<u>***Effectiveness Monitoring Committee Full Project Proposal Form***</u>

Project #: EMC-2024-006 **Date: July 24, 2024**

Project Title: *Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests*

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Project Duration and Dates (Years/Months): 01/2025 – 03/2027

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1) <u>Project Description</u>

a) Background and Justification:

Fire suppression, cessation of Indigenous burning practices, and climate change conditions have dramatically increased the size and intensity of California wildfires over the past half-century (Cova et al. 2023). As a result, postfire restoration and reforestation needs at scale present significant challenges to current public and private agency workforces, budgets, and traditional practices. Recent publications such as PSW-GTR-270 (Meyer et al. 2021) and PSW-GTR-278 (Long et al. 2023) have proposed holistic approaches to western forest restoration, to prioritize management actions across landscapes at scale. Complementary to these new approaches are strategic changes in reforestation and planting practices, which can improve seedling survival and growth, and restore resilient forest structural conditions, in an era of changing climate conditions and disturbance regimes (North et al. 2019). These challenges confront all foresters, regardless of differences in ownership, acreage, and intended forest output. We will study approaches to these challenges in yellow pine and mixed conifer forests, using the following climate-smart reforestation practices across a wide range of climatic conditions in California:

i) Climate-Smart Reforestation Technique #1: *Application of planting spatial patterns based on Individual trees, Clumps of trees, and Openings (ICO) that improve forest resistance to severe fire. Species composition and spacing between and within clumps is selected in response to slope position, microsite moisture, and likely fire behavior.*

Traditional gridded planting design comes from an agronomic approach, designed to maximize tree stock to provide for sustained timber yield, boost initial growth rates, and rapidly shade competing shrubs (Rubilar et al. 2018). Gridded planting has been extensively studied and provides some of the core data and concepts that drive widely-used forest growth and yield models. As a planting pattern, however, it has no analog in natural ecosystems, and depends heavily on labor-intensive future thinning treatments. Under current state and USFS regional guidance (i.e., recommended range of 150-300 trees per acre in drier pine to mesic mixed conifer), the dense, uniform structure of young stands (<60 years old) strains limited seed and nursery capacity early on (Dobrowski et al. 2024), while lacking resistance to fire and drought over time (Zald and Dunn 2018). Young plantations are often now exposed to frequent severe stresses through fire and drought (Stevens-Rumann et al. 2018). More resilient reforestation approaches are needed, based on natural spatial patterns of fire-resilient mature forest stands that include a mixture of Individual trees, Clumps of trees, and Openings (ICOs) (Figure 1). In California's yellow pine and mixed-conifer forests, ICO spatial structure and forest heterogeneity improves resistance to severe fire (Koontz et al. 2020; Ziegler et al. 2021; Ritter, et al. 2023) and drought (Thomas et al. 2024). Species composition and spacing between and within clumps would vary in response to slope position, microsite moisture, and likely fire behavior (Lydersen and North 2012; Ng et al. 2020; Marshall et al. 2023). Variable spacing and ICO spatial pattern are often observed in young, developing stands, and conifer regeneration in active fire regime forest landscapes of California (Fertel et al. 2022) (Figures 1 & 2).

Figure 1: ICO pattern produced by a restored fire regime in Yosemite National Park

Figure 1: A mixed-conifer forest in Yosemite National Park with a pattern of individual trees, clumps of trees, and openings (ICO) produced by frequent low to moderate severity fire (4 burns in the last 50 years).

Figure 2: Giant sequoia seedling cluster in a recently burned grove

Figure 2. Cluster of naturally-regenerating young giant sequoia seedlings in a low to moderate severity burned patch of the Long Meadow Grove, Giant Sequoia National Monument.

ii) Climate-Smart Reforestation Technique #2: *Use of initial planting densities that are roughly 1.2-1.5 times the densities of mature forest (i.e., 60-160 seedlings per acre) with restored fire regimes (North et al. 2007, 2022).*

In studies of mature ICO patterns, local site conditions influencing soil moisture (i.e., concave shape, northerly aspect, gentler slope, less porous soils) and fire intensity (i.e., slope steepness, southwestern aspect) affect forest composition and spatial patterns at topographic and microsite scales (North et al. 2009, Kane et al. 2015). In general, wetter, flatter slope positions can support larger tree clumps, including some fire-intolerant and moisture-sensitive species (i.e., fir and cedar). Steeper, drier topographies burn with greater intensity and frequency, favoring pines, individual stems, and small tree clumps (Meyer et al. 2007, Lydersen et al. 2013, Fry et al. 2014, Ng et al. 2020, Marsh et al. 2022, 2023). Planted species should favor those more adapted to fire and future climate stress rather than fir and cedar which often naturally recruit (North et al. 2021). Differences in these site factors provide a range of mature stand densities and spatial patterns, which could be used to guide reforestation patterns (Meyer et al. 2021, Long et al. 2023).

At finer spatial scales, variation among microsites that influence soil moisture, sun exposure, and fire intensity can influence the growth and survival of tree seedlings. Pockets of deeper soil can improve growing conditions for conifers, and understory vegetation can provide critical shading for developing seedlings in harsh environments (Marsh et al. 2022, 2023, Marshall et al. 2023). When planting for these mature forest conditions, the literature suggests following the percentage of trees occurring as individuals and in clump sizes based on topography, but with planting at densities and distances that account for about 20-35% seedling mortality. Site conditions and future stand treatments, such as the use of prescribed fire, should also influence mortality estimates (Kane et al. 2015, Zald et al. 2024). Within wind-dispersal distance of live mature trees (generally about 200 ft), natural regeneration may be sufficient to meet desired densities and spatial arrangements of conifer seedlings, but strategic planting can help supplement low densities of heavy-seeded pines.

iii) Climate-Smart Reforestation Technique #3: *The use of early beneficial fire and targeted shrub control to build young forest resilience.*

Although shrubs provide many ecosystem services, they can be strong competitors with tree seedlings for sunlight and scarce soil moisture. Many shrub species that are common in Mediterranean climates, including the montane forests of California, rapidly resprout from below-ground root crowns and maintain persistent seed banks that germinate following fire. Depending on several factors, vigorous regrowth can either compete with or facilitate the recruitment of developing tree seedlings (McDonald and Fiddler 2010, Marsh et al. 2022, Zald et al. 2024). Severely burned Sierra Nevada mixed conifer and yellow pine forests that contain high shrub cover (>60-70%) typically have low conifer regeneration densities, especially for large-seeded pines, which suggests a competitive effect of shrubs (Welch et al. 2016).

