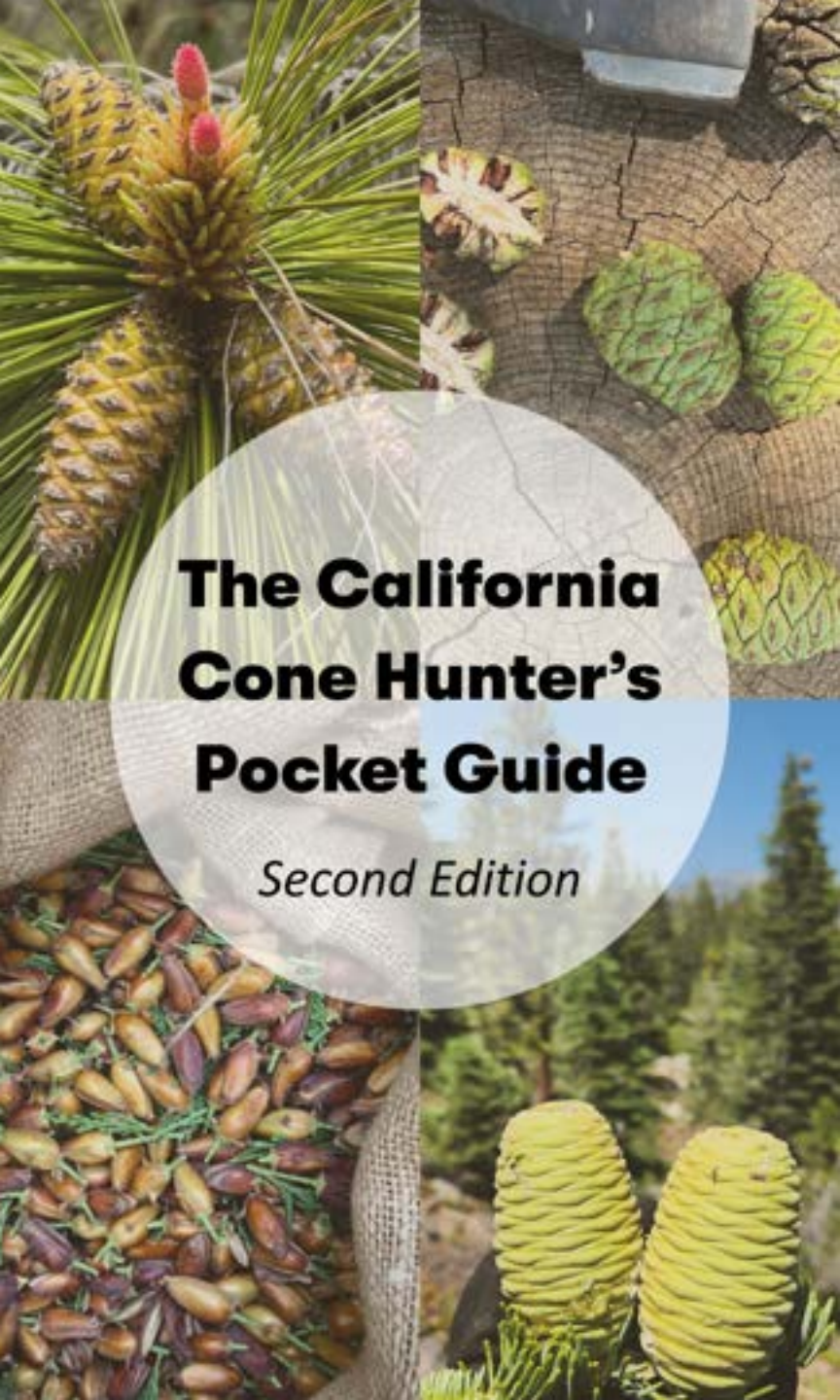

The California Cone Hunter's Pocket Guide

Second Edition

This pocket guide belongs to:

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The California Cone Hunter's Pocket Guide

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About this Guide

The California Cone Hunter's Pocket Guide (Second Edition) was developed to provide clear, concise, practical guidance and essential resources for those participating in cone collection efforts, particularly in wild stand collections. Developed in close cooperation with the California Department of Forestry and Fire Protection (CAL FIRE), the USDA Forest Service, and private industry experts, this guide aims to create a shared language, standardize best practices, and promote effective collaboration. Additionally, it seeks to equip readers with the knowledge and tools to harvest high-quality seeds.

Whether you are surveying forests, leading collections, climbing trees, or planning the logistics, this guide intends to empower readers to support successful cone collections. By uniting contributors with a shared purpose and approach, together cone hunters can restore California's forests and strive to meet reforestation demands to protect these crucial ecosystems for future generations.

Indigenous Acknowledgment

It is important to acknowledge that Indigenous peoples of California have collected, stored, eaten, utilized, and shared conifer seeds since time immemorial. Indigenous lineages carry these significant cultural and traditional values and knowledge to this day. There are many ways conifer cones and seeds were and are gathered and utilized across California, including as a critical food source, in medicinal remedies, and for trade, ornamentation, and ceremony. These practices involve species ranging from sugar pine (*Pinus lambertiana*), singleleaf pinyon pine (*Pinus monophylla*), gray pine (*Pinus sabiniana*), coulter pine (*Pinus coulteri*), and Jeffrey pine (*Pinus jeffreyi*) to Colorado pinyon pine (*Pinus edulis*).

The collection practices of the many unique California Native American Tribes differ, sometimes widely, from place to place and from species to species, using methods such as tree climbing, hooked sticks, and pruning (Anderson, 2005). Native people were known to skillfully climb trees, some over 200 feet in height, adapting their methods and tools to the size and form of the tree. As Anderson (2005) notes in Tending the Wild, "the Sierra Miwok, for example, propped a dead tree against the trunk to serve as a ladder, or used a special climbing pole. To retrieve the cones on young trees, the Pomo lashed a deer antler to the end of a straight pole" (p. 180).

Not only did Native people of California skillfully collect cones through their methods, but also through their knowledge of place. For example, it has been said that the Washoe people know when pinyon pinecones are ripe for harvesting when the rose hips, the fruiting bodies of Rosa californica, in the area reach a certain hue of dark red. This type of place-based Indigenous knowledge is not widely available in the written record, and instead has been passed down orally and through practice over many generations. In many cases, this is privileged knowledge within communities, with its sharing governed by trust, consent, cultural responsibility, and respect for Tribal sovereignty.

The activities of cone surveying, monitoring, and collection have deep cultural roots and meaningful traditions for Indigenous peoples across California, with practices tracing back millennia. "Mature trees that reached an age of more than five hundred years must have had grandfathers, fathers, sons, and grandsons for many generations climb their trunks" (Anderson, 2005, p. 180). Cone scouts and collectors alike can respect this truth by being mindful of the land, trees, cones, and seeds that they survey, sample, and collect. While the forest provides people and wildlife with shelter, habitat, food, medicine, and culture, people and wildlife can, in turn, cultivate, maintain, protect, and restore the forest to continue the life-sustaining cycle that starts with a single seed. Cone scouts and collectors can also recognize the privilege of participating in seed collections from trees that many Tribes no longer have access to due to colonial settlement, development, habitat degradation, and the loss of land access.

This guide is primarily written as guidance for cone surveying, monitoring, and collection according to Western forestry practices. Considering the protected nature of Indigenous knowledge, as well as its historical and modern extraction and misuse, this guide does not attempt to offer a comprehensive overview of Indigenous practices in conifer seed collection.

Recommended reading

Anderson, M. K. (2005). Tending the wild: Native American knowledge and the management of California's natural resources. University of California Press.

- Paying Attention to Cyclical Changes (p. 53)
- Promoting Open Montane Forests Studded with Large Sugar Pines (p. 179 - 181)
- Pine Nuts (p. 280 - 281)
- Gray Pine (p. 281 - 283)
- Singleleaf Pinyon Pine (p. 283 – 285)
- Threats to Traditional Gathering (p. 318 – 325)

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Introduction

California's conifer forests span nearly 19 million acres, providing critical ecological, cultural, climatic, and economic value (Brodie & Palmer, 2020). However, these forests face a growing crisis, with over 8.2 million acres burned and 247 million trees lost to drought, pests, and disease since 2010 (CAL FIRE, 2022; Office of Environmental Health Hazard Assessment, 2025). High-severity wildfire driven by climate change, fire exclusion, loss of cultural burning, and dense fuel loads have placed approximately 1.5 million acres of land at risk for permanent forest loss—highlighting the urgent need for active restoration (Hessburg et al., 2021; Steel et al., 2015; Wang et al., 2022; Denniston et al., 2014; Parks & Abatzoglou, 2020).

The reforestation pipeline—a coordinated process for seed collection, seed processing and banking, nursery seedling production, site preparation, planting, and post-planting monitoring—aims to support the active recovery of post-fire landscapes (Fig. 1). Large-scale reforestation efforts of conifer forests are strongly dependent on availability and access to local seed as they require careful selection of seed sources to optimize genetic and climatic suitability to planting sites. Compatible seed sources needed for reforestation projects have been depleted in recent years due to wildfire, insect infestations, disease, drought, and workforce shortages, leaving cone crops uncollected and public seed banks in short supply of appropriate genetic material to meet the high reforestation demands.

This, California cone hunters, is where **you** enter the picture.

Figure 1. Reforestation pipeline from cone collection and seed processing through nursery production, site preparation, outplanting, and monitoring.

Cone collection is the critical first step in the reforestation pipeline—supplying seed banks and nurseries that provide the seedlings necessary for replanting efforts across the state, while aiming to bolster genetic diversity and climate resilience. In California, that work includes capturing extraordinary ecological diversity across 85 seed zones (designated geographic areas defined by the U.S. Forest Service and CAL FIRE based on similar climate, soil, and topography), more than 12,000 feet of elevation variation (separated into 500 ft. increments for seed sourcing), and more than 50 native conifer species statewide, with approximately 15 common species routinely prioritized for large-scale reforestation seed collection. Capturing this geographic, elevation, and species-level variation is essential to ensuring that seed banks represent the vast range of local and climate-adapted seed sources needed for current and future reforestation efforts. By preserving this diversity, seed banks help land managers match seed to appropriate planting sites, strengthen long-term forest resilience, and scale reforestation toward California's 1.5-million-acre need.

Cone collection at a glance

There are three primary methods of procuring native conifer seed:

- **Seed orchards** are planted and managed environments where trees, often grafted with local root stock, are cultivated to produce high levels of genetic variation and high-quality seed to propagate desirable traits, such as improved growth, volume, and pathogen resistance. These orchards are carefully monitored to optimize cone production, ensuring a consistent and reliable seed supply.
- **Seed production** areas are typically established in young cone-bearing stands with gentle slopes and landscapes that are operable with tracked vehicles. Stands are maintained through active thinning by silviculturists.
- **Wild stand** seed collection occurs in natural unplanted forest environments. Collecting from wild stands requires identifying genetically diverse and well-adapted trees, often in challenging terrains, and timing the harvest precisely to maximize the viability of seeds collected.

While orchards offer efficiency, uniformity, and are a necessary tool for the future of seed procurement in the state, wild stand collections continue to be an important and accessible seed source contributing to genetic diversity and volume of seed stores in the state. **This guide is primarily focused on wild stand collection methods.**

Wild stand collections

Wild stand collections can be broken down into three general phases: surveying, monitoring, and collection. The cone season begins with identifying stands of suitable trees with developing cone crops—this is known as cone surveying. After stands with significant cone crop have been identified from surveying, it's important to regularly return to surveyed sites of interest to assess the maturity and viability of the cone crop through sampling—this is known as cone monitoring. Once cones show signs of ripening and seed viability, cones can be collected, bagged, and tagged for transportation and processing at a seed extractory.

These phases typically have some overlap as different locations and species can vary in their developmental timeline (Fig. 2). Cone crop surveys can begin as early as late spring and continue into mid-fall depending on species, elevation, latitude, and regional weather. After surveyed stands have been selected for continual observation and sampling, cone monitoring occurs until the cones and seeds are developed enough for harvesting. Typically, this ripening occurs in early summer and continues through fall but varies by species, elevation, and seasonal weather throughout California's ecoregions.

Figure 2. Recommended time of year to conduct cone surveying, monitoring, and collection.

How cones are made

Vascular plants such as trees can be categorized into angiosperms (flowering plants that produce seeds enclosed within fruits) and gymnosperms (non-flowering plants that produce seeds exposed on cones or other structures). Conifers are a subset of gymnosperms, characterized by their cone-bearing reproductive structures including both male (pollen) cones and female (seed) cones (see Fig. 3; Bonner & Karrfalt, 2008; Clark et al., 2018).

In most conifer species, both pollen and seed cones are found on the same tree (monoecious) as opposed to being produced on separate trees (dioecious). Male cones generate pollen grains containing sperm cells, which are dispersed by the wind. When pollen grains reach a receptive female seed cone, they adhere to the ovule. Once attached, the pollen grain germinates and forms a pollen tube, which grows towards the ovule. This tube delivers sperm cells to an egg cell within the ovule, leading to fertilization (Bonner & Karrfalt, 2008; Clark et al., 2018; Williams, 2009).

Unlike angiosperms, most gymnosperms do not rely on pollinators for this process. Following fertilization, the ovule develops into a seed containing the embryo of a new plant. The seed is protected within the cone until it is mature enough to be dispersed (Clark et al., 2018; Williams, 2009).

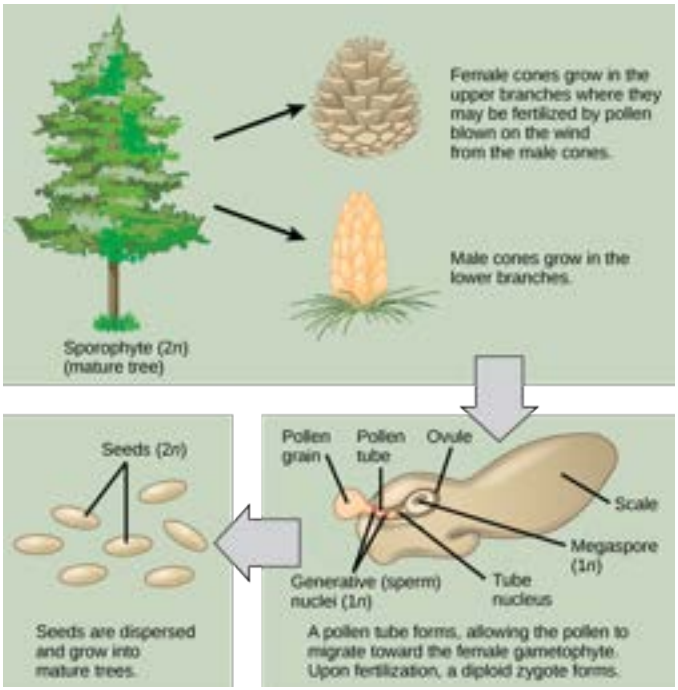

Figure 3. Conifer life cycle. *Source: OpenStax, Biology 2e.*

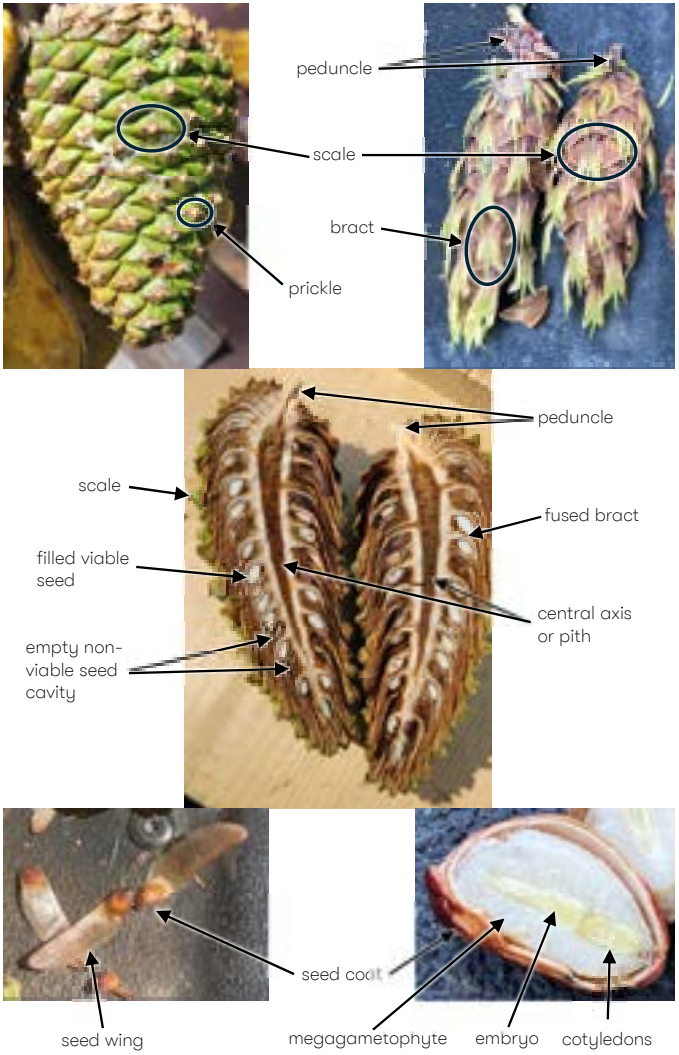

Figure 4. Ripening Jeffrey pine cone (top left), ripe Douglas-fir cones with visible mouse tail-like bracts (top right), cut test of ripe ponderosa pine cone with high seed count and less conspicuous bracts fused to scales (middle), ripening ponderosa pine seeds with attached seed wings (bottom left), and cut test of sugar pine seed showing a viable seed with healthy megagametophyte tissue and 100% embryo fill (bottom right).

Cone anatomy

A female cone is composed of several key structural components that support seed development and dispersal (see Fig. 4). At its core is the **central axis** also known as the **pith**, which provides the main support and holds the cone's scales in place. Attached to this axis are the **scales**, the primary structures that house and protect the developing seeds. Beneath each scale lies a **bract**, a modified leaf-like structure that may be small and hidden or fused to the scale upon maturity in some species (e.g., ponderosa pine, white fir, sugar pine, etc.) or more prominent and visible in others (e.g., Douglas-fir, Shasta red fir, noble fir). The seeds develop on the upper surface of the scales, nestled securely until they are ready for dispersal. Some cones also feature a **prickle**, a small, sharp projection on the scales (e.g., 'prickly' ponderosa pine). The entire cone is connected to the tree by the peduncle, a short stalk that attaches it to a branch, ensuring stability throughout the seed maturation process (highly visible in some species, such as sugar pine) (Bonner & Karrfalt, 2008; Kolotelo, 1997).

Each **seed** within the cone contains multiple specialized parts essential for germination and early growth. The **seed wing** is a thin, papery extension that aids in wind dispersal, allowing the seed to travel away from the parent tree. Encasing the seed is the **seed coat**, a protective outer layer that shields the delicate structures inside from injury and varying environmental conditions. Within the seed, the **megagametophyte**, a firm whitish opaque tissue surrounding the embryo, provides stored nutrients that sustain the embryo during germination. At the heart of the seed lies the **embryo**, the young, developing plant that will grow into a new conifer if conditions are favorable. The embryo contains **cotyledons**, the first seed leaves that help provide energy for early growth until the seedling can photosynthesize on its own. Together, these components ensure the successful reproduction and spread of conifer species across their habitats (Bonner & Karrfalt, 2008; Kolotelo, 1997; Clark et al., 2018).

Cone development

Depending on the species, cones take one or two years (or seasons) to reach full maturity after fertilization, with the exception of Torrey pine (*Pinus torreyana*) cones, which require three years for development.

Commonly collected species that take **one year** or **one season** (spring to fall) for cones to develop include firs, spruces, hemlocks, and others. This includes species such as Douglas-fir, white fir, red fir, incense cedar, redwoods, and mountain hemlock (see illustrative example of Douglas-fir, Fig. 5).

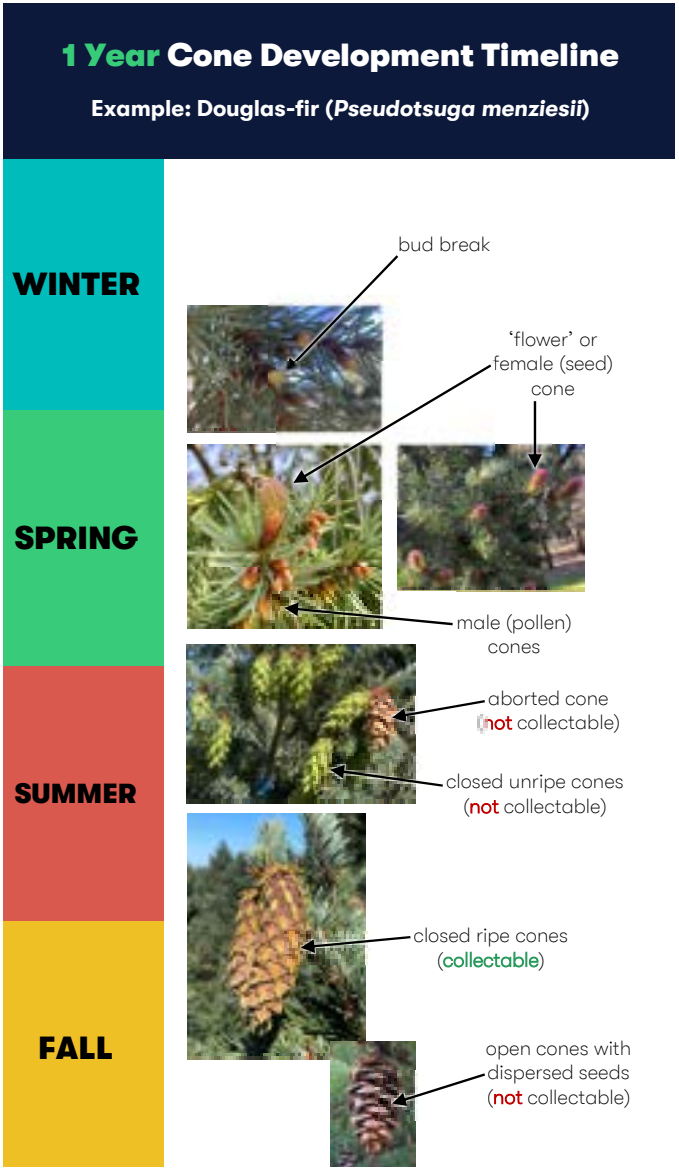

Figure 5. One-year cone development timeline for Douglas-fir (*Pseudotsuga menziesii*), showing representative photos corresponding to the seasonal progression from bud break and flowering to cone ripening and seed dispersal.

Commonly collected species that take **two years** for cones to develop include many pine species such as sugar pine, ponderosa pine, Jeffrey pine, western white pine, lodgepole pine, and others. These species can present both one-year 'conelets' and two-year cones on the same tree at any given time (see Fig. 6 and 7). While surveying, it's typically easy to distinguish one-year conelets from the two-year cones. Knowing which species may produce conelets in the targeted survey area may help to avoid mistaking first-year conelets as a viable crop for the current season. One-year conelets can be recorded during surveying to mark potential crops for the following year. Check **Appendix J** (p. 82) for more species-specific information, as developmental timelines can vary significantly between species.

Figure 6. The first year of cone development for ponderosa pine (*Pinus ponderosa*), showing representative photos for two-year species corresponding to the seasonal progression from flowering to conelets.

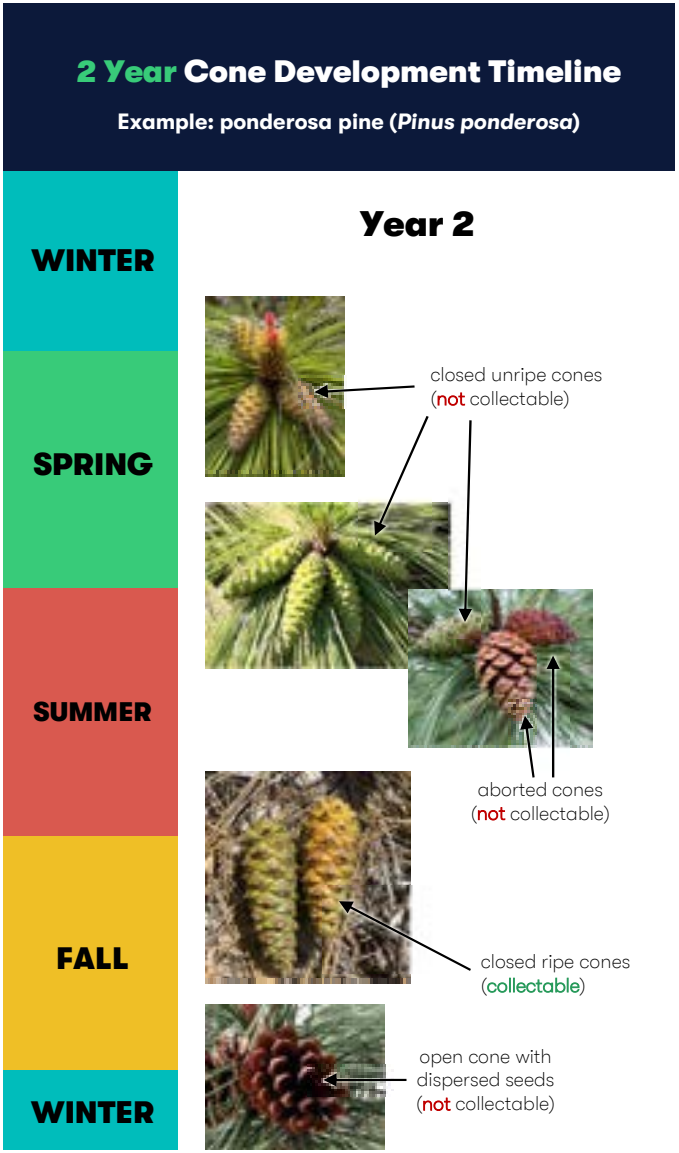

Figure 7. The second year of cone development for ponderosa pine (*Pinus ponderosa*), showing representative photos for two-year species corresponding to the seasonal progression from unripe to ripe closed cones then to open cones.

Cone crop periodicity

Conifers often exhibit cyclical patterns of cone production, with some years characterized by abundant cone production and others by fewer cones. For some species, good crops may occur roughly every 3 years, while exceptional **bumper crops** (also known as 'mast year' or 'masting event'; the production of larger than average cone crops) occur less frequently. In some cases, the interval between good crops, also known as **periodicity**, may be as long as 10 to 15 years in certain species (Burns & Honkala, 1990; USFS, 2013).

While estimates of cone crop intervals exist for some species, average periodicities are still being determined for many. In other species, crops are produced sporadically and lack a defined interval (e.g., redwood). Several other factors can influence regular crop production and mast events including local site characteristics, elevation, age, varying climatic and seasonal conditions, and stress (USFS, 2013). Recent studies demonstrate declines in the frequency of masting events in species such as pinyon pine due to climate change (Redmond et al., 2012).

Tree identification and species-specific information

It is critical to know how to identify different tree species accurately when cone hunting. Proper tree identification ensures accurate cone surveys and labeling of cones during collection. Many species can appear very similar to others (e.g., ponderosa pine and Jeffrey pine; red fir and white fir) but have key differences. Additionally, it is essential to understand species-specific variations in cone production and visual indicators that distinguish a heavy crop from a light crop. Knowing species-specific information with help ensure accurate timing for surveys, monitoring, and collection, as well as proper evaluation of crop size and quality.

See '**Appendix J: California conifer codes, identification, and cone development guide**' for help with identifying native conifers and specific information on cone production. Other useful resources include:

- *Trees and Shrubs of California* (Stuart & Sawyer, 2001)
- *Pacific Coast Tree Finder* (Watts, 2004)
- SelecTree: *A Tree Selection Guide* (Urban Forest Ecosystems Institute, 1995–2026)
- *The Woody Plant Seed Manual* (Bonner & Karrfalt, 2008)

Materials & Equipment

Cone Surveying

4x4 vehicle. Highly recommended for varying road conditions.

Binoculars. Visualize cones and accurately evaluate crops from a distance.

Emergency communication device. Access to contact authorities or emergency contacts when in remote locations with no phone service (e.g., Garmin inReach).

Field apparel and personal supplies. Prepare for the outdoors (e.g., hiking boots, extra layers, extra food and water, sunscreen, sunglasses).

First aid kit. Safety recommendation (e.g., insect bite/sting treatment, allergy medication, tweezers, electrolytes, ibuprofen, band aids, gauze, alcohol wipes, etc.)

GPS device & pre-downloaded Survey123 app with CA Cone Crop Survey. Digitally report surveys, recording latitude and longitude (e.g., smartphone, tablet).

Hard hat. Safety recommendation for walking under trees and sampling cones.

Notebook and pen. Record information about the stand or keep count of trees with crop.

Species identification guide or dichotomous key. Accurately identify observed species (see Appendix J).

Cone Monitoring

All of the same supplies needed for cone surveying are also recommended for monitoring with the following additions:

Big Shot Sling Shot / Air Powered Tree Access (APTA) with a throwline kit. Shoot throwlines high into the trees to knock or shake out cones off branches (see Appendix B).

Colored flagging. Physically mark trees for continual monitoring or collection.

Cone cutter. Cut cones longitudinally to assess the cone ripening and seed development and quality (see Appendix C).

Gloves. Handle sappy or sharp cones (e.g., disposable and leather gloves).

GPS mapping platform. Plot stands and selected individual trees for continual monitoring (e.g., Avenza, ArcGIS Field Maps, Google Earth).

Sap Removal Supplies. Remove sap from hands and clothing (e.g., hand sanitizer, alcohol wipes, baby powder, Goo Gone, etc.).

Seed Dissection Tools. Assess seed development and quality (e.g., pocket knife, razor blades, tweezers).

Cone Collection

All of the same supplies required for cone surveying and monitoring are also recommended for collection with the following additions:

4- or 5- gallon bucket. Measure bushels of cones for bagging.

Bushel bags. Bag cones for transportation, delivery, and storage. Mesh or burlap materials with high ventilation. No plastic or other materials with low ventilation. Check with the recipient seed extractory to see if there are available bags or specific requirements.

Cone collection tags. Identify the bushels collected. Two tags are needed per bushel (one inside, and one tied outside). Check with the recipient seed extractory for access to tags (e.g., state and federal seed banks have agency-specific tags that can be provided).

Permanent markers. Fill out collection tags.

Various colored flagging. Differentiate bushels by collection site and/or species. This can support efficient processing at the extractory and is required by some (e.g., USFS R5 Placerville Nursery).

Walkie-talkies / Two-way radios. Communicate between ground crew and climbers.

Zip ties. Secure the end of the bushel bag (~3 inches from the top).

Cone Surveying

Figure 8. Cone surveying by road and binoculars.

