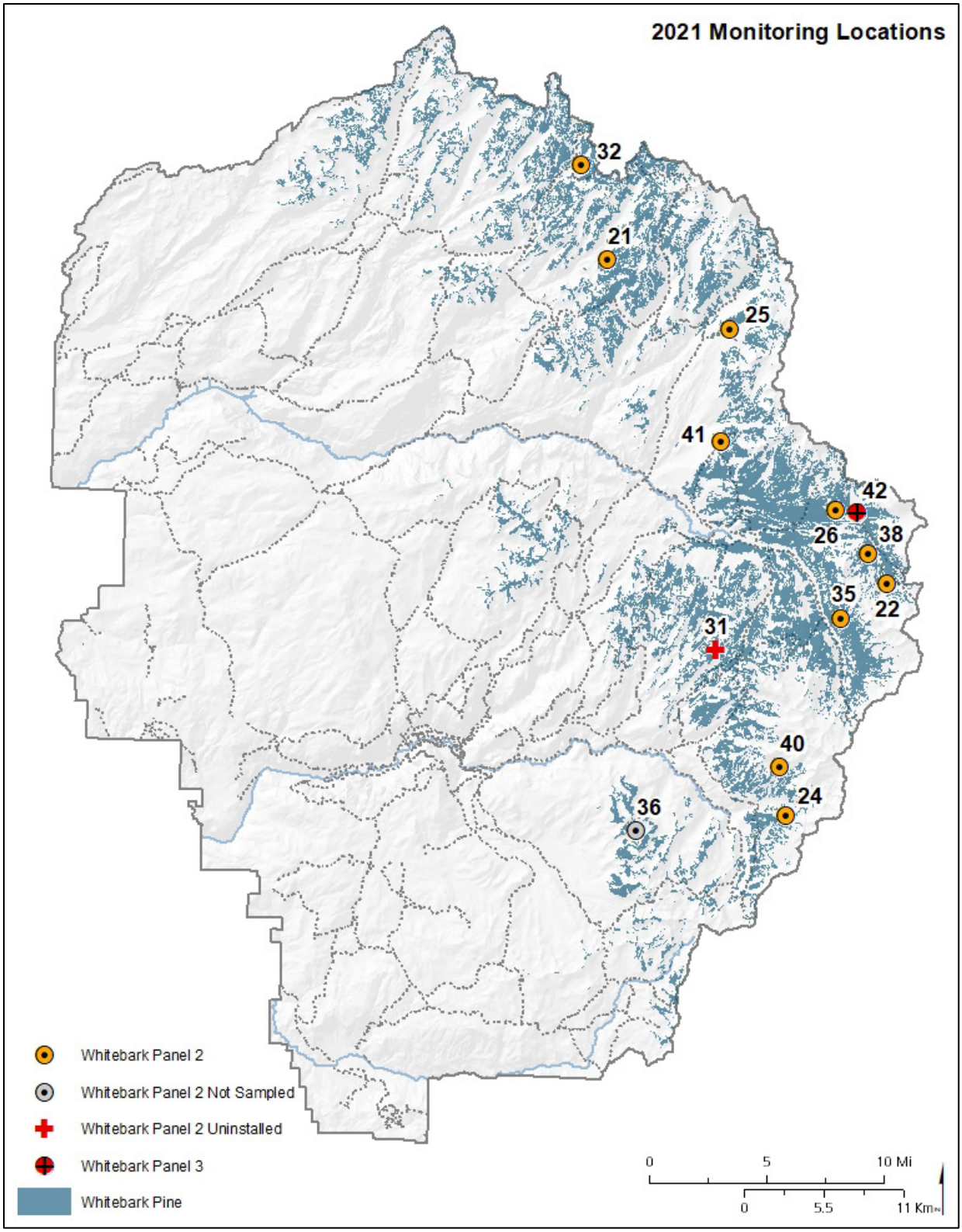

Figure 8. Location of Panel 2 plots and the Panel 3 plot sampled in Yosemite National Park during the 2021 field season. One previously installed plot that was uninstalled in 2021 is also shown.

Table 3. Summary statistics of whitebark pine plots measured at YOSE in 2021 (n = 11). Mountain pine beetle infestation rate is calculated using only live and recently dead host trees.