However, under low-to-moderate levels of shrub cover (generally <50-60%), conifer seedlings have higher growth rates in regenerating Sierra Nevada and other mixed conifer stands following fire, possibly associated with microsite conditions (e.g., lower evapotranspiration rates, greater soil moisture and nutrients) (Fertel et al. 2022) (Figure 3). Under warming climate conditions, shrubs may have an increasingly neutral or positive effect on regenerating conifers, by providing critical shading in hot and exposed post-fire environments (Werner et al. 2019). Under current climate conditions, recent studies of shrub cover in arid forestlands of the southwestern US and Mediterranean climate regions suggest shrubs can have a neutral or facilitative effect on planted conifer seedling survivorship and growth (Gómez-Aparicio et al. 2005; Marsh et al. 2022, 2023). However, the influence of shrubs on post-fire conifer regeneration is largely untested in California, except under traditional gridded and high-density plantations in mild climate conditions (McDonald and Fiddler, 2010).

Figure 3: Naturally regenerating Jeffrey pine seedlings within a shrub patch in Yosemite National Park

Figure 3. Naturally regenerating Jeffrey pine seedlings (bottom right of photo) located in a shrub patch of moderate cover within a forest landscape with a reestablished natural fire regime, Yosemite National Park.

Prescribed fire, cultural burning, and some wildfires (with beneficial effects) can be used before initial planting, and after saplings (especially pines) are at least 13-20 years old, to reduce shrub cover and surface fuels, and build greater seedling fire tolerance (Bellows et al. 2016, York et al. 2021). Dry or older shrubs can be a fuel accelerant, but young, vigorous shrubs in burn scars can act as a heat sink, because of rapid uptake of soil moisture and relatively high foliar moisture content (Royce and Barbour 1991). Prescribed burns implemented shortly after rain can use shrubs to buffer adjacent tree seedling clumps from heat-related injury, while still consuming surface fuels. Beneficial fire can also reduce stem densities and promote heterogeneity in young, dense stands established with homogenous grid spacing (Knapp et al. 2011, York et al. 2022) (Figure 4). However, the use of these practices to build resilient heterogeneity in gridded plantations is also largely untested in California.

Figure 4: Burned (top) and unburned (bottom) Jeffrey pine plantations on the Inyo National Forest

Figure 4. Older (~25 year) Jeffrey pine plantation burned in a recent wildfire managed for resource objectives (top) and a neighboring unburned plantation of similar age, but with noticeably higher density and homogenous spatial structure (bottom), Inyo National Forest.. Both plantations were initially established using a gridded planting design.

Each of these climate-smart reforestation techniques has the potential to substantially increase the resilience of developing planted yellow pine and mixed conifer stands in California. However, these techniques have been untested or lack critical evaluation through effectiveness monitoring and study. Additionally, California's yellow pine and mixed conifer forest types are compositionally diverse and distributed across a wide environmental gradient, from drier Jeffrey pine forests in Southern California to mesic giant sequoia groves in the Sierra Nevada. Consequently, any evaluation of climate-smart reforestation techniques must cover a broad portion of the state, in order to effectively capture results in a representative variety of forest compositional and environmental conditions. We intend to capture this environmental variation in our study, by assessing climate-smart reforestation techniques across a wide array of yellow pine and mixed conifer forest types throughout the state of California (Table 1, Figure 5).

b) Research Questions, including Objectives and Scope:

While we recognize the importance of hardwood species in forests that historically experience frequent fire regimes, for practical reasons (i.e., lack of seed collection and nursery production of hardwood seedlings), our current project focuses on conifers. This proposal will leverage already planned reforestation projects across California, to address the following research questions:

1. *Does seedling spatial pattern influence reforestation success?*
2. *Does planting at lower densities similar to historical conditions (i.e., natural range of variability) result in improved reforestation outcomes?*
3. *How does shrub cover influence conifer seedling survivorship and growth?*
4. *Do climate-smart reforestation outcomes vary across an environmental gradient, represented by different geographic regions of California?*
5. *Does early use of fire (prescribed fire, wildfire) result in reduced fuels and stem densities, and more variable spatial patterning in existing young (13-40 year old) gridded planted stands*?

Our overall goal is to evaluate the effectiveness of climate-smart reforestation techniques based on active-fire regime landscapes in California's mixed conifer and yellow pine forests. This will be accomplished through a combination of implementation support and effectiveness monitoring of targeted reforestation areas throughout the state of California. Our specific objectives to achieve this goal include:

A. Providing effective implementation support to land managers and reforestation crews in select reforestation sites. This ensures consistency in the application of climate-smart reforestation techniques and approaches.
B. Conducting effectiveness monitoring of climate-smart reforestation sites on federal and non-federal (e.g., private) lands and acquire standardized monitoring data to evaluate research questions 1-4
C. Conducting effectiveness monitoring of young planted stands managed using prescribed and wildland fire to evaluate research question 5.
D. Broadly sharing results of effectiveness monitoring and implementation lessons with agency staff, partners, collaborators, and stakeholders.This will provide the foundation for building collaboration around climate-smart reforestation approaches focused on variable seedling spatial patterns, lower seedling densities, and the early use of wildland fire in young planted stands.

2) <u>Research Methods</u>

Our study will include the use of a microsite cluster planting design, implemented across several representative forest regions of California: the Southern California (Angeles National Forest), Southern Sierra Nevada (Sequoia NF, Sequoia National Park, or Inyo NF), Central/Northern Sierra Nevada (Eldorado, Plumas, or Lassen NF), and Northwestern California (Mendocino NF). The broad geographic range captured by this study provides a unique opportunity to address climate-smart reforestation actions across a wide diversity of forest types and productivity gradients. Locations will be selected for feasibility of climate-smart reforestation actions implemented in the 2025 planting season, with several project areas already identified in existing NEPA/CEQA and implementation plans. In each region, we will select one or more study sites in the mixed conifer and yellow pine forest zone, which have experienced a recent (past 10 years) stand-replacing fire or other disturbance, and which have been identified for climate-smart reforestation efforts by the US Forest Service (USFS), National Park Service (NPS), and agency partners on selected state and private lands (Table 1, Figure 5).