Before cones can be collected, cone crops must first be located, evaluated, and reported through cone surveying. Because cone production is cyclical and varies by year, stands must be surveyed annually to determine where viable cone crops are present. As the critical first step to wild stand cone collection, surveying typically consists of:

- **Route planning:** prioritizing routes by seed needs; securing land access; and reviewing maps for landownership boundaries, accessibility, vegetation types, and fire scars.
- **Exploring the great outdoors in search of desirable cone crops:** driving forest roads for many hours and hiking with a good pair of binoculars, assessing stand conditions and crop availability.
- **Reporting:** recording information about the location, accessibility, site conditions, species, number of seed trees, crop ratings, bushel estimates, and photos.

When to survey

Many of the commonly collected conifer cones ripen in late summer and early fall. Surveying takes place before this ripening period begins to allow for time to cover ground and to track the crops as they develop. Surveying typically occurs over the summer, starting as **early as May or as late as July**, depending on the region, elevation, species, and capacity to survey (Fig. 2; see Appendix J for species-specific timing).

Preparing to survey

Land access. Determine and contact the appropriate land manager or landowner and obtain permission, access, and any relevant local knowledge. For private land, the landowner must be contacted directly to secure permission to access the property. It is also important to ask whether the property has any locked gates that require keys or gate codes, any unfriendly dogs or hazardous road conditions, and if the landowner has downloadable maps that can be shared. **Resources for landownership boundaries can be found in Appendix D**.

Field conditions and vegetation types. Check weather, road conditions, fire history, vegetation types, and nearby gas stations before conducting field surveys. Satellite imagery can help identify fire scars, vegetation patterns, and areas without living conifers to support route planning and avoid unproductive survey areas. Weather reports should be reviewed for rain, snow, poor air quality, or active wildfires, and fuel stops should be identified in advance. **Resources for vegetation types can be found in Appendix D**.

Download offline maps. Be prepared to navigate without phone service by downloading maps to a smartphone or tablet before entering the field. Apps such as Avenza or Google Earth can store offline maps and provide tracking and GPS mapping. **Resources for offline maps can be found in Appendix D**.

Identify Seed Needs. If there is limited capacity to cover ground, use seed need information to prioritize areas and routes by species, elevation band, and seed zone. Additionally, consider climate-adapted seed needs when prioritizing survey areas, routes, and target species. Seed collected across a wide range of seed zones, elevation bands, and site conditions helps seed banks maintain the genetic diversity needed for climate-informed reforestation, seed transfer planning, and assisted migration. **Resources for identifying seed needs and climate-adapted seed planning can be found in Appendix D**.

Assessing stands & tree conditions

If several seed trees (trees with cone crops) are observed, surveyors should stop and inspect the area, as additional crop trees may be present nearby. Once a crop is identified, evaluate and record information about the site conditions and the seed trees (Table 1). This information helps determine whether a crop is suitable for further monitoring and collection by providing key insights into the stand's genetic integrity, crop abundance, operational feasibility, and financial viability.

The recommended standards presented are intended as best-practice guidelines for recognizing strong candidate stands (**Table 1**). In practice, not every stand will meet each standard for collection—suitability often depends on how multiple factors balance together, including seed need, crop abundance, genetic diversity, access, slope, vegetation density, etc.

Surveyors should report all observed cone crops regardless of whether they appear to meet ideal collection standards. Seed bank managers and local resource specialists will review the submitted data and determine whether a crop is suitable for further monitoring.

Check with regional or local authorities to determine if there are specific guidelines for cone surveying due to variations in seed need, specialized collections, operational capacity, etc.

What is a stand for cone collection?

When identifying a stand for cone collection, a 'stand' is defined differently from a traditionally forestry stand. In general forestry terminology, a stand is an aggregation of trees or other growth occupying a specific area and sufficiently uniform in species composition, size, age, arrangement, and condition as to be distinguished from the forest or other growth on adjoining areas (Ford-Robertson, 1971). For cone collection, the term is used more practically to describe a defined spatial area of trees presenting cone crop that also demonstrates relative unity in species composition, elevation, and other geographic or ecological features.

Stand size can vary greatly depending on the cone crop distribution, topography, geology, and operational accessibility. For example, a mid-slope, west-facing road, spanning 40 acres at a constant elevation could be considered a stand, while a small seven-acre parcel may also function as an appropriate stand for collection. A key consideration when determining a stand should be genetic integrity—prioritizing collections with many trees that are adequately spaced apart.

When learning to survey, it may help to start by interpreting a stand as an area with cone crop extending roughly along a quarter mile of road—enlarging or shrinking the area depending on the crop present along with other distinguishing factors. Other considerations and variations to consider when determining the stand boundaries include:

- Changes in slope orientation (aspect).
- Changes in elevation. Functionally for seed sourcing, cone collection stands are separated by 500 ft. increments. For example, if a crop was identified near 2,200 ft. in elevation, the boundaries of the stand should remain within 2,000 - 2,500 ft. Generally, any trees below 2,000 ft. or above 2,500 ft. would be considered part of a separate stand.
- Dramatic changes in other geographic and ecological features (species composition, canyons, rivers, soil types, etc.).
- Operational and financial feasibility (accessibility and safety for climbers, ground crew, and vehicles, and budgetary constraints).

Table 1. Guidelines for desirable candidate stands and key characteristics to evaluate and record.

Characteristic	Recommendation
Number of stands and spacing between stands for seed lots	**≤ 20 unrelated stands, ~200 feet apart.** It is recommended to collect and combine (bulk) seed from up to 20 unrelated stands separated by 200 ft. within a given seed zone and elevation band. Seed from stand collections can be bulked at seed banks to meet agency-specific seed lot diversity standards.

Table 1 (continued). Guidelines for desirable candidate stands and key characteristics to evaluate and record.

Characteristic	Recommendation
Number of Seed Trees per Stand	**≥ 10 trees; 20 – 30 trees per species is ideal.** Fewer trees are acceptable if more stands nearby will also be collected within the same elevation band and seed zone. Aim to collect equally from each tree to ensure that no individual tree contributes to more than 10% of the total collection. Only count and report potentially collectable seed trees that are free of disease, accessible, and adequately spaced apart (e.g., if two seed trees are within 100 ft. of each other, only account for one tree). Generally, do not include trees with light crops (dependeing on seed need or purpose of collection; e.g., high seed need, MGR testing, etc.).
Spacing Between Collectable Trees	**100 – 300 feet minimum.** Spacing between trees is crucial to optimize diversity by collecting from genetically unrelated individuals (Figure 10). Collecting cones from related trees in a stand is strongly discouraged and can compromise the genetic integrity of a seed lot.
Stand Type	**Native conifer stands only; avoid plantations and unique sites.** Seed sources are often unknown in planted forests and may not match local genetics. Planted forests are typically identifiable through visual uniformity in species, age, and layout. Avoid areas with unique site traits, such as unusual soils (e.g., serpentine), extreme or marginal environments, or small, isolated stands with low genetic diversity.
Vehicle Access	**Select trees within ~200 feet from the road.** Full bushel bags and climbing gear are heavy. Ensure that the reported trees allow for relatively easy access to vehicles. If collecting from roadside trees with high traffic, ensure that proper traffic control is set in place for the collection (e.g., traffic cones, extra crew, caution tape, etc.)

Table 1 (continued). Guidelines for desirable candidate stands and key characteristics to evaluate and record.

Characteristic	Recommendation
Vegetation	**Avoid dense understory.** Thick vegetation is difficult to navigate and operate in (Figure 9). If cones are harvested via dropping to the ground, it will be very difficult to gather fallen cones that are hidden or inaccessible.
Slope	**Minimal sloping.** Steep slopes can make it difficult and dangerous for both climbers and ground crew. Aim to select stands with flatter, walkable terrain to ease navigation and the transportation of materials (Figure 9).
Plant and Animal Hazards	Check for the presence of poisonous plants (e.g., poison oak), reptiles (rattlesnakes), beehives, wasps' nests or other potentially dangerous insects.
Tree structure & climbing considerations	When there is canopy diversity in the stand, what a climber may consider desirable to collect may differ from what an ecologist or forester would prefer for genetic diversity. Where there are no conical canopies to choose from, due to species phenotype or stand maturity, it is up to the collection manager to determine what trees to target for collection, and it is up to the climber to determine if they feel safe to climb. In general, it's recommended to: • Avoid split tops (co-dominant stems) by observing the tree with binoculars from different sides (Fig. 11). • Avoid unhealthy and hazardous trees (See Appendix A; Fig. 11). • Avoid heavily downward or upward sloping ('cathedral') branches. Notably, production climbers will generally avoid 'mushroom' or 'lollipop'-shaped trees in most species with the exception of giant sequoia and Major Gene Resistant (MGR) sugar pine (Fig. 11).

Figure 9. Ideal site conditions with minimal vegetation and slope and adequate vehicle access (left), suboptimal site conditions with high vegetation (middle) and steep slopes (right).

Figure 10. Adequate spacing (>100 ft.) between seed trees for survey tree count.

Figure 11. Generally ideal phenotypic traits in candidate seed trees (conical, straight, no defoliation; left); suboptimal candidate seed trees showing co-dominant stem with signs of disease (defoliation, browning; middle left), multistemmed (middle right); and example of a 'mushroom'-shaped crown (right).

Assessing cone crops

To determine whether a stand is potentially suitable for collection, surveyors need to measure and record the crop abundance in the stand. Generally, cone crops are first rated by individual trees and then reported as an average for the stand. Cone crops can be assessed qualitatively by characterizing cone volume or quantitatively using cone counts and bushel estimates. Surveyors should use whichever methods most appropriately fits their experience, project needs, or agency guidance. Regardless of the method, the following guidelines should be applied consistently (Fig. 12):

- **Only evaluate the top 2/3rds of the tree's crown.** Cones positioned in the lower canopy have a higher likelihood of insect activity, self-pollination (poor genetics), and are typically more difficult and less efficient for climbers to collect. Some climbing contracts or agency protocols may recommend measuring and collecting from the **top 1/3rd** of the crown due to collection efficiency and other climbing considerations.
- **Count only closed live cones.** Open or aborted cones should not be taken into consideration when evaluating cone crop ratings as these cones do not retain viable seed.

Figure 12. General guidelines for assessing cone crops.

Pro tips:

- Face the tree with the sun at the back to improve visibility and accuracy. Plan routes to optimize the direction of the sun.
- Thoroughly evaluate the accessible areas of the stand before reporting. Roadside trees tend to produce more cones due to increased light.

Cone volume

Rating cone crops by volume categorizes crop abundance into a four-point scale (none, light, medium, and heavy) based on the percentage of canopy covered by cones (0%, <25%, 25-50%, and >50%; Fig. 13).

Volume ratings can be a quick, simple, and effective method for assessment; however, it can also be subjective. While prior experience and direct comparison between seed trees can be informative when rating crops, it should not inform assessments *alone*—a crop that appears unusually abundant may still qualify as a medium or light crop when evaluated against the appropriate rating standards.

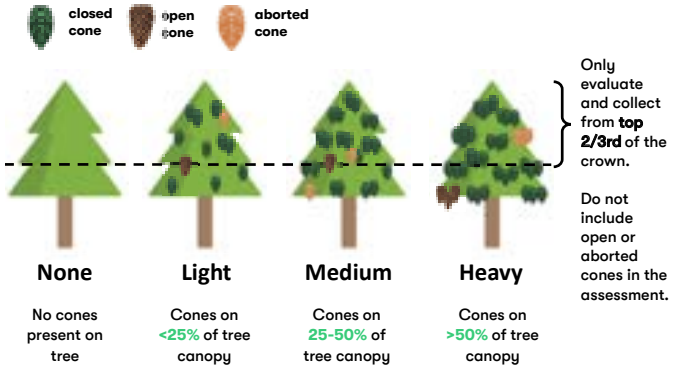

Figure 13. Representative visual of cone crop ratings by volume.

Species-specific cone arrangement patterns and crop ratings. Accuracy can improve when observations are additionally informed by species-specific cone arrangement patterns (see Fig. 14-18 and Appendix J). The following guidelines are intended to support consistent evaluations and help prevent over- or underestimating crop abundance, by grounding ratings in defined characteristics.

Example of how clusters and distribution can affect crop ratings in ponderosa pine:

- Clusters of cones abundantly present with an average of 1 cone per cluster would likely indicate a light crop.
- Clusters of cones moderately present with 2-4 cones per cluster would likely indicate a medium crop.
- Clusters of cones abundantly present with 4-6 cones per cluster would likely indicate a heavy crop.
- Very few clusters of cones irregularly present with 4-6 cones per cluster would likely indicate a light or medium crop.

CHARACTERISTICS FOR COMMON CA SPECIES

White and red fir. Look for the top 6 - 10 ft. of the crown to be heavily covered in cones for medium to heavy cone crops.

Figure 14. White fir light (left), medium (middle), and heavy crop (right).

Incense cedar. The top of the crown will appear 'dotted' with thousands of very small cones and branches for medium to heavy crops.

Figure 15. Incense-cedar light (left), medium (middle), and heavy crop (right).

Sugar pine. Look for many clusters of 2-7 cones on tips of branches with some interior for a medium to heavy cone crop.

Figure 16. Sugar pine light (left), medium (middle), and heavy crop (right).

Jeffrey and ponderosa pine. Look for many clusters of 3-10 cones distributed on interior of branches and branch tips for heavier crops.

Figure 17. Ponderosa pine light (left), medium (middle), and heavy representative clusters (right).

Douglas-fir. Look for clusters of cones and drooping branches for a medium to heavy cone crop; individual cones scattered across the crown tend to be light crops with lower yields.

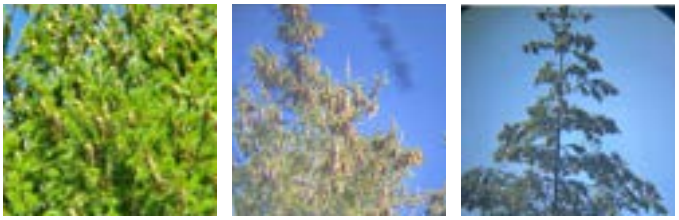

Figure 18. Douglas-fir light (left), medium (middle), and heavy crop (right).

Averaging the stand and recording seed trees. Once individual trees have been evaluated within a stand, report the average cone crop rating and the number of potentially collectable seed trees for each species present (e.g., Fig. 19; see Table 1 for recommendations for characterizing collectable seed trees). If unsure whether a tree is collectable, it's better to include it in the survey rather than omit it.

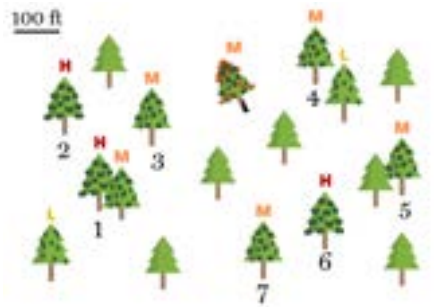

Figure 19. Representative stand with a medium average cone crop rating and potential collectable seed tree count of 7. Unhealthy trees, no crops, and light crops are omitted from the final count. For seed trees within 100 ft of each other, only one is counted.

Surveying individual trees. Surveying and reporting individual trees is not ideal since collecting cones from individual trees is typically an inefficient use of resources for the surveyors, monitors, and collectors and does not provide adequate genetic diversity for seed lot bulking in the nursery setting. It is typically reserved for the testing or collection of Major Gene Resistance (MGR) trees for white pine blister rust (WPBR) resistance (e.g., sugar pine). Collections from known or candidate parent trees may support progeny testing, resistance verification, breeding or seed orchard programs, or the production of resistant seed stock. Pre-identified MGR individuals are typically visibly marked through tagging, metal sheets, spray paint, etc. (see example of marked tree in Appendix J, p. 149).

Other special collections may call for surveying individual trees (e.g., extremely high collection need or research), but unless advised to by a local manager, it is not recommended.

Cone Counts & Bushel Estimates

Cone counts and bushel estimates are methods that provide quantitative measurements of crop abundance. While no method is perfectly accurate, these measurements may reduce subjectivity when reporting. Conducting a cone count simply consists of estimating and reporting the number the cones present on in the top 2/3rds of the crown on one side of the tree. The process of counting cones can be adapted to estimate bushels by multiplying by a species-specific multiplier to account for the entire upper crown and then dividing by the number of cones expected to fill one bushel.

Estimating the number of potential bushels in a stand provides critical insights for planning collections. This estimate can help determine the number of climbers and ground crew needed during collection, the approximate cost of climbing services, and the relative priority of potential collection sites within a seed zone and elevation band. Bushel estimates may also be used to validate or adjust a cone volume ratings. Variation in cone size from tree to tree and region to region within the same species can generate inaccuracies in this method.

Cone Counts. Because counting every individual cone in the top 2/3rds of the crown is rarely practical, it's recommended to break down the count into smaller sections and use simple multiplication to approximate the total cone count on one side of the tree and then use a species-specific multiplier to account for the entire top 2/3rd of crown.

BREAK IT DOWN BY CLUSTERS OF CONES (BEST FOR MOST PINE SPECIES)

1. Determine the average number of cones per cluster (e.g., sugar pine crop with avg. of 2 cones per cluster, Fig. 20).
2. Count the number of clusters present in the top 2/3rds of the crown on one side of the tree and multiply by average cones per cluster. Some surveys may request reporting this calculation alone, designated as 'Cone Count' (e.g., 2 cones per cluster x 40 clusters = 80 cones, Fig. 20).
3. Multiply by species-specific factor to account for the entire upper crown (Table 2). If a species-specific factor is unavailable, it is generally reliable to multiply by 2. **Note:** If using a general multiplier, it may generate over- or underestimates depending on the species. (e.g., 80 cones x 1.5 (factor for sugar pine) = 120 cones).

Figure 20. Sugar pine crop with 2 cones in a cluster (left) and crop with ~40 visible clusters of 2 cones in the top 2/3rds of the crown.

BREAK IT DOWN BY GENERAL AREA (BEST FOR SMALL CONE SPECIES & FIRS)

Figure 21. White fir with ~30 cones in an imaginary circle.

1. Designate a general area (Fig. 21, e.g., draw an imaginary circle) that is reasonable for counting and count the number of cones in that area (e.g., 30 cones in a 'circle').
2. Count how many sections of that same-size area is present in the top 2/3rd of the crown on one side of the tree and multiply by the number of cones counted. Some surveys may request reporting of this number alone (e.g., 30 cones x 7 'circles' = 210 cones).
3. Multiply by species-specific factor to account for the entire upper crown (Table 2). If a species-specific factor is unavailable, it is generally reliable to multiply by 2. **Note:** If using a general multiplier, it may generate over- or underestimates depending on the species. (e.g., 210 cones x 1.7 (factor for white fir) = 357 cones).

Table 2. Species-specific crown multiplier to calculate the cone count for the entire top two-thirds after counting one side of the tree.[1,2]

Species	Factor
Pacific silver fir, white fir, grand fir, red fir, sugar pine	1.7
Shasta red fir, noble fir, western white pine, Jeffrey pine, ponderosa pine	1.5
Douglas-fir, spruces, mountain hemlock	2.0
Lodgepole pine	4.0
Incense cedar, giant sequoia, western redcedar, western hemlock, mountain hemlock	40*

[1] USDA Forest Service, Missoula Technology and Development Center, "Methods," Reforestation Toolbox: Cone Collection, accessed May 19, 2026, https://www.fs.usda.gov/t-d/seedlings/conecoll/methods.htm
[2] Peter A. Theisen, Cone Crop Surveys, Tree Seed Paper No. 3 (Portland, OR: U.S. Forest Service, Region 6, 1976).
* Only count the cones on one-twentieth of the visible crown down its length

Bushel Estimates. Accurately estimating bushels is a skill developed through experience, practice, and comparison with completed collections. New surveyors should use this guidance as a starting point and may consider providing a small range, include notes in the survey records, or omit the estimate when confidence is low. Consultation with experienced collectors, repeated field observation, and review of actual collection outcomes will improve estimation accuracy over time.

WHAT IS A BUSHEL?

A bushel is a standard agricultural unit of measurement that is used to quantify cone yields (Fig. 22). While different organizations and individuals can have slightly different ways of measuring a bushel, the standard definition is:

Figure 22. A bushel is typically measured in the field using a 5 gallon bucket with a designated 4 gallon fill line twice to measure a total of 8 gallons.

1 US bushel of unopened cones = 37.2 fluid quarts = 32 dry quarts = 9.3 fluid gallons = 8 dry gallons.

Always confirm the bushel definition in the climbing contract or with the receiving seed extractor.

CALCULATING BUSHELS FROM CONE COUNTS:

When estimating bushels for an individual tree, count the cones visible in the upper two-thirds of the crown and estimate how many bushel bags they would fill by dividing the number of cones that fill one bushel (Table 3).

1. Calculate the number of cones present in the entire top 2/3rd of the crown (see 'Cone Counts'; e.g., ponderosa pine crop = 800 cones)
2. Divide by the number of cones that fit into 1 bushel. This will vary by species due to the size of cones and can even vary from individual to individual, population to population, or region to region within the same species (e.g., the average cones per bushel for ponderosa pine in a wild stand may vary, let's say for this example it's ~200 cones. 800 cones / 200 = 4.5 estimated bushels)
3. Calculate and report a bushel estimate for the entire stand for each unique species with cone crop. (e.g., if the seed tree was a good representative for the stand: 15 seed trees present x average of 4.5 bushels each = 60 estimated bushels for the stand; if the crops vary significantly, estimate the bushels for each one and add it together for a total stand estimate).

Table 3. Average cones per bushel and species for common California conifers.[1,2]

Species	Avg. Cones/Bushel
***Abies concolor* (white fir)**	170 – 200 (600) Northern CA • Low elevation (<4,000 ft.): ~ 226 Central Sierra • High elevation (>6,000 ft.): ~596 Southern CA • High elevation (>6,000 ft.): ~188

[1] Stewart et al., *Reforestation Manual for California Conifers* (Davis: University of California Agriculture and Natural Resources, 2026), https://doi.org/10.3733/PJMF6526
[2] U.S. Forest Service, El Dorado National Forest, *Placerville Nursery, A Nursery Tale: From Collection to Reforestation*, 2016.

Table 3 (continued). Estimated cones per bushel and species for common California conifers.[1,2]

Species	Avg. Cones/Bushel
***Abies magnifica* (red fir)**	~50 – 85 Northern CA • Low elevation (<6,500 ft.): ~49 Central Sierra • Low elevation (<6,500 ft.): ~49 • High elevation (>7,500 ft.): ~61 Southern CA • Low elevation (<6,500 ft.): ~51 • High elevation (>7,500 ft.): ~82
***Calocedrus decurrens* (incense cedar)**	1,000s
***Pinus lambertiana* (sugar pine)**	12 - 18
***Pinus jeffreyi* (Jeffrey pine)**	35 – 50 Northern CA • Low elevation (3,500 – 4,500 ft.): ~46 • High elevation (>6,000 ft.): ~45 Central Sierra • High elevation (>6,000 ft.): ~37 Southern CA • High elevation (>6,000 ft.): ~58
***Pinus ponderosa* (ponderosa pine)[1]**	90 – 230 Northern CA • Low elevation (3,500 – 4,500 ft.): ~230 • High elevation (>6,000 ft.): ~198 Central Sierra • Low elevation (3,500 – 4,500 ft.): ~168 • High elevation (>6,000 ft.): ~164 Southern CA • High elevation (>6,000 ft.): ~129
***Pseudotsuga menziesii* (Douglas-fir)[1]**	700 - 1,000 (700-900 in the Sierra Nevada, 900-1000 in coastal regions)

[1] Stewart et al., *Reforestation Manual for California Conifers* (Davis: University of California Agriculture and Natural Resources, 2026), https://doi.org/10.3733/PJMF6526
[2] U.S. Forest Service, El Dorado National Forest, *Placerville Nursery, A Nursery Tale: From Collection to Reforestation*, 2016.

Reporting & viewing cone crops

To report and view cone crops, use the statewide digital survey tool, Survey123 - CA Cone Crops (see Appendix F). Survey123 is a powerful cloud-based data collection tool designed to support reforestation efforts in California by streamlining the way cone crop observations are reported and shared. The tool functions through a mobile app or browser and allows users to submit detailed surveys about cone crops, including location, site conditions, accessibility, tree species, crop ratings, bushel estimates, and photos. Once submitted, the data feeds directly into a centralized database managed through ESRI ArcGIS, enabling seed bank managers and ArcGIS Online users to track cone crop availability in real-time across the state.

Report: CA Cone Crop Survey

Scan to access the survey through the online desktop version or mobile device app (recommended).

Direct link: https://arcg.is/1qSKra0

View: Public Dashboard

Scan to view public survey data and explore cone crop trends in real time across the state.

Direct link: https://qrco.de/conedashboard

View: Join Private Data Group

Scan to request access to affiliation-specific data viewing group through an AGOL account.

Direct link: https://qrco.de/bf32cC

Cone Monitoring

After stands with significant cone crops have been identified from surveying, it's crucial to revisit these sites to sample cones and evaluate *if* and *when* the crop is both ripe and viable for collection. Monitoring is the method used to assess ripeness and viability by tracking cone and seed development and quality, observing potential damage to cone crops, and preparing for cone collection. Monitoring consists of:

- **Tracking cone and seed development.** If cones are collected too early, before seeds and cones are fully developed, nursery germination rates may be poor and the risk of case hardening (when cones seal shut during drying) may increase, thus making collection efforts ineffective. Conversely, collecting too late may result in seed loss through natural dispersal as cones open, leaving little or nothing to harvest. Patience and accurately informed assessments of cone and seed development are critical when determining cone ripeness and timing successful collections.
- **Evaluating potential damage to cone crops.** Along with natural seed dispersal from cone opening, cone crops can become compromised due to high levels of predation from insects, squirrels, or birds. Additionally, environmental stress (e.g., extreme drought or heat waves), poor tree health, and predation can sometimes lead to widespread cone abortions (when the tree halts nutrient and resource allocation to the growing cones, thus terminating any further cone development). When crops have become significantly compromised from damage, planned collection efforts for a site may need to be withdrawn, as the crop may no longer be suitable for collection.
- **Preparing for collection.** It is crucial to communicate, coordinate, and share site information and timing estimates with the recipient seed extractory and climbing crews prior to collection. Specific trees should be digitally recorded (e.g., marking GPS location on a sharable map in the app "Avenza" or similar application) and physically marked with bright colorful flagging. This makes revisiting a site and specific trees for continual monitoring easier and provides climbers with clear direction on which trees to collect from.

When to monitor

Monitoring occurs after surveying and prior to cone collection. Some overlap with surveying and collection may occur, as different sites begin to exhibit signs of cone and seed ripeness at different rates due to variation between regional locations, elevations, populations, species, and weather events. Generally for most commonly collected California conifers, monitoring starts around late July and continues until collections occur thorough August to October (Fig 2.).

How often to monitor

Once cones are fully ripe, the window for cone collection is short for non-serotinous species, typically only 1 - 2 weeks before natural seed dispersal—more frequent monitoring is essential as cones approach maturity. Sites should ideally be monitored every 2 - 4 weeks throughout the summer season until cones begin to show noticeable changes in physical appearance and seed development. Once this occurs, the monitoring frequency should increase to weekly and, if possible, every 2 - 4 days.

Sites should be revisited 1 - 2 days before a scheduled collection to confirm that cones are still closed with viable seed, and that seed dispersal has not already occurred or that the crop has not been comprised by heavy predation. This precaution helps avoid unnecessary trips for climbing crews. Recommended frequency of monitoring:

- Earlier in the season, spread out the frequency (~ 2 - 4 weeks)
- Closer to maturation, increase frequency to once per week
- Once a collection is scheduled, visit 1 - 2 days before to ensure cones are still closed and seeds remain viable and have not yet dispersed.

Example monitoring timeline informed by ripeness indicators (Table 5 & 6):

- *Lime-green stiff cones, <30% embryo fill, light seed coats:* sample every ~2-4 weeks.
- *Yellowing in cones, >50% embryo fill, darkening seed coats:* start to sample every ~1 week.
- *Stronger golden/browning color, >80% embryo fill, detaching seed wings:* schedule the collection to take place in the next ~1-2 weeks, check every ~2-3 days and check 1-2 days before collection is scheduled.
- *Golden brown, scales slightly opening, more flex, drying out, >90% fill of embryo, dark seed coats and wings detaching:* time to collect!

Factors that influence the rate of ripening

Variation in species, elevation, microclimates, weather, and regions can influence the rate and timing of cone ripening (Table 4). Weather events such as heat waves can especially impact this timeline; it is important to check predicted weather conditions frequently. Altogether, these factors play a role in determining when and how often you should monitor.

Table 4. Factors that can influence the annual timing of cone ripening.[1,2]

Variable	Effect
Seasonal Weather & Events[1]	• Early spring with a dry summer, heat waves and drying winds may lead to earlier ripening. • Late heavy snow may lead to later flowering and may even inhibit cone maturation. • Heavy rain may lead to later ripening, but in the event of high wind or rainstorm, a cone crop may disperse rapidly.
Regional (statewide)	• It has been observed by experienced California cone hunters that stands in southern regions typically ripen earlier than in northern regions of the state.
Elevation & Slope[1]	• Stands in lower elevations along with southern and western facing slopes generally ripen earlier. • Stands in higher elevations along with northern and eastern facing slopes generally ripen later.
Species-specific[1]	• A typical succession of ripening for common species occurs as follows: Douglas-fir, ponderosa pine, sugar pine, Jeffrey pine, incense cedar, red fir, and then white fir. This can be used as a general guide to support initial planning for surveying and monitoring as there is likely significant site-specific variation and overlap within this order. • See Appendix J for more information on species-specific ripening periods.

[1] Bonner & Karrfalt, The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008), https://www.fs.usda.gov/rm/pubs_series/wo/wo_ah727.pdf

[2] Y. Tanaka, "Assuring Seed Quality," in *Forest Nursery Manual*, ed. M. L. Duryea and T. D. Landis (Oregon State University, 1984), 28.

Collecting cone samples

Obtaining live cone samples is essential to make proper assessments of cone and seed ripeness and quality. It is a mandatory task of the monitoring process as monitors need to evaluate both the exterior of the cone and the interior through cone cut tests (cutting open a cone longitudinally to assess seed development and quality and further assess cone ripeness).

There are various methods for retrieving cone samples, including shooting cones with a rifle; using a sling shot, pneumatic launcher, or crossbow with throwline; and climbing. A common and recommended method is to use a throwline kit with a Big Shot Sling Shot or Air Powered Tree Access (APTA) device to knock cones from the trees (see **Appendix B** for more information and tips when using these specialized sampling tools). The use of rifles by trained and permitted marksmen is an uncommon method for cone sampling, but may be an efficient option on private property, and is subject to individual landowner discretion and permissions.

Best practices for collecting samples from candidate stands according to the CAL FIRE Reforestation Services Program recommendations include:

- Sample from 3 - 6 trees per stand.
- Collect 6 - 10 cones per tree.
- Aim for the top 2/3rd of the tree crown.