Plot Metrics	Average (SD)	Range
P. albicaulis density (trees/ha)	213 (224)	4 – 732
Other species density (trees/ha)	763 (578)	4 – 1500
Snag density (dead trees/ha)	46 (41)	0 – 120
P. albicaulis DBH (cm)	8.0 (3.8)	2.4 – 13.4
Other species DBH (cm)	16.1 (9.2)	0 – 30.8
P. albicaulis Basal Area (m^2/ha)	3.5 (5.1)	0 – 16.2
Other species Basal Area (m^2/ha)	33.5 (27.1)	0 – 79.6
P. albicaulis blister rust infection rate (# of infected trees/ha)	0.4 (1.2)	0 – 4
Dwarf mistletoe infection rate (# of infected trees/ha)	0	0
Mountain pine beetle infestation rate (# of infested trees/ha)	5.5 (13.3)	0 – 44
P. albicaulis seedling regeneration 20-136 cm (seedlings/ha)	90 (157)	0 – 494
Other species seedling regeneration 20-136 cm (seedlings/ha)	325 (418)	0 – 1358
P. albicaulis female cone production (# of trees with cones/ha)	3 (8)	0 – 28
P. albicaulis # of cones/tree for cone-bearing trees	1.5 (0.7)	1 – 2

Sequoia and Kings Canyon

From June 26 to September 5, 2021, 13 plots were visited in the SEKI-whitebark pine population (Figure 9). Eleven of these plots were sampled, with ten from Panel 2 and one from Panel 3, SEKI-PINALB_51. The SEKI_PINALB_43 plot in the Charlotte Lake area was uninstalled after reading it due to unsafe terrain. Two Panel 2 plots were not visited due to limited capacity of the two-person crew: SEKI_PINALB_38 near Blue Canyon and SEKI_PINALB_48 near Hogsback Peak. Two plots were scouted for Panel 3: SEKI_PINALB_86 was rejected due to unsafe terrain, but SEKI_PINALB_87 was found to be suitable for long term monitoring. From June 7 to August 22, 2021, ten plots were visited from the SEKI-foxtail pine sampling frame. Nine Panel 2 plots were read, and SEKI_PINBAL_46 was scouted for Panel 3. Three Panel 2 plots, SEKI_PINBAL_26, SEKI_PINBAL_27 and SEKI_PINBAL_29, were not visited due to limited capacity.