Table 1: Planned Climate-Smart Reforestation Study Sites on Federal and Private Lands in California*

Location	Partners	Forest Type
Climate-Smart Reforestation (Study Sites):		
1. Angeles National Forest	TreePeople	Jeffrey pine, mixed conifer
2. Sequoia National Forest	American Forests, Save the Redwoods League	Giant sequoia, mixed conifer
3. Plumas National Forest	Berry Creek Rancheria	Ponderosa pine, mixed conifer
4. Mendocino National Forest	Clear Lake Environmental Research Center	Ponderosa pine, mixed conifer
5. Sequoia and Kings Canyon National Parks	National Park Service, University of California Berkeley, American Forests	Giant sequoia, mixed conifer
6. **Private Lands: **** Tulare County, or Plumas County	Save the Redwoods League, or Feather River Resource Conservation District, or University of California Cooperative Extension **	Giant sequoia, or Ponderosa pine, mixed conifer
Recently-Burned Young Planted Stands^ (Study Sites):		
7. Inyo National Forest	University of California Davis	Eastside Jeffrey pine
8. Sequoia National Forest	Fire Restoration Group	Mixed conifer

**Table does not show additional potential study sites that will likely be planted in 2025 or 2026. All study sites were recently burned in high severity wildfires.*
***Several private lands partners are currently being considered for inclusion as a study site in this proposal besides the two listed. Currently listed partners have communicated their interest in participating in this study proposal.*
^Monitoring work for recently burned young stand study sites is underway.

The general implementation schedule for all planting activities will be coordinated with all partners and take into account specific condition requirements for each region and site, starting with southern and lower elevation, to end at the northern and higher elevation locations. A virtual project workshop with all participating land managers will be presented to describe project objectives and planting design prior to the start of the planting season. At each study site, we will provide on-the-ground implementation support to ensure consistency across planting locations. Implementation support will include a pre-planting site visit for evaluation of site characteristics and flagging of target microsite areas for climate-adaptive planting. Members of the lead implementation team will be present on each planting day, to assist local partners and planting crews, as well as to ensure the uniform consistency of project methods and planting design.

We will identify plantations burned in a recent (2014 or later) prescribed fire or wildfire, to evaluate Research Question 5. Our analysis will focus on recently-managed wildfires (low-moderate severity) that had the potential to create openings or significantly reduce stem densities and fuels in gridded plantations. Pre-fire treatment information will be gathered using USFS records and documentation. We have already identified study sites related to several recent burn scars in national forests of California (Table 1, Figure 5).

Figure 5: State Map of Selected Reforestation Project Sites

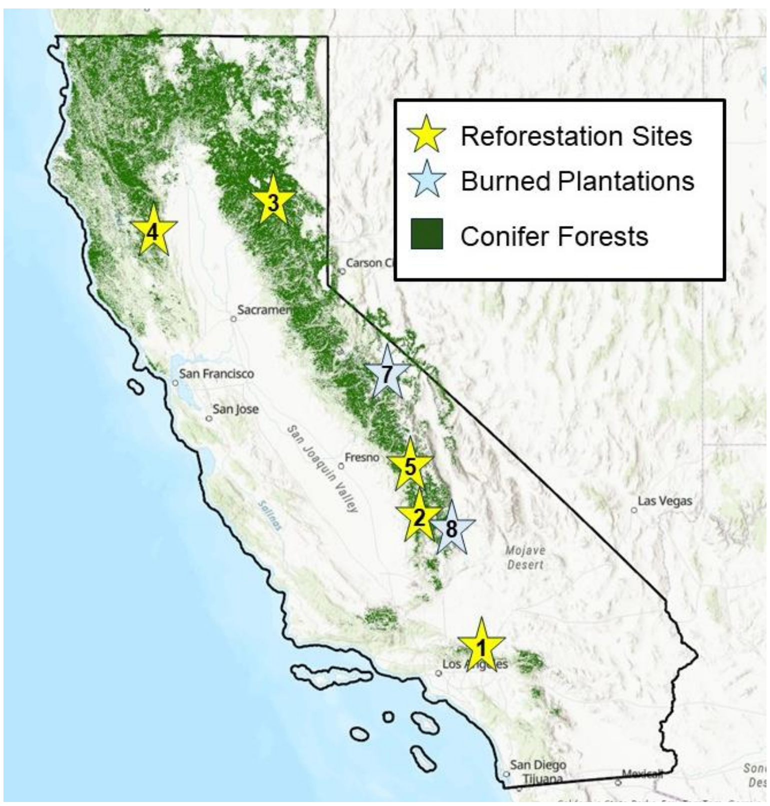

Figure 5: Map of study sites including reforestation sites (planned for 2025) and burned plantations in yellow pine and mixed conifer forests of California. The geographic scope and diverse range of yellow pine and mixed conifer forest types addressed in this study makes it broadly applicable throughout the state.

Variations in planting design and its comparison to traditional gridded planting will allow us to address Research Question 1 (spatial pattern), Question 2 (seedling densities), and Question 3 (shrub cover). Comparisons among study regions of California will address Research Question 4 (environmental gradient). Our reforestation metrics will include: (a) seedling survivorship and growth, (b) seedling densities (planted vs. target) and spatial arrangement, (c) understory species composition and diversity (including native versus invasive species), and (d) surface fuels. We will use fixed-radius plots for metrics (a) through (c) and Brown's fuel transects method (Brown 1974), combined with ground cover estimates of coarse woody debris for metric (d).

Each study site will include 3 to 5 seedlings in a cluster, within 10 to 15 feet of a central point, frequently in the following microsite conditions: (1) in open canopy, (2) at the edge of a shrub canopy, (3) in the shade of a perennial herb, stump, rock, or other shading structure, and (4) at the edge of a second shrub or herb species, if present (Figure 6: Microsite cluster planting design). In most cases, seedlings will be planted at least 6 feet apart in each cluster. This approach will skip areas of rocky soils, natural regeneration, resprouting hardwoods, and very high shrub cover (>70%). Planting design will result in a range of planted seedling densities between 80-170 stems per acre but possibly higher (170 to 250 or more stems per acre) in certain locations, based on land ownership.