Cones in the lower canopy tend to have more insect activity and may not reflect the overall quality of the cones in the upper canopy. In some cases, reaching the upper crown can be very difficult and may require several failed attempts before successfully obtaining a single cone sample. If there is limited accessibility to the upper crown, cones collected from the lower canopy can still provide representative insights to the crop quality and development. If experiencing limited personnel capacity for robust sampling, strive to sample from many trees evenly distributed throughout the stand with fewer cones per tree—striving to capture a well-rounded representation and insight of crop quality in the stand.

Physically flag and/or digitally pin candidate trees and consider making digital notes for each tree sampled. It's best to have sampled every tree prior to collection to ensure that each seed tree retains quality seed. Tracking this information for each tree will help with organization for continual monitoring and final selection of collectable seed trees.

Evaluating cone and seed development and quality

Once cone samples are retrieved, the cones and seeds need to be assessed for ripeness and quality. These observations will inform recommendations for continual monitoring and suitability for collection in a given stand.

Cone and seed ripeness generally develop together (not always perfectly coinciding), but they should not be treated as interchangeable. Cone condition provides useful external indicators of maturity, but cone appearance alone can be misleading. Monitors must additionally evaluate seed maturity by performing **cut-tests** (Fig. 24); seed coat, embryo, and megagametophyte development is critical for determining whether a collection will produce high-quality seed. If cones are collected before seed maturity is confirmed, germination rates, seedling vigor, and long-term storage quality may be reduced; immature, high-moisture cones may increase risk for processing losses, including case hardening, where cone scales fail to open properly during drying and make seed difficult or impossible to extract. Because cones lose moisture as they mature, specific gravity (relative density) is another notable measurement that can be used for evaluating cone ripeness and seed quality by comparing cone weight to water displacement using a graduated cylinder (see Bonner & Karrfalt, 2008, p. 60 - 61, 171, 829 for guidance). As the cone matures, the specific gravity decreases.

Figure 23. Cut tests of nearly ripe white fir (left) and Jeffrey pine (middle), and immature incense cedar presenting resin pockets (red dots) and insect activity (right).

Evaluating the exterior of the cone

Changes to the exterior of the cone can vary between individuals, populations, species, slopes, elevation, and regions. Inform assessments with species-specific characteristics (see **Appendix**

J). Monitors should evaluate the characteristics listed in Table 5 to determine cone ripeness and quality.

Table 5. Indicators of ripeness and maturity when evaluating the exterior of the cone.[1]

Ripeness Indicator	Description
Color	As cones ripen, they typically turn from green to golden brown, yellow, gray, or purple depending on the species. Notably, aborted cones change colors as well, often to a paler brown or reddish color compared to browning ripening healthy cones (Fig. 12).  Incense cedar cones varying in ripeness from unripe (lime green; left) to ripe (golden brown; middle) to overripe and opened (brown; right) as observed by color changes.
Shape	Cones should generally be straight and/or smooth, depending on the species. Some natural curvature can be expected in elongated cones, and certain species such as knobcone pine naturally produce curved cones; however, sharply hooked (J-shaped), or irregularly bumpy cones often indicate insect damage and should be avoided during collection.  Ponderosa pine cones showing normal variation in shape (left and middle) compared with an insect-damaged cone showing abnormal sharp curvature (right).
Flex	Ripening cones will be able to slightly bend when applying pressure. Unripe cones will be stiff and inflexible. Cones tend to become more flexible as they ripen and begin to open.

[1] Bonner & Karrfalt, The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008), https://www.fs.usda.gov/rm/pubs_series/wo/wo_ah727.pdf

Table 5 (continued). Indicators of ripeness and maturity when evaluating the exterior of the cone.[1]

Ripeness Indicator	Description
Scale Opening	Ripening cones may begin to open slightly, while fully open cones indicate seed dispersal; however, serotinous species may remain closed until exposed to heat.  Ripe Douglas-fir cone with scale slightly opening
Insect Activity	Cones with significant visible insect activity should be avoided during collection. External signs of insect predation include: • Entry and exit holes with frass (fine powdery brown debris produced by wood-boring insects). • Irregularly 'J' shaped cones or bumpy (many pines, Douglas-fir) or hourglass shaped cones (true firs). • Irregular scale coloring such as distinct browning of only select scales of the cone.  Ponderosa pine (top left) and sugar pine (top right) with irregular browning on scales, J-shaped Douglas-fir (bottom left), and Douglas-fir cones with visible entry and exit holes with frass (bottom right).

[1] Bonner & Karrfalt, The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008), https://www.fs.usda.gov/rm/pubs_series/wo/wo_ah727.pdf

Evaluating the interior of the cone & seed: Cone cut tests

Figure 24. Cone cut tests of ponderosa pine using cone cutters.

To examine the interior of the cone and check seed quality, a cone cut test will need to be performed by using a cone cutter to slice cones longitudinally down the center (Fig. 24; see **Appendix C**).

To evaluate individual seeds, remove the seeds and cut them longitudinally using a razor blade or pocketknife and tweezers. Check the different characteristics listed in the table below to assess cone ripeness and seed viability. These descriptions vary between species and even individual populations; see **Appendix J** for more species-specific information.

Table 6. Indicators of ripeness, viability, and quality in cone and seed from cone cut test.[1]

Ripeness Indicator	Description
Oxidation	If the cone tissue begins to turn from white to brown after ~1 min, this indicates oxidation, which signifies that the cone is immature and is not ready for collection.  Photo taken immediately after cut test (left), and then 1 minute after showing browning caused by oxidation in cone tissue indicating immaturity (right).

[1] Franklin T. Bonner and Robert P. Karrfalt, eds., The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008).

Table 6 (continued). Indicators of ripeness, viability, and quality in cone and seed from cone cut test.[1]

Ripeness Indicator	Description
Embryo & Megaga-metophyte	The ripeness of the seed embryo is critical to a successful collection. A mature seed embryo will fill no less than 90% of the seed cavity in length. The inner seed tissue (megagametophyte) should be white or yellow (depending on species), opaque, and a firm nut-like texture. If the texture is gelatinous or milky, it is likely immature or potentially improperly developing. Throughout the season, cut tests of healthy, viable seed should show progressively greater embryos fill and firming tissue, indicating that the seed is developing and nearing ripeness.  Healthy developing seed with 50% embryo fill (left), viable seed with >90% embryo fill (middle), and milky megagametophyte with <30% embryo fill (right).
Seed Wing & Seed Coat	Early in development, seed wings and coats will typically appear light or pale brown. As they continue to develop and become ready for collection, their color will change to a darker brown and seed wings will begin to detach from the scale.  Ponderosa pine immature (left) and ripening (right) seed coat and wings.

[1] Franklin T. Bonner and Robert P. Karrfalt, eds., The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008).

Table 6 (continued). Indicators of ripeness, viability, and quality in cone and seed from cone cut test.[1]

Ripeness Indicator	Description
Insect Activity & Abortion	Empty seeds can indicate insect predation or abortion. Seed cavities filled with debris indicate insect predation. These seeds are not viable. Trees with signs of heavy insect activity or widespread abortion should not be collected from.  Ponderosa pine cut tests with visible worms and empty seed cavities (left and middle left), Douglas-fir with visible frass and empty seed cavities (middle right), and ponderosa pine with no viable seed from potential abortion or early predation (right).
Seed Count	Seed count helps determine whether a cone crop contains enough filled, viable seed to justify collection (recommended minimums in Table 7; if unknown 50% fill is a recommended general guideline). Counts only include healthy viable seed present on one cut face. Empty seed cavities may result from abortion, insect predation, immature seed development, or an early cut test. Trees or stands with consistently low filled-seed counts should not be collected because they may produce poor seed yield.  Ponderosa pine cut tests with no viable seed (left), visible insect activity (middle), and many viable seeds (right).

[1] Franklin T. Bonner and Robert P. Karrfalt, eds., The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008).

Table 7. Recommended minimum number of filled seeds exposed on one-half of cone face.[1,2,3]

Species	Minimum Seed Count (# of seeds or % of seed cavities)
Bigcone Douglas-fir	50%
Brewer spruce	10 seeds
Colorado pinyon pine	3-4 seeds
Cuyamaca cypress	50%
Engelmann spruce	5-6 seeds
Foxtail pine	10 seeds
Gray pine	12 seeds
Incense cedar	50%
Jeffrey pine	2 seeds or 50%
Knobcone pine	50%
Limber pine	8 seeds or 50%
Macnab cypress	6 seeds
Noble fir	6 seeds or 50%
Pacific silver fir	8 seeds
Ponderosa pine	7-10 seeds or 75%
Port-Orford cedar	3 seeds
Red fir	50%
Redwood	50%
Sitka spruce	50%
Subalpine fir	5 seeds or 50%
Sugar pine	12-15 seeds or 66%
Western hemlock	3 seeds
Western redcedar	2 seeds
Western white pine	10 seeds or 66%
White fir	50%

[1] F. T. Portlock, A Field Guide to Collecting Cones of British Columbia Conifers (British Columbia Tree Seed Dealers' Association, 1996).
[2] Franklin T. Bonner and Robert P. Karrfalt, eds., The Woody Plant Seed Manual, Agriculture Handbook No. 727 (Washington, DC: U.S. Department of Agriculture, Forest Service, 2008).
[3] U.S. Forest Service, El Dorado National Forest, Placerville Nursery, From Collection to Reforestation: A Nursery Tale (U.S. Department of Agriculture, Forest Service, 2016).

When to discontinue monitoring a stand

One or two low-quality cones and cut-tests in a sample can be normal; however, if the majority of cones in a sample fall below the recommended quality standards (Table 5 and 6), that tree should be excluded from the collection pool. If a majority of trees in the stand produce samples poor enough that the stand not longer meets the minimum number of acceptable seed trees, monitoring should be discontinued and collection plans should be canceled; it is likely that the other candidate trees in the stand have low-quality crop.

Depending on the collection need and local guidance, significant decreases in the average cone crop rating for the stand due to predation or widespread abortion can be cause for a stand to be discontinued. For example, heavy squirrel predation has been known to reduce heavy crop ratings to a medium or light crop.

Reporting to the seed extractory and climbers

Communication is key when planning a collection. It is ideal to notify the recipient seed bank and climbers at least 1 week in advance of collection if possible. While actively monitoring a stand, notify the collection manager and/or recipient seed bank with the following information:

- The number of collectable trees in the stand.
- Species of trees to be collected from.
- Crop ratings per species (if more than one).
- Bushel estimates per species (if more than one species is to be collected).
- Quality of cone and seed (with photos; optional: dependent on seed bank manager).
- Driving directions and other access information (including gate codes, landowner contact number, etc.).
- GPS coordinates of the stand to be collected from.
- GPS coordinates of individual trees and physically mark trees with bright colorful flagging (if difficult to see from the road or access point, add a flagged path to the tree).
- Estimated time of collection (e.g., "recommend collection should begin in approximately 1 - 2 weeks, based on the following observations…").

Cone Collection

When to collect

The timing of cone collection is critical and usually occurs in late summer to early fall (Fig. 2), but exact ripening varies by species, region, elevation, aspect, slope, and weather (Table 4). Collection should begin only after monitoring and cone cut tests confirm ripeness, viability, sufficient embryo development, adequate seed counts (Table 5 and 6). If collected too early, seeds may be immature, low-vigor, or difficult to extract; if collected too late, cones may open and disperse seed before collection.

Figure 25. Representative visual ripening in sugar pine. Remember, exterior evaluation alone should not inform complete ripeness.

Because the collection window is short for non-serotinous species—roughly 5–20 days after full ripeness is reached—cones should be sampled one to two days before collection, again on the day collection begins, and from each tree before it is fully collected to confirm crop quality.

Serotinous and semi-serotinous species may allow more flexibility in collection timing because their cones do not always open and release seed shortly after maturity. For species such as knobcone, Coulter, foothill, and Torrey pine, cone scales may remain sealed by resin for months or longer after the seed is mature, allowing collection to occur after more time-sensitive species have been completed (Stewart et al., 2026). However, collectors should still confirm seed maturity, cone condition, and seed viability before collection, as older or weathered cones may have reduced seed quality, insect damage, or prior partial seed release.

Giant sequoia is a special case because mature cones can persist in the crown for several years and release seed intermittently, allowing collection outside the typical fall collection window. However, collectors should target mature cones that are generally yellowish-green and avoid immature second-year cones that may appear nearly full-sized by fall, as well as very old gray or weathered cones that often contain fewer viable seeds (Stewart et al., 2026; Woodward, 2025).

Who to contact for cone collection & seed extractory delivery

To ensure that cones get collected and that the appropriate seed extractories are prepared to receive cones, coordination with the correct land managers and seed extractory managers for the collection location is essential (Table 8). Make sure to contact recipient seed extractory at least a week before and again one to two days before cone delivery. The earlier, the better. Approval for collection and delivery is likely required before planning and coordinating agency-lead collections (e.g., USFS collections need approval prior to planning from the R5 Genetics Program and Nursery).

Table 8. Who to contact for cone collection and seed extractory delivery.

Landowner / Manager Type	Lead Contact
Federal—USDA Forest Service	Contact the USFS Placerville Nursery 2375 Fruitridge Road Camino, CA 95709 Ph: (530) 622-9600
Federal—Bureau of Land Management	Secure BLM field office permissions. Cones processed at the USFS Placerville Nursery. 2375 Fruitridge Road Camino, CA 95709 Ph: (530) 622-9600
Federal— Other	Contact or visit nearest information/visitor center to inquire.
State—Demonstration State Forest	CAL FIRE Reforestation Services Program 5800 Chiles Road Davis, CA 95618 Ph: (530) 753-2441 reforestation@fire.ca.gov

Table 8 (continued). Who to contact for cone collection and seed extractory delivery.

Landowner / Manager Type	Lead Contact
State—California State Parks	Cone collection is not currently allowed within CA State Parks except in rare cases for research purposes or special permission. CAL FIRE Reforestation Services 5800 Chiles Road Davis, CA 95618 Ph: (530) 753-2441 reforestation@fire.ca.gov
Privately owned land—industrial, non-industrial, Tribal, and trust lands	Explicit written permission to access property for cone surveys, monitoring and collection from the landowner must be secured before any activity occurs. CAL FIRE Reforestation Services Program is available to receive, process, and store cones and seed for private and independent clientele. CAL FIRE Reforestation Services 5800 Chiles Road Davis, CA 95618 Ph: (530) 753-2441 reforestation@fire.ca.gov

Methods of cone collection

While this guide focuses on climbing as a primary cone collection method, it's important to know that there are other collection methods available depending on the collection site, funding, resources, and tree species. Each method has different advantages and disadvantages; guidelines and considerations are noted for each method below.

- **Tree climbing.** The most common and recommended method for wild stand collection, often completed by independent contractors (Fig. 26).
- **Hydraulic lifts.** Useful in orchards and plantations, but may be costly and can limit crown access depending on tree height and site conditions.
- **Helicopter.** Aerial cone rakes can be practical in steep coastal terrain or other limited-access areas, but they are costly, require

highly skilled pilots, and may increase the risk of tree damage.

- **Shooting.** Practical for small collections but not commonly used by state or federal agencies because it can damage future cone production. Some private landowners use this method, but special permits may be required.
- **Ladders.** Rarely effective alone because they provide limited upper-crown access, but they are commonly used with climbing when lower branches allow quicker crown entry (Fig. 26).
- **Felled trees.** May simplify collection, but trees must be felled when cones are ripe and collected quickly afterward. This method increases fungal contamination risk through ground contact and should be avoided for high-value seed trees when possible.
- **Squirrel cache.** Generally not recommended because cone origin is difficult to verify and long-term ground contact creates a high risk of fungal contamination. This method should only be used by highly experienced and qualified collectors.
- **Ground collection.** Generally not recommended or common, but may be useful for certain serotinous or persistent-cone species, such as giant sequoia, or in areas with highly uniform growing stock. This method should only be used by highly experienced and qualified collectors.

Figure 26. Tree climbers in tree for collection (left), and climber preparing to enter tree for climbing using a ladder for entry access (right).

Roles, responsibilities, and collection recommendations for tree climbing

Collecting cones by tree climbing is a team effort. It's vital that everyone involved is clear about their roles and responsibilities to best support the collection, overall safety, and each other. There are typically three different groups involved during the day of a collection including the collection lead, ground crew, and tree climbers. Typical roles and responsibilities are outlined below, but be sure to check your contract, as specific guidelines may vary.

Collection manager. Manages day-of tree climbing contract services and ensures quality standards are maintained from collection through transport, storage, and delivery.

- **Know the contract.** The collection lead is responsible for understanding the contract terms to avoid asking the crew to perform work outside the agreed scope.
- **Direct climbers to approved trees.** Trees should be pre-identified and flagged during monitoring. Climbers should check in before climbing any tree, but the climber has final authority to decline a climb for safety reasons.
- **Check tree viability.** The collection lead should request cone samples, perform cut tests, and determine whether each tree is suitable for collection. If samples show heavy insect damage, abortion, low seed counts, or other quality issues, the lead may stop collection from that tree.
- **Prepare tags early.** Each bushel bag requires two tags, one inside and one outside. Tags should be written as early as possible rather than waiting until cones are being bagged.
- **Track bushels and tree entries.** Record the number of bushels bagged, trees climbed, and trees sampled but abandoned due to poor crop quality, safety hazards, or other issues. This information is important for invoicing, especially when contracts include sampling or base tree rates. Check records with the ground crew at the end of the day and keep copies when possible.
- **Coordinate loading, transport, storage, and delivery.** Unless otherwise stated, the collection lead is responsible for ensuring all bushels are loaded, transported, and temporarily stored properly. The recipient seed bank or extractory should be notified at least three days, preferably one week, before collection. For USFS collections, cones generally must be stored as close to the collection site as possible for at least two weeks, with limited exceptions. The collection lead is responsible for coordinating

this offsite storage before delivery.

- **Support the ground crew when possible.** If time allows, the collection lead may help measure bushels, bag cones, tag bags, and load vehicles.

Ground crew. Support the bagging, tagging, and record-keeping. In climbing contracts, ground crew are essential for maintaining communication with climbers, assisting with rigging and gear, and helping ensure a safe and successful collection.

- **Measure, clean, bag, tag, and record bushels.** After cones are dropped or received from climbers, ground crew measure bushels according to contract specifications, remove debris and poor-quality cones, and bag cones with proper tags. Ideally, cones should be dropped onto a clean tarp rather than directly onto the ground, especially for species susceptible to *Fusarium* or other fungal contamination, such as sugar pine and firs. If cones do touch the ground, they should be bagged promptly and not left on the forest floor for several hours or overnight. If immediate bagging is not possible, cones should be kept off the soil on a clean tarp.
- **Maintain safety during cone drop.** Ground crew should wear hard hats and wait until climbers are finished dropping cones and are out of the tree before entering the drop zone to bag cones, reducing the risk of injury from falling cones, branches, or debris.
- **Track production and records.** Ground crew should record how many bushels are collected by each climber and from how many trees. These records support invoicing for both the climbing contractor and the contracting organization. The ground crew may request the collection lead's signature at the end of the day to confirm matching records.
- **Support climbers and communication.** Ground crew may help assess tree hazards, carry gear, rig and de-rig trees, retrieve dropped items, move vehicles, and respond to emergencies. They should maintain clear communication with climbers and know where each climber is working at all times.
- **Assist with loading and transport.** Ground crew typically help load bushels into vehicles for transport to the temporary storage or delivery location.

Climbers. Assess tree hazards and ascend selected trees to collect cones by either dropping them or bagging and lowering them from the tree.

- **Prioritize safety.** Climbers harvest cones from trees selected by the collection manager, but they have final authority to refuse or stop a climb for safety reasons. Climbers and collection managers may also decide to abort a climb due to split tops, poor tree structure, open or blown cones, poor seed quality, hornets or yellow jackets, poison oak, smoke, rain, lightning, high winds, fire, or any other safety concern.
- **Collect primarily from the upper crown.** In general, cones should be collected up to the top 2/3rds of the crown. Some contracts may alternatively indicate the top 1/3rds for efficiency and safety considerations; always refer to the contract.
- **Provide samples for evaluation.** Climbers should provide cone samples for the collection lead to inspect before continuing with collection. If samples show heavy insect predation, low seed quality, or other issues, the collection lead may request that the climb or collection from that tree be stopped.
- **Drop or bag cones according to the contract and species.** Depending on the contract and species, it is recommended for cones to be dropped (to a clean tarp when possible) or bagged in the tree and lowered by rope. Some evidence from squirrel-cut cone studies suggests that dropped cones can still produce acceptable germination when seed is ripe and cones are not left on the forest floor too long (Wagg, 1964; Lavender & Engstrom, 1956; Hurly et al., 1987); however, direct research comparing dropped cones to bagged cones is limited. For this reason, some contracts may require all cones to be bagged and lowered. Bagging in the tree is generally preferred or even required for species such as Douglas-fir, white fir, red fir, redwood, giant sequoia, and incense cedar. For species such as ponderosa pine, Jeffrey pine, western white pine, limber pine, sugar pine, and Coulter pine, in-tree bagging can be inefficient and may not always be required.
- **Avoid climbing spurs unless specifically justified.** Climbing spurs should not be used on valuable seed trees or species with easily damaged stems, such as five-needle pines. Although spurs are not typically used for cone collection, they may be appropriate in limited species-specific scenarios or special collections, or may necessary in emergencies, including climber rescue.

Bagging and tagging cones

Properly bagging and tagging cones on the day of collection are important steps to protect the quality of the cones, identify where the cones came from, and to quantify how many cones were collected. Without proper storage and identification, recipient seed extractories will not be able to process the cones.

How to bag cones

Bushels are typically measured using a 4-gallon bucket or 5-gallon bucket with a pre-marked 4-gallon fill line, filled twice, and placed into a bushel bag. For larger-coned species, such as sugar pine or large ponderosa pine, rigid containers may create void spaces and reduce measurement accuracy; use bushel bags with pre-marked fill lines or flexible containers when possible, and visually account for uneven packing or cones extending above the fill line. Other guidance includes:

- Use a well-ventilated mesh or burlap material for bushel bags. Do not store cones in plastic bags as this will suffocate the cones and lead to the growth of mold.
- Do not overfill bushel bags. Each bag should only carry one bushel of cones. Bushel bags are larger than one bushel to allow room for expansion within the bags as the cones dry and open.
- Remove as much debris from bushel bags as possible (needles, twigs, etc.). Debris can cause damage to cone and seed processing equipment and make the process more difficult.
- Tightly tie off the bushel 2-3 inches from the top of the bag with a zip tie. Tying the bushel bag any lower will prevent room for cone expansion and opening (Fig. 27).

Figure 27. Instructions for properly bagged cones in bushel bags (left) and example of secured bushel and buckets used for measuring (right).

How to tag bushel bags

All bushels of cones must be properly labeled with seed lot identification tags. Seed lot identification is crucial to retain information on seed sources for successful future plantings. Guidance and requirements for tagging includes:

- All bushel bags require TWO identical seed lot identification tags, one inside the bag AND one on the outside of the bag.
- The outer tag provides quick identification when handling, and the inner tag provides confirmation of the contents should the outer tag separate from the bushel. The types of tags required depend on the land manager of the collection site.

USDA FOREST SERVICE SEED LOT IDENTIFICATION TAGS

If delivering cones to the USFS Placerville Nursery, managers will need to acquire and properly fill out USDA Forest Service seed lot identification tags (Fig. 28), and the Seed Handler's Checklist (Fig 29). Additionally USFS R5 Placerville Nursery requires differentiating bushels by collection site and/or species with coordinated colored flagging. See Appendix H, I, and J for relevant tag information.

Figure 28. Instructions for filling out USFS R5 Placerville Nursery seed lot identification tag.

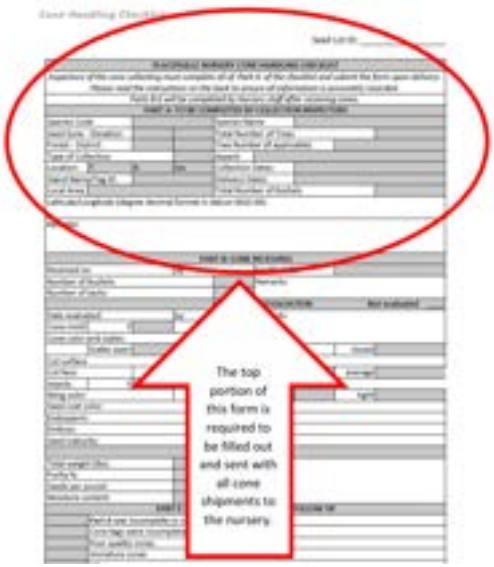

Figure 29. USFS R5 Placerville Nursery's Seed Handler's Checklist.

CAL FIRE SEED LOT IDENTIFICATION TAGS

If delivering cones to the CAL FIRE facility at the L.A. Moran Reforestation Center in Davis, managers will need to acquire and properly fill out CAL FIRE seed lot identification tags (Fig. 30) or obtain tag stickers by contacting the Reforestation Services Program (Table 8). See Appendix G, I, and J for relevant tag information.

Figure 30. Instructions for filling out CAL FIRE L.A. Moran Reforestation Center seed lot identification tag.

Transportation and storage

Proper transportation and storage of bushels is key to retaining the quality of the seed. Improper storage can damage the viability of the seed and cause contaminants, such as mold to flourish and compromise the collected seed.

Transportation & drop-off communications

Contact the appropriate seed extractory at least one week prior to cone delivery to allow for preparation of delivery and plan for interim storage logistics in the case that rapid transportation to a processing center is not possible. Other guidance for transportation and communications includes:

- Limit stacking of bushels on top of each other when possible during transport.
- Transport bushels in a properly ventilated trailer or truck. Avoid transporting bushels in an enclosed vehicle, as this can promote molding (Fig. 32).
- Take caution to properly secure the load of bushels before driving. Cargo netting or tie downs may be required. Consider checking the load periodically along the route for any shifting of bushels.
- Schedule the bulk of travel time during cooler periods of the day when less direct sunlight exists when possible.
- Confirm with the appropriate seed extractory manager upon arrival of proper drop-off time, location, and bushel and stand information.

Proper storage

The most important storage needs are high ventilation and free airflow along with shade, dryness, and protection from heat, rain, pests, and rough handling (Fig. 33). Freshly harvested cones contain moisture; as they dry, they can expand, heat up, mold, or become difficult to process if stored improperly. True fir, incense cedar, and other high-moisture cone species are especially vulnerable to mold and seed damage (Stewart et al., 2026; Tanaka, 1984).

Depending on the recipient seed extractory or collection plan, cones may need to be stored temporarily prior to delivery (e.g., USFS R5 Placerville Nursery currently requires collections to be stored for 2 weeks prior to delivery, with few exceptions). Guidance for interim storage includes:

- Collection managers should contact local stations or districts and coordinate short-term storage in appropriate conditions.
- Store cones in bushel bags in a dry, shaded, well-ventilated

location off the ground, such as on wire racks, pallets, or other raised surfaces.

- Lay sacks flat and spread cones out as much as possible to improve airflow.
- Do not stack bushels, leave them in piles, store them directly on soil, or cover them with plastic or tarps.
- Keep cones out of direct sunlight, heat, rain, and areas with high squirrel or rodent activity.
- Turn sacks regularly (daily or every other day) to promote even drying and reduce the risk of mold or case hardening.
- If cones get wet, spread them out to surface-dry and rebag them in dry sacks as soon as possible.
- Avoid dropping or roughly handling bushels, especially for species with delicate cones or seed structures.

Figure 31. Processing and measuring collected white fir for bagging.

Figure 32. Packed bushels in a truck ready for transportation.

Figure 33. Cones stored flat in bushel bags on wire racks with high air flow and ventilation.

Further Reading & Resources

Cone Collection, USDA Forest Service

- https://www.fs.usda.gov/t-d/seedlings/conecoll/index.htm

Cone Hunting 101, The CA Reforestation Pipeline Partnership

- https://conehunting101.learnworlds.com/

Cone Scouting Guide, Silvaseed by Mast

- https://23185209.fs1.hubspotusercontent-na1.net/hubfs/23185209/Silvaseed/Cone-Scouting-Guide.pdf

The CA Reforestation Pipeline Partnership, American Forests

- https://www.americanforests.org/coalition/reforestation-pipeline-partnership/

Reforestation Services Program, CAL FIRE

- https://www.fire.ca.gov/what-we-do/natural-resource-management/wildfire-resilience/reforestation-services-program

Seed zone and elevation searchable map, CAL FIRE

- https://experience.arcgis.com/experience/ee7c8259e92a40d7b617da59ed60801f/page/Page/?org=CALFIRE-Forestry

Silvics of North America. Volume 1. Conifers, USDA Forest Service

- https://www.srs.fs.usda.gov/pubs/misc/ag_654_vol1.pdf

Woody Plant Seed Manual, USDA Forest Service

- https://www.fs.usda.gov/rm/pubs_series/wo/wo_ah727.pdf

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Glossary

Abortion. The premature cessation of cone development, where the cone fails to fully mature and becomes non-viable. Due to environmental stressors, resource limitations, predation, disease, or unfavorable climatic conditions, trees may cut off nutrients and resources to the cone such as water and sugar, thus leading to cone death. Aborted cones may fall off or remain on the tree, and are unsuitable for seed collection. They are typically pale brown or reddish in color and dried out.

Angiosperms. Flowering plants that produce seeds enclosed within fruits.

APTA (Air Powered Tree Access). An air-powered device for launching lines into tall trees to facilitate cone sampling and collection.

Big Shot Sling Shot. A high-powered sling shot device used to launch throwlines into tree canopies for cone retrieval.

Bushel. A standard measurement for cone collections. 1 US bushel is defined as 37.2 fluid quarts, 32 dry quarts, 9.3 fluid gallons, or 8 dry gallons.

Bushel Bag. A ventilated bag made of burlap or mesh that is used to store collected cones, allowing for proper drying and storage.

Bushel Estimate. An approximation of the number of bushels of cones available for collection from a tree or stand from the top 2/3rds of the tree crown.

CAL FIRE Assessment of Needs (AON) Tool. A digital tool that provides data on bushels needed by species, elevation, and seed zones to fulfill state reforestation goals.

Climbers. Trained professionals (often arborists) who use ladder and rope systems to access tree canopies to collect cones from the upper canopy.

Climbing Contract. An agreement specifying the terms, conditions, expectations, and cost for tree climbing crews involved in cone collection.

Climbing Spurs. Spiked equipment used by climbers to ascend trees; generally avoided for high-value or delicate species during cone collection but can be necessary and useful in rescue situations.

Codominant Tree. Trees that make up the general height of the canopy. They receive direct light from above, but little or no light from the sides. Generally, they are shorter than the dominant trees.

Codominant Stem. Trees that have two or more stems coming from the same point of origin. The attachment between the stems may be weak, making them more dangerous to climb.