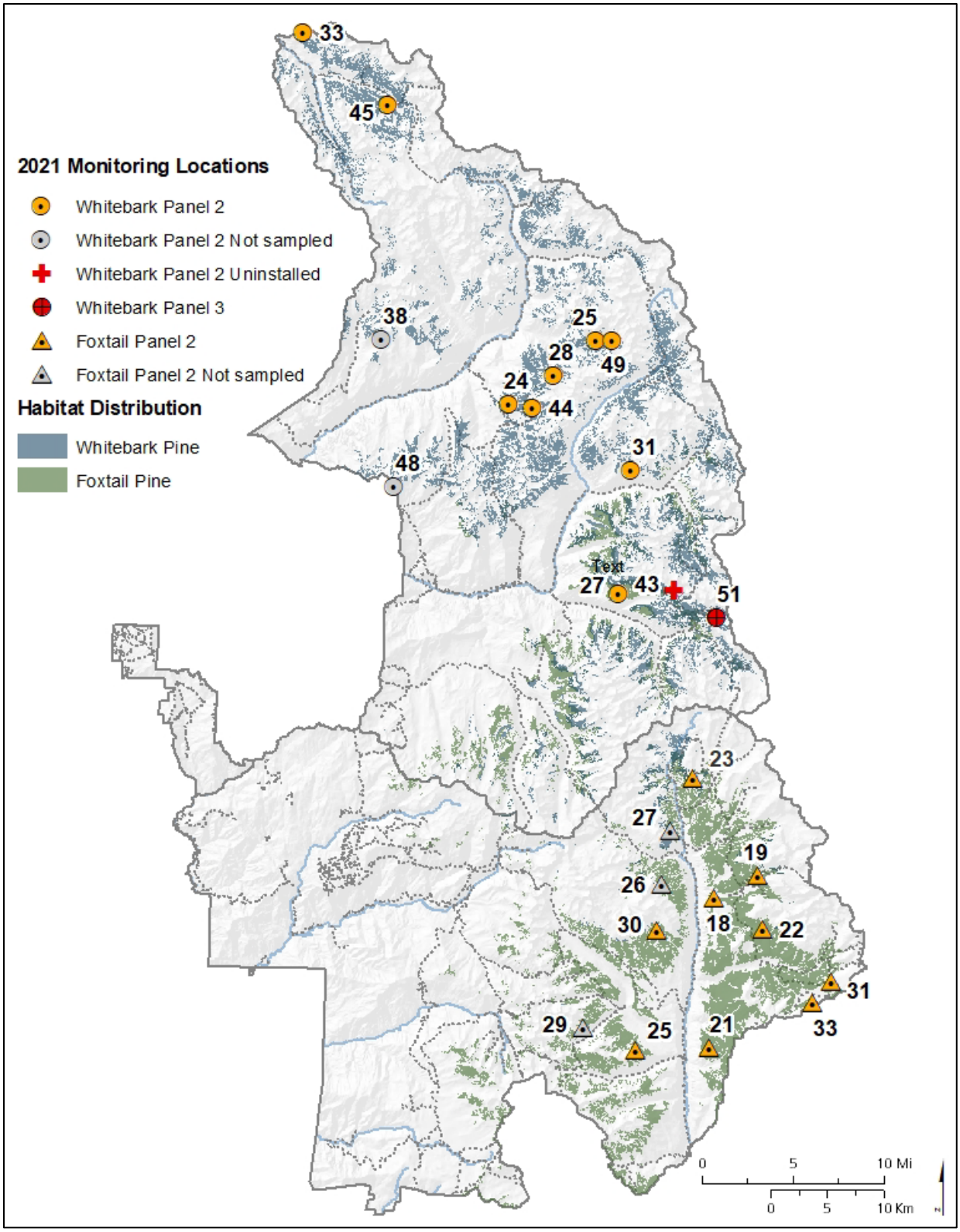

Figure 9. Location of Panel 2 plots and the Panel 3 plot sampled in Sequoia and Kings Canyon during the 2021 field season.

Whitebark Pine

Eleven whitebark plots were sampled in 2021 in SEKI, from Panel 2 (10 plots) and Panel 3 (1 plot). Summary statistics are provided in Table 4. The 11 sampled whitebark plots contained a total of 2,204 trees: 1,246 live whitebark (28 dead, 10 recently dead), 860 live lodgepole (21 dead, 6 recently dead), 30 live foxtail pine, 1 live mountain hemlock, and 2 dead snags of unidentified species. The average number of live whitebark pines per plot was 113 (SD = 86) with a range of 8 to 253. Data were not collected on the prevalence of the krummholz form, or the number of stems per clump, but these data are available for previous samples of these plots.

Table 4. Summary statistics on whitebark pine plots sampled in SEKI in 2021 (n = 11). Mountain pine beetle infestation rate is calculated using only live and recently dead host trees.

Plot Metrics	Average (SD)	Range
P. albicaulis density (trees/ha)	453 (344)	32 – 1012
Other species density (trees/ha)	324 (504)	0 – 1516
Snag density (dead trees/ha)	24 (25)	0 – 84
P. albicaulis DBH (cm)	8.4 (4.5)	2.2 – 14.0
Other species DBH (cm)	22.5 (6.9)	12.3 – 33.4
P. albicaulis Basal Area (m^2/ha)	7.2 (9.3)	0 – 23.3
Other species Basal Area (m^2/ha)	17.8 (20.8)	0 – 58.9
P. albicaulis blister rust infection rate (# of infected trees/ha)	1.1 (2.6)	0 – 8
Dwarf mistletoe infection rate (# of infected trees/ha)	0	0
Mountain pine beetle infestation rate (# of infested trees/ha)	1.1 (1.9)	0 – 4
P. albicaulis seedling regeneration 20-136 cm (seedlings/ha)	303 (319)	0 – 988
Other species seedling regeneration 20-136 cm (seedlings/ha)	112 (187)	0 – 617
P. albicaulis female cone production (# of trees with cones/ha)	4 (6)	0 – 16
P. albicaulis # of cones/tree per plot, for cone-bearing trees	1.4 (0.6)	1.0 – 2.3

The incidence of white pine blister rust infection across all 1,246 live whitebark pine trees was 0.24%, and among the 30 live foxtail trees was 0%. The average infection rate per plot in 2021 was 0.1% (SD = 0.3%) of live whitebark trees (range = 0 – 1%). No aecia were observed in any plot, but inactive cankers were documented in 2 whitebark pine trees in Plot 31 near Window Creek and 1 whitebark pine tree in Plot 44 near Upper State Lake. These infections were new to Plots 31 and 44, bringing the total number of plots where white pine blister rust has been observed in the SEKI_PINALB sample frame to 9. Interestingly, two plots with infections documented in previous samples did not meet criteria for infection in 2021. Two trees were documented as infected in plot 27 during the last Panel 2 sample in 2016 (tree numbers 315 and 491), based on putative inactive cankers having three out of five rust indicators, but they showed fewer than three rust indicators in

2021, so no infection was documented for that plot. Similarly, three trees were documented as infected in plot 51 (tree numbers 547, 661, 693) during the last Panel 3 sample in 2017 but these three trees showed fewer than three signs of infection in 2021 so no WPBR was documented in the plot this year. Mountain pine beetle activity was observed in three different plots, on one live lodgepole pine and two recently dead whitebark pine. The forest crew noted that there were few signs of beetle activity in 2021, with the exception of areas just outside of SEKI_PINALB_31, where they noted many recently dead clumps of whitebark pine trees with signs of mountain pine beetle activity. This area is near stands at Twin Lakes with unexplained mortality that was reported anecdotally in August (N.Stephenson, personal communication). Dwarf mistletoe was not encountered.