Figure 6: Microsite Cluster Planting Design

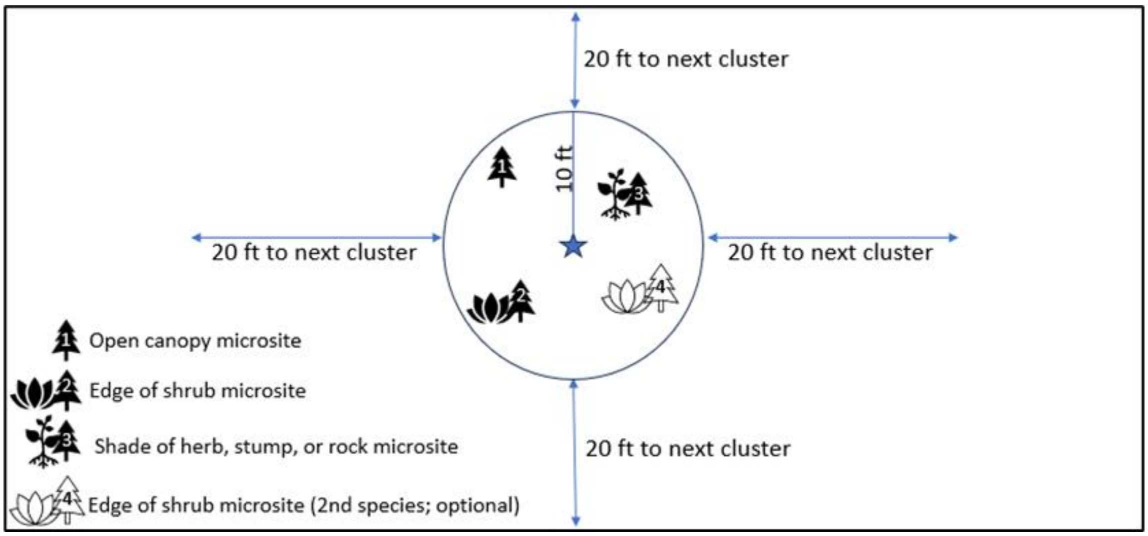

Figure 6: Diagram illustrating the microsite cluster planting design, where seedlings are planted in clusters of 3 to 5 stems, generally within 10 or 15 feet of a central point in the following microsite conditions: (1) within open canopy, (2) at the edge of a shrub canopy, (3) in the shade of a perennial herb, stump, rock, or other shading structure, and optionally (4) at the edge of a second shrub or herb species, if present. The approach avoids areas of rocky soils, natural regeneration, sprouting hardwoods, and very high shrub cover. (>70%), and seedlings are planted at least 6 feet apart in each cluster. This planting design would result in a stocking density of 80 to 170 stems per acre depending on cluster spacing and density.

We will compare microsite cluster planting sites with nearby traditional gridded planting designs, where available, based on USFS regional stocking standards (i.e., 150 to 300 seedlings per acre) and State of California FPR stocking standards (minimum of 100 to 200 small stems per acre, or an average of 300 stems per acre for timber operations). Reforestation sites may vary in the level of site preparation (e.g., shrub control) intensity and extent, contributing to some variation in shrub cover across study sites. The size of experimental planting units will vary by study site (10 to 150 acres), and will represent a subset of the total reforestation project area. The remaining (non-experimental) project area will be planted using the established planting design (often gridded), based on the landowner's preferences for each site. Besides evaluating differences in planting designs, our study design will allow us to assess a wide array of microsite and stand conditions (e.g., presence or absence of nearby shrub canopy, forest type) for several conifer species (especially ponderosa and Jeffrey pines), across a wide environmental gradient throughout California (Table 1, Figure 5).

3) <u>Scientific Uncertainty and Geographic Application, including Monitoring Locations</u>

Climate-smart reforestation is relatively new and subject to uncertainty, especially in studying planting designs that emphasize the importance of: (1) spatial heterogeneity, (2) lower stem densities (aligned with natural range of variability), (3) low-moderate shrub cover for seedling microsite suitability, and (4) early beneficial fire use for young stand resilience. Our study specifically aims to examine each of these areas of uncertainty, by using a design that addresses each of these factors independently or in combination. Our geographic applicability is

Statewide, as relevant to both public and private lands, with a focus on study sites in public forests (Table 1, Figure 5). Although our project appears ambitious, we have secured enthusiastic support from numerous USDA Forest Service and agency partner staff (including silviculturists, foresters, restoration ecologists, and other natural resource professionals), who are committed to experimenting with climate-smart reforestation in their upcoming (2025) planting season. We will also continue to expand this work to include longer-term monitoring beyond the project duration, in order to develop a broader network of experimental reforestation sites on state, federal and private land. We are committed to seeking future funding to support this project over at least 5-7 years, to support longer-term effectiveness monitoring of reforestation units that will effectively assess the success of reforestation approaches under climate change.

4) <u>Critical Questions and Forest Practice Regulations (FPRs) Addressed</u>

Our research questions will address the following Critical Monitoring Questions and FPRs (CalFire 2020):

1. *<u>6d - Are FPRs and associated regulations effective in managing forest structure and stocking standards to promote wildfire resilience</u>?*
    a. Addressed by research questions: 2 and 4, by testing climate-smart reforestation planting densities within a common species across different forest lands and geographic gradients.
    b. Relevant to rules/regulations: *14 CCR §§ 912.7(b)(1) [932.7(b)(1), 952.7(b)(1)] (Resource Conservation Standards for Minimum Stocking); 14 CCR §§ 913.4(d)(10) [933.4 (d)(10), 953.4(d)(10)] (Special Prescriptions: Variable Retention); and Article 5 4561(a) (Stocking standards).*
2. *<u>6e - Are FPRs and associated regulations effective in achieving post-fire recovery and restoration</u>?*
    a. Addressed by research questions: 1 through 5, by evaluating historical conditions and climate-smart reforestation techniques, as applied to the needs for improved outcomes among land managers and reforestation crews from both public and private interests.
    b. Relevant to rules/regulations: *14 CCR §§ 913.4(b)(2) [933.4 (b)(2), 953.4(b)(2)] (Special Prescriptions: Rehabilitation of Understocked Area Prescription); and Article 5 4561(a) (Stocking standards).*
3. *<u>12a - Are FPRs and associated regulations effective in improving overall forest wildfire resilience and the ability of forests to respond to climate change</u>?*
    a. Addressed by research questions: 1, 2, 4, and 5, by including study design, implementation, and monitoring focused on the effectiveness and efficiency of variations among spatial planting patterns, shrub cover, and use of wildland fire in improving reforestation outcomes.
    b. Relevant to rules/regulations: Please see above No. 2 above, as well as *14 CCR §§ 913.4(c) [933.4 (c), 953.4(c)] (Special Prescriptions: Fuelbreak/Defensible Space).*
4. *<u>12c - Are FPRs and associated regulations effective in meeting ecological objectives and adaptation to future climate</u>?*
    a. Addressed by research questions: 1, 2, 3, and 4, by evaluating traditional reforestation methods, as compared to methods adapted for projected future climatic conditions – utilizing key conifers as a unifying comparison factor.
    b. Relevant to rules/regulations: Please see No. 3 above.
5. *<u>12d - Are FPRs and associated regulations effective in maintaining or recruiting adequate amounts of early- and mid-seral wildlife habitats which are well adapted to future climate</u>?*
    a. Addressed by research questions: 3 and 5, by testing reforestation techniques that include considerations for native vegetative species (shrubs) adjacent to the key species studied (conifers), as well as prescribed fire and wildfire that utilize positive outcomes from natural habitat conditions within the project area landscapes studied.
    b. Relevant to rules/regulations: *14 CCR §§ 915.2(a)(b) [935.2 (a)(b), 955.2 (a)(b)] (Site Preparation: Treatment of Vegetative Matter) and 14 CCR §§ 915.3(b) [935.3(b), 955.3(b)] (Site Preparation: Protection of Natural Resources.*