Collection Lead. The person responsible for overseeing cone collection operations who ensures quality standards and compliance with contracts.

Cone Crop Rating. A system used to evaluate the abundance and quality of cones in a tree or stand (e.g., light, medium, or heavy crop).

Cone Cut Test. A method of slicing cones longitudinally to evaluate the quality and viability of seeds inside and to monitor cone development.

Conifers. A subset of gymnosperms characterized by cone-bearing reproductive structures, including male (pollen) cones and female (seed) cones. Conifers are mostly evergreen, woody plants with needle-like or scale-like leaves.

Dioecious. Trees that have pollen and seed cones on separate individual trees.

Dominant Tree. A tree that is taller and receives more sunlight than surrounding trees, often targeted for cone collection due to its health and vigor.

Elevation Band. A specific range of altitudes within a forested area, used to categorize and manage vegetation or ecological characteristics. Elevation bands are often defined to account for variations in climate, soil, and species composition across different altitudes, and are commonly used for planning activities such as reforestation, seed collection, and habitat conservation. In cone collection, elevation bands are grouped by 500 ft sections.

Embryo. The part of a conifer seed that develops into a new plant. It is formed after fertilization and is surrounded by nutrient-rich tissues (megagametophyte), which provide energy for the embryo's growth during germination. The embryo includes structures such as the radicle (future root), cotyledons (seed leaves), and a shoot apex; together they enable the seedling's development into a mature conifer.

Embryo Fill. The proportion of the seed cavity occupied by the embryo. A well-filled embryo (>90%) is a key indicator of seed maturity and viability, with poor fill often signaling immaturity or damage.

Flagging (for marking). Colored markers, such as tape, used to designate specific trees or areas for monitoring or collection.

Flagging (tree condition). A condition when tree branches throughout the tree's crown turns yellow, red, or brown, indicating stress or damage. This can result from various factors, including drought, insect infestations, disease, or environmental conditions such as wind or frost. Flagging often affects specific branches or sections of a tree and can serve as an early warning sign of underlying health issues.

Frass. Fine powdery debris left by wood-boring insects, often found on or inside infested cones.

Genetic Diversity. The range of genetic variation within a population.

An essential factor for successful reforestation as higher levels of genetic diversity within populations and communities can increase resiliency to various stressors such as drought and disease.

Ground Crew. The team that supports climbers and/or the collection lead through communication, bagging and tagging of cones, and record keeping during collections.

Gymnosperms. Non-flowering plants that produce seeds exposed on cones or other structures. Conifers are a large subset of gymnosperms.

Insect Activity. The predation of seeds in cones via insects. Indicators for insect activity include entry/exit holes, frass, and J or hook shaped cones. Cones with insect activity should not be collected.

J- or Hook-Shaped Cone. A malformed cone often indicative of insect damage or genetic abnormalities.

Megagametophyte. Inner seed tissue that provides nutrients to the embryo. When immature it appears milky and gelatinous. When mature, it appears firm, opaque, and nut-like.

Monoecious. Trees that produce both pollen and seed cones on the same individual.

Ovule. A specialized structure in female cones where pollen adheres and fertilization occurs, developing into a seed.

Oxidation. A chemical reaction where the cone's inner tissue changes color from off-white to brown, often indicating immaturity.

Phenotypic Traits. Observable characteristics of a tree, such as vigor or shape.

Pollen (male) Cones. The male reproductive structure of conifers that produces and releases pollen. Pollen cones are typically smaller and less durable than seed cones and are found in clusters on branches. They release pollen into the air, which is carried by wind to fertilize ovules in seed cones.

Pollen Tube. A structure that grows from a pollen grain towards the ovule, enabling fertilization in conifers.

Scale. The individual plate-like structures that make up a cone. Scales protect the seeds when closed. As cones ripen, scales open to release the seed, playing a key role in seed dispersal for conifers.

Seed Extractory. A facility or program for processing cones and extracting seeds from various species and locations.

Seed Bank. A facility or program for storing seeds from various species and locations, maintaining genetic diversity for future reforestation.

Seed Coat. The protective outer layer of a seed. The color and condition of the seed coat (e.g., transitioning from pale to darker brown) indicate the maturity and readiness of the seed for collection.

Seed (female) Cone. The female reproductive structure of conifers that contains ovules. After fertilization by pollen, the ovules within the seed cone develop into seeds. Seed cones are typically larger and more durable than pollen cones, with scales that protect the developing seeds until they are mature and ready for dispersal.

Seed Lot Identification Tag. A label attached to bushel bags to provide essential details about seed origin, collection location, and species. Used by seed banks to create seed lots for future reforestation.

Seed Orchard. A managed area where genetically superior trees are cultivated to produce high-quality seeds with desirable traits.

Seed Source. The geographic and genetic origin of seeds, critical for ensuring compatibility with reforestation sites.

Seed Wing. A thin, papery extension of the seed that aids in wind dispersal. In mature seeds, the wing is well-formed, darker brown in color, and begins detaching from the scale.

Seed Zone Map. A map used to delineate geographic regions based on climatic and ecological conditions, ensuring appropriate seed sourcing. Created in 1946 and revised in 1970 by the USFS and CAL FIRE.

Serotinous Species. Species whose cones require heat (e.g., from fire) to open and release seeds.

Stand (cone collection). A relatively uniform group of trees selected for cone collection based on species composition, elevation band, cone crop presence, and other geological conditions.

Stand (general forestry). A contiguous group of trees sufficiently uniform in species composition, age, structure, and condition to be distinguishable from adjacent groups of trees and managed as a single unit in forestry. Stands are the fundamental units used for inventory, planning, and management in forest ecosystems.

Throwline Kit. Arborist equipment used for tree access; a kit includes a throwline, weight(s), and a storage cube.

Tree Crown. Part of the tree that includes anything above the first major lateral branches.

Tree Hazards. Potential risks in a tree, such as decay, structural weakness, or wildlife, that may impact safety during climbing or collection.

Wild Stand. A natural, unmanaged forest area where trees are selected for seed collection based on their genetic diversity and adaptability.

Appendix A: Hazard tree identification

Resources for hazard tree assessments:

USDA Forest Service PSW Hazard Tree Identification and Mitigation Guidelines

ISA Tree Risk Assessment

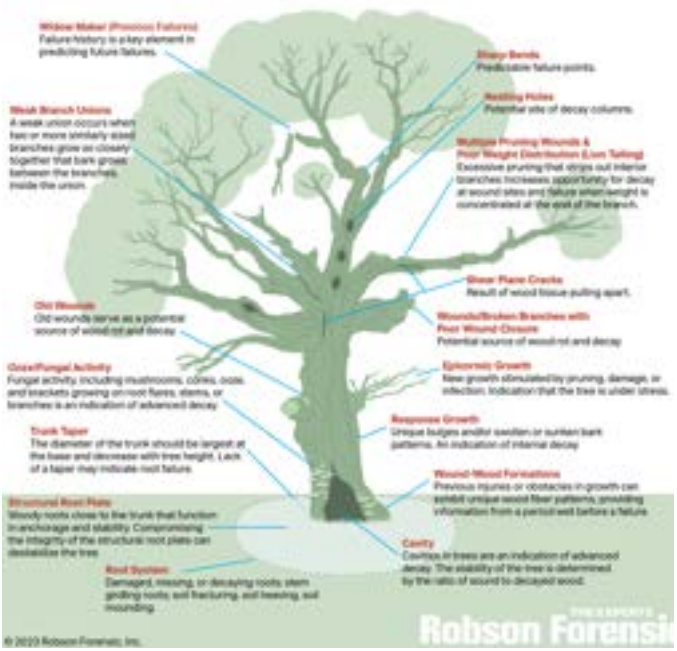


Figure 1. Hazard tee identification. *Source:* Robson Forensic, Inc., 2023

Appendix B: Sampling cones using throwline

To knock or shake cones out of the trees for sampling, while aiming for the top 2/3rd of the crown, you can use a throwline to secure the end of a branch with cones and pull on the line to remove cones. This can be a very physically and mentally demanding task that requires good aim, a bit of strength, and a lot of patience. Luckily, with practice it can get easier over time.

This guide is intended only as a supplemental field reference and is not a substitute for manufacturer instructions for the tools reviewed, site-specific safety procedures, or qualified training.

OPERATIONAL SAFETY WHILE SAMPLING

- Wear a hard hat, eye protection, and gloves at all times.
- Before launching, confirm that no people, animals, vehicles, power lines, or other hazards are in the line of fire.
- Anyone not throwing should stand behind the thrower and outside the drop zone.
- Before firing, call “Clear!” and wait for all crew members to confirm the area is clear; then call “Firing!” before throwing.
- While shaking branches, watch for falling cones, dead branches, and other debris.
- When retrieving a line with the weight still attached, keep everyone clear of the weight’s path and ensure everyone is paying close attention. Never try to catch a falling weight.

THROWLINE KIT MATERIALS & CONSIDERATIONS (FIG. 1)

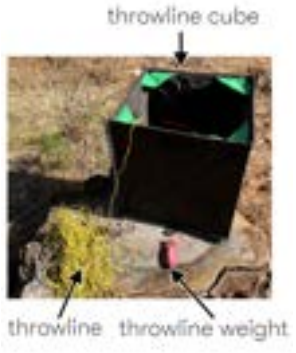


Figure 1. Throwline kit with cube, line, and weight.

- Throwline cube
- Throwline (1.5mm – 2.2 mm cord)
  - >200 ft. for most conifers
  - >300 ft for redwood and giant sequoia
- Throwline weight(s) (10 - 16 oz)
  - Lighter weight is best for higher targets, clear shots with low friction, and species with smooth bark (10 - 12 oz).
  - Heavier weight is best used for species with rough bark and dense crown (14 - 16 oz).

TIPS & CONSIDERATIONS FOR SETTING UP THROWLINE KIT AND GETTING LINE IN THE TREE FOR SAMPLING

- Secure the throwline to the throw cube's interior loop and to the throw weight using a reliable knot, such as a poacher's loop, slipped anchor hitch, or ring hitch (Fig. 2).
- Flake the throwline into the cube in clean alternating layers and remove sticks or debris to prevent tangles.
- Place the throw cube 2–3 ft in front of the thrower, aligned with the line's natural path to the target branch and clear of debris.
- Aim for the upper two-thirds of the crown, targeting branch tips with cones present.
- Choose a branch with a manageable retrieval path, enough clearance to maneuver the line, and space above it to avoid tangling in dense crown.
- Avoid downsloped branches where the line may slide off easily.
- Aim just above the target branch. After release, the thrower may slow or stop the line mid-air to avoid overshooting; gloves should be worn and jewelry/rings removed to prevent rope burn or injury.
- Expect added friction in dense crowns or species with rough, pitchy bark.

Figure 2. Throwline secured to cube and weight.

METHODS AND TOOLS FOR GETTING A LINE INTO A TREE

When setting a throwline for sampling, the preferred approach is generally to use the simplest method that will reliably achieve a clean and usable line path. The choice of method will depend on tree height, crown density, target position, individual experience, and the need for efficiency or repeatability.

BY HAND

Hand throwing is often the best option when working with smaller conifers, lower target heights, or trees with a relatively open crown structure. It is a simple and quick method and requires the least equipment. It does require good aim and often a lot of practice before becoming an efficient method, especially for higher targets.

Using a circular swing. Hold the throwline roughly 2 – 3 ft from the weight, spin the weight in a circular motion to one side (similar to a sideways lasso) and release at the top of the swing (Fig. 3).

Using a pendulum swing. Standing with legs apart, grab a section of the line 3-4 ft from the weighted end and pull it through the loop of the weight so that the weight sits between each hand. Gently swing the weight between your legs gaining more and more momentum until releasing the line from both of hands at the top of the swing (Fig. 3).

Figure 3. Stance for swinging weight to the side or between the legs.

BIG SHOT SLING SHOT

A Big Shot is a more practical choice for medium to high targets and allow for greater consistency compared to hand throwing. The Big Shot can propel throw weights over 100 feet or more, with actual performance varying depending on throw weight, length of pull, line drag, and operator technique. Recommended brand: *Notch Big Shot with or without a trigger.* Read and follow the manufacturer's instructions for the specific Big Shot and trigger configuration being used, as these are the primary sources of operating and safety information:

- Notch User Guide: https://notchequipment.com/content/downloads/manuals/NOTCH-BIGSHOT-and-Trigger-Instructions-20170509.pdf

Supplemental tips & considerations:

- Set the weight in the Big Shot basket with the line running outside the basket, not between the basket and pole, to reduce friction and injury risk (Fig. 4).
- When sighting along the pole, use the top of the "V" in the Big Shot head as a guide and aim for a clean path just above the target branch. Adjust the point of aim based on target height, distance, and shot clearance.

- An adjustable trigger can improve accuracy, consistency, high-target shots, and reduce arm fatigue by allowing the sling to be set before final aiming. Some users prefer no trigger because it allows small height adjustments while aiming.
- If using a trigger with a safety latch, reduce trigger tension if needed before pushing up to release the latch.

Figure 4. Set up for Big Shot Sling Shot aim, weight, and throwline.

AIR POWERED TREE ACCESS (APTA)

An APTA may be most appropriate when working in especially tall conifers or in situations where repeated high placements are needed, in which hand throwing and slingshots are unlikely to provide adequate height, consistency, or efficiency. The APTA can propel throw weight over 300 feet or more, with actual performance varying dependent on throw weight, PSI, line drag, and operator technique. Read and follow the manufacturer's instructions for the specific APTA being used, as they are the primary source of operating and safety information:

- Tree Stuff APTA User Guide: https://www.treestuff.com/content/pdf/Final_APTA_Instructions.pdf

Supplemental tips & considerations:

- Recommended default weight: 12 oz. Before heading into the field check to ensure that weights fit into the chamber; proper seal is important for height and velocity.
- Fill the tank of the APTA to 100-140 PSI. Pressure exceeding 200 PSI is not recommended by manufacturers.
- Treat it like a weapon; never point it at any persons, animals, or property while pressurized or unpressurized.
- APTAs can be pressurized using a bicycle pump or electric pump of adequate pressure.
- Once the chamber is loaded and pressurized and aim is set, release the handle as quickly as possible to allow the air pressure to released at once. Pulling the handle slowly will result in a minimized or failed launch (Fig. 5).

Figure 5. Set up for Air Powered Tree Access (APTA).

OTHER TOOLS FOR THROWLINE SET UP & CONE SAMPLING

Crossbows and other nonstandard throwline launcher systems are outside the scope of this guide. Such systems are known to be used in some settings, including for line placement in exceptionally tall trees such as giant sequoias. Rifles are also known to be used for retrieving cone samples. Where such equipment is used, its selection and operation should be governed by organization-specific protocols, applicable law, qualified training, manufacturer instructions, and site-specific safety procedures.

TIPS & CONSIDERATIONS FOR RETRIEVING CONES WITH THROWLINE

- Once a line is over a branch with cones, remove the weight and grab both ends of the line together in one hand. **Pro tip:** Wrap the lines around a sturdy stick or tie it to a carabiner to act as a handle—this can be helpful for both retrieving cones and untangling line. Do not wrap throwline directly around bare hands (Fig. 6).
- If the line is sitting on top of the target branch, either pull hard in one swift motion, or begin to pull up and down rhythmically—pulling down quickly at the top of the swing to generate a whip-like motion. Be careful not to do this for too long, especially in species with rough bark (e.g., ponderosa pine), as the heat and friction from the line and the branch can potentially cause the line to break.
- If the line is caught on the base of a cone, pull hard to 'cut' off the cone with the line. Before pulling, try crossing the line and pulling the two ends of the line apart to fully capture the end of the branch with the line to cut off cones that are hanging on the underside of the branch.

REMOVING A LINE

- If accessible, it is best practice to remove the throw weight before pulling the line out of the tree. Pulling both the line and weight back over branches can cause the weight to swing, build momentum, wrap around branches, or pop back quickly toward the retriever and nearby crew.
- Watch the weight closely while retrieving the line and pull slowly to reduce swing momentum. If the weight begins swinging heavily, release several feet of line quickly to slow it down, then continue pulling slowly. When the weight is close to the branch, either pull very slowly or wait for the backswing and pull quickly.
- If the line or weight becomes tangled or wrapped around a branch, first assess what it is caught on and how it is wrapped. To free the snag, try pulling the line taut and creating vibrations by pinching and releasing the line, flicking a wave up the line, pulling hard with a stick or carabiner as a handle, or using a second throwline over the same or adjacent branch to knock the weight free.
- If the line becomes stuck, it may need to be retrieved by climbing or abandoned (worst-case scenario).

Figure 6. Throwline wrapped around stick to create handle for pulling on line.

Appendix C: Cone cutters

Cone cutters are used to slice cones lengthwise so the interior cone and seed condition can be evaluated for quality and development. These tools are usually homemade because they are not commercially available, and designs should be matched to the cone sizes and species being sampled; for example, sugar pine, Coulter pine, and Douglas-fir cones may require different cutter sizes or a more adaptable design.

COMMON CONE CUTTER COMPONENTS

- **Blade.** A sturdy, sharp steel blade, such as a utility knife blade, butcher knife, machete, or thick sheet metal. The blade should be long enough to cut the full length of the cones being sampled.
- **Base.** A durable wood or metal base, either flat or curved, used to support the cone and mount the blade.
- **Handle.** A wood or metal handle for leverage; longer handles provide more cutting force.
- **Hinge mechanism.** A strong hinge or fixed attachment that keeps the blade aligned with the base while allowing it to move vertically without slipping side to side.
- **Fasteners.** Screws, bolts, nuts, or welding materials to secure the parts.
- **Safety features.** Guards or other protective features near the blade to reduce injury risk.

POTENTIAL TOOLS REQUIRED:

- Drill and bits
- Wrench or screwdriver
- Screws, bolts, and nuts
- Metal file or grinder
- Welding equipment, if needed
- Measuring tape
- Clamps for securing parts during assembly

Figure 1. Different styles of homemade cone cutters.

Appendix D: Resources for survey planning

RESOURCES FOR IDENTIFYING LANDOWNERSHIP

- National Map Data Downloader (https://apps.nationalmap.gov/downloader/)
- CAL FIRE California Land Ownership Map (https://qrco.de/bgoXa8)
- OnX Property Boundary App (https://www.onxmaps.com/)
- BLM National Map Viewer (https://experience.arcgis.com/experience/9a89ee80c604431e8f8d939a186fbdbb)

RESOURCES FOR RANGE MAPS, VEGETATION TYPES, AND FUTURE FIRE RISK

- California Statewide LiDAR Map (https://wildfiretaskforce.org/california-unveils-first-ever-statewide-lidar-maps/)
- Cone Scouting Tool (https://conescout.duckdns.org/)

RESOURCES FOR DOWNLOADING OFFLINE MAPS

- USFS PSW National Forest Motor Vehicle Use Maps (https://www.fs.usda.gov/r05/data-tools/interactive-maps/mvum-finder)

RESOURCES FOR IDENTIFYING SEED NEEDS

- For public federal lands, consult local district foresters or the USDA Forest Service Region 5 Genetics Program for seed need information.
- For public state lands and private non-industrial lands, use the CAL FIRE Reforestation Services Program website to access the CAL FIRE Assessment of Needs (AON) Tool, which estimates bushels needed by species, 500-foot elevation band, and seed zone to support state seed bank needs for reforesting non-federal lands (see Appendix E).

RESOURCES FOR CLIMATE-ADAPTED SEED SELECTION PLANNING

- Climate-Adapted Seed Tool (CAST) (https://reforestationtools.org/climate-adapted-seed-tool/)
- Seedlot Selection Tool (https://seedlotselectiontool.org/sst/)

Appendix E: CAL FIRE Assessment of Needs (AON) Tool

CAL FIRE's California Seed Bank Assessment of Needs (AON) tool provides estimated bushels needed by species, 500 ft. elevation band, and seed zone to support state seed bank needs for 14 common species to reforest 25% of non-federal conifer timberlands.

Scan to access the tool to identify estimated seed needs for non-federal conifer timberlands.

Direct link: https://qrco.de/bfH4b5

This tool allows users to search a town, address, or coordinates, or directly select the map to determine local seed needs. Once a location has been identified, a drop-down list will appear providing statistics on the select 500 ft. elevation band and seed zone, including:

- Collection priority ranking.
- List of estimated bushels for the local species. A positive number of bushels indicates a need while a negative number indicates a surplus of stored seed for reforesting 25% of non-federal lands.
- Statistics on recent local disturbances and tree mortality (e.g., fire, pathogens).
- Statistics on climate exposure risk for local species.

Figure 1. Screenshot from the CAL FIRE AON Tool showing estimated bushel need for seed zone 522 and elevation band 4,501 - 5,000 ft.

Appendix F: Survey123 - CA Cone Crop Survey

To report cone crops, many cone hunters use a digital survey tool called Survey123. It is a powerful cloud-based data collection tool designed to support reforestation efforts in California by streamlining the way cone crop observations are reported and shared. The tool functions through a mobile app or browser and allows users to submit detailed surveys about cone crops, including location, tree species, crop ratings, bushel estimates, land accessibility, and photos. Once submitted, the data feeds directly into a centralized database managed through ESRI ArcGIS, enabling seed bank managers to track cone crop availability in real-time across the state. Survey123 empowers a wide range of users, from agency staff and contractors to forestland owners and outdoor enthusiasts, to contribute valuable data that supports efficient and timely seed collection for postfire reforestation.

Survey123 - 2026 CA Cone Crop Survey

Scan to access the survey through the online desktop version or mobile device app (recommended).

Direct link: https://arcg.is/1qSKra0

HOW TO DOWNLOAD AND FILL OUT THE SURVEY: STEP-BY-STEP

OPEN THE APP

- An AGOL (ArcGIS Online) account can be used to sign in, however, all surveys can be submitted and viewed on the app and online **without** an account. Select 'Continue without signing in' unless an AGOL account is preferred.

DOWNLOAD THE SURVEY

- If the 'CA Cone Crop Survey' did not download upon scanning the QR code above, try manually downloading the Survey123 app and using the app's internal QR code scanner (found in top right corner of the app), and scan the QR below (left). If that fails, then try using the internal scanner and using the other QR code below to get access to the most-up-to-date survey link (right).

For USFS personnel use only

SURVEYOR INFORMATION

- Identify yourself and your affiliation. This will determine which ArcGIS group your submissions will be visible to.
- **Pro Tip:** To avoid filling out the name and affiliation every time a survey is submitted, open the menu in the top right corner and select 'Set as favorite answers.' Be sure to check that this does not accidentally populate a different location.

SITE INFORMATION

- Verify that the location and timestamp are accurate.
- Identify the property type. For private property, it will ask for the owner's name and contact information, which will remain confidential. Only the seed bank managers will see private lands data.
- Share any accessibility concerns or hazards identified that might make cone collection difficult.

DATA COLLECTION TYPE

- Select whether reporting crop abundance represented as cone volume (see p. 21) or cone count (see p. 24).

TREE OBSERVATION

- Determine the observation scale. Report whether the observation is for a stand or an individual tree. Unless it's a special collection such as MGR sugar pine, reports should be for stand observations (see p. 23).
- Identify the tree species. Use the tree species filter to narrow down the list, then select or type which species are present. Multiple species can be reported in one survey and can include trees without cones to capture the species composition of the stand.

Cone Volume

- Report the average crop rating (see p. 21).
- Report the average bushel estimate per tree (see p. 26).
- Indicate whether reporting a 1-year conelet crop or 2-year crop for species that take two years to mature (Fig. 5-7; Appendix J). For these species, surveys should primarily report the crop available for collection in that same year (2 year cones), but reporting conelets can be useful for the following year, especially if there are plans to continually survey the same area year after year.
- Report the number of potentially collectable seed trees in the stand (see p. 23) or the % of the stand with similar crop.
- Take at least one photo of a cone producing tree. **Pro tip:** Take

photos through binocular lenses for higher quality reporting.

Cone Count

- Selecting a seed tree that represents the average crop in the stand, report the cone count visible from one side of that tree in the top 2/3rds of the crown (see p. 24).
- Similar to cone volume, indicate which year of development the crop is in (1-year or 2-year cones).
- Report the number of potentially collectable seed trees with comparable crop (see p. 23) or the % of the stand with similar crop.
- Take at least one photo of a cone producing tree. **Pro tip:** Take photos through binocular lenses for higher quality reporting.

ADDITIONAL INFORMATION

Upload any other photos and add any additional notes. It's recommended to include photos that represent the stand condition or any hazards. **Pro tip:** Taking notes on the relative stand or tree height may give the climbers valuable insight as to the time commitment and workforce needed for their planning purposes.

SUBMIT

Click the check mark when finished. Either select 'Send now' if it's ready to go; 'Continue this survey' if edits need to be made immediately; or 'Save to Outbox' to review and edit later or if out of internet service. During a full day of surveying, it is recommended to save all surveys to the outbox and to review at the end of the day to confirm accuracy. It also allows users to edit throughout the day if corrections need to be made on site. Once surveys are reviewed, select 'Send now' to fully submit them.

Note: The above guidance follows the 2026 version of the CA Cone Crop Survey. The survey typically undergoes annual updates based on user feedback and partner requests. If using this guide after 2026, the guidance may not align with current survey layout.

ABOUT SURVEY123 - CA CONE CROP SURVEY

WHO CAN USE SURVEY123

Everyone. Anyone interested in contributing to the timely and efficient collection of conifer seed for reforestation is encouraged to use this application. Notable groups this application is relevant for:

- United States Forest Service (USFS)
- CA Dept. of Forestry and Fire (CAL FIRE)
- Bureau of Land Management (BLM)
- National Park Service (NPS)
- Department of Fish and Wildlife (DFW)
- Agency partners and cone specialists (e.g., contractors working with an agency on cone collections)
- CA Cone Corps
- Students (e.g., Forestry, conservation biology, etc.)
- Private owners of forested land
- People who recreate in the forests (e.g., mountain biking, hiking, bird watching, camping, etc.)

WHAT IS IT USED FOR?

Seed bank managers with oversight and funding to support cone collections need to know where cone crops are developing as early in the season as possible. When users report information on cone development in forested stands, the "CA Cone Crop Survey" tool is how seed bank managers will be able to receive, review, and work with that crucial information.

The tool was created to enhance the coordination and capacity for cone collection, and to ensure that as many viable cone crops as possible are collected on a yearly basis.

WHO MADE IT?

This reporting tool was created by a working group with participation by the University of California Cooperative Extension, CAL FIRE, USDA Forest Service (Pacific Southwest Region) and American Forests organized by the CA Reforestation Pipeline Cooperative, an all-comers platform with a mission to serve diverse stakeholders to accelerate timely, effective, climate-informed reforestation practices across all lands. The tool receives annual review and updates based on user feedback and partner requests. Funding for this program comes from the USDA Forest Service and the California Department of Forestry and Fire (CAL FIRE) Wildfire Resilience program.

VIEWING DATA

Once surveys have been submitted, they can be viewed through a few different options depending on the required level of access and affiliation of the survey submitted.

ON THE APP

To view or revisit the surveys submitted on the device used to submit them, use the app. Select the '2026 CA Cone Crop Survey', then select 'Sent' to see the list of surveys submitted. Select 'Map' to visualize the spatial plotting of the surveys submitted.

VIEW PUBLIC DATA

If the survey was submitted with the affiliation marked as 'Public' you can view all public data on a public database, the CA Cone Dashboard!

Data Viewing: Public Dashboard

Scan to view public survey data and explore cone crop trends in real time across the state.

Direct link: https://qrco.de/conedashboard

Figure 1. Screenshot of the CA Public Dashboard for public CA Cone Crop Surveys

VIEW & MANAGE PRIVATE DATA

Some of the data is filtered at the discretion of user group needs and landowner rights (e.g., private landowners, agency-specific requirements). If filtered data needs to be accessed, request to join the specific affiliation-based user group needed, or request to create a new private data group. An AGOL account will be required to access this data. Additionally, a template of the survey is available for download and reproduction for private use.

View: Join Private Data Group

Scan to request access to affilation-specific data viewing group through via an AGOL account.

Direct link: https://qrco.de/bf32cC

Download template (Excel)

For private collections not associated with or in collaboration with the state or federal seed banks, a template of the cone crop survey is available.

Appendix G: California Tree Seed Zone Map

Resource for online seed zone search:

CAL FIRE California Seed Zone and Elevation Lookup Viewer (https://experience.arcgis.com/experience/ee7c8259e92a40d7b617da59ed60801f?org=CALFIRE-Forestry)

Figure 1. California Tree Seed Zone Map (1970). *Source:* State of California.

Appendix H: USFS forest and district codes

Table 1. USFS forest and district codes for seed lot collection tags.[1]

Forest	Forest Code	District	District Code
Angeles	01	Los Angeles Gateway San Gabriel Mountains National Monument	51 52
Cleveland	02	Trabuco Paolomar Descanso	52 53 54
Eldorado	03	Amador Georgetown Pacific Placerville	51 52 55 56
Inyo	04	Mono Lake Mammoth White Mountain Mt. Whitney	51 52 53 54
Klamath	05	Oak Knoll Happy Camp Salmon River Scott River Goosenest Ukonom	51 52 54 55 57 58
Lassen	06	Almanor Hat Creek Eagle Lake	51 53 56
Los Padres	07	Monterey Santa Lucia Santa Barbara Ojai Mt. Pinos	51 53 54 55 57
Mendocino	08	Grindstone Upperlake Covelo	53 54 56

[1] U.S. Forest Service, El Dorado National Forest, *Placerville Nursery, A Nursery Tale: From Collection to Reforestation*, 2016.

Table 1 (continued). USFS forest and district codes for seed lot collection tags.[1]

Forest	Forest Code	District	District Code
Modoc	09	Warner Mountain Big Valley Devil's Garden Doublehead	53 54 55 56
Six Rivers	10	Gasquet Orleans Lower Trinity Mad River	51 52 53 54
Plumas	11	Beckwourth Mt. Hough Feather River	1 2 3
San Bernardino	12	Mountaintop Front Country San Jacinto	52 53 55
Sequoia	13	Hume Lake Western Divide Kern River	51 52 54
Shasta-Trinity	14	Yolla Bolla Hayfork Big Bar Weaverville Shasta Lake Mt. Shasta McCloud	51 52 54 56 58 59 61
Sierra	15	Bass Lake High Sierra	51 52
Stainlaus	16	Mi-work Calaveras Summit Groveland	51 52 53 54
Tahoe	17	Yuba River American River Sierraville Truckee	53 54 56 57
Lake Tahoe Basin Management Unit	19	—	—

[1] U.S. Forest Service, El Dorado National Forest, *Placerville Nursery, A Nursery Tale: From Collection to Reforestation*, 2016.