Cone production was low for whitebark pine, similar to that in Yosemite stands this year. Only 0.9% of the 1,246 live whitebark pine trees produced female cones in 2021, with the per-plot percentage ranging from 0 to 2.9%. Among the 11 cone-bearing whitebark pine trees observed in 2021, the average number of cones per tree was 2 (SE=1) with a maximum load of 5 cones. On the other hand, 40% of the 30 live foxtail pine trees observed in whitebark plots bore cones, with an average of 24 cones per tree (SD = 8) and maximum of 33 cones per tree. There were 27 whitebark pine seedlings recorded in the plots, resulting in an estimated 303 (SD = 319) seedlings per hectare. The largest number of seedlings found in a plot was eight, and these were whitebark pine seedlings. Eight of the 11 plots contained at least one whitebark seedling. One Jeffrey pine seedling was found, and nine lodgepole pine seedlings were also found within four plots.

Foxtail Pine

Nine foxtail pine plots from Panel 2 were re-measured in 2021 (Figure 9). Summary statistics are provided in Table 5. The 9 foxtail pine plots contained a total of 714 trees: 413 live foxtail pine (64 dead, 1 recently dead), 67 live whitebark pine, 138 live lodgepole pine (5 dead), and four live western white pine (*Pinus monticola*). There were an additional 22 dead snags of unidentified species. The average number of live foxtail pines per plot was 46 (SD = 33) with a range of 20 to 110. All 67 live whitebark pine occurred within a single plot, Plot 23 in the Upper Kern.

Symptoms of WPBR and mistletoe were not observed on any trees within the foxtail pine panel. Through 2021, WPBR has been documented from only a single whitebark pine tree in Panel 1 plot 40 in the SEKI_PINBAL sampling frame. No mountain pine beetle activity was observed in any plots.

Fifty-four percent (54%) of the 714 live foxtail pine trees produced female cones in 2021, with the per-plot percentage varying between 35% and 86%. These 224 trees produced 14 cones per tree on average, with average production rates per plot ranging from 6 to 33 cones per tree. Whitebark pine cone production was higher in this sampling frame than it was in Yosemite or the SEKI_PINALB frame, with 6% of trees producing 1-2 cones per tree, but these data come from just a single plot. There was one foxtail pine seedling recorded in a single plot, resulting in an estimated 14 (SD = 41) seedlings per hectare. Eight whitebark pine seedlings were also observed in two plots, along with one lodgepole pine seedling.

Table 5. Summary statistics of Panel 2 foxtail pine plots sampled at SEKI in 2021 (n = 9). Mountain pine beetle infestation rate is calculated using only live and recently dead host trees.

Plot Metrics	Average (SD)	Range
P. balfouriana density (trees/ha)	184 (132)	80 – 440
P. albicaulis density (trees/ha)	30 (89)	0 – 268
Other *species* density (trees/ha)	63 (105)	0 – 292
Snag density (dead trees/ha)	30 (24)	4 – 84
P. balfouriana DBH (cm)	42.2 (22.6)	19.6 – 87.3
P. albicaulis DBH (cm)	5.4 (NA)	5.4 – 5.4
Other species DBH (cm)	23.9 (8.9)	12.3 – 39.5
P. balfouriana Basal Area (m^2/ha)	30.6 (18.2)	9.0 – 64.0
P. albicaulis Basal Area (m^2/ha)	0.1 (0.3)	0 – 0.8
Other species Basal Area (m^2/ha)	6.5 (9.7)	0 – 22.0
P. balfouriana blister rust infection rate (# of infected trees/ha)	0	0
P. albicaulis blister rust infection rate (# of infected trees/ha)	0	0
Dwarf mistletoe infection rate (# of infected trees/ha)	0	0
Mountain pine beetle infestation rate (# of infested trees/ha)	0	0
P. balfouriana seedling regeneration 20-136 cm (seedlings/ha)	110 (209)	0 – 617
P. albicaulis seedling regeneration 20-136 cm (seedlings/ha)	0	0
Other species seedling regeneration 20-136 cm (seedlings/ha)	0	0
P. balfouriana female cone production (# of trees w/ cones/ha)	100 (63)	44 – 252
P. balfouriana # cones/tree per plot, for cone bearing trees	15 (8)	6 – 33
P. albicaulis female cone production (# of trees w/ cones/ha)	2 (5)	0 – 16
P. albicaulis # cones/tree per plot, for cone bearing trees	2 (NA)	2 – 2