5) <u>Roles, Collaborations, and Project Feasibility</u>

TreePeople will lead the implementation of climate-smart reforestation activities in Southern California, also supervising partners' implementation in additional regions through subcontract (Feather River Resource Conservation District, National Parks Service, Save the Redwoods League, Berry Creek Rancheria, Clear Lake Environmental Research Center, American Forests, and University of California Berkeley), to ensure project consistency. The USFS Region 5 Ecology Program (Nicole Molinari, Lacey Hankin, Marc Meyer, Kyle Merriam, and Gabrielle Bohlman) and PSW Research Station (Malcolm North) will oversee monitoring data collection in reforestation areas, and will coordinate closely with national forest staff and other partners (Table 1), to ensure climate-smart reforestation activities meet study requirements. Principal Investigators will coordinate data management and assist collaborators in analysis, reporting, manuscript preparation, and other project activities and deliverables (Table 2).

Additional research partners may choose to participate in this project, as we seek to include state and private landowners and local tribes. As one example, we will engage with the University of California Cooperative Extension staff early in our study, to help identify additional private landowner partners and study sites in California, and to later disseminate scientific results from our study to non-federal land managers (Table 2). Moreover, several study sites in recently-burned gridded plantations on national forests have already been identified by agency staff as readily accessible for field sampling (Table 1, Figure 5). We also expect further sampling locations will emerge with focused interviews of agency staff and others as the project commences.

We anticipate high feasibility in this study, having already obtained commitments by the USFS Regional Forester's Office in the Pacific Southwest Region, as well as several national forests currently planning climate-smart reforestation projects in recently burned areas, in addition to agency partners planning similar reforestation efforts in mixed-conifer forests (e.g., National Park Service, American Forests). These commitments include strong logistical, planning (e.g., NEPA), and financial support (both state and federal) of proposed climate-smart project activities across the region.

The US Forest Service Region 5 Ecology Program (REP) and the US Forest Service Pacific Southwest Research Station (PSW) have frequently partnered and successfully implemented treatment effectiveness and fire effects monitoring for forest ecosystems in California over nearly two decades. Examples include fuel treatment effectiveness monitoring during wildfires (e.g., Safford et al. 2012, North et al. 2009, North and Hurteau 2011, Coppoletta et al. 2016), forest restoration treatment effectiveness monitoring during extreme drought (e.g., Restaino et al. 2019, Young et al. 2020, 2023, Steel et al. 2021), fire regime alteration and vegetation type conversion evaluation (e.g., Coppoletta et al. 2019, Guiterman et al. 2022), and effectiveness monitoring of wildland fire treatments in restoring forest structure and natural fire regimes (e.g., Meyer 2015, Meyer et al. 2019, Merriam et al. 2022, Chamberlain et al. 2023). Additionally, the REP and PSW have many years of experience conducting post-fire conifer regeneration monitoring and research in forest ecosystems (e.g., Meyer and Safford 2011, Fertel et al. 2022, Soderberg et al. 2024), developing technical assessments and tools for post-fire landscapes (e.g., Meyer et al. 2021, Williams et al. 2021, Long et al. 2023, USFS REP 2024), as well as creating climate adaptation and reforestation strategies for forest landscapes (e.g., North et al. 2019, Swanston et al. 2020) in the Pacific Southwest Region. All of these projects were accomplished in close collaboration with other federal, state, private, and NGO partners. Our combined expertise and accomplishments in post-fire forest monitoring and scientific application and translation (Safford et al. 2017) demonstrate our ability to successfully oversee the implementation and monitoring of the proposed project, in order to accomplish the proposed activities and deliverables (Table 2).

6) Project Deliverables and Detailed Timeline

Table 2: Anticipated activities and deliverables produced as a result of proposed research

Activity (A) or Deliverable (D)	Description	Timeline
Establish Study Sites (A)	Selection of priority study sites in California, including engagement with the University of California Cooperative Extension	December 2024
Virtual workshop (A)	Virtual workshop to participating land managers to describe reforestation monitoring project objectives and planting design	Winter 2025
Reforestation Implementation	Technical assistance and training provided to planting crews to help implement climate-smart reforestation techniques	Winter & Spring 2025 and 2026

Support (A)		
Monitoring Data Collection (A)	Collection of effectiveness monitoring data from study sites	Summer 2026 and 2027
Project updates (D)	Project update to funders and collaborators	December 2025, 2026, 2027
Final Report and EMC presentation (D)	Completed Research Assessment (CRA) Presentation to the Effectiveness Monitoring Committee	Summer (June) 2027
Project presentation (D)	Project presentation to funders and collaborators, including final project presentation in Fall 2027	Fall 2026, 2027
Board presentation (D)	Completed Research Assessment (CRA) Presentation to the Board	Fall 2027
Science publications (D)	Peer-reviewed science publications to be submitted to refereed journals	Fall 2027 to December 2028
Manager brief (D)	Land manager brief summarizing results of effectiveness monitoring and relevance to land managers	Fall 2027
Webinar presentation(s) (D)	Presentation at a Fire Science Webinar Series (e.g., CalFire, CA Fire Science Consortium)	Winter/ Spring 2025 or 2026
Conference presentation(s) (D)	Presentation(s) at national or regional science & management conferences (e.g., Fire Ecology & Management Conference)	Fall/ Winter 2027 and 2028
Field trip (D)	Presentation and discussion of climate-smart reforestation with land managers and scientists at targeted field trip (e.g., CFSC field trip)	Summer 2025 or 2026

7) Detailed Budget and Requested Funding (please see attached Budget Detail spreadsheet)

TreePeople and collaborators seek support of $324,921.68 as a total project request, inclusive of the partners' implementation team, contracting, supervision of local planting groups, field monitoring, and data collection. This total has slightly increased from the concept proposal, to cover additional costs in field staff added to the project for two new study site locations on private lands. TreePeople will also leverage a potential award in this proposal with funding received for reforestation from the Rivers & Mountains Conservancy, in addition to a recent CAL FIRE state award, as well as in-kind contributions from the USDA Forest Service Pacific Southwest Region for their staff time on the project – along with future funding opportunities. Total leverage of in-kind and matching contributions of $154,017.97 (32% of total costs) will assist restoration planting at field locations in this project, as well as work time for PIs and collaborators in project design, implementation, data collection, and monitoring analysis. Regional foresters have expressed the commitment to continue and expand this project in the future.