Table 1 (continued). USFS forest and district codes for seed lot collection tags.[1]

Forest	Forest Code	District	District Code
Toiyabe	20	—	—
BLM California	40	Bakersfield Susanville Redding Folsom Ukiah	01 02 03 04 05
BLM (non WCF)	41	—	—
BLM Nevada	42	Carson City	30
Blodgett	50	—	—
PSW	55	—	—
Nevada Division of Forestry	60	—	—
Bureau of Reclamation	70	—	—
Bureau of Indian Affairs	80	—	—
Vandenberg Air Force Base	85	—	—
National Park Service - Sequoia Kings Canyon	90	—	—
National Park Service - Yosemite	91	—	—

[1] U.S. Forest Service, El Dorado National Forest, *Placerville Nursery, A Nursery Tale: From Collection to Reforestation*, 2016.

Appendix I: Township, section, and range determination

Township, section, and range (TSR) are terms used in the Public Land Survey System (PLSS), a method for surveying and dividing land in the United States. This system is commonly used for legal land descriptions and is required on some seed lot collection tags. While the CAL FIRE collection tags have the space to write in this information, **recording latitude and longitude is generally sufficient**. In case it is needed, use this to determine TSR values.

- **Township.** Refers to a square area of land that measures 6 miles by 6 miles (36 square miles total). Townships are identified based on their location north or south of a baseline (a horizontal reference line). e.g., T3N means "Township 3 North" of the baseline.
- **Range.** Refers to a column of townships running east or west of a principal meridian (a vertical reference line). Ranges are identified based on their location east or west of the meridian. e.g., R2W means "Range 2 West" of the meridian.
- **Section.** Each township is divided into 36 sections, with each section measuring 1 mile by 1 mile (640 acres). Sections are numbered 1 through 36 in a snake-like pattern, starting in the top-right corner (northeast) and ending in the bottom-right corner (southeast). e.g. S17 means that the location is in the 17th section of that township and range.

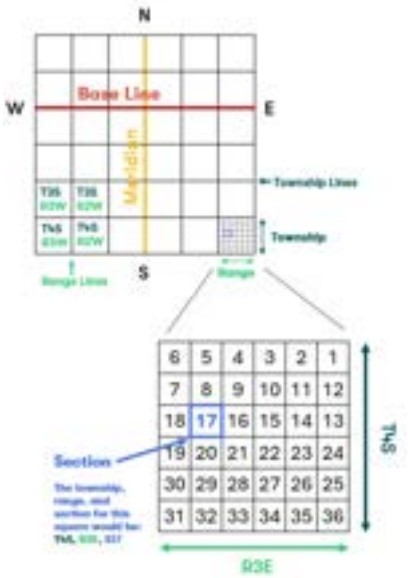


Figure 1. Concept of determining TSR through PLSS.

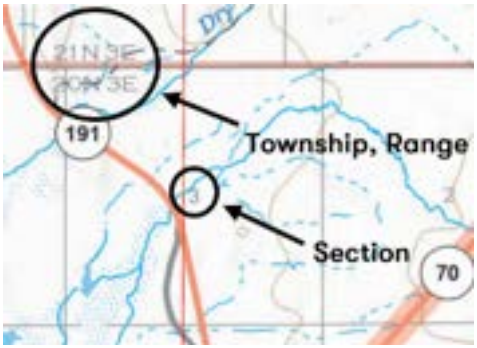


Figure 2. Screenshot of Forest Service Ranger District map noting '20N 3E' (township and range) in light gray, and gray square below noting a '3' in the center (section). The TSR of this square would be T20N R3E S3.

WHERE TO DETERMINE TOWNSHIP, SECTION, AND RANGE

Using a Map. Many downloadable PDF maps have notation for TSR (Forest Service, CAL FIRE, BLM General Land Office Records, Plat map, landowner or parcel map, etc.) (Fig. 2).

Online Tools. There are several online tools that allow entering coordinates or an address to provide the associated TSR of that location.

- Earth Point (Search by Latitude and Longitude; https://www.earthpoint.us/TownshipsSearchByLatLon.aspx)
- Randy Majors Research Hub (https://www.randymajors.org/township-range-on-google-maps)
- BLM Land Catalog (https://glorecords.blm.gov/default.aspx)

Appendix J: California conifer codes, identification, and cone development guide

All native California conifers (with the exception of California nutmeg) are presented in this guide (56 species including some variants). They are listed belo, sorted by their scientific name from A to Z (Table 1) with their respective common names, Natural Resources Conservation Service (NRCS) Plant Symbols (4-letter code), 3-digit USFS code, and corresponding page number where more detailed information on species identification, cone production, and example photos can be found.

NOTES

- The "Cone Development Period" defines the maximum time from fertilization to full ripeness and maturity unless otherwise noted. For example, Douglas-fir female cones are fertilized in the spring and reach full ripeness in the fall; this is noted as a "1 year" species.
- The distribution maps represent species presence by county (Baldwin et al., 2025).

Table 1. CA native California conifer species, identification codes, and corresponding page number.

Scientific Name	Common Name	Plant Symbol (NRCS)	3 Digit USFS Code	Page
Abies amabilis	Pacific silver fir	ABAM	011	86
Abies bracteata	Santa Lucia fir, bristlecone fir	ABBR	014	88
Abies concolor	white fir	ABCO	015	90
Abies grandis	grand fir	ABGR	017	93
Abies lasiocarpa	subalpine fir	ABLA	019	95
Abies magnifica var. magnifica	California red fir	ABMA1	020	97
Abies magnifica var. shastensis	Shasta red fir	ABMAS	021	99
Abies procera	noble fir	ABPR	022	101
Callitropsis nootkatensis	yellow cedar	CANO9	042	103

Table 1 (continued). CA native California conifer species, identification codes, and corresponding page number.

Scientific Name	Common Name	Plant Symbol (NRCS)	3 Digit USFS Code	Page
Calocedrus decurrens	incense cedar	CADE27	081	104
Chamaecyparis lawsoniana	Port-Orford-cedar, Lawson cypress	CHLA	041	107
Hesperocyparis abramsiana	Santa Cruz cypress	HEAB2	—	109
Hesperocyparis bakeri	Baker cypress, Modoc cypress, Siskiyou cypress	HEBA5	052	111
Hesperocyparis forbesii	Tecate cypress	HEFO10	055	113
Hesperocyparis goveniana	Gowen cypress	HEGO3	—	115
Hesperocyparis macnabiana	MacNab cypress	HEMA21	—	117
Hesperocyparis macrocarpa	Monterey cypress	HEMA22	—	118
Hesperocyparis nevadensis	Piute cypress	HENE2	—	120
Hesperocyparis pigmaea	pygmy cypress, Mendocino cypress	HEPI11	—	121
Hesperocyparis sargentii	Sargent cypress	HESA17	—	122
Hesperocyparis stephensonii	Cuyamaca cypress	HEST10	054	123
Juniperus californica	California juniper	JUCA7	—	124
Juniperus grandis	Sierra juniper, grand juniper	JUGR7	—	125
Juniperus occidentalis	western juniper	JUOC	064	126
Juniperus osteosperma	Utah juniper	JUOS	065	127
Picea breweriana	Brewer spruce	PIBR	092	128

Table 1 (continued). CA native California conifer species, identification codes, and corresponding page number.

Scientific Name	Common Name	Plant Symbol (NRCS)	3 Digit USFS Code	Page
Picea engelmannii	Engelmann spruce	PIEN	093	130
Picea sitchensis	Sitka spruce	PISI	098	132
Pinus albicaulis	whitebark pine	PIAL	101	133
Pinus attenuata	knobcone pine	PIAT	103	135
Pinus balfouriana	foxtail pine	PIBA	104	136
Pinus contorta var. contorta	beach pine, shore pine	PICOC	—	138
Pinus contorta var. murrayana	lodgepole pine	PICOM	108	139
Pinus coulteri	Coulter pine	PICO3	109	140
Pinus edulis	Colorado pinyon pine, two-needle pinyon	PIED	—	142
Pinus flexilis	limber pine	PIFL2	113	143
Pinus jeffreyi	Jeffrey pine	PIJE	116	145
Pinus lambertiana	sugar pine	PILA	117	147
Pinus longaeva	bristlecone pine	PILO	102	150
Pinus monophylla	singleleaf pinyon pine	PIMO	140	152
Pinus monticola	western white pine	PIMO3	119	154
Pinus muricata	bishop pine	PIMU	120	156
Pinus ponderosa	ponderosa pine	PIPO	122	157
Pinus quadrifolia	Parry pinyon pine	PIQU	138	160
Pinus radiata	Monterey pine	PIRA2	124	161
Pinus sabiniana	gray pine, foothill pine, ghost pine	PISA2	127	162
Pinus torreyana	Torrey pine	PITO	139	163
Pseudotsuga macrocarpa	bigcone Douglas-fir	PSMA	201	164
Pseudotsuga menziesii	Douglas-fir	PSME	202	166

Table 1 (continued). CA native California conifer species, identification codes, and corresponding page number.

Scientific Name	Common Name	Plant Symbol (NRCS)	3 Digit USFS Code	Page
Sequoia sempervirens	redwood, coast redwood	SESE3	211	169
Sequoiadendron giganteum	giant sequoia	SEGI2	212	171
Thuja plicata	western redcedar	THPL	242	173
Tsuga heterophylla	western hemlock	TSHE	263	175
Tsuga mertensiana	mountain hemlock	TSME	264	177

Abies amabilis

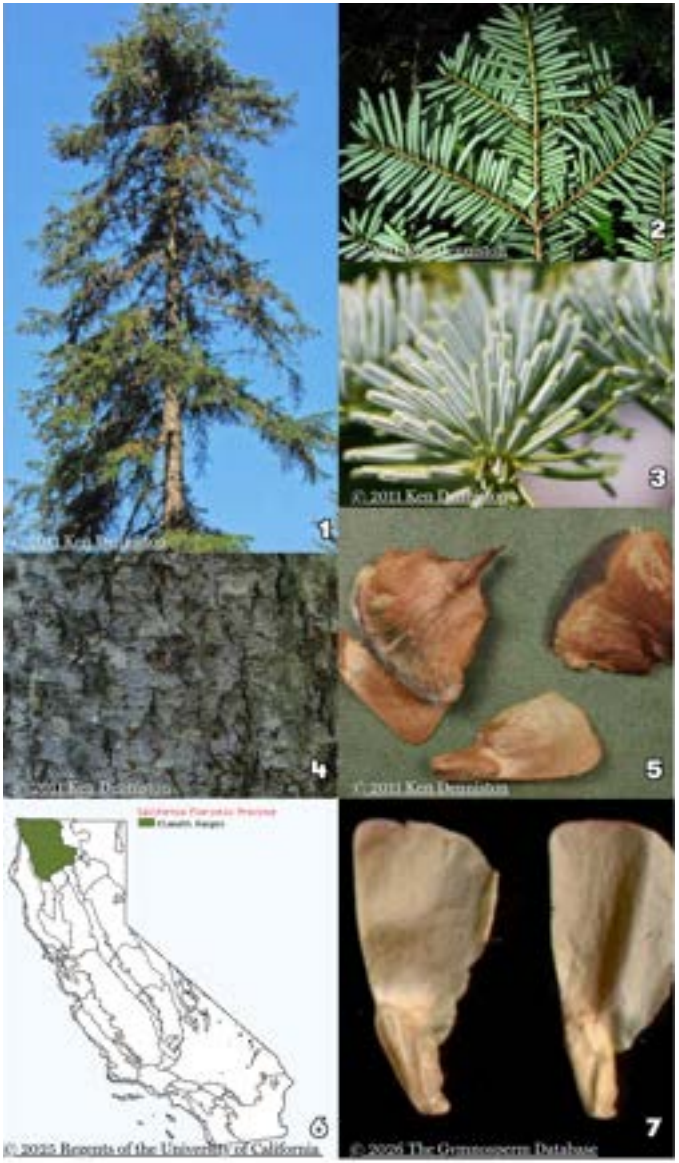
Pacific silver fir

ABAM, 011

Height: 80 – 160 (203) ft. **Distribution and Habitat:** Rare in California, only found in Marble and Siskiyou Mountains of northern California in subalpine and coastal coniferous forests; more common in the Pacific Northwest. **Elevation Range:** 1,700 – 7,000 ft. **Bark:** Light gray; thin; smooth with resin blisters when young becoming somewhat scaly with age. **Leaves:** Needle-like; dark green; ~1 in. long; flat; notched or rounded tips; grooved; appear as flat spray from below; appear as clustered pointed towards end of twig and upwards; silvery-white stomatal bands on bottom side; arranged spirally but twisted at the base to appear in two rows. **Cones:** Purple to green turning to yellow, green, gray or purple upon ripening; 3.5 in – 6 in. long; cylindrical; disintegrate at maturity to release seeds; positioned upright on branch. **Seed:** Tan; winged; wing turning light brown or pale purple upon ripening. **Flowering:** April – June. **Ripening:** August – September. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 8 seeds. Cone Production Cycles: 3 – 6 year interval.

Additional Remarks: Pacific silver fir is highly shade-tolerant and often establishes under the canopy of other conifers. It is susceptible to several diseases and insect pests, including root rot and adelgids.

Pacific silver fir cone crop (1), and broken cone with visible scales, wings, and seed (2).



Pacific silver fir tree (1), needles (2,3), bark (4), seeds with wings attached (5,7), and distribution map (6).

Abies bracteata

bristlecone fir, Santa Lucia fir

ABBR, 014

Height: 40 – 100 (182) ft. **Distribution and Habitat:** Endemic to the Santa Lucia Mountains of coastal California. **Elevation Range:** 200 – 5,200 ft. **Bark:** Red-brown; thin; smooth; occasional resin blisters. **Leaves:** Needle-like; bright green; 1.25 – 2.25 in. long; 2-ranked to spiraled; flattened; stiff; sharp; stomatal bloom underneath. **Cones:** Green to purple turning brown upon ripening; 2.5 – 4 in. long; egg-shaped; exserted bristle-tipped bracts; positioned on upper side of branch. **Seed:** Light brown; winged. **Flowering:** April – May. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Bristlecone fir grows in isolated populations and is adapted to serpentine soils. It is considered a relict species and has limited distribution and habitat.

Bristlecone fir cones in tree crown (1), unripe cone (2), and ripe cone (3).

Bristlecone fir tree (1), needles and pollen (male) cones (2), needles (3), distribution map (4), and bark (5).

Abies concolor

white fir

ABCO, 015

Height: 130 – 180 (217) ft. Distribution and Habitat : Found across the western United States, from the Rocky Mountains to the Sierra Nevada; montane coniferous forests; roughly coincides with lower limit of snowpack. **Elevation Range:** 3,000–10,000 ft. **Bark:** Smooth and gray on young trees, becoming thick, rough, and furrowed with age, tan inner bark. **Leaves:** Needle-like; blue-green or silver-green; 1.5 - 2.75 in. long; flat shape; arranged in flat or V-shaped sprays; protruding from twig at 90-degree angle; straight; two white stomatal bands on the underside. **Cones:** Green to olive turning brown or purple upon ripening; barrel shaped; 3 - 5 in. long; bract smaller than scale; positioned upright on branch. **Seed:** Light brown; winged; wing uniform brown, deep magenta edge upon ripening. **Flowering:** May – June. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** 170 - 200 (600). ~226 in low elevations below 4,000 ft. near northern CA; ~600 in high elevations above 6,000 ft. near central Sierra Nevada; ~188 in high elevations above 6,000 ft. near southern Sierra Nevada. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** 5-year intervals with variation from 3 to 9 years for heavy crops.

Additional Remarks: Wings will be uniformly brown and loosely attached or even detached from the cone scale when ripe. Water will be released from cone when squeezed by hand if unripe. Hourglass-shaped cones are an indication of insect activity. Signs of heavy cone crops are indicated by cones heavily covering top 6-10 ft. of tree crown. In comparison to red fir, white fir needles are typically slightly longer, straight, and arranged in a flatter spray while protruding from twig at 90-degree angle; crown appears 'bushier'; cones are smaller; and inner bark is tan.

White fir unripe cones (1), and ripe cones (2).

White fir tree crown (1), outer bark (2), yellow inner bark (3), needles (4), cut test of very unripe early cone (5), cut test of a ripening cone with a high seed count (6), cut test of a very ripe cone showing a low seed count (7), distribution map (8), and viable ripe seed with full embryo (9).

White fir tree light crop (1), medium crop (2), and heavy crop (3).

Abies grandis
grand fir
ABGR, 017

Height: 140 – 160 (257) ft. **Distribution and Habitat:** Coastal coniferous forests of northern California, western Oregon, and western Washington. **Elevation Range:** < 2,300 ft. **Bark:** Light gray turning darker with age; thin turning thick with deep irregular furrows with age; purple-red inner bark; numerous resin blisters. **Leaves:** Needle-like; dark green; 1 – 1.5 in. long; arranged in flat sprays; upper grooved surface; stomatal bloom underneath; apex notched; bases twisted. **Cones:** Green to purple turning brown upon ripening; 2.5 – 4 in. long; barrel shaped; bracts are shorter than scales; positioned upright on branch. **Seed:** Light brown; winged; wing purple-brown detaching from scale upon ripening. **Flowering:** May – June. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 2-3 years.

Additional Remarks: Readily hybridizes with white fir in western Klamath Mountains in California and Oregon. Grand fir cones tend to be smaller than white fir cones.

Grand fir unripe cones (1) and ripe cone (2).

Grand fir tree (1), needles (2), distribution map (3), and bark (4).

Abies lasiocarpa
subalpine fir
ABLA, 019

Height: 60 – 100 (129) ft. **Distribution and Habitat:** Subalpine coniferous forests from California to Alaska, with populations in California isolated to the Marble Mountains, Russian Wilderness Area, Trinity Alps, and Siskiyou Mountains. **Elevation Range:** 5,500 – 7,000 ft. **Bark:** Gray; resin blisters; Rough and scaly with age. **Seed:** Light brown; winged. **Leaves:** Needle-like; blue-green; 1 – 1.5 in. long; flat; arranged in bottlebrush with majority clustering on upper side of twig; flat; notched or rounded tips; stomatal bloom on both sides. **Cones:** Deep purple with fine yellow-brown pubescence turning brown upon ripening; 2.5 – 4 in. long; cylindrical; positioned upright on branch. **Flowering:** May – June. **Ripening:** August – early October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 5 seeds or 50%. **Cone Crop Periodicity:** NA.

Additional Remarks: Subalpine fir is adapted to harsh, high-altitude environments and often forms the timberline in mountainous areas. It is also used for reforestation in alpine zones.

Bristlecone fir cones in tree crown (1), unripe cone (2), and ripe cone (3).

Subalpine fir tree (1), needles (2), pollen (male) cones (3), bark (4), distribution map (5), and scale (6).

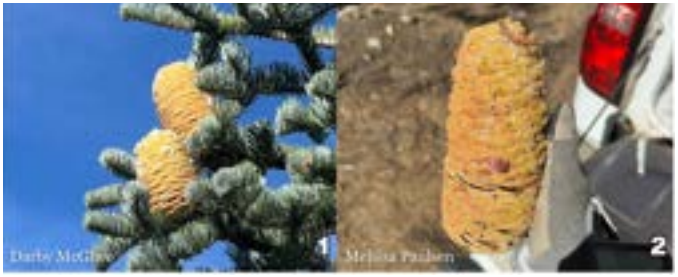
Abies magnifica var. magnifica

California red fir

ABMA1, 020

Height: 150 – 180 ft. **Distribution and Habitat:** Found in the montane and subalpine coniferous forests throughout the Sierra Nevada, northern coastal ranges, Klamath Mountains, and Cascade Range of California and southern Oregon. **Elevation Range:** 4,000 – 9,200 ft. **Bark:** Reddish-brown, deeply furrowed, red or purplish brown inner bark, and thick on mature trees. **Leaves:** Needle-like; blue-green; 0.75 – 1.5 in. long; clustered on upper side of twigs; 4-angled cross section; hockey-stick or S-shape coming out of branch at 45-degree angle; easy to roll between fingers. **Cones:** Green or purplish turning deep purple-brown upon ripening; cylindrical or barrel shaped; 4 – 9 in. long; positioned upright on branch. **Seed:** Light brown; winged; wing < 0.4 in. **Flowering:** Late May – early June. **Ripening:** August – October. **Cone Development Period:** 1 year. **Cones per Bushel:** 50-85 (~50 cones in low elevations below 4,000 ft., and ~60-85 cones above 7,500 ft,). **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** NA.

Additional Remarks: Wings will be uniformly brown and loosely attached or even detached from the cone scale when ripe. Hourglass shaped cones are an indication of insect activity. Heavy cone crops are indicated by cones heavily covering top 6-10 ft. of tree crown. For examples of cone crop ratings, refer to examples for white fir (p. 92) as crops are rated similarly for these species. In comparison to white fir, red fir needles are typically slightly shorter, arranged in a tighter V-shape on upper side of twig and protrude from twig at 45-degree angle with S-shaped curve; branching in snowflake-like patterns; cones are larger; and inner bark is red to purple. In comparison to Shasta red fir, red fir bracts are typically not visible, however, a populations of red fir in the southern Sierra Nevada also exhibits cones with exserted bracts. Red fir is known to hybridize with noble fir in regions north of Mt. Lassen.



Red fir cones ripening on tree (1) and large ripe cone (2).

Red fir tree crown (1), young bark (4), mature bark (6), underside of twig showing needles with hockey-stick shape (2), needles positioned upright on twig (3), cut test of ripening cone with no viable seeds (5), ripe collected cones (7), distribution map (8), and medium cone crop (9).

Abies magnifica var. Shastensis

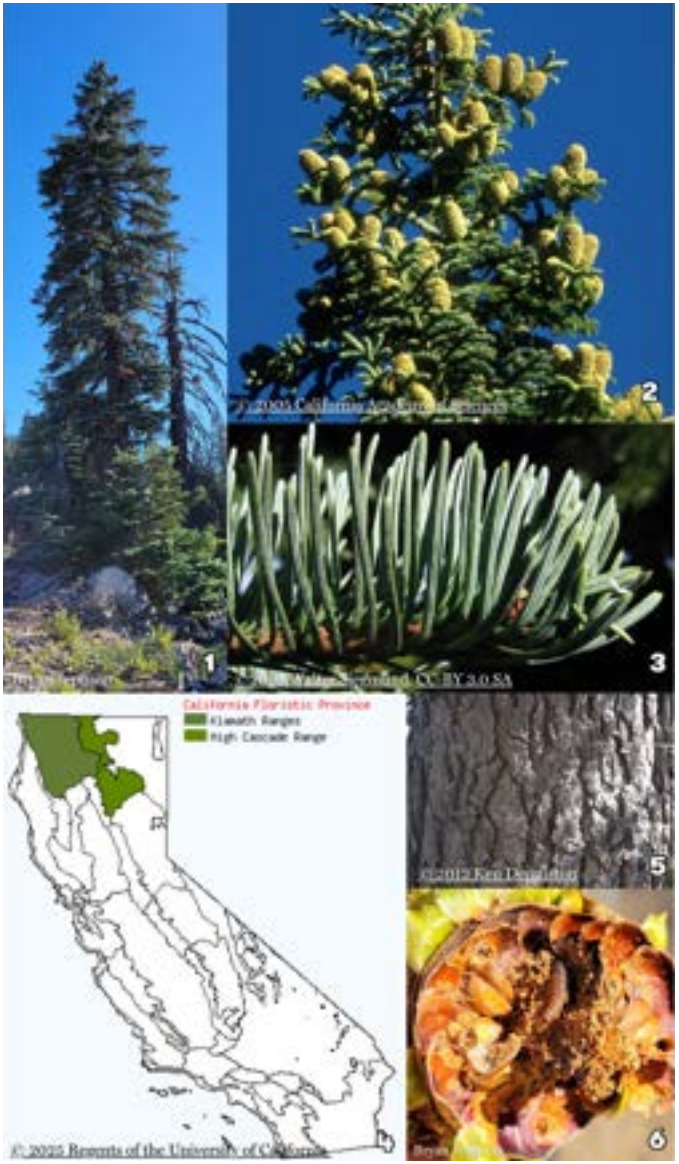
Shasta red fir

ABMAS, 021

Height: 150 – 180 (228) ft. **Distribution and Habitat:** Found in similar range to California red fir with less predominance in southern California. **Elevation Range:** 4,000 – 9,200 ft. **Bark:** Red-brown to purplish black; deeply furrowed; thick on mature trees; red inner bark. **Leaves:** Needle-like; blue-green; 0.75 – 1.5 in. long; clustered on upper side of twigs; 4-angled cross section; hockey-stick or S-shape coming out of branch at 45-degree angle; easy to roll between fingers; stomatal bloom on both sides of needle. **Cones:** Green or purplish turning deep purple-brown upon ripening; cylindrical or barrel shaped, 6 – 9 in. long; bracts are longer than scales and cover 25 – 50% of cone surface; visible bracts that taper with a short 'tail'; positioned upright on branch. **Seed:** Light brown; winged; < 0.4 in. long with wing. **Flowering:** June. **Ripening:** Late September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** 50-85 (for higher elevations above 7,500 ft., there are typically more cones per bushel due to smaller cone size). **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** NA.

Additional Remarks: Wings will be uniformly brown and loosely attached or even detached from the cone scale when ripe. Hourglass shaped cones are an indication of insect activity. Heavy cone crops are indicated by cones heavily covering top 6-10 ft. of tree crown. Shasta red firs are easily confused with Noble fir in the Klamath region. Noble fir often grows north and west of Klamath River in the Siskiyou mountains and on South Forth Mountain. Bracts on Noble fir cones have longer pointed 'tails' than Shasta red fir. Shasta red fir cones typically have visible bracts that extend beyond the scales, making them distinguishable from California red fir cones, where the bracts are shorter and remain hidden beneath the scales. Shasta red fir readily hybridizes with noble fir.

Shasta red fir cones (1), and cut-test showing insect activity (2).



Shasta red fir tree (1), with cone crop (2), needles (3), distribution map (4), bark (5), cross-section of cone with heavy insect activity showing a cone worm with frass (6).

Abies procera

noble fir

ABPR, 022

Height: 140 – 220 (272) ft. **Distribution and Habitat:** Upper montane to subalpine conifer forests of the Cascade Range and coastal ranges of Washington and Oregon, and the Klamath Mountains and northern coastal ranges of California. **Elevation Range:** 5,000 – 6,500 ft. **Bark:** Gray-purple; furrowed; purple inner bark; young trees are smooth gray with resin blisters. **Leaves:** Needle-like; blue-green; 1 – 1.5 in. long; hockey stick or S-shaped; 4-angled cross-section; clustered on upper side of twig; brilliant silvery stomatal bloom on both sides of new growth. **Cones:** Olive brown to purple when ripening; 4 – 6 in. long; barrel shaped; exserted yellow-green bracts with pointed bract tips that point down with 'tails'; positioned upright on branch. **Seed:** Light brown; winged. **Flowering:** June – July. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** ~80. **Seed Count Minimum for Cut-Test:** 6 seeds or 50%. **Cone Crop Periodicity:** Good seed crops occur every 3–6 years.

Additional Remarks: Noble firs are easily confused with Shasta red firs in the Klamath region. Noble fir often grows north and west of Klamath River in the Siskiyou mountains and on South Forth Mountain. Noble fir readily hybridizes with red fir and Shasta red fir. Bracts on Noble fir cones have longer pointed 'tails' than Shasta red fir.

Noble fir tree with unripe crop (1) and nearly ripe cone (2).

Noble fir tree with light cone crop (1), needles (2,4), dried scale with bract from cone (3), distribution map (5), and bark (6).

Callitropsis nootkatensis

Alaska cedar, Nootka cypress, yellow cedar

CANO9, 042

Height: 65 – 100 (124) ft. **Distribution and Habitat:** Coastal regions from southeastern Alaska to northern California in the Siskiyou Mountains. **Elevation Range:** < 7,200 ft. (~5,000 ft. in California). **Bark:** Gray-brown; thin; shallow furrows. **Leaves:** Scale-like; blue-green when young and yellow green when mature; ~0.12 in. long; opposite alternating pairs; flat and lacy sprays. **Cones:** Green with two yellow brown or red brown with whitish blooms upon ripening; 0.25 – 0.5 in. diameter; spherical; resembling a soccer ball when immature. **Seed:** Brown; winged. **Flowering:** April – May. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 2 seeds. **Cone Crop Periodicity:** > 4-year intervals between heavy crops.

Additional Remarks: Shade tolerant, very susceptible to fire.

Alaska cedar tree (1), nearly ripe closed cones (2), opened cone and foliage (3), distribution map (4), and bark (5).

Calocedrus decurrens

incense cedar

CADE27, 081

Height: 80 – 150 (152) ft. **Distribution and Habitat:** Native to the western United States, from Oregon to Baja California in montane coniferous forests and woodlands. **Elevation Range:** 150 – 9,500 ft. **Leaves:** Scale-like; dark green or yellow-green; 0.25 - 0.75 in.; blunt tipped; arranged in opposite alternating pairs; flat foliage sprays, giving the branches a flattened appearance. **Bark:** Cinnamon brown; thick; deeply furrowed; fibrous. **Cones:** Banana yellow to light golden or red-brown upon ripening; 0.75 –1.25 in. long; 'duck bill' shape; cones are mature when cleavage lines appear. **Seed:** Light brown; winged; ~ 0.5 in. long with wing. **Flowering:** March – April. **Ripening:** August – November. **Cone Development Period:** 1 year. **Cones per Bushel:** 1,000's. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** Often light crops with geographic variability.

Additional Remarks: The window for collection is short after cleavages appear between the scales of many cones on a tree. Not all cones may ripen at the same time on an individual tree; it is best to wait until most are ripe, even if some cones open. Another ripeness indicator is darkening near the shoulder of the seed, where the seed body transitions into the seed wing. Cones are most efficiently collected by raking cones from branches into buckets or bags.

Incense cedar with unripe cones (1), ripe collected cones (2), opened uncollectable cones resembling a duck's bill (3), and darkening 'triangle' (within red outline) at juncture between seed and seed wing as an indicator of ripening (4).

Incense cedar with heavy crop (1), needles (2), bark (3), heavy ripe crop (4), distribution map (5), and cones with insect activity (6,7).

Incense cedar with green unripe cones individually scattered across crown showing a light crop (1), green unripe cones in moderate clusters throughout crown showing a medium crop (2), and golden brown ripe cones densely produced with drooping branches showing a heavy crop (3).

Chamaecyparis lawsoniana

Port-Orford-cedar, Lawson cypress

CHLA, 041

Height: 125 – 150 (219) ft. **Distribution and Habitat:** Restricted to southwestern Oregon and northwestern California. **Elevation Range:** < 5,000 ft. **Bark:** Gray-brown; thick; fibrous; deeply furrowed. **Leaves:** Scale-like; yellow-green to blue-green; ~0.12 in. long; flat sprays; blunt tip; stomatal bloom in X-shape on underside; opposite alternating pairs. **Cones:** Green turning green yellow or red brown upon maturity; ~0.25 in. diameter; resemble soccer ball when immature. **Seed:** Brown; winged. **Flowering:** April – May. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 3 seeds. **Cone Crop Periodicity:** 3 – 5-year interval for heavy crops.