Summary

Our data suggest that the whitebark pine and foxtail pine populations in areas sampled during the 2021 field season continue to have low incidence of white pine blister rust and mountain pine beetle, though compared to the last sample in 2016, rust spread to one additional plot in Yosemite whitebark pine and two additional plots in SEKI whitebark pine. One whitebark pine tree in Yosemite and three whitebark pines in Kings Canyon showed symptoms of new infections of WPBR. This is many fewer new infections than were documented in Panel 1 in 2019 (46 new infections), and there were five trees in two additional plots that no longer met criteria for infections that were documented in 2016 and 2017. This was the third sample for all plots measured in 2021. Tracking changes in forest composition, structure, and health through time will be particularly powerful in subsequent re-measures if incorporated into an adaptive management framework. Figure 10 shows the 2021 SIEN forest monitoring crew lead working near Pavilion dome in Kings Canyon National Park.

Figure 10. Sean Auclair, 2021 Forest Crew Lead, stretches out a forest plot tape near Pavilion Dome, Kings Canyon National Park. NPS/Emma Kahle.

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Appendix 1. Notes on Field Methods

From year to year there can be procedures in the protocol sampling methods that are interpreted differently or are ambiguous (i.e., plot and tree level measurements), and crews have to resolve them while conducting field sampling. This appendix attempts to document these known issues and interpretations for the 2021 field season.

We continued to collect electronic data using Juniper Systems MESA 2 Rugged Tablet. We continued to implement some of the changes made in 2017 including recording a crown condition rating, counting cones, and tagging seedlings. Also, snag diameter was not recorded in 2019, though this remains an important suggestion for calculating snag basal area and documenting stand structure in future visits.

Appendix 2. Plot Status and Location

Table A-1. List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either "Incomplete" indicating that not all subplots have been completed or "Scouted", indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
YOSE-PIAL	01	272730	4211038	Panel_1x	Rejected	–	>35_Slope
YOSE-PIAL	02	288803	4213209	Panel_1x	Rejected	–	No trees
YOSE-PIAL	03	296088	4182250	Panel_1	2011	2019	–
YOSE-PIAL	04	290567	4185341	Panel_1	2011	2019	–
YOSE-PIAL	05	285267	4218542	Panel_1x	Rejected	–	No trees
YOSE-PIAL	06	279029	4195055	Panel_1	2015	2019	–
YOSE-PIAL	07	286332	4191015	Panel_1	2011	2019	Plot boundaries moved in 2015
YOSE-PIAL	08	295120	4177650	Panel_1	2011	2019	–
YOSE-PIAL	09	289361	4208460	Panel_1x	Rejected	–	>35_Slope
YOSE-PIAL	10	296034	4197576	Panel_1	2011	2019	–
YOSE-PIAL	11	295423	4193440	Panel_1x	Rejected	–	No trees
YOSE-PIAL	12	265845	4218338	Panel_1x	Rejected	–	No trees
YOSE-PIAL	13	290527	4215554	Panel_1x	Rejected	–	>35_Slope
YOSE-PIAL	14	298862	4191734	Panel_1	2011	2019	–
YOSE-PIAL	15	294711	4185917	Panel_1	2011	2019	–

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
YOSE-PIAL	16	268730	4223684	Panel_1	2015	2019	–
YOSE-PIAL	17	272205	4217495	Panel_1x	Rejected	–	>35_Slope
YOSE-PIAL	18	295937	4212170	Panel_1	2013	2019	–
YOSE-PIAL	19	303605	4189886	Panel_1	2014	2019	–
YOSE-PIAL	20	286082	4173212	Panel_1	2013	2015	–
YOSE-PIAL	21	284547	4213602	Panel_2	2014	2021	–
YOSE-PIAL	22	303861	4191215	Panel_2	2013	2021	–
YOSE-PIAL	23	290671	4198498	Panel_2x	Rejected	–	No Trees
YOSE-PIAL	24	296891	4175231	Panel_2	2013	2021	–
YOSE-PIAL	25	293052	4208800	Panel_2	2013	2021	–
YOSE-PIAL	26	300265	4196210	Panel_2	2013	2021	–
YOSE-PIAL	27	292618	4193551	Panel_2x	Rejected	–	No Trees
YOSE-PIAL	28	287655	4220242	Panel_2x	Rejected	–	No Route
YOSE-PIAL	29	288002	4215672	Panel_2x	Rejected	–	>35_Slope
YOSE-PIAL	30	297811	4192202	Panel_2x	Rejected	–	No Trees
YOSE-PIAL	31	292132	4186649	Panel_2x	2014	2021	Plot installed in 2014, read in 2016, then uninstalled in 2021 due to safety concerns