- Year 1 – $119,616.26: Partner meetings, study design, planning and implementation of plantings.
- Year 2 – $104,401.92: First year of project monitoring and data collection.
- Year 3 – $100,903.50: Second year of monitoring and data collection for all sites, as well as analysis.

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Board of Forestry

Reforestation for Resilience

Budget Detail

		Year 1 (2024/25)	Year 2 (2025/26)	Year 3 (2026-27)	Total
Personnel					
	Director of Mnt Forestry - 300hrs x $45.32	$ 5,438.40	$ 4,532.00	$ 3,625.60	$ 13,596.00
	Program Manager - 1120hrs x $32.96	$ 15,820.80	$ 10,547.20	$ 10,547.20	$ 36,915.20
	Senior Coordinator - 1120hrs x $24.72	$ 11,865.60	$ 7,910.40	$ 7,910.40	$ 27,686.40
	Senior Scientist - 220hrs x $45.32	$ 3,625.60	$ 2,719.20	$ 3,625.60	$ 9,970.40
	Grant Manager - 140hrs x $46.68	$ 2,334.00	$ 1,867.20	$ 2,334.00	$ 6,535.20
	Marketing & Communication - 80hrs x $41.50	$ 1,245.00	$ 830.00	$ 1,245.00	$ 3,320.00
	Accounting - 120hrs x $27.80	$ 1,112.00	$ 1,112.00	$ 1,112.00	$ 3,336.00
	Administrator - 240hrs x $32.96	$ 2,636.80	$ 2,636.80	$ 2,636.80	$ 7,910.40
	Total Personnel	**$ 44,078.20**	**$ 32,154.80**	**$ 33,036.60**	**$ 109,269.60**
Fringe Benefits					
	32% Fringe benefits on all above personnel	**$ 14,105.02**	**$ 10,289.54**	**$ 10,571.71**	**$ 34,966.27**
Other		$ -			
	Planting Crews Contracts - 6 x $5,000	$ 30,000.00			$ 30,000.00
	Monitoring Field Crew Contract				$ -
	--- Summer 2025 (1 lead + 2 pers. crew, 3 months)		$ 70,000.00		$ 70,000.00
	--- Summer 2026 (1 lead + 2 pers. crew, 3 months)			$ 70,000.00	$ 70,000.00
	Principal Investigator 1 - 30d x $800 (UCDavis/USFS)	$ 4,000.00	$ 12,000.00	$ 8,000.00	$ 24,000.00
	Principal Investigator 2- 30d x $605 (USFS)	$ 3,025.00	$ 9,075.00	$ 6,050.00	$ 18,150.00
	Collaborator 1 - 30d x $526 (USFS)	$ 2,630.00	$ 7,890.00	$ 5,260.00	$ 15,780.00
	Collaborator 2 - 25d x $605 (USFS)	$ 4,840.00	$ 6,050.00	$ 4,235.00	$ 15,125.00
	Collaborator 3 - 25d x $526 (USFS)	$ 4,208.00	$ 5,260.00	$ 3,682.00	$ 13,150.00
	Collaborator 4 - 25d x $526 (USFS)	$ 5,260.00	$ 2,630.00	$ 5,260.00	$ 13,150.00
	Total Other	**$ 53,963.00**	**$ 112,905.00**	**$ 102,487.00**	**$ 269,355.00**

		Year 1	Year 2	Year 3	Total
Operating Expenses					
	Seedlings protection tubes	$ 3,000.00			$ 3,000.00
	Stake flags	$ 7,200.00	$ 1,800.00		$ 9,000.00
	Addtnl field supplies - flagging tape, misc		$ 750.00	$ 750.00	$ 1,500.00
	HOBO Humidity trackers per plots (7 x 6)	$ 2,940.00			$ 2,940.00
	Computer & Software - 2 Field Ipads		$ 1,900.00		$ 1,900.00
	Total Operating Expenses	**$ 13,140.00**	**$ 4,450.00**	**$ 750.00**	**$ 18,340.00**
Indirect					
	15% On all above costs	**$ 10,698.48**	**$ 7,034.15**	**$ 6,653.75**	**$ 24,386.38**
Travel					
	CalTrans Truck rate - TreePeople sites $42.39 x160hrs	$ 3,391.20	$ 1,695.60	$ 1,695.60	$ 6,782.40
	wks	$ 5,100.00			$ 5,100.00
	60ds	$ 3,540.00			$ 3,540.00
	48ds	$ 7,200.00			$ 7,200.00
	Total Travel	**$ 19,231.20**	**$ 1,695.60**	**$ 1,695.60**	**$ 22,622.40**
Total Cost		**$ 155,215.91**	**$ 168,529.09**	**$ 155,194.66**	**$ 478,939.65**
In-kind contributions					
	Provinces	$ 23,963.00	$ 42,905.00	$ 32,487.00	$ 99,355.00
Match					
	prep and	$ 11,636.64			$ 11,636.64
	CAL FIRE - staff time for establishment & monitoring		$ 21,222.17	$ 21,804.16	$ 43,026.32
	Total in-Kind + Matching Contributions	**$ 35,599.64**	**$ 64,127.17**	**$ 54,291.16**	**$ 154,017.97**
Total Request		**$ 119,616.26**	**$ 104,401.92**	**$ 100,903.50**	**$ 324,921.68**
	Overall budget includes: TreePeople's implementation team, contracting of local group planting groups and their supervision, 2 first years of monitoring and data collection. TreePeople will seek additional funding to keep the monitoting and data collection and anylisis beyond the term of this grant.	Year 1: Partner meetings, study design, site selection, planning & planting at 6 locations.	Year 2: First year monitoring and data collection at 6 planted locations.	Year 3: Second year of monitoring and data collection for all sites, data analysis, conclusions and final report.	