Additional Remarks: Shade tolerant; fire-resistant; susceptible to root rot (*Phytophthora lateralis*). Monoecious. It is recommended for cones to be collected up to 2 years after ripening.

Port orford cedar unripe cones (1), cones starting to ripen (2), and opened cones (3).

Port orford cedar tree crown (1), upper side of needles (2), bark (3), lower side of needles showing 'x' pattern (4), distribution map (5), and pollen (male) cones (6).

Hesperocyparis abramsiana

Santa Cruz cypress

HEAB2

Height: ~ 30 ft. **Distribution and Habitat:** Endemic to chaparrals and coniferous forests of Santa Cruz Mountains in west central California. Only 5 populations exist in the following groves: Eagle Rock, Bonny Doon, Majors Creek, Butano Ridge, Brancken Brae. **Elevation Range:** 1,250 – 2,500 ft. **Bark:** Grey to red-brown; thin; fibrous; peeling in narrow strips. **Leaves:** Scale-like; bright green; < 0.12 in. long; 3 or 4-angled; opposite, alternating pairs; lack puts with resinous glands. **Cones:** Green turning brown or gray upon ripening; 0.62 – 1.25 in. diameter; spherical; scales are umbrella-like; serotinous. **Seed:** Brown; often glaucous; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Santa Cruz cypress is federally listed as endangered. Monoecious. It is recommended for cones to be collected up to 2 years after ripening. Primary distinctions from other cypress species include cones typically > 0.62 in. long and found in the Santa Cruz Mountains.

Santa Cruz cypress unripe cones (1), cone opened by fire with dispersed seeds (2), and mature unopened cones (3).

Santa Cruz cypress (1), scale-like leaves and pollen (male) cones (2), bark (3), distribution map (4), and sapling (5).

Hesperocyparis bakeri

Baker cypress, Modoc cypress, Siskiyou cypress

HEBA5, 052

Height: 40 – 90 ft. **Distribution and Habitat:** Montane coniferous woodlands and mixed forests found in scattered populations across California and southern Oregon. **Elevation Range:** 3,500 – 6,900 ft. **Bark:** Red-brown to gray with age; thin; peeling and broken into plates with age. **Leaves:** Scale-like; gray-green; < 0.12 in. long; 3 or 4 angled; opposite, alternating pairs; pits with resinous glands. **Cones:** Green turning gray to dull brown upon ripening; 0.5 – 1 in. diameter; warty and umbrella-like scales with predominant projections; serotinous. **Seed:** Light tan to dull red-brown; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Thrives in nutrient-poor soils. Monoecious. It is recommended for cones to be collected up to 2 years after ripening. Primary distinctions from other cypress species include gray-green new leaves with conspicuous puts with resinous glands, cones with pointed projections, and found in northern California.

Baker cypress unopened cones (1), and opened cones (2).

Baker cypress (1), scale-like leaves (2), distribution map (3), and bark (4).

Hesperocyparis forbesii

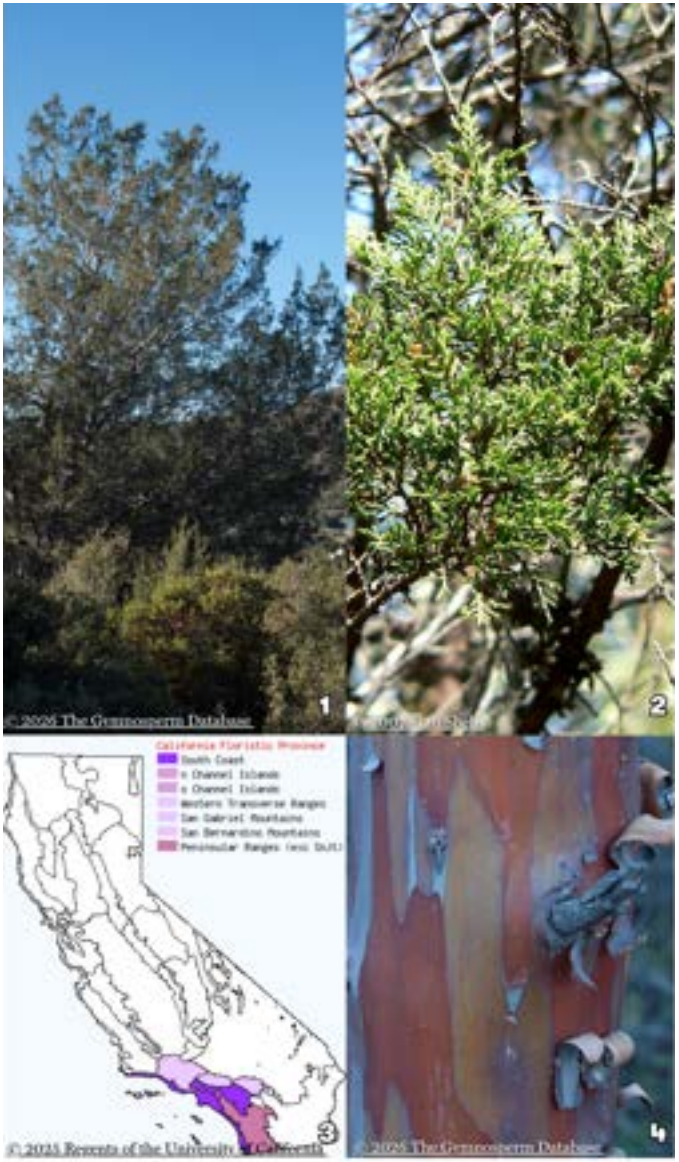
Tecate Cypress

HEF010, 055

Height: < 30 ft. **Distribution and Habitat:** Endemic to southern California and northern Baja California occurring in chaparral and woodlands. **Elevation Range:** 1,000 – 8,000 ft. **Bark:** Cherry-red to mahogany-brown inner bark, brown older bark; thin; mottled inner bark similar to sycamore; peels in strips. **Leaves:** Scale-like; light to dull green; ~ 0.12 in. long; opposite, alternating pairs; lacking pits with resinous glands. **Cones:** Green turning dull brown or gray when ripening; ~0.75 – 1 in. diameter; spherical; scales with inconspicuous projections; serotinous. **Seed:** Dark to dull red-brown; ~0.08 – 0.12 in. long; narrow wings. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Fire-dependent species; seeds germinate in mineral-rich soil exposed by fire. It is recommended for cones to be collected up to 2 years after ripening. Primary distinctions from other cypress species include light green coloration of new leaves and lack of pits with resinous glands.

Tecate cypress unopened cones (1), and opened cones (2).



Tecate cypress (1), scale-like leaves (2), distribution map (3), and bark (4).

Hesperocyparis goveniana

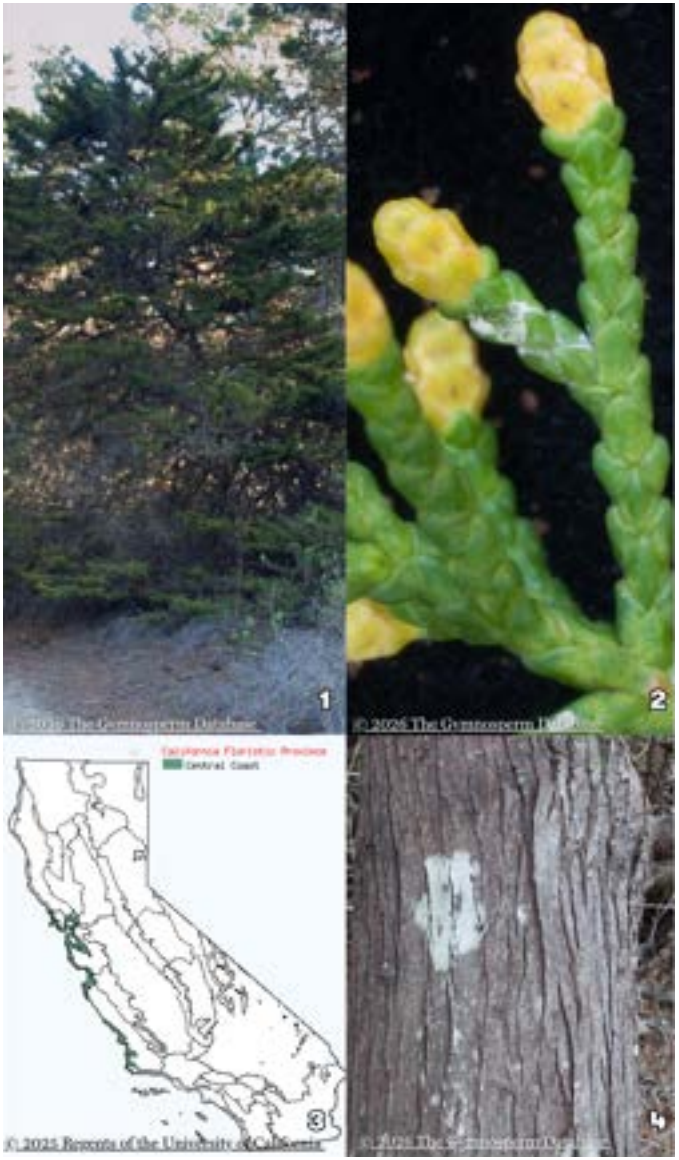
Gowen cypress

HEGO3

Height: ~10 – 30 ft. **Distribution and Habitat:** Endemic to coastal central California; restricted to small populations near Monterey and Carmel, found on sandy or rocky soils in coastal chaparral and mixed conifer forests. **Elevation Range:** < 500 ft. **Bark:** Thin; gray-brown; fibrous; peeling in narrow strips or small plates. **Leaves:** Scale-like; green to yellow-green; ~0.12 in. long; opposite, alternating pairs; lacking pits with resinous glands; aromatic when crushed. **Cones:** Green turning brown to gray-brown when ripening; 0.38 – 1 in. diameter; spherical; serotinous. **Seed:** Dull dark brown to nearly black; 0.08 – 0.12 in. long; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Gowen cypress is rare and highly restricted in range, making conservation efforts critical. Primary distinctions from other cypress species include light to dark green coloration of new leaves lacking pits with resinous glands, not growing on serpentine soils, cones typically < 0.62 in. long, and growing along the Monterey Peninsula. Differs from pygmy cypress found in near Mendocino due to leaves being lighter yellow-green.

Gowen cypress unopened cones (1), and cut open cone with seeds (2).



Gowen cypress (1), scale-like leaves (2), distribution map (3), and bark (4).

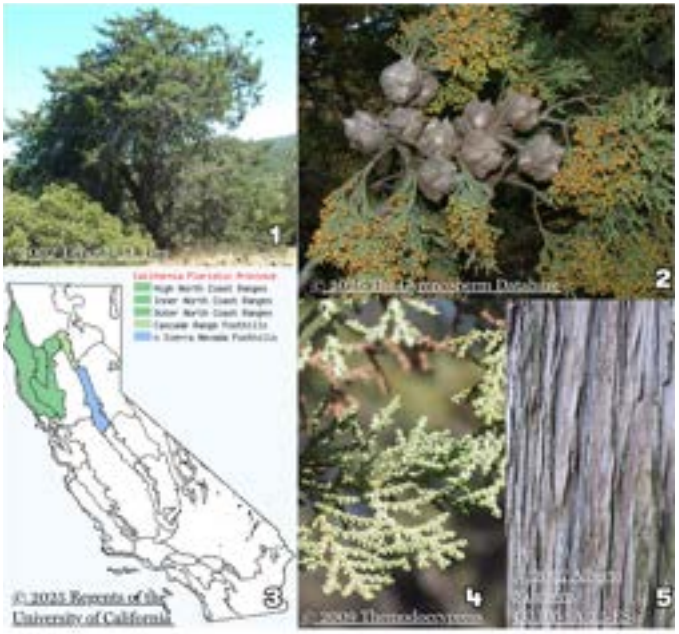
Hesperocyparis macnabiana

MacNab cypress

HEMA21

Height: 6.5 – 30 ft. **Distribution and Habitat:** Found in chaparral, oak woodlands, and coniferous woodlands northern California, particularly in the Coast Ranges and Sierra Nevada foothills. **Elevation Range:** 900 – 2,750 ft. **Bark:** Red-brown; thin; peeling in strips. **Leaves:** Scale-like; green to gray-green; < 0.12 in. long; aromatic when crushed; opposite, alternating pairs; pits with resinous glands; flat sprays. **Cones:** Green turning brown-gray upon ripening; 0.62 – 1 in. diameter; spherical; serotinous. **Seed:** Medium brown to glaucous brown when ripe; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 6 seeds. **Cone Crop Periodicity:** NA.

Additional Remarks: Drought-tolerant and thrives in poor, rocky soils. Foliage forming a flat aromatic spray is a primary distinction from other cypress species.



MacNab cypress tree (1), mature cones (2), distribution map (3), scale-like leaves (4), and bark (5).

Hesperocyparis macrocarpa

Monterey cypress

HEMA22

Height: 65 – 80 (106) ft. **Distribution and Habitat:** Native to the central coast of California, particularly around Monterey Bay. **Elevation Range:** < 175 ft. **Bark:** Rich brown to ash-gray with age; fibrous. **Leaves:** Scale-like; green; 0.12 – 0.38 in. long; opposite, alternating pairs; lacking pits with resinous glands; thick and coarse sprays. **Cones:** Green turning brown upon ripening; 1 – 1.5 in diameter; spherical; weakly serotinous. **Flowering:** Late fall, winter, and spring. **Seed:** Dull red-brown to black when ripe; not glaucous; winged. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Monterey cypress is widely cultivated as an ornamental tree, highly valued for windbreaks and erosion control. Primary distinctions from other cypress species include light to dark green coloration of new leaves lacking pits with resinous glands, not growing on serpentine soils, cones 1 – 1.5 in. long, thick and coarse foliage sprays, and growing to 65 – 80 ft. tall.

Monterey cypress unopened ripe cone (1), and open cones (2).

Monterey cypress (1), scale-like leaves (2), distribution map (3), and bark (4).

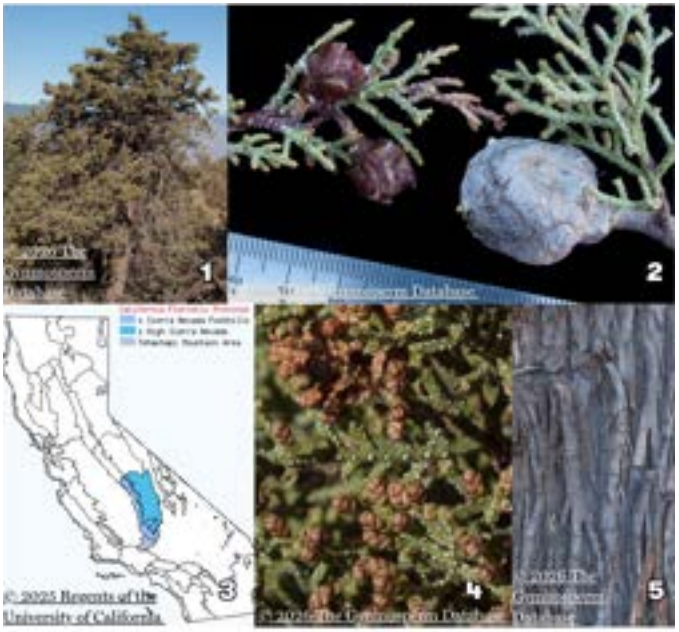
Hesperocyparis nevadensis

Piute cypress

HENE2

Height: 20 – 50 (82) ft. **Distribution and Habitat:** Endemic to California; restricted to the Piute Mountains in Kern County, found on steep, rocky slopes in chaparral and woodland habitats. **Elevation Range:** 2,500 – 6,000 ft. **Bark:** Red-brown; thin; fibrous. **Leaves:** Scale-like; dull to gray-green; 0.12 – 0.16 in. long; pits with resinous glands; aromatic when crushed. **Cones:** Green turning glaucous or silver-gray when ripening; 0.5 – 1 in. diameter; spherical; serotinous, opening primarily after fire. **Seed:** Rich light tan; ~0.08 – 0.12 in. long; winged. **Flowering:** February – March. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Piute cypress is rare and highly restricted in range, making conservation efforts critical. It is recommended for cones to be collected up to 2 years after ripening.



Piute cypress (1), small brown pollen cone and ripe cones (2), distribution map (3), scale-like leaves and many pollen cones (4), and bark (5).

Hesperocyparis pigmaea

Mendocino cypress, pygmy cypress

HEPI11

Height: 30 – 65 (157) ft. **Distribution and Habitat:** Endemic to coastal northern California; found in Mendocino and Sonoma Counties, growing in pygmy forests on nutrient-poor, acidic soils. **Elevation Range:** 150 – 1,000 ft. **Bark:** Gray-brown; thin; fibrous. **Leaves:** Scale-like; green to gray-green; 0.12 in. long; aromatic when crushed. **Cones:** Green turning weathered gray when ripening; 0.5 – 1 in. diameter; spherical; serotinous. **Seed:** Brown; 0.08 – 0.12 in. long; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: It is highly restricted in range and sensitive to habitat disturbance. It is recommended for cones to be collected up to 2 years after ripening.

Mendocino cypress immature cones (1), distribution map (2), and scale-like needles and mature cone (3).

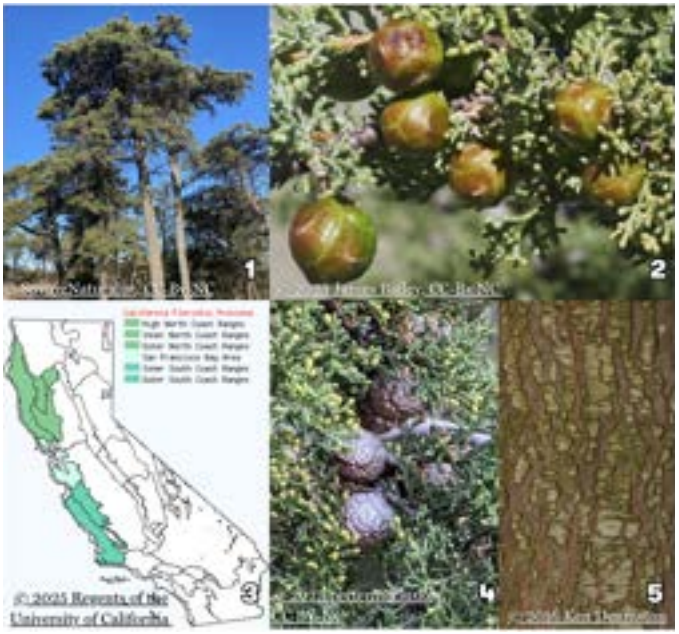
Hesperocyparis sargentii

Sargent cypress

HESA17

Height: 30 – 75 ft. **Distribution and Habitat:** Endemic to California; found in the Coastal Ranges on serpentine or rocky soils, often in chaparral or mixed woodland habitats. **Elevation Range:** 650 – 3,200 ft. **Bark:** Gray-brown; thick; fibrous. **Leaves:** Scale-like; gray-green; 0.12 – 0.38 in. long; opposite, alternate pairs; pits with resinous glands. **Cones:** Green turning dull brown or gray and often glaucous when ripening; ~0.5 – 1 in. diameter; spherical; serotinous. **Seed:** Brown; 0.08 – 0.12 in. long; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: It is recommended for cones to be collected up to 2 years after ripening. Primary distinctions from other cypress species include light to dark green coloration of new leaves lacking pits with resinous glands, growing in serpentine soils.



Sargent cypress tree (1), ripening cones (2), distribution map (3), mature cones (4), and bark (5).

Hesperocyparis stephensonii

Cuyamaca cypress

HEST10, 054

Height: 30 (15) – 50 ft. **Distribution and Habitat:** Endemic to southern California; restricted to the Cuyamaca Mountains in San Diego County, found on rocky slopes in chaparral and mixed woodland habitats. **Elevation Range:** 3,000 – 6,000 ft. **Bark:** Cherry-red; thin; smooth; peeling in narrow strips or small plates. **Leaves:** Scale-like; gray-green; 0.12 – 0.16 in. long; opposite, alternating pairs, resin gland at base of tip; lemony odor when crushed. **Cones:** Green turning dull brown or gray when ripening; 0.5 – 1 in. diameter; spherical; serotinous. **Seed:** Very dark brown; 0.08 – 0.12 in. long; winged. **Flowering:** Late fall, winter, and spring. **Ripening:** 15 – 18 months after pollination. **Cone Development Period:** 15 – 18 months after pollination. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** NA.

Additional Remarks: Cuyamaca cypress is rare and highly restricted in range, making conservation efforts critical. It is recommended for cones to be collected up to 2 years after ripening.

Cuyamaca cypress tree (1), mature cones and foliage (2), distribution map (3), ripe cones (4), and bark (5).

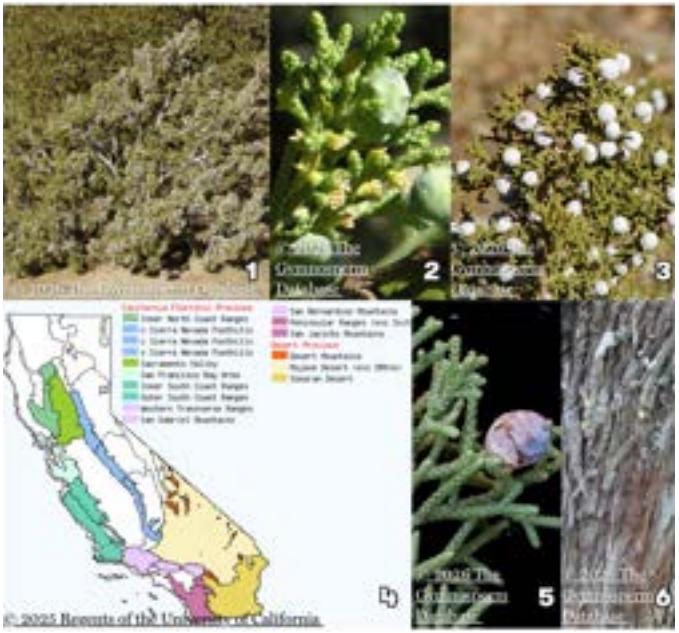
Juniperus californica

California juniper

JUCA7

Height: 3 – 15 (33) ft. **Distribution and Habitat:** Found across much of the northern hemisphere, including parts of northern California, growing in a variety of habitats, including montane forests, rocky slopes, and open woodlands. **Elevation Range:** 150 – 5,000 ft. **Bark:** Gray-brown; thin; fibrous. **Leaves:** Scale-like; yellow-green; tightly appressed to twig; whorled in 3s; obvious pits with resinous glands; juvenile leaves are awl-like. **Cones:** blue with whitish bloom turning red-brown when ripening; 0.25 – 0.5 in. diameter; spherical. **Seed:** Brown; pointed; angled. **Flowering:** Late spring – early summer. **Ripening:** Fall. **Cone Development Period:** NA. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** Heavy seed crops are irregular, but some seeds are produced almost every year.

Additional Remarks: California juniper is highly drought-tolerant. Juniper cones are typically harvested in the fall by handpicking them directly into containers or by shaking or flailing branches to dislodge cones onto netting or drop cloths.



California juniper tree (1), unripe cones (2), ripe cones (3), distribution map (4), ripe cone and foliage (5), and bark (6).

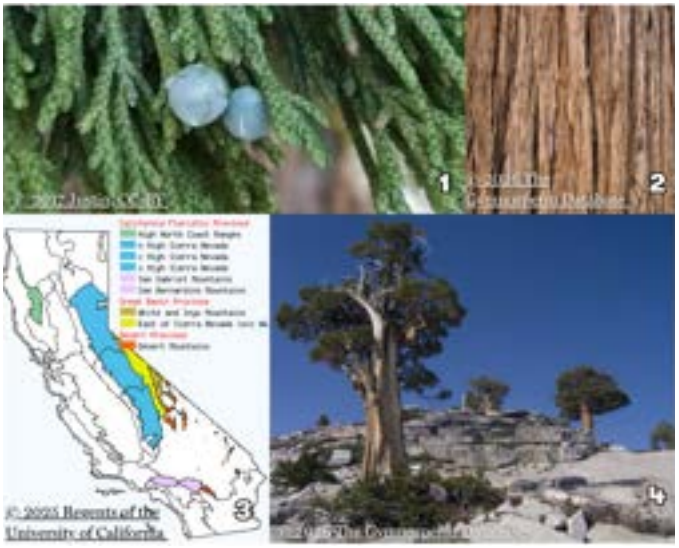
Juniperus grandis

Sierra juniper, grand juniper

JUGR

Height: 25 – 65 (100) ft. **Distribution and Habitat:** Found in high-elevation areas of the Sierra Nevada and southern Cascade Range in California and Nevada, occurring on rocky slopes and ridges in subalpine woodlands. **Elevation Range:** 300 – 10,000 ft. **Bark:** Red-brown; thin; fibrous. **Leaves:** Scale-like; dark blue-green; tightly appressed to twig; whorled in 3s or opposite; pits with resinous glands; juvenile leaves are awl-like. **Cones:** Purple-red turning blue-black or purple and glaucous when ripening; 0.25 – 0.5 in. diameter; spherical. **Flowering:** Late spring – early summer. **Seed:** Brown. **Ripening:** September – October. **Cone Development Period:** NA. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** Heavy seed crops are irregular, but some seeds are produced almost every year.

Additional Remarks: Drought-tolerant. In comparison to western juniper, Sierra juniper typically grows in high elevations of the Sierra Nevada Range, taller, more tree-like with typically slightly larger cones. Juniper cones are typically harvested in the fall by handpicking them directly into containers or by shaking or flailing branches to dislodge cones onto netting or drop cloths.



Sierra juniper ripe cones and foliage (1), bark (2), tree (bottom right), distribution map (3), and tree (4).

Juniperus occidentalis

western juniper

JUOC

Height: 15 – 33 ft. **Distribution and Habitat:** Found in the Great Basin and eastern slopes of the Cascades and Sierra Nevada, preferring dry, rocky soils in arid woodlands. **Elevation Range:** 2,300 – 7,500 ft. **Bark:** Red-brown; thin; fibrous. **Leaves:** Scale-like; blue-green; tightly appressed to twig; whorled in 3s or opposite; pits with resinous glands; juvenile leaves are awl-like. **Cones:** Blue-green turning blue-black and glaucous when ripening; 0.25 – 0.5 in. diameter; spherical. **Seed:** Brown. **Flowering:** April – May. **Ripening:** September – October. **Cone Development Period:** NA. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** Heavy crops are irregular, but some seeds are produced almost every year.

Additional Remarks: Drought tolerant. In comparison to Sierra juniper, western juniper typically grows in northern California, slightly lower elevations, shorter, shrubby with typically slightly smaller cones. Juniper cones are typically harvested in the fall by handpicking them directly into containers or by shaking or flailing branches to dislodge cones onto netting or drop cloths.

Western juniper tree (1), ripe cones (2), distribution map (3), foliage (4), and bark (5).

Juniperus osteosperma

Utah juniper

JUOS, 065

Height: 15 – 30 (38) ft. **Distribution and Habitat:** Found across the Great Basin and Colorado Plateau, best represented in California in southeastern mountains, and north along the California-Nevada border; growing in dry, rocky soils in arid woodlands and desert scrub. **Elevation Range:** 3,200 – 8,400 ft. **Bark:** Gray-brown; thin; fibrous. **Leaves:** Scale-like; yellow-green; tightly appressed to twig; whorled in 3s or opposite; lacking pits with resinous glands; juvenile leaves are awl-like. **Cones:** Glaucous green turning red-brown when ripening; 0.25 – 0.75 in. diameter; spherical. **Seed:** Brown. Strongly angled. **Flowering:** March – April. **Ripening:** September. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 2 -year intervals between heavy crops.

Additional Remarks: Cones may be collected from ground but take care not to accidentally collect immature green cones as they can be difficult to separate from ripe cones. Juniper cones are typically harvested in the fall by handpicking them directly into containers or by shaking or flailing branches to dislodge cones onto netting or drop cloths.

Utah juniper tree (1), ripe cones and foliage (2), distribution map (3), and bark (4).

Picea breweriana

Brewer spruce

PIBR, 092

Height: 50 – 100 (176) ft. **Distribution and Habitat:** Endemic to the Klamath Mountains of northern California and southern Oregon, growing in moist, cool mountain forests on rocky soils. **Elevation Range:** 3,300 – 7,500 ft. **Bark:** Red-brown; thin; exfoliating scales appearing as corn flakes. **Leaves:** Needle-like; dark green; 0.25 – 0.75 in. long; linear; flat; stomatal bands underneath. **Cones:** Green to dark brown or black when ripening; 3 – 6 in. long; cylindrical; papery scales with smooth round edges. **Seed:** Light brown; winged. **Flowering:** Spring. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 10 seeds. **Cone Crop Periodicity:** 2-year intervals between heavy crops.

Additional Remarks: Striking, weeping branch structure. Cones can be harvested slightly prior to ripening if artificially ripened to release seeds for maximized germination. Seeds typically reach maturity prior to cone ripening, with ripening times varying across the same tree and between trees in the same stand.

Brewer spruce tree with cone crop (1), ripening cones (2), open cone (3).

Brewer spruce tree (1), needles (2), bark (3), distribution map (4), and opening ripe cone (5).

Picea engelmannii

Engelmann spruce

PIEN, 093

Height: 100 – 120 (179) ft. **Distribution and Habitat:** Montane and subalpine coniferous forests in the Rocky Mountains, Cascades, and near Russian Peak and Clark Creek in Siskiyou and Shasta Counties. **Elevation Range:** 3,300 – 6,500 ft. **Bark:** Red- or purple-brown; very thin; loosely attached scales. **Leaves:** Needle-like; blue-green; 0.75 – 1.25 in. long; 4-angled cross-section; sharp-pointed tips; unpleasant odor when crushed; stomatal bloom on all surfaces. **Cones:** Green turning light brown when ripening; 1.5 – 2.5 in. long; cylindrical; papery scales with ragged edges. **Seed:** Light brown; winged. **Flowering:** May – June. **Ripening:** September. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 5 – 6 seeds. **Cone Crop Periodicity:** 2 – 6 year intervals between heavy cone crops.

Additional Remarks: Spiral-like crown. Cones can be harvested slightly prior to ripening if artificially ripened to release seeds for maximized germination. Seeds typically reach maturity prior to cone ripening, with ripening times varying across the same tree and between trees in the same stand. Frost is commonly known to damage Engelmann spruce cones.

Engelmann spruce early unripe cones (1), and opened cone (2).

Engelmann spruce tree (1), needles and branch (2, 3), bark (4), distribution map (5), and two successive heavy crops showing previous years (open cones) and current season ripening crops (6).