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
YOSE-PIAL	32	282831	4220099	Panel_2	2014	2021	–
YOSE-PIAL	33	281485	4206089	Panel_2x	Rejected	–	>35_Slope
YOSE-PIAL	34	295896	4203615	Panel_2x	Rejected	–	>35_Slope
YOSE-PIAL	35	300685	4188869	Panel_2	2014	2021	–
YOSE-PIAL	36	286581	4174238	Panel_2	2014	2016	–
YOSE-PIAL	37	282114	4211493	Panel_2x	Rejected	–	>35_Slope
YOSE-PIAL	38	302534	4193310	Panel_2	2014	2021	–
YOSE-PIAL	39	291731	4196540	Panel_2x	Rejected	–	No Trees
YOSE-PIAL	40	296396	4178608	Panel_2	2014	2021	–
YOSE-PIAL	41	292441	4201020	Panel_2	2016	2021	–
YOSE-PIAL	42	301791	4196147	Panel_3	2014	2021	–
YOSE-PIAL	43	294453	4183421	Panel_3	2014	2017	–
YOSE-PIAL	44	276329	4225930	Panel_3	2017	2017	–
YOSE-PIAL	45	294473	4210376	Panel_3x	Rejected	–	>35_Slope
YOSE-PIAL	46	298760	4187833	Panel_3	2017	2017	–
YOSE-PIAL	47	288739	4186425	Panel_3x	Rejected	–	–
YOSE-PIAL	48	278555	4224311	Panel_3x	Rejected	–	Unsafe terrain

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
YOSE-PIAL	49	285782	4214700	Panel_3	Rejected	–	Plot was installed in 2011 and rejected in 2017 due to unsafe terrain
YOSE-PIAL	50	279271	4196291	Panel_3x	Rejected	–	No Trees
YOSE-PIAL	51	302369	4185092	Panel_3	2015	2017	–
YOSE-PIAL	52	294465	4174505	Panel_3	2011	2017	–
YOSE-PIAL	53	280552	4217599	Panel_3	2011	2017	Plot boundaries moved in 2017 due to unsafe terrain. Original plot uninstalled.
YOSE-PIAL	54	297249	4199689	Panel_3	2011	2017	–
YOSE-PIAL	55	294244	4198696	Panel_3	2017	2017	–
YOSE-PIAL	56	287430	4166358	Panel_3	2017	2017	–
YOSE-PIAL	57	293520	4200811	Panel_3x	Rejected	–	>35_Slope
YOSE-PIAL	58	297189	4193810	Panel_3x	Rejected	–	No Trees
YOSE-PIAL	59	293338	4182489	Panel_3x	Rejected	–	Trail within plot boundaries
YOSE-PIAL	60	267368	4220379	Panel_3	2017	2017	
YOSE-PIAL	61	291778	4214161	Panel_3	Scouted	2021	–
YOSE-PIAL	62	297642	4188103	Panel_3	Scouted	2021	–
SEKI-PIAL	01	367290	4027141	Panel_1x	Rejected	–	No Trees

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIAL	02	345651	4118343	Panel_1	2014	2019	–
SEKI-PIAL	03	374530	4075808	Panel_1	2015	2019	–
SEKI-PIAL	04	375909	4084188	Panel_1	2015	2019	–
SEKI-PIAL	05	372907	4093446	Panel_1	2015	2019	–
SEKI-PIAL	06	343590	4112006	Panel_1x	Rejected	–	>35_Slope
SEKI-PIAL	07	368793	4067831	Panel_1x	Rejected	–	>35_Slope
SEKI-PIAL	08	357644	4085977	Panel_1	2019	2019	–
SEKI-PIAL	09	366236	4101569	Panel_1x	Rejected	–	>35_Slope
SEKI-PIAL	10	364469	4059015	Panel_1	2019	2019	–
SEKI-PIAL	11	372573	4075346	Panel_1	2015	2019	–
SEKI-PIAL	12	357557	4083750	Panel_1	2012	2019	First full read in 2019
SEKI-PIAL	13	360381	4105785	Panel_1	2015	2019	–
SEKI-PIAL	14	376492	4057576	Panel_1x	Rejected	–	No Trees
SEKI-PIAL	15	368275	4091574	Panel_1	2015	2019	–
SEKI-PIAL	16	356989	4077572	Panel_1x	Rejected	–	>35_Slope
SEKI-PIAL	17	362761	4033663	Panel_1x	Rejected	–	No Trees
SEKI-PIAL	18	343283	4112827	Panel_1	Incomplete	2019	Subplots 4 – 5 not installed in 2019