USDA United States Department of Agriculture | Forest Service | Pacific Southwest Region

Regional Office, R5
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File Code: 1500
Date: July 23, 2024

Effectiveness Monitoring Committee
Board of Forestry and Fire Protection
Sacramento, CA 94244-2460

Dear Board of Forestry and Fire Protection:

I would like to express my strong support for the "Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests" implementation support and effectiveness monitoring proposal to the Effectiveness Monitoring Committee. The proposed work will provide the national forests in the Pacific Southwest Region with much needed science information pertaining to the use of climate-informed reforestation techniques and maintenance treatments in coniferous forest ecosystems.

The monitoring and implementation support proposed will greatly assist the national forests of the Pacific Southwest Region by ensuring successful implementation of climate-informed restoration techniques and assessing the effectiveness of climate-smart and traditional gridded reforestation techniques under current forest landscape conditions. Furthermore, the proposal leverages funding and efforts that are parallel and complementary by Pacific Southwest Region to test concepts of climate-informed reforestation in planned projects. The Region has indicated its support for this work through additional funding and capacity in order to achieve reforestation goals. This approach will help federal and non-federal forest managers develop science-based reforestation practices that are resilient and sustainable in the face of uncharacteristically severe wildfires, climate change, and other ecosystem stressors.

The principal investigators and collaborators have the unique technical expertise, scientific qualifications, and partnership experience necessary to successfully carry out the proposed monitoring work. They have a long and successful track record of executing, publishing, and applying the results of effectiveness monitoring projects throughout the Pacific Southwest Region. Collectively, this team has decades of experience monitoring the effectiveness of forest restoration, post-fire management, and other vegetation and fuels treatments on federal, state, and private lands in California. I wholeheartedly endorse their effectiveness monitoring proposal.

Thank you for considering support of this high priority project of the national forests in the Pacific Southwest Region.

Sincerely,

[redacted]

Signed by: Department of Agriculture

DIANA CRAIG
Director, Ecosystem Management

cc: Marc Meyer, Nicole Molinari, Lacey Hankin, Richard Hopson

United States Department of the Interior

NATIONAL PARK SERVICE
Interior Region 10
Sequoia and Kings Canyon National Parks
47050 Generals Highway
Three Rivers, California 93271-9651
(559) 565-3341

IN REPLY REFER TO:

Effectiveness Monitoring Committee
P.O. Box 944246
Sacramento, CA 94244-2460

Dear Effectiveness Monitoring Committee:

I wholeheartedly support the proposal entitled “Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests” submitted by Tree People, the U.S. Forest Service, and colleagues. The proposed effectiveness monitoring proposal will greatly complement ongoing post-fire reforestation efforts at Sequoia and Kings Canyon National Parks and help fill important science information gaps regarding climate-informed reforestation approaches in mixed conifer forests.

This research is critical to effectively addressing threats to forest resilience, endangered species habitat, and overall ecosystem health throughout the burned forest lands of California and is crucial to meeting several state and federal goals. Current estimates from the State of California indicate that as much as 6.4 million acres of forest in California currently needs post-fire reforestation. The state’s recently released Nature Based Climate Solutions Targets identifies a post-fire reforestation goal of 322,000 acres per year while the state’s Wildfire and Resilience Task Force Draft Reforestation Strategy targets 1.4 million acres to address fire damage from 2019-2022. Additionally the US Dept of Agriculture has a goal of post-fire reforestation on 2.3 million acres by 2030 in Oregon and California. Loss of habitat due to high severity fire is a primary reason for listing on the Endangered Species Act for California Spotted Owl and Fisher. In order to meet these important goals and protect ecosystem health, wildlife habitat, carbon storage, and recreation and tourism income, just to name a few overlapping goals, we need to understand how to effectively and efficiently implement reforestation under hotter, drier conditions and higher fuel loads.

Over the past decade, Sequoia and Kings Canyon National Parks (SEKI) have experienced several large and severe wildfires, significant climate warming, and widespread drought-induced tree mortality that have dramatically altered our forest landscapes. This has led to a substantial loss of large, iconic giant sequoia trees and a deficit in post-fire giant sequoia regeneration in severely burned areas, which may result in the permanent loss of sequoia grove area throughout the southern Sierra Nevada. Science-based information on the effectiveness of climate-smart reforestation practices is essential to successful post-fire restoration efforts within SEKI in an era of rapid environmental change. The proposed work by Tree People, the U.S. Forest Service, and colleagues will help support SEKI’s efforts to better understand the effectiveness of climate-informed reforestation techniques in comparison to other more conventional reforestation approaches currently employed by U.S. Forest Service and land ownerships. This approach will promote successful post-fire reforestation practices under a warming climate prone to future wildfires and exceptional droughts.

The new approaches proposed in this research are feasible – we are currently using them in our efforts to restore five giant sequoia groves and a fisher critical habitat corridor, however they have not been comprehensively tested across the landscape. The proposed approach, which involves multiple landowners across a wide range of environmental conditions, is a very effective way to understand how effectiveness may vary across environmental gradients and past land use history.

The principal investigators have a history of successful collaboration with SEKI in fire effects monitoring and science delivery. This includes an ongoing project focused on post-fire regeneration in giant sequoia groves and mixed conifer forests, which has had implications for reforestation in high severity burned areas of SEKI. I enthusiastically support their monitoring proposal for funding.

Sincerely yours,

Best wishes,

Christy Brigham Ph.D.
Chief of Resources Management and Science

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RESOURCE CONSERVATION DISTRICT

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Effectiveness Monitoring Committee
P.O. Box 944246
Sacramento, CA 94244-2460

June 17, 2024

Dear Effectiveness Monitoring Committee:

Feather River RCD would like to express our support for the "Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests" implementation and monitoring proposal submitted by Tree People, the Pacific Southwest Region Ecology Program (REP), the Pacific Southwest Research Station (PSW), and colleagues. The proposed work will provide public and private land managers in California with much needed scientific information about the use of climate-informed reforestation techniques and maintenance treatments in coniferous forest ecosystems.