Picea sitchensis

Sitka spruce

PISI, 098

Height: 130 – 180 (191) ft. **Distribution and Habitat:** Coastal coniferous forests from southeastern Alaska to northern California with its southern most range near Fort Bragg. **Elevation Range:** < 650 ft. **Bark:** Gray to silver gray; thin; large exfoliating scales like potato chips. **Leaves:** Needle-like; dark green above, bluish-white beneath; 0.5 – 1.5 in. long; 4-angled cross-section; stiff; sharp-pointed tip. **Cones:** Yellow-green turning brown when ripening; 2 – 3.5 in. long; cylindrical; papery scales with ragged tips. **Seed:** Light brown; winged. **Flowering:** May. **Ripening:** August – September. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** 2 – 4-year intervals between heavy crops.

Additional Remarks: Sitka spruce is one of the fastest-growing spruces, shade-tolerant, and susceptible to fire. The best way to tell the difference between Sitka spruce and Engelmann spruce is location and elevation, and needles of Sitka spruce are generally stiffer.

Sitka spruce tree crown (1), ripe cones (2), unripe early cones (3), opened cones (4), distribution map (5), twig with needles (6), and bark (7).

Pinus albicaulis

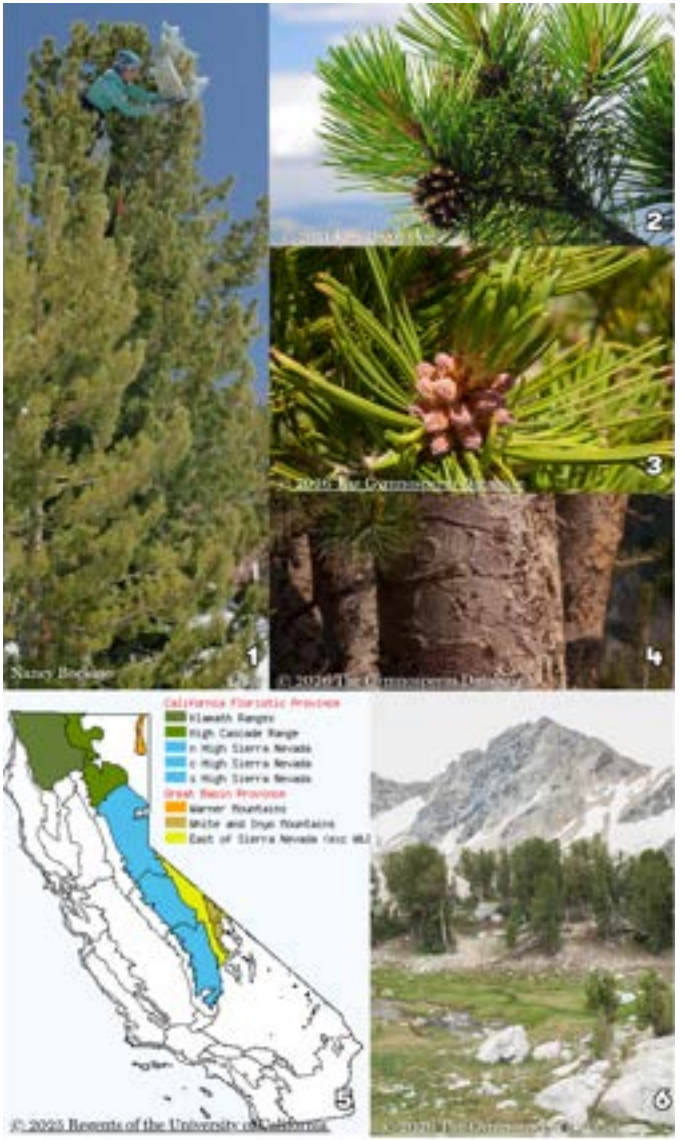
whitebark pine

PIAL, 101

Height: 25 – 50 (69) ft. **Distribution and Habitat:** Native to high-elevation regions of western North America, including the Rocky Mountains, Cascades, and Sierra Nevada, Warner Mountains, and Klamath Mountains; found in subalpine and timberline habitats. **Elevation Range:** 6,000 – 12,000 ft. **Bark:** Light gray to pale brown; thin; scaly or flaky. **Leaves:** Needle-like; bundles of 5; dark blue-green; 1.25 – 2.75 in. long; stiff; stomatal bloom on all surfaces; slightly curved and densely arranged. **Cones:** Dark purple turning dull purple to brown when ripening; 1.5 – 3.5 in. long; egg-shaped; short stalks; thick scales with sharp-tips; 50-70 seeds per cone. **Seed:** Wingless; brown. **Flowering:** July. **Ripening:** August – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 3 – 5 year-interval between heavy crops.

Additional Remarks: Whitebark pine is a keystone species in subalpine ecosystems. It is threatened by white pine blister rust, pine beetles, and climate change. It relies on Clark's Nutcracker for seed dispersal. Collections of whitbpark pine typically include a specialized process of caging immature cones in mid-summer to prevent predation and enable successful collection in the fall. For heavier crops, look for many clusters of 3 - 5 cones per cluster.

Whitebark pine 1st-year conelets (1), 2nd-year immature cones (2), and mature 2nd-year cones with 1st-year conelets visible at tip of branch (3).

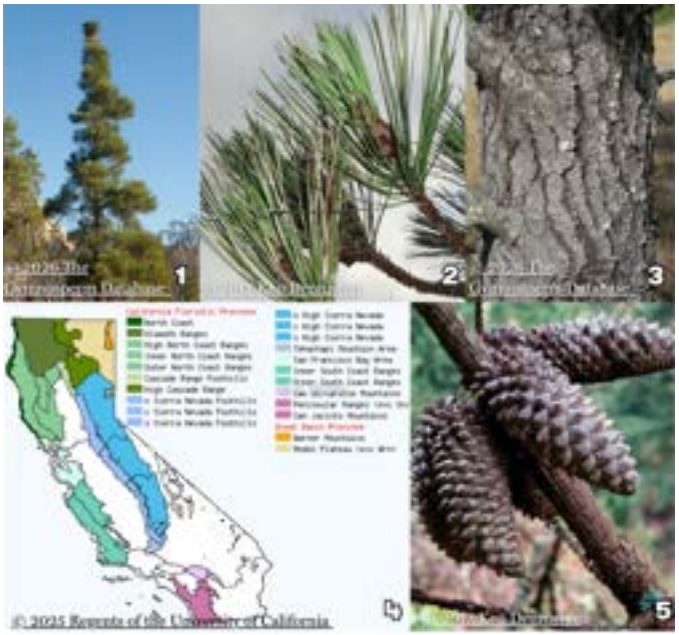


Whitebark pine tree with climber caging branch ends for eventual cone collection (1), foliage with opened cone (2), pollen (male) cones (3), bark (4), distribution map (5), and same-aged stand (6).

Pinus attenuata
knobcone pine
PIAT, 103

Height: 20 – 40 (117) ft. **Distribution and Habitat:** Chaparral and coniferous forests and woodlands, found in coastal and inland California, southern Oregon, and northern Baja California; extensive in Klamath Mountains, and northern Coast Ranges. **Elevation Range:** < 6,200 ft. **Bark:** Gray-brown; shallow furrows; superficial scaly ridges. **Leaves:** Needle-like; bundles of 3; yellow-green; 3 – 6 in. long; slender and slightly twisted. **Cones:** Green-brown turning lustrous tawny yellow to light brown when ripening; 3 – 6 in. long; asymmetrical, elongated, conical, curved; set in whorls of 3; scales with prickles, larger on upper sides; serotinous. **Seed:** Brown; winged. **Flowering:** April. **Ripening:** January – February. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** 1 year-interval between heavy crops.

Additional Remarks: Serotinous; cones open after several years, if at all, normally requiring fire. Mature closed cones from previous years can be collected.



Knobcone pine tree (1), needles (2), bark (3), and distribution map (4), and closed mature cones (5).

Pinus balfouriana
foxtail pine
PIBA, 104

Height: 30 – 60 (76) ft. **Distribution and Habitat:** Endemic to California; found in two disjunct populations: the southern Sierra Nevada and the Klamath Mountains; growing in subalpine forests on rocky slopes and ridges. **Elevation Range:** 6,700 – 12,000 ft. **Bark:** Gray- to red-brown; deeply fissured on mature trees; gray-white on young trees. **Leaves:** Needle-like; bundles of 5 (4); dark green; 0.75 – 1.5 in. long; densely packed, arranged in bottlebrush, resembling a fox's tail; stiff; somewhat curved; stomatal bands underneath. **Cones:** Deep purple turning dark brown, red-brown, or russet-brown when ripening; 3.5 – 5 in. long; egg to barrel shaped; thick scale tips; with small or absent prickles. **Seed:** Winged; light brown. **Flowering:** July – August. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 10 seeds. **Cone Crop Periodicity:** 5 – 6 year-interval between heavy crops.

Additional Remarks: Highly adapted to harsh, high-elevation environments and is closely related to bristlecone pines.

Foxtail pine open cone, purple conelet, and ripening 2nd-year cones (1); developing cones (2); and open cone, conelet and vegetative growth (3).

Foxtail pine tree (1), needles (2), bark (3), pollen (male) cones (5), and distribution map (4).

Pinus contorta var. contorta

shore pine, beach pine

PICOC

Height: 20 – 50 (101) ft. **Distribution and Habitat:** Coastal and low-elevation montane coniferous forests from Alaska to Mendocino County, growing on ultramafic, serpentine, and highly acidic soils. **Elevation Range:** < 500 ft. **Bark:** Thick; fissured. **Leaves:** Needle-like; bundles of 2; green; 1 – 3 in. long; twisted. **Cones:** Purple-green turning yellow-brown when ripening; 1.5 – 2 in. long; egg-shaped to spherical; scales have thick tips and long recurved prickles. **Seed:** Winged; dark brown. **Flowering:** May – June. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 1 year-interval between heavy crops.

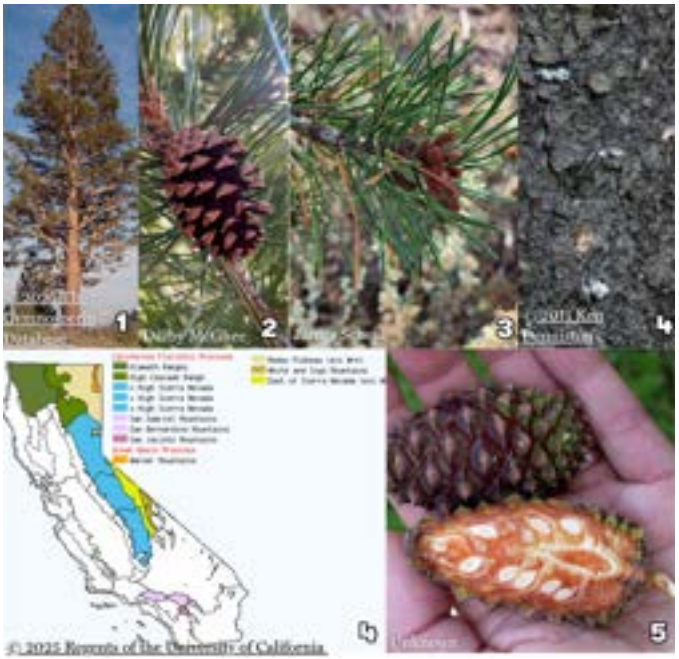
Additional Remarks: Shade and fire intolerant. Needles and cones smaller than ponderosa pine or Jeffrey pine.

Shore pine tree (1), needles (2), bark of close relative *P. contorta var. murrayana* (3), distribution map (4), and closed cones (5).

Pinus contorta var. murrayana
lodgepole pine
PICOM, 108

Height: 60 – 110 (124) ft. **Distribution and Habitat:** Found in high-elevation regions of the Sierra Nevada, Cascades, and southern Rocky Mountains; growing in moist soils, montane meadows, and subalpine forests. **Elevation Range:** 5,000 – 11,600 ft. **Bark:** Light brown to gray; thin; scaly. **Leaves:** Needle-like; bundles of 2; yellow-green to dark green; 1 – 3 in. long; fine stomatal blooms on all surfaces. **Cones:** Purple-green turning clay brown; 1 – 2 in. long; egg-shaped to spherical; scales have thick tips and long recurved prickles. **Seed:** Winged; dark brown. **Flowering:** May – June. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 1 year-interval between heavy crops.

Additional Remarks: Shade and fire intolerant. Needles and cones smaller than ponderosa pine or Jeffrey pine.



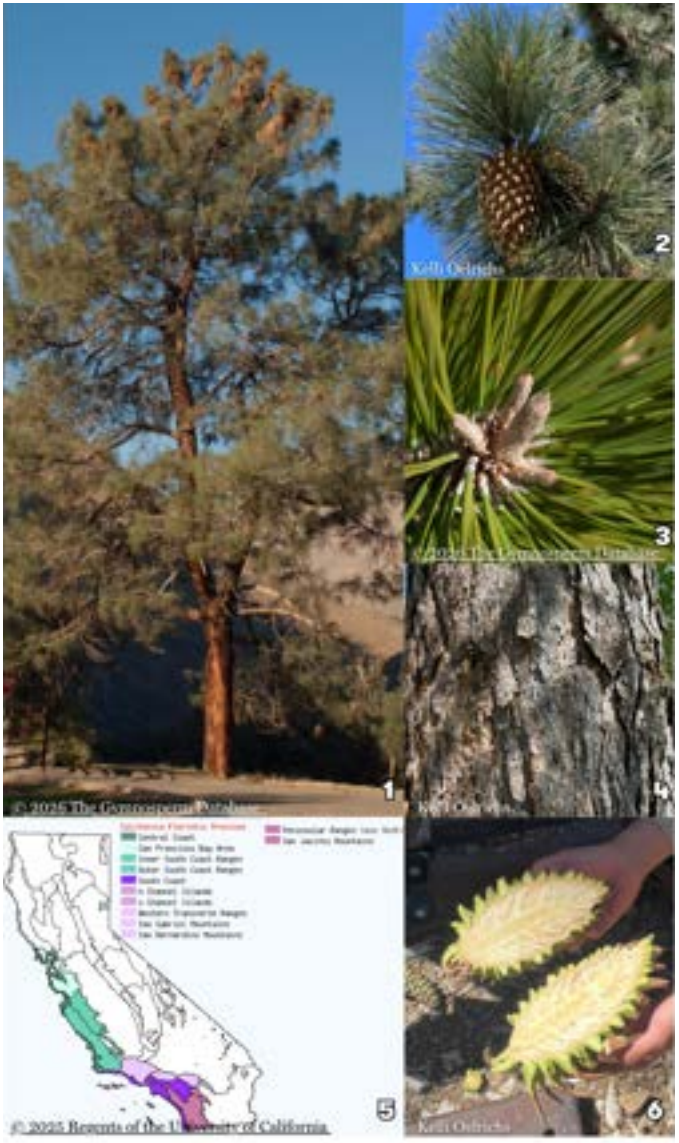
Lodgepole pine tree (1), opened cone (2), foliage and pollen cones (3), bark (4), cut test of unripe early cone showing high seed count (5), and distribution map (4).

Pinus coulteri
Coulter pine
PICO3, 109

Height: 30 – 85 ft. **Distribution and Habitat:** Found in coastal and inland mountain ranges of southern California and northern Baja California. Grows in dry, rocky soils in chaparral and mixed conifer woodlands. **Elevation Range:** 500 – 7,000 ft. **Bark:** Dark gray-brown to black with yellow-brown plates; thick; deeply furrowed. **Leaves:** Needle-like; bundles of 3; dark green; 6 – 12 in. long; stiff and sharp. **Cones:** Green turning shiny brown to yellow brown when ripening; 10 – 14 in. long; oblong to egg shaped; massive with sharp, heavy scales; serotinous with ecotypical variations. **Seed:** Dark brown; winged. **Flowering:** May – June. **Ripening:** August – September. **Cone Development Period:** 2 years. **Cones per Bushel:** 10 – 12. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 3 – 6 year-interval between heavy crops.

Additional Remarks: Coulter pine produces the heaviest cones of any pine species, weighing up to 10 pounds, opening slowly, and shed seeds over several months. In chaparral areas among canyon live oak, pine, and Sargent cypress, cones are serotinous; among coast live oak, cones are non-serotinous. It is adapted to dry, rocky soils and is fire-tolerant. Likeness to gray pine, but coulter pine cones are larger and sharper, needles are stiffer and sharper, and typically grows in higher elevations.

Coulter pine mature cone with closed scales (1), and open scales (2).



Coulter pine tree (1), cone with foliage (2), buds and foliage (3), bark (4), distribution map (5), and cut test of very early unripe cone (6).

Pinus edulis

Colorado pinyon pine, two-needle pinyon

PIED

Height: < 40 ft. **Distribution and Habitat:** Widespread in the southwestern United States, including Colorado, Utah, Arizona, New Mexico, and the New York Mountains in southeastern California. **Elevation Range:** 4,000 – 9,000 ft. **Leaves:** Needle-like; dark green; 0.5 – 2.5 in. long. **Bark:** Red-brown; shallow-furrows. **Seed:** Brown; wing persistent on scale. **Cones:** Green turning light yellow-brown; ovoid; 1 – 2 in. long. **Flowering:** June. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 3 – 4 seeds. **Cone Crop Periodicity:** 2 – 5 year-interval between heavy crops.

Additional Remarks: Pinyon pine is a vital species in arid ecosystems, providing food and shelter for wildlife. Its edible seeds, known as pine nuts, are an important resource for humans and animals alike. Cultural keystone species of California's Indigenous communities.

Colorado pinyon pine tree (1), mature cone (2), opened cone (3), distribution map (4), needles (5), and bark (6).

Pinus flexilis

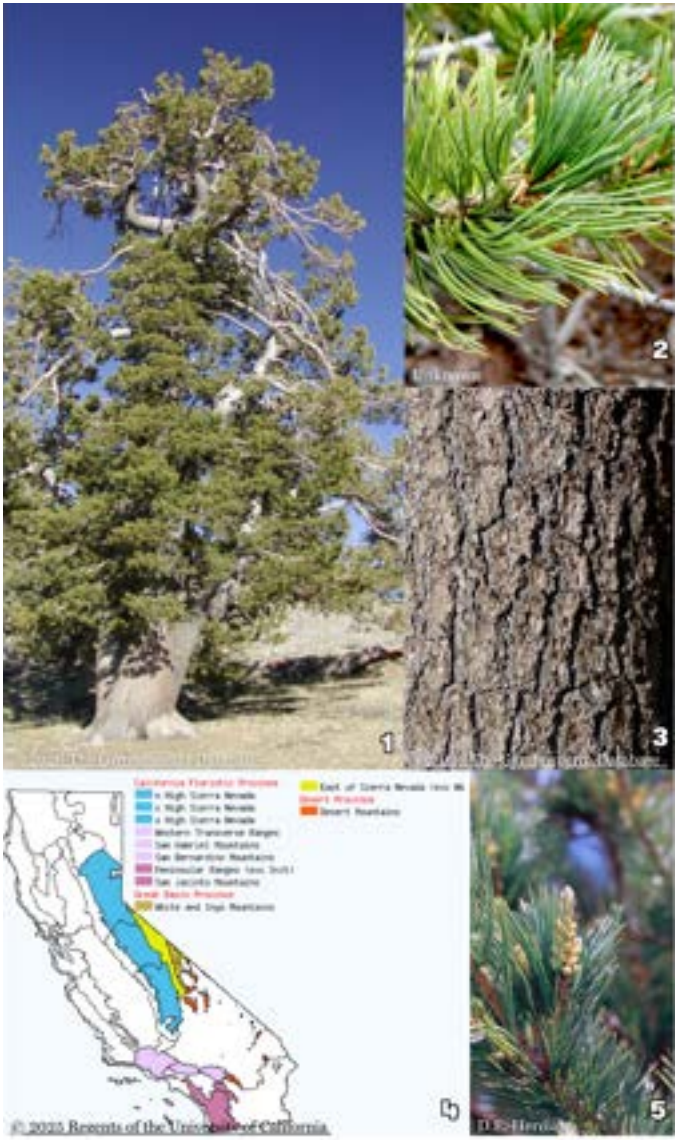
limber pine

PIFL2, 113

Height: 25 – 50 (58) ft. **Distribution and Habitat:** Found in the Rocky Mountains, Great Basin, Sierra Nevada and southern California, growing on rocky slopes and ridges at high elevations. **Elevation Range:** 3,000 – 11,000 ft. **Bark:** Light gray to dark brown; thin; scaly or fissured. **Leaves:** Needle-like; bundles of 5; blue-green; 2 – 3.5 in. long; tufted at end of branches; curved; somewhat stiff; stomatal bloom on all surfaces. **Cones:** Green turning yellow-brown to light brown when ripening; 2 – 7 in. long; cylindrical to pendant; scale tips slightly reflexed and lack prickles. **Seed:** Light brown, wing persistent on scale. **Flowering:** June – July. **Ripening:** August – September. **Cone Development Period:** Cones mature in two years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 8 seeds or 50%. **Cone Crop Periodicity:** 2 – 4 year-interval between heavy crops.

Additional Remarks: Limber pine is highly adapted to harsh environments and is often found at the tree line. It plays a critical role in stabilizing soils and providing food for wildlife. Forms hybrids with whitebark pine.

Limber pine opened cone (1), and unripe early cones (2).



Limber pine tree (1), cone with foliage (2), bark (3), distribution map (4), buds and foliage (5).

Pinus jeffreyi

Jeffrey pine

PIJE, 116

Height: < 180 ft. **Distribution and Habitat:** Montane and subalpine coniferous forests in the mountains of southern Oregon, California, and western Nevada. **Elevation Range:** 200 – 10,000 ft. **Leaves:** Needles; bundles of 3; dark green; 5 - 11 in. long. **Bark:** Reddish-brown or yellow to orange-red; thick; deeply furrowed; broad plates with black crevices; puzzle-piece-like scales; vanilla, butterscotch, or pineapple-like scent. **Seed:** Brown; winged. **Cones:** Green or dark purple turning dull purple or light brown upon ripening; egg shaped to cylindrical; 5 – 10 in. long; prickles from scales pointed downwards. **Flowering:** June – July. **Ripening:** August – September. **Cone Development Period:** 2 years. **Cones per Bushel:** 35 – 50. **Seed Count Minimum for Cut-Test:** 2 seeds or 50%. **Cone Crop Periodicity:** 2 – 4 year-interval between heavy crops.

Additional Remarks: When looking for heavier cone crops look for many clusters of cones with 3 – 10 cones per cluster distributed on interior portions of the branch and branch tips. Compared to ponderosa pine, Jeffrey pine needles are duller in color and can be slightly longer, cones are larger and less prickly ('gentle' Jeffrey cones are less painful to hold), and bark can have an aromatic scent such as vanilla or pineapple. Although rare, Jeffrey pine can hybridize with ponderosa pine, and suspected hybrids may produce cones with intermediate or variable characteristics that can make identification difficult.

Jeffrey pine ripening cone (1) with respective cut test showing low seed cone from insect activity (3), and ripe cone (2) with respective cut test showing high seed count of 9 viable seeds (4).

Jeffrey pine tree (1), needles (2), bark (3), cone crop (4), opened cones (5), interior of ripening cone showing darkening of seed wing and seed coat with wings still attached to scale (6), distribution map (7), seed cut test showing viable seed with full embryo and mature seed with seed wing (8), and opened ponderosa pine compared to opened Jeffrey pine cone (9).

Pinus lambertiana

sugar pine

PILA, 117

Height: < 250 ft. **Distribution and Habitat:** Montane and subalpine coniferous forests, woodlands, and chaparral of north-central Oregon, California, and Baja California. **Elevation Range:** 1,000 – 10,000 ft. **Leaves:** Needles; bundles of 5; blue-green; 2 – 4 in. long. **Bark:** Gray-brown to red-brown; thick; furrowed with scaly ridges. **Seed:** Brown, winged, large. **Cones:** Green turning lustrous green-brown to light brown upon ripening; cylindrical or pendant; 10 – 24 in. long; lacking prickles; sappy; the longest cone of any pine species. **Flowering:** June – July. **Ripening:** August – September. **Cone Development Period:** 2 years. **Cones per Bushel:** 12 – 18. **Seed Count Minimum for Cut-Test:** 12 – 15 seeds or 66%. **Cone Crop Periodicity:** 3 – 5 year-interval between heavy crops.

Additional Remarks: Sugar pine is the tallest and largest of all pine species. Cultural keystone species of California's Indigenous communities. For heavier cone crops, look for many clusters of 2 – 7 cones on the ends of branches and some on interior portions of branches. Sugar pine is highly susceptible to white pine blister rust (WPBR) and individual trees may undergo Major Gene Resistance (MGR) testing. Confirmed or candidate MGR trees are typically handled as special individual-tree collections rather than general bulk seed collections. MGR collections depend on known parent-tree identity; collectors should only target trees confirmed by local records, GPS points, physical markers such as metal sheets or tags, or direct manager guidance.

Sugar pine cones showing changes in color and shape varying from underripe and too early to collect (top left 3 cones), ripe cones (top right 5 cones), aborted uncollectable cones (bottom right 2 cones), and opened overripe uncollectable cones (bottom left 2 cones).

Sugar pine 1st year cones (uncollectable) to right and 2nd year ripening cone left (1), needles (2) 1st year cones (uncollectable) (3), bark (4), cone with insect activity as shown by irregular browning (5), marked MGR tree (6), cut test with high seed count (7), distribution map (8), seed cut test showing viable seed with full embryo and mature seed with darkened seed wing (9), and seed cut tests showing viable seeds with full embryos (10).

Sugar pine trees with light crop (1), medium crop (2), heavy crop (3), and examples of clusters with many cones, typically indicating a heavier crop (4, 5), and cone crop showing dramatic curving or J shape indicating insect activity (6).

Pinus longaeva

Great Basin bristlecone pine

PILO, 102

Height: 30 – 40 (47) ft. **Distribution and Habitat:** Subalpine coniferous woodlands on desert mountains, found in high-elevation regions of the Great Basin, including Utah, Nevada, and in the White Mountains, Inyo, Last Chance, and Panamint Mountains of eastern California. **Elevation Range:** 7,500 – 12,000 ft. **Bark:** Red-brown to gray; thin; scaly or peeling. **Leaves:** Needle-like; bundles of 5; dark green; 0.5 – 1.5 in. long; resin-covered with bristle tips; curved; stiff. **Cones:** Purple turning red-brown when ripening; 2 – 5 in. long; egg to barrel shaped; bristle-tipped scales. **Seed:** Dark brown; winged. **Flowering:** June. **Ripening:** September – October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 5 seeds or 50%. **Cone Crop Periodicity:** Irregular.

Additional Remarks: Great Basin bristlecone pine is one of the oldest living organisms on Earth, with some individuals exceeding 5,000 years in age. It thrives in rocky, high-altitude environments.

Great Basin bristlecone pine early ripening 2nd year cone (1), 1st year conelet (2), 2nd year ripening cone and opened cone (3).

Bristlecone pine tree (1), foliage (2), bark (3), 5-needle bundle (4) distribution map (5), and pollen (male) cones (6).

Pinus monophylla

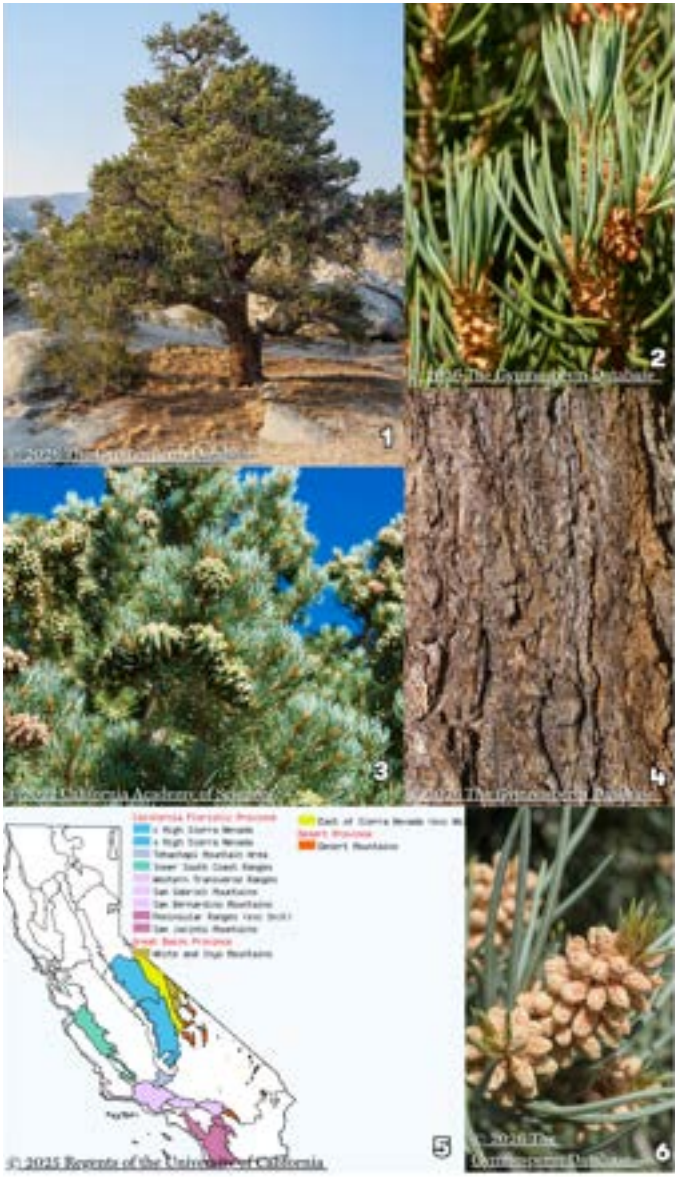
singleleaf pinyon pine

PIMO, 140

Height: 15 – 50 ft. **Distribution and Habitat:** Found in the Great Basin and southwestern United States, growing in arid woodlands on rocky soils. **Elevation Range:** 3,000 – 10,000 ft. **Bark:** Gray to red-brown; thin; scaly or furrowed. **Leaves:** Needle-like; single (sometimes in bundles of 2); gray-green; 1 – 2.5 in. long; incurved; stout; sharp; resinous. **Cones:** Green turning shiny deep russet brown when ripening; 1.5 – 4.5 in. long; egg shaped; broad at base; thick scales; deep recesses housing 2 large seeds. **Seed:** Large; wingless; light brown; 0.4 – 0.6 in. long; edible, known as pine nuts. **Flowering:** May. **Ripening:** August. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 2 – 7 year-interval between heavy crops.

Additional Remarks: Cultural keystone species of California's Indigenous communities.

Singleleaf pinyon pine unripe green cone (1), conelet (2), and opened cone (3).



Singleleaf pinyon pine tree (1), needles (2), cone crop (3), bark (4), distribution map (5), and pollen (male) cones (6).