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIAL	19	375619	4074608	Panel_1x	Rejected	–	>35_Slope
SEKI-PIAL	20	361155	4084009	Panel_1	2013	2019	–
SEKI-PIAL	21	371958	4097865	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	22	351408	4095437	Panel_2x	Rejected	–	No Route
SEKI-PIAL	23	372112	4065836	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	24	358026	4089119	Panel_2	2013	2021	–
SEKI-PIAL	25	365621	4094633	Panel_2	2013	2021	–
SEKI-PIAL	26	355753	4057139	Panel_2x	Rejected	–	No Trees
SEKI-PIAL	27	367661	4072341	Panel_2	2013	2021	–
SEKI-PIAL	28	361949	4091581	Panel_2	2013	2021	–
SEKI-PIAL	29	357722	4109427	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	30	367938	4039738	Panel_2x	Rejected	–	No Trees
SEKI-PIAL	31	368793	4083219	Panel_2	2013	2021	–
SEKI-PIAL	32	365839	4066495	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	33	339897	4121834	Panel_2	2014	2021	–
SEKI-PIAL	34	345544	4113490	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	35	376672	4068290	Panel_2x	Rejected	–	>35_Slope

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIAL	36	362322	4084241	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	37	361596	4104498	Panel_2x	Rejected	–	No Route
SEKI-PIAL	38	346720	4094780	Panel_2	2014	2016	–
SEKI-PIAL	39	372095	4070727	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	40	354109	4085347	Panel_2x	Rejected	–	No Trees
SEKI-PIAL	41	363987	4095543	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	42	361901	4057273	Panel_2x	Rejected	–	No Route
SEKI-PIAL	43	372447	4072712	Panel_2	2014	2021	Subplots 4 - 5 not completed in 2016. Uninstalled after reading in 2021 due to safety concerns.
SEKI-PIAL	44	360112	4088754	Panel_2	2014	2021	–
SEKI-PIAL	45	347366	4115429	Panel_2	2014	2021	–
SEKI-PIAL	46	370788	4038875	Panel_2x	Rejected	–	No Trees
SEKI-PIAL	47	372218	4084481	Panel_2x	Rejected	–	>35_Slope
SEKI-PIAL	48	347886	4081797	Panel_2	2014	2016	–
SEKI-PIAL	49	367097	4094696	Panel_2	2014	2021	–
SEKI-PIAL	50	342764	4117298	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	51	376111	4070297	Panel_3	2014	2021	–

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIAL	52	364852	4084028	Panel_3	2017	2017	–
SEKI-PIAL	53	363263	4099360	Panel_3	Rejected	–	No Route
SEKI-PIAL	54	338892	4118855	Panel_3	Rejected	–	Unsafe terrain
SEKI-PIAL	55	368946	4075659	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	56	359700	4080686	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	57	359051	4104460	Panel_3x	Rejected	–	No Route
SEKI-PIAL	58	372709	4063450	Panel_3	Incomplete	2017	Subplots 1-3 completed in 2017
SEKI-PIAL	59	372495	4091307	Panel_3	2017	2017	2017
SEKI-PIAL	60	361751	4085403	Panel_3	Tagged	2019	Plot tagged but not read in 2019
SEKI-PIAL	61	348673	4115246	Panel_3	Rejected	–	Unsafe terrain
SEKI-PIAL	62	376844	4044787	Panel_3	Rejected	–	No trees
SEKI-PIAL	63	371096	4080482	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	64	349766	4082680	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	65	348874	4112395	Panel_3	Rejected	–	Unsafe terrain
SEKI-PIAL	66	358734	4091091	Panel_3	2017	2017	
SEKI-PIAL	67	364688	4062127	Panel_3	Scouted	2016	Rebar installed
SEKI-PIAL	68	358068	4082392	Panel_3	2017	2017	–

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIAL	69	367417	4051647	Panel_3x	Rejected	–	No trees
SEKI-PIAL	70	363423	4076489	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	71	359118	4093582	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	72	372846	4069794	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	73	360249	4093039	Panel_3	Incomplete	2017	Subplots 1-3 completed in 2017
SEKI-PIAL	74	369176	4073598	Panel_3	2017	2017	–
SEKI-PIAL	75	356689	4106954	Panel_3	Rejected	–	No route
SEKI-PIAL	76	367611	4079353	Panel_3x	Rejected	–	No Route
SEKI-PIAL	77	346084	4099017	Panel_3x	Rejected	–	>35_Slope
SEKI-PIAL	78	355533	4082622	Panel_3	2017	2017	
SEKI-PIAL	79	373490	4059513	Panel_3	2017	2017	
SEKI-PIAL	86	372470	4090216	Panel_3x	Rejected	2021	Unsafe terrain
SEKI-PIAL	87	347925	4116730	Panel_3	Scouted	2021	--
SEKI-PIBA	01	355122	4029380	Panel_1	2015	2019	–
SEKI-PIBA	02	375721	4039069	Panel_1	2011	2019	–
SEKI-PIBA	03	363289	4043329	Panel_1	2015	2015	–
SEKI-PIBA	04	362613	4067179	Panel_1x	Rejected	–	No trees