Over the past two decades, California has experienced numerous large and severe wildfires that have created a tremendous reforestation backlog exceeding 1.5 million acres. In the face of a warming climate and exceptional droughts, there is a critical need for science-based guidance to inform post-fire reforestation practices that produce resilient, diverse, and productive forest stands for current and future generations. Feather River RCD is one of the leading implementation bodies for reforestation on private non-industrial forests in Plumas County. The monitoring and implementation support proposed by Tree People, REP, PSW, and colleagues will greatly assist our program in reforestation efforts by assessing the effectiveness of climate-smart reforestation techniques and developing science-based reforestation practices that are resilient and sustainable in the face of uncharacteristically severe wildfires, climate change, and other ecosystem stressors. The conditions and landscapes our Districts serves are representative of the type of high severity, cross boundary, wildfires to be expected into the future. Our organization relies on best available science to implement effective reforestation

The REP, PSW, and Tree People have the unique technical expertise, scientific qualifications, and partnership experience necessary to successfully carry out the proposed monitoring work. The principal investigators and collaborators have a long and successful track record of executing, publishing, and applying the results of effectiveness monitoring projects throughout California. Collectively, this team has decades of experience monitoring the effectiveness of forest restoration, post-fire management, and other vegetation and fuels treatments on federal, state, and private lands in California. We wholeheartedly endorse their effectiveness monitoring proposal and look forward to working with them on this important effort.

[redacted]

Michael Hall
District Manager

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Agriculture and Natural Resources

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July 23rd, 2024

California Board of Forestry

Dear Effectiveness Monitoring Committee,

I am writing to provide support for the proposal by TreePeople titled *Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests.*

As you are aware, there is a great need for reforestation, especially after high severity wildfire, in California's yellow pine and mixed conifer forests, both on public and private land. The US Forest Service has pioneered a new strategy (planting for the Individual, Clumps and Openings – ICO) structure. To date this planting strategy has primarily been carried out on public lands. However, to be able to use these methods on private lands (after timber harvest), compatibility with the state's Forest Practices Act must be assessed. I think that such an assessment is important for the future planning of our state's forest landowners, especially private non-industrial landowners (NIPF).

There are 75,000 NIPFs in California that own 10 acres of forest land or more. In my role as an extension forester, I have conducted outreach and education programs on forest stewardship and post-fire forest restoration. To date we have had long-term personal interactions with nearly 1,000 NIPF landowners across the state through our workshops and field days. We also have on-going newsletters, blogs, and social media reach landowners and many others in the state. Our statewide forestry newsletters reach almost 10,000 subscribers.

Though I'm not currently aware of any private landowner who has undertaken planting for the ICO pattern, I pledge to provide support to this project through outreach and education using our various outreach methods. We will feature the subject of planting patterns in one of our bi-monthly newsletters and solicit involvement in the project by landowners who are interested in exploring patterned plantings on their own property.

Please feel free to contact me with any questions. I hope you will consider this application favorably.

Sincerely,

Susie

Susie Kocher, Forestry Advisor, Registered Professional Forester #2874

University of California Cooperative Extension – Central Sierra (El Dorado, Calaveras, Amador and Tuolumne Counties)

Al Tahoe Learning Center - 1100 Lyons Avenue, South Lake Tahoe, CA 96150

[redacted]

Save The Redwoods
LEAGUE

Effectiveness Monitoring Committee

P.O. Box 944246

Sacramento, CA 94244-2460

Dear Effectiveness Monitoring Committee:

On behalf of Save the Redwoods League, I wish to express my sound support of the proposal prepared by Tree People, the U.S. Forest Service, and colleagues entitled "Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests". The proposed work will considerably inform the League's ongoing post-fire restoration and reforestation work in giant sequoia groves located on both federal lands and on League property.

In recent years, several large and severe wildfires have significantly impacted giant sequoia groves throughout the Sierra Nevada, resulting in an unprecedented loss of large giant sequoia trees throughout the region. Coupled with significant climate warming and widespread drought-induced tree mortality, these groves and surrounding forest landscapes are extremely vulnerable to disappearing at a rapid rate. Due to the unprecedented nature of extensive, contiguous high severity patches within giant sequoia groves, the League and its partners in the Giant Sequoia Lands Coalition require timely science-based information on the effectiveness of climate-informed reforestation practices to successfully restore giant sequoia groves that are failing to naturally regenerate after very severe and large wildfires. The proposed work by Tree People and colleagues will help support the League's efforts to use the best available science to restore sequoia groves on both federal and private lands. We see this as an essential step that fosters greater collaboration and shared learning within the Giant Sequoia Lands Coalition and its many active members.

The League believes that Tree People and colleagues have the scientific expertise and partnership experience necessary to successfully carry out the proposed effectiveness monitoring project. For example, over the past few years one of the proposal's principal investigators has been successfully leading post-fire regeneration monitoring efforts in a number of sequoia groves on the Giant Sequoia National Monument and Sequoia and Kings Canyon National Parks. We are excited about this proposed project that aligns greatly with the League's and Coalition's goal of conserving and stewarding giant sequoia groves ecosystems across its geographic range. We sincerely hope you will consider funding their monitoring proposal.

Sincerely yours,

Ben Blom

Digitally signed by Ben Blom
DN: OU=Programs, O=Save the Redwoods League, CN=Ben Blom, E=bblom@savetheredwoods.org
Reason: I am the author of this document
Location: your signing location here
Date: 2024-07-22 14:10:32
Foxit PhantomPDF Version: 10.0.0

Ben Blom

Director of Stewardship and Restoration

July 19, 2024

State of California
The Natural Resources Agency
Effectiveness Monitoring Committee, State Board of Forestry and Fire Protection
Effectiveness Monitoring Program Grant Guidelines

To Whom It May Concern,

I am writing on behalf of American Forests to express our support for the U.S. Forest Service (USFS) and TreePeople's "*Reforestation for Resilience: Evaluating Climate-Smart Reforestation Techniques in California's Mixed Conifer and Yellow Pine Forests"* project.

This project is an important and timely effort to improve the success of reforestation and ecological restoration in the face of compounding challenges including wildfire, climate change, and critical shortages across the reforestation supply chain. By rigorously monitoring and evaluating non-traditional planting designs, this applied research has the potential to outline which treatments most effectively confer resilience to stressors at a young age and make the most efficient use of scant collective resources.

This proposal aligns with American Forests' mission to create healthy and resilient forests that benefit people, wildlife, water and the climate. In California, we are working toward achieving postfire ecological restoration and early resilience to future stressors. American Forests supports the direct impact this project will have on improving our ability to achieve these goals by refining best practices and bolstering them with the best available science. American Forests will work with the applicants to identify opportunities to support implementation of these efforts, and to disseminate the resulting findings.

We are pleased to support TreePeople and the USFS on this proposal and urge your consideration for the application submitted.

Sincerely,

[redacted]

Leana Weissberg
Director, California