Pinus monticola

western white pine

PIMO3, 119

Height: 120 – 180 ft. **Distribution and Habitat:** Found in the Pacific Northwest, northern Rocky Mountains, and mountains of California, growing in moist montane and subalpine forests. **Elevation Range:** 5,000 (500) – 11,000 ft. **Bark:** Gray-brown to red-brown; thin; smooth when young, becoming thick and furrowed with age; broken into plates resembling alligator skin. **Leaves:** Needle-like; bundles of 5; blue-green; 2 – 4 in. long; stomatal bloom on inner surface. **Cones:** Green to purple-black turning yellowish beige-brown to reddish when ripening; 5 – 10 in. long; cylindrical, pendant; slight curve; round scales with thin lip lacking prickles; sappy. **Seed:** Winged; light brown; 0.2 – 0.3 in. long. **Flowering:** June – July. **Ripening:** August. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 10 seeds or 66%. **Cone Crop Periodicity:** 3 – 7 year-interval between heavy crops.

Additional Remarks: Susceptible to white pine blister rust which currently acts as a significant threat to its populations. Individual trees may undergo Major Gene Resistance (MGR) testing for resistance to WPBR. Confirmed or candidate MGR trees are typically handled as a special collection. MGR collections depend on known parent-tree identity; collectors should only target trees confirmed by local records, GPS points, physical markers such as metal sheets or tags, or direct manager guidance.

Western white pine ripening cones (1), and opened cone (2).

Western white pine tree with heavy cone crop (1), needles (2), cone crop (3), bark (4), distribution map (5), and pollen (male) cones (6).

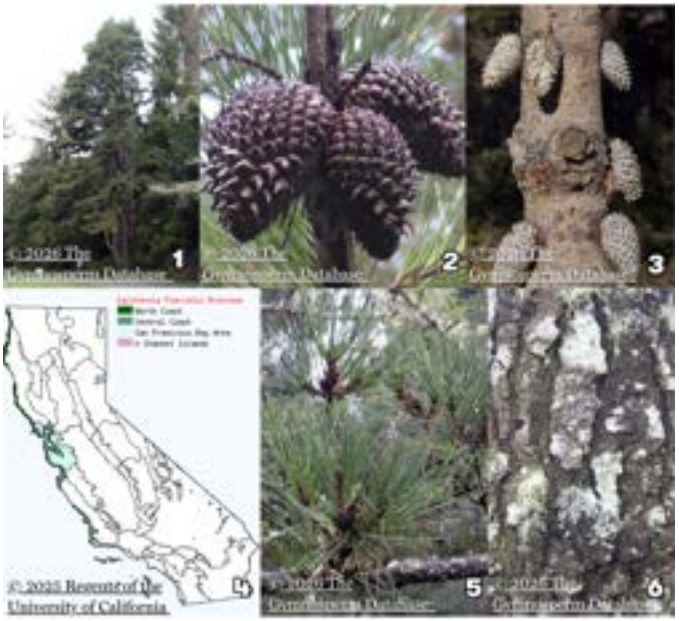
Pinus muricata

bishop pine

PIMU, 120

Height: 40 – 80 (112) ft. **Distribution and Habitat:** Found along the coastal regions of California and Baja California, from Mendocino County to Guadalupe Island, growing in coastal chaparral and mixed conifer forests, often in sandy or rocky soils. **Elevation Range:** < 1,300 ft. **Bark:** Brown; thick; irregularly furrowed on older trees. **Leaves:** Needle-like; bundles of 2; blue-green, yellow-green (southern populations); 4 – 6 in. long; slender and slightly twisted. **Cones:** Green to purple turning shiny light chestnut brown when ripening; 2 – 4 in. long; asymmetrical egg shaped; thick scales with stout, flat, or curved prickles; serotinous. **Seed:** Winged; light brown; ~0.2 – 0.4 in. long. **Flowering:** April – June. **Ripening:** September. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 2 – 3 year interval for heavy crops.

Additional Remarks: Adapted to foggy coastal environments and plays a key ecological role in stabilizing soils and providing habitat for wildlife.



Bishop pine tree (1), mature cone (2), mature cones grown on stem of tree (3), bark (6), needles (5), and distribution map (4).

Pinus ponderosa

ponderosa pine

PIPO, 122

Height: < 200 ft. **Distribution and Habitat:** Widespread across western North America, from British Columbia to Mexico and east to Nebraska in montane coniferous forests, woodlands, and chaparral. **Elevation Range:** 500 – 9,500 ft. **Bark:** Reddish-brown or yellow to orange-red; thick; deeply furrowed; broad plates with black crevices; puzzle-piece-like scales. **Leaves:** Needles; bundles of 3 (2); green to yellow-green; 4 – 11 in. long. **Cones:** green to yellow green turning brown-green or yellow-brown upon ripening; egg shaped, 3 – 6.5 in. long, outward-pointing spines ('prickly' ponderosa). **Seed:** Brown; winged. **Flowering:** April – June. **Ripening:** August – September. **Cone Development Period:** 2 years. **Cones per Bushel:** 90 – 230. In northern California, ~230 cones in lower elev. below 4,500 ft. and ~198 in high elev. above 6,000ft; in central California, ~165 cones; in southern CA, ~129 cones in high elev. above 6,000 ft. **Seed Count Minimum for Cut-Test:** 7 – 10 seeds or 75%. **Cone Crop Periodicity:** 2 – 10 year-interval between heavy crops.

Additional Remarks: When looking for heavier cone crops look for many clusters of cones with 3 – 10 cones per cluster distributed on interior portions of the branch and branch tips. Compared to Jeffrey pine, ponderosa pine needles tend to be brighter in color and can be slightly shorter, cones are smaller and sharper ('prickly' ponderosa cones are more painful to hold). Although rare, Jeffrey pine can hybridize with ponderosa pine, and suspected hybrids may produce cones with intermediate or variable characteristics that can make identification difficult.

Ponderosa pine 1st year conelets (1), unripe cones (2), ripening cones (3), two aborted uncollectable cones appearing reddish and pale brown with one green live cone (4) and freshly opened cone (5).

Ponderosa pine tree (1), needles (2), bark (3), signs of insect activity demonstrated by J-shaped cone (4), frass present on exterior (5), cut tests of unripe cone showing light brown seed coat and wings (6), ripen cone and seed with darker seed coat and detaching wings (7), ripe cone with high seed count (8), cone with low seed count due to insect activity (9), and distribution map (10), seed cut test showing viable seed with full embryo fill (11), pollen (male) cones (12), unfertilized flower (early female seed cone) above with very immature 2nd-year cones below (13).

Ponderosa pine trees with light crop with clusters of 1-3 and few clusters per branch (1), medium crop of with clusters of 2-4 and several clusters per branch (2), heavy crop with clusters of 3-6 and many clusters per branch all over upper crown (3); and examples of average clusters for typical light crops (4), medium crops (5), and heavy crops (6).

Pinus quadrifolia

Parry pinyon, four-needle pinyon

PIQU, 138

Height: 15 – 35 (53) ft. **Distribution and Habitat:** Found in southern California and northern Baja California, growing on dry, rocky slopes in pinyon-juniper woodlands and chaparrals. **Elevation Range:** 4,000 – 8,500 ft. **Bark:** Red-brown; thin; scaly or furrowed. **Leaves:** Needle-like; bundles of 4 (3 or 5); blue-green; 1 – 2 in. long; stomatal bloom on inner surface; stiff; thick. **Cones:** Green turning yellow- or red-brown when ripening; 1.25 – 3 in. long; egg shaped to spherical; thick scales with deep recesses. **Seed:** Large; light brown; wing persistent on scale; 0.4 – 0.6 in. long; edible pine nuts. **Flowering:** June. **Ripening:** September. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 1 – 5 year-interval between heavy crops.

Additional Remarks: Cultural keystone species of California's Indigenous communities.

Parry pinyon pine tree (1), unripe green cone (2), opened cone (3), distribution map (4), 1st year conelet and foliage (5), pollen (male) cones (6), and bark (7).

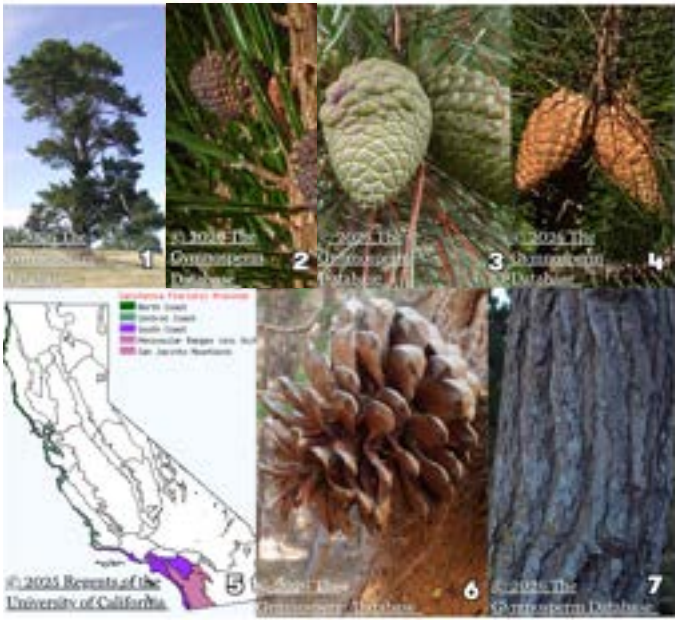
Pinus radiata

Monterey pine

PIRA2, 124

Height: 50 – 125 (170) ft. **Distribution and Habitat:** Endemic to coastal central California, growing in sandy or rocky soils near Monterey Bay and widely planted worldwide in temperate regions. **Elevation Range:** < 1,300 ft. **Bark:** Dark brown to black; thick; deeply furrowed. **Leaves:** Needle-like; bundles of 3 (2); dark green; 4 – 6 in. long; slight curve. **Cones:** Green turning lustrous nut brown to light brown when ripening; 3 – 6 in. long; broad egg shape; thick scales, larger on upper side, rounded at base, and flatter on bottom; often serotinous; persistent on branches for several years. **Flowering:** January – February. **Ripening:** November. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 1 year-interval between heavy crops.

Additional Remarks: One of the most widely planted pines globally, but it's natural populations are endangered. Many cones remain closed for several months or years.



Monterey pine tree (1), 1st year conelet (2), unripe green cone (3), ripe collectable cone (4), distribution map (5), opened uncollectable cone (6), and bark (7).

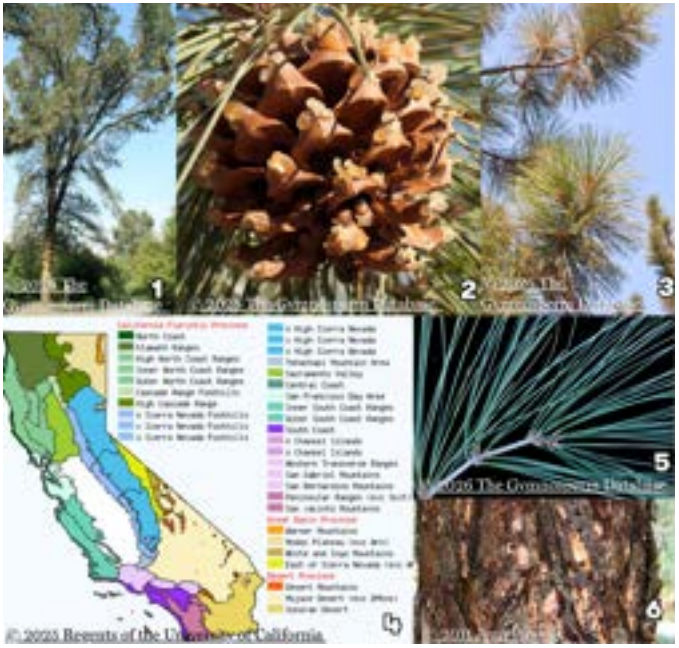
Pinus sabiniana

Gray pine, foothill pine, ghost pine

PISA2, 127

Height: 40 – 80 (161) ft. **Distribution and Habitat:** Endemic to California, growing in oak woodlands, chaparral, and foothills. **Elevation Range:** 100 – 7,000 ft. **Bark:** Gray; irregular fissures. **Leaves:** Needle-like; bundles of 3; gray-green; 7 – 17 in. long; drooping and flexible. **Cones:** Green to light brown turning red to red-brown or chestnut brown when ripening; 6 – 10 in. long; egg shaped; sharp claw-like scales; sometimes serotinous. **Flowering:** March – April. **Ripening:** October. **Cone Development Period:** 2 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 12 seeds or 50%. **Cone Crop Periodicity:** 2 – 4 year-interval between heavy crops.

Additional Remarks: Cultural keystone species of California's Indigenous communities. Irregularly spaced branching with open crown. Cones are massive, open slowly, and shed seeds over several months.



Gray pine tree (1), opened cone (2), branching (3), distribution map (4), needles (5), and bark (6).

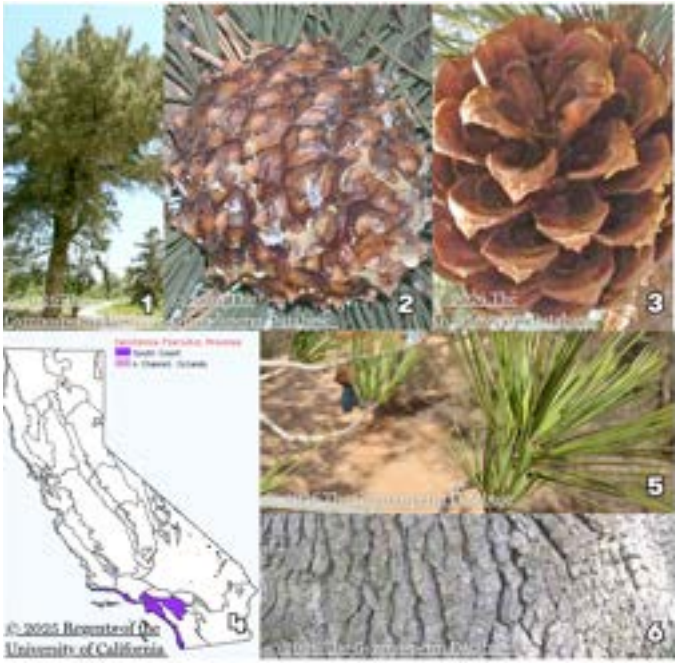
Pinus torreyana

Torrey pine

PITO, 139

Height: 25 – 60 (126) ft. **Distribution and Habitat:** Endemic to San Diego County and Santa Rosa Island, California, growing on coastal bluffs and sandy soils. **Elevation Range:** 200 – 500 ft. **Bark:** Dark brown; thick; deeply furrowed and scaly. **Leaves:** Needle-like; bundles of 5; dark green; 6 – 10 in. long; stiff and straight. **Cones:** Green to dark violet turning shiny deep chestnut brown when ripening; 4 – 6 in. long; egg shape to spherical; pyramid like tips with small prickles on thick scales. **Seed:** Wingless; brown; 0.5 – 0.8 in. long. **Flowering:** February – March. **Ripening:** June – July. **Cone Development Period:** 3 years. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** 1 year-interval between heavy crops.

Additional Remarks: One of the rarest pines in the world, with extremely limited natural populations. Cones are massive, open slowly, and shed seeds over several months. Notably, their cones take 3 years to mature compared to the 2 year period of all other pine species.



Torrey pine tree (1), ripe closed cone (2), opened cone (3), distribution map (4), needles (5), and bark (6).

Pseudotsuga macrocarpa

bigcone Douglas-fir

PSMA, 201

Height: ~60 (145) ft. **Distribution and Habitat:** Southern California mountain ranges, including the San Gabriel and San Bernardino Mountains; growing in montane coniferous forests and often found with Coulter pine, ponderosa pine and other conifers and broadleaved trees in chaparral. **Elevation Range:** 2,000–6,000 ft. **Bark:** Red-brown to dark brown; thick; deeply furrowed. **Leaves:** Needle-like; blue green; 0.75 – 1.25 in. long; flat; linear; arranged in bottlebrush; stomatal bloom underneath; pointed tips. **Cones:** Green turning gold brown when ripening; 4- 6 in. long; cylindrical to pendant; 3-lobed bracts barely extending past scales resembling a 'mouse-tail'; hanging from lower side of branch. **Seed:** Winged, light brown, about 0.5 cm long. **Flowering:** February - April. **Ripening:** August – October. **Cone Development Period:** 1 year. **Cones per Bushel:** 300 - 400. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** NA.

Additional Remarks: Commonly grows in steep, rocky areas and intolerant of shade. It is not a true fir but shares some characteristics with the genus *Abies*. Cones drooping from underside of branch unlike true fir cone that sits upright on branches.

Bigcone Douglas-fir very early unripe cone (1), ripening cones (2), and opened cone (3).

Bigcone Douglas-fir tree (1), new emerging foliage (2), bark with woodpecker damage (3), distribution map (4), and pollen (male) cones with surrounding foliage (5).

Pseudotsuga menziesii

Douglas-fir

PSME, 202

Height: < 330 ft. **Distribution and Habitat:** Widespread across western North America, from British Columbia to Mexico, and east to the Rocky Mountains in coniferous and hardwood forests. **Elevation Range:** < 7,200 feet. **Leaves:** Needles; single; green with white stomatal bands; ~1 in; flat; arranged in 'bottlebrush' pattern around twig. **Bark:** Dark brown to gray and smooth on younger trees; deeply furrowed; corky; thick in older trees. **Cones:** Bright green turning light brown upon ripening; 2 – 4 in. long; cylindrical or pendant; distinctive three-pointed bracts or 'mouse-tails' extending beyond the scales; hanging from lower side of branch. **Seed:** When ripe, golden brown to dark brown; seed wing light brown to tan; and embryo yellowish green. **Flowering:** March – April. **Ripening:** August. **Cone Development Period:** 1 year. **Cones per Bushel:** ~1,000 (700 – 900 for the Sierra Nevada, 900 – 1000 for coastal areas). **Seed Count Minimum for Cut-Test:** > 5 seeds. **Cone Crop Periodicity:** 2 to 11 years between large crops.

Additional Remarks: It is not a true fir but is named for its resemblance to the genus *Abies*. Flowering female cones first develop upright on branches; soon after fertilization, developing cones drop to hang from underside of branch, unlike true firs, whose cones sit upright on branches. Crops can appear to rate heavier than they are when many individual cones are scattered across the tree crown; for heavier crops, look for drooping branches and clusters of cones.

Douglas-fir upright unfertilized flowering cone (color can vary between individuals from lime green to magenta) (1), early unripe green cones and pale brown aborted cone (2), ripening cones (3), very ripe cones (4, 5), and opened cones (6).

Douglas-fir trees (1), needles (2,3), bark (4), cut test of an unripe cone with high seed count (5), ripe cones some moderate and low seed counts (6), and ripe cone with low seed count and visible frass due to insects (7), distribution map (8), dramatically curved or J shaped cone indicating insect activity (9), and cone with visible entry and exit holes with frass due to insect activity (10).

Douglas-fir with upright branches and individual cones showing a light crop (1), slightly dropping branches with a few more clustered cones showing a medium crop (2), drooping branches with more clustered cones showing a heavy crop (3), many individual cones scattered throughout canopy giving the false appearance of a heavy crop when it is actually a light crop (aka 'Christmas lights', 4), more clustered cones for a heavy crop (5), single cone typical of lighter crops (6), and more clustered cones typical of a heavier crop (7).

Sequoia sempervirens

redwood, coast redwood

SESE3, 211

Height: 200 – 300 (363) ft; tallest species in the world. **Distribution and Habitat:** Found along coastal regions of California and southern Oregon, growing in moist, foggy environments in coastal forests. **Elevation Range:** < 3,000 ft. **Bark:** Red-brown; thick; fibrous; deeply furrowed and fire-resistant. **Leaves:** Needle-like; dark green on upper surface, white bands beneath; 0.75 – 1 in. long; arranged in flat sprays; lacking petioles; leaves from upper canopy can be awl-like. **Cones:** Green turning green-yellow when ripening; 0.5 – 1.25 in. long; barrel shaped; umbrella-like scales; scales slightly separating when ripening. 30 - 100 seeds per cone. **Seed:** Brown wing with slightly dark seed coat, about equal width of seed; embryos with 2 cotyledons. **Flowering:** November – March (May fertilization, generally). **Ripening:** September – January. **Cone Development Period:** 1 year. **Cones per Bushel:** 1000s. **Seed Count Minimum for Cut-Test:** 50%. **Cone Crop Periodicity:** Irregular or sporadic.

Additional Remarks: Some seed extractories may require peduncles to be removed from cones prior to bagging and delivery. Cone crops are highly variable and seed viability is often low. Redwood seed does not persist long in the seed bank. Although coast redwood regenerates primarily by sprouting with cuttings and clonal reproduction acting as primary source for manual regeneration, collecting viable seed remains important for genetic diversity and long-term adaptation.

Redwood two green unripe cones and one open brown cone (1), opened cones (2), and heavy crop of ripening cones (3).

Redwood tree from Lady Bird Johnson Grove (1), mature needles from ornamental tree (2), mature needles from old growth tree (3), distribution map (4), and bark (5).

Sequoiadendron giganteum

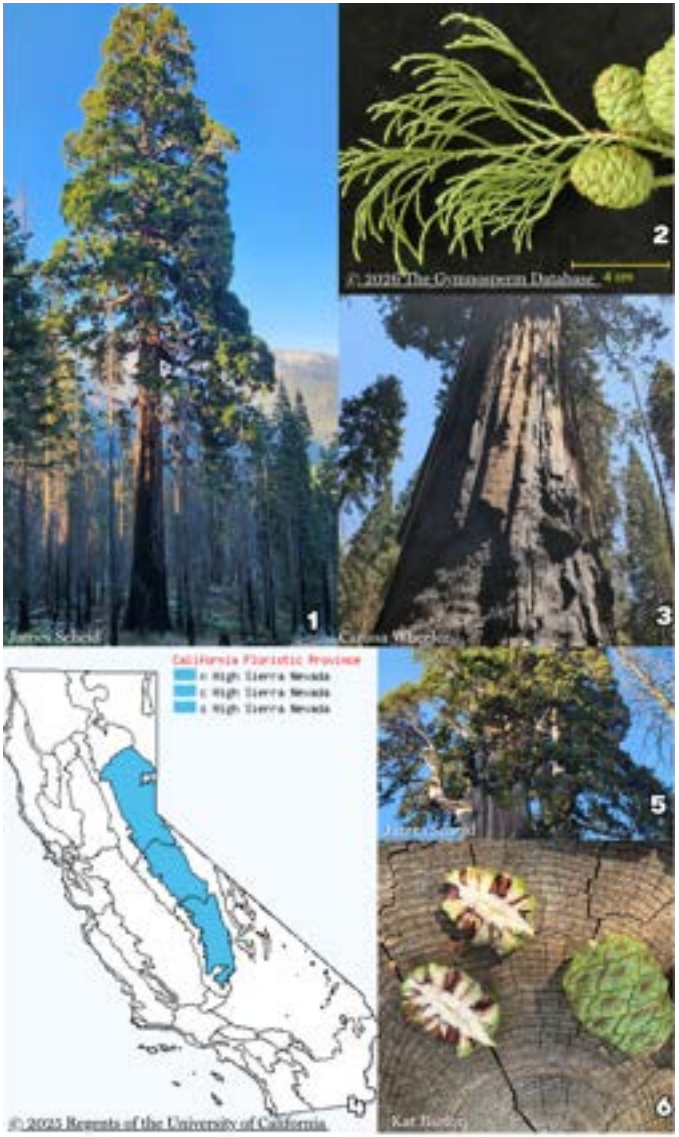
giant sequoia

SEGI2, 212

Height: 225 – 275 ft. Largest tree in the world by volume (diameter ranging from 10 – 20 (>40) ft.). **Distribution and Habitat:** Found in the Sierra Nevada of California in scattered groves ranging from Placer County to Tulare County, growing in montane forests with moist soils and frequent fire cycles. **Elevation Range:** 2,700 – 8,800 ft. **Bark:** Red-brown; thick; fibrous; deeply furrowed and highly fire-resistant. **Leaves:** Awl-like; blue green; ~0.25 in. long; sprays; stomatal bloom on all surfaces. **Cones:** Green turning brown when ripening; 1.75 – 2.75 in. long; barrel shaped; umbrella shaped scales; serotinous. **Seed:** Winged; light brown; ~0.2 – 0.3 in. long. **Flowering:** April – May. **Ripening:** September – October. **Cone Development Period:** Cones begin forming in summer, are pollinated the next spring, and fertilized by fall. They fully mature by the following summer, taking 13 months to mature after fertilization. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** NA.

Additional Remarks: Highly fire-adapted; thick bark and serotinous cones enable them to regenerate after wildfires. Search for clusters of cones located proximal to the bole in the upper crown. Mature cones can persist in the crown for many years and release seed intermittently and may be collected at any time; however, cones older than 6 years may have ~10% reduced viability. Collectors should target mature yellowish-green cones, and avoid very old grey lichen-covered cones and nearly full-sized immature green cones. The distinction between immature and ripe cones is easiest to determine in late spring or early summer.

Giant sequoia green ripening cones (1), freshly collected ripe cones (2), very old mature cones with lichen (3), various stages of cone maturity (4).



Giant sequoia tree (1), needles and cones (2), trunk with fire scarred bark (3), distribution map (4), upper crown (5), and cut test of ripening cone (6).

Thuja plicata

western redcedar

THPL, 242

Height: 70 –130 (159) ft. **Distribution and Habitat:** Found in the Pacific Northwest, from Alaska to northern California in Del Norte County and Humboldt County and inland to Montana; growing in moist forests, riparian areas, and wet soils. **Elevation Range:** < 7,000 ft. **Bark:** Red-brown or cinnamon brown; thin; fibrous; furrowed. **Leaves:** Scale-like; dark green; 0.12 in. long; arranged in flattened sprays; blunt tips; opposite-alternating pairs; aromatic. **Cones:** Green to yellow to cinnamon brown when ripening; 0.5 in. long; oblong; leathery. **Seed:** Light chestnut-brown; lateral wings; embryos with 2 cotyledons. **Flowering:** Spring to summer, pollen shedding in late winter to early spring. **Ripening:** Fall. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** 2 seeds. **Cone Crop Periodicity:** 3 – 5-year interval for heavy crops.

Additional Remarks: Cones can be raked from the tree, or stripped onto canvas, burlap, or plastic. Cones have been collected with aerial rakes attached to helicopters. The ideal time for collection is from late August to early September when seeds are firm, and most cones have turned from yellow to brown. Cones tend to open soon after ripening.

Western red cedar ripe cones starting to open (1), and opened cones (2).

Western red cedar (1), upper side of foliage (2), lower side of foliage (3), distribution map (4), and bark (5).

Tsuga heterophylla

western hemlock

TSHE, 263

Height: 100 – 150 (174) ft. **Distribution and Habitat:** Found along the Pacific Coast from Alaska to California along northern coastline and in Humboldt and Del Norte County, and inland to the northern Rocky Mountains; growing in moist, shaded forests. **Elevation Range:** < 2,000 ft. **Bark:** Gray-brown; thin; scaly or furrowed on mature trees; red-purple inner bark. **Leaves:** Needle-like; dark green above, whitish beneath; 0.25 – 0.75 in. long, variable in length; blunt-tipped; drooping flat sprays. **Cones:** Green with purple tips turning brown with red-brown tips when ripening; 0.75 – 1 in. long; cylindrical; papery or leathery scales with smooth or wavy margins. **Seed:** Small; winged; light brown. **Flowering:** April – June. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** ~1,600. **Seed Count Minimum for Cut-Test:** 3 seeds. **Cone Crop Periodicity:** Typically produce some cones almost every year, with 3 – 4-year intervals for heavy crops.

Additional Remarks: Shade-tolerant. In comparison to mountain hemlock, western hemlock is found at lower elevations, with needles in flat sprays, slightly smaller cones, and more pyramidal crown.

Western hemlock ripening cones (1), and mature cones (2).

Western hemlock tree (1), needles (2), closed pollen (male) cones (3), opened pollen cone (4), and distribution map (5), and bark (6).

Tsuga mertensiana

mountain hemlock

TSME, 264

Height: ~ 100 (113) ft. **Distribution and Habitat:** Found in subalpine regions of the western United States and Canada, including the Sierra Nevada, Klamath, Cascades, and Rocky Mountains, growing on rocky slopes and ridges. **Elevation Range:** 4,000 – 11,600 ft. **Bark:** Gray to red-brown; thick. **Leaves:** Needle-like; dark green to blue-green; 0.25 – 1 in. long; soft and radially arranged; 3-angled cross section. **Cones:** Yellow-green to brown turning brown when ripening; 1 – 3 in. long; cylindrical to pendant; papery or leathery scales; with smooth margins with prominent radial lines. **Seed:** Small; winged; light brown; 0.1 – 0.2 in. long. **Flowering:** June. **Ripening:** September – October. **Cone Development Period:** 1 year. **Cones per Bushel:** NA. **Seed Count Minimum for Cut-Test:** NA. **Cone Crop Periodicity:** Typically produce some cones almost every year.

Additional Remarks: In comparison to western hemlock, mountain hemlock is found at higher elevations, with needles arranged radially, slightly larger cones, and a broader crown.

Mountain hemlock immature cones (1), opened cones (2, 3).

Mountain hemlock tree (1), needles (2,3), distribution map (4), and bark (5).

NOTES

Pine Cone Trees

by Ken Chawkin

Marveling, Beholding
Sequential symmetries
Nature reveals to me
Her inner mysteries

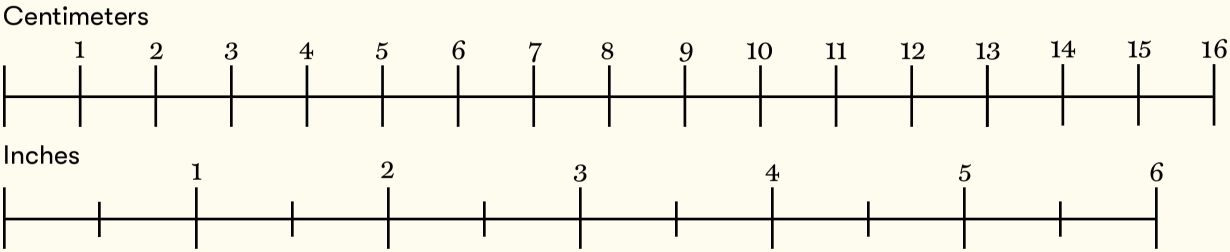
Spiraling, Unfolding
To spread their seeds
The cones of conifers
Look like trees

Parallel Helices
Winding all around
Evergreen miniatures
Painted everbrown

Dancing and Whirling
Rolling on the ground
The trees in the pine seeds
Are wanting to be found

We are Found to be
Wanting

You are Wanting to be
Found


Centimeters
1
2
3
4
5
6
7
8
9
10
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15
16
Inches
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