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIBA	05	370617	4026165	Panel_1	2015	2019	–
SEKI-PIBA	06	376988	4042810	Panel_1	2011	2019	–
SEKI-PIBA	07	374789	4056572	Panel_1	2011	2019	–
SEKI-PIBA	08	362507	4062625	Panel_1	2019	2019	–
SEKI-PIBA	09	377826	4033520	Panel_1	2011	2019	–
SEKI-PIBA	10	380915	4038349	Panel_1	2011	2019	–
SEKI-PIBA	11	375675	4050116	Panel_1	2011	2019	–
SEKI-PIBA	12	367913	4076907	Panel_1x	Rejected	–	No Trees
SEKI-PIBA	13	363692	4033498	Panel_1x	Rejected	–	>35_Slope
SEKI-PIBA	14	366283	4038676	Panel_1x	Rejected	–	>35_Slope
SEKI-PIBA	15	386345	4040899	Panel_1x	Rejected	–	Plot was installed in 2011 and rejected in 2015 due to unsafe terrain
SEKI-PIBA	16	356739	4061068	Panel_1	2013	2019	–
SEKI-PIBA	17	355948	4031543	Panel_1	2013	2019	–
SEKI-PIBA	18	375967	4045554	Panel_2	2013	2021	–
SEKI-PIBA	19	379846	4047488	Panel_2	2013	2021	–
SEKI-PIBA	20	367540	4067377	Panel_2x	Rejected	–	>35_Slope

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIBA	21	375557	4032343	Panel_2	2013	2021	–
SEKI-PIBA	22	380284	4042853	Panel_2	2013	2021	_
SEKI-PIBA	23	374094	4056105	Panel_2	2013	2021	–
SEKI-PIBA	24	361953	4059325	Panel_2x	2016	2019	Plot read and uninstalled in 2019 due to safety concerns
SEKI-PIBA	25	369054	4032210	Panel_2	2013	2021	–
SEKI-PIBA	26	371357	4046768	Panel_2	2016	2016	–
SEKI-PIBA	27	372176	4051432	Panel_2	2013	2016	
SEKI-PIBA	28	373060	4084548	Panel_2x	Rejected	–	>35_Slope
SEKI-PIBA	29	364439	4034149	Panel_2	2013	2016	–
SEKI-PIBA	30	371006	4042667	Panel_2	2014	2021	–
SEKI-PIBA	31	386287	4038225	Panel_2	2014	2021	–
SEKI-PIBA	32	360362	4059458	Panel_3x	Rejected	–	>35_Slope
SEKI-PIBA	33	384714	4036309	Panel_2	2014	2021	–
SEKI-PIBA	34	373202	4045338	Panel_3	Tagged	2016	Rebar & tags installed
SEKI-PIBA	35	377887	4048446	Panel_3	2014	2017	–
SEKI-PIBA	36	373289	4057861	Panel_3	2014	2017	–

Table A-1 (continued). List of sampling locations for white pine monitoring plots in the SIEN. The column EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Incomplete” indicating that not all subplots have been completed or “Scouted”, indicating that the plot has been visited and confirmed as target habitat, but not installed. If the plot was completed, the year it was fully installed is listed. Note that UTM X and UTM Y coordinates for established plots are the plot corner 1 (SW corner) coordinates as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up.

Park-Species	Plot ID	UTM X	UTM Y	Panel	Installed	LastVisit	EvalNotes
SEKI-PIBA	37	376739	4029729	Panel_3	2014	2017	–
SEKI-PIBA	38	376735	4036915	Panel_3	2014	2017	–
SEKI-PIBA	39	375604	4053148	Panel_3	2014	2017	–
SEKI-PIBA	40	371733	4071478	Panel_3	2014	2017	–
SEKI-PIBA	41	367280	4034622	Panel_3	2014	2014	–
SEKI-PIBA	42	369440	4050366	Panel_3x	Rejected	–	No trees
SEKI-PIBA	43	382685	4040573	Panel_3	2017	2017	–
SEKI-PIBA	44	373659	4077444	Panel_3	2017	2017	–
SEKI-PIBA	45	363766	4029223	Panel_3	2018	2018	–
SEKI-PIBA	46	369487	4038685	Panel_3	Scouted	2021	–

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

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