

Chapter 9: Planting

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Table of Contents

Introduction.....	4
Planting Season.....	5
Central and Northern Coastal Area	6
West and East Sides of the Sierra-Nevada/Cascade Ranges	6
Considerations for Fall versus Spring Planting in the Sierra Nevada/Cascades and Eastside.....	7
Summary of Advantages of Fall Planting.....	11
Summary of Challenges and Risks with Fall Planting (especially east of the Sierras/Cascades)	11
Species, Stock Types, and Spacing across California	12
Sierra/Cascades and Eastside.....	12
Species.....	12
Stock Type	13
Spacing	14
North Coast Region	15
Species.....	15
Stock Type	15
Spacing	16
Southern California Mountains	17
Receiving Seedlings from Nursery and/or Cold Storage.....	17
Transport, Handling, and Storage in the Field	20
Importance of Seedling Care.....	20
Transportation from Nursery and/or Storage to Planting Site	20
Handling Seedlings at the Landing or Daily Storage Site.....	21
Planter Handling at the Landing or Other Daily Storage Site	21

Chapter 9: Planting

Container Seedlings	21
Bare-Root Seedlings.....	22
Seedling Handling During Planting	22
Planting Methods	22
Essential Steps.....	22
Planting Tools	26
Hoedad	26
Shovel.....	30
Power Auger	31
Machine Planter	32
Contracting.....	33
Contractor Selection	33
Crew.....	34
Foreman.....	34
Experience, Reputation, and References	34
Production & Timing.....	35
Enforceable Inspection Guidelines.....	35
Production Targets.....	35
Penalties and Incentives	36
Payment Methods and Rates	36
Organizational Needs.....	37
Inspectors	37
Seedling Deliveries	37
Inventory.....	37
Field Considerations.....	38
Unit Layout.....	38
Maps	38
Detailed Unit by Unit Planting Plans.....	38
Unit Planting Folders.....	38
Trash Disposal	38
Pre-operational Meeting.....	39
Planting Inspection	39

Chapter 9: Planting

Number of Inspectors per Crew.....	39
Inspection Procedures.....	39
Documentation.....	40
Tree Information	40
Installing Protection Measures in Conjunction with Planting	42
Artificial Shading Devices.....	42
Mulch Materials.....	43
Animal Pest Protection Materials & Methods	44
Planting Follow Up.....	47
Stocking Survival Surveys.....	47
Interplanting	48
Vegetation and Pest Problem Surveys.....	49
Diagnosing Problems	49
Acknowledgements	50

Introduction

Prior to implementing the planting steps of a reforestation project, it is very important to consider how it fits with the other key steps to a successful reforestation plan. These key steps are based upon the following “Five Principles of Successful Reforestation” that have been developed and refined by reforestation foresters over the past several decades in California’s Mediterranean climate:

1. Plant species from known, appropriate seed sources

Typically, this means tree species which are native to the site using seedlings that are grown from native, adapted seed as described in *Chapter 4 – Seed*.

2. Use quality seedlings

As described in *Chapter 5 – Seedlings*, seedlings must be grown using excellent, up- to- date nursery practices. Seedlings must be vigorous enough to grow roots down to permanent soil moisture during the first growing season of establishment and be able to withstand sun, wind, cold, and any other environmental conditions that might be encountered.

3. Control competing vegetation

During the critical first year of establishment in a typical Mediterranean climate, planted seedlings need all the available water in the soil that is within reach of the rapidly expanding seedling root system. The main cause of soil moisture depletion at the rooting level during the long, hot and dry summer period is transpiration from competing vegetation, and not evaporation. Experience over the past few decades has shown good control of competing vegetation results in soils retaining sufficient moisture to provide for very high survival rates, even on very dry sites during prolonged droughts. Mechanical and hand control methods as described in *Chapter 6 – Site Preparation*, can also be used to control competing vegetation but are most effectively done in combination with herbicides in order to minimize erosion and/or topsoil disturbance, and to effectively constrain costs. A very cost-effective method of vegetation control is through the carefully planned and regulated application of registered herbicides as described in *Chapter 8 – Vegetation Management*.

4. Properly handle, transport, store, and plant seedlings

This *Chapter 9 – Planting* describes the details of these critical reforestation steps. The information here has been developed and refined through many discussions with regeneration foresters with decades of experience across California. Unlike some of the other topics addressed in this book, these best management practices have rarely been done under research conditions where the results have been published. Generally, the most common and cost-effective method used in successful

reforestation projects in California, especially interior California, is to use hoedads to plant relatively small, container grown stock. However other stock types and methods are appropriate in certain climates, soil types and other situations. For example, on coastal sites where competition for light is more critical and transpiration stress is less significant than on interior sites, larger seedlings are used and often planted with shovels rather than hoedads. Proper handling includes minimizing exposure to drying and high temperatures prior to and during planting. Proper planting includes planting deep enough so that the growing media is completely covered by moist mineral soil and ensuring that seedling roots are not bent over in the hole nor have air pockets around them. Proper timing means having soil moisture and soil temperatures adequate for root growth on the site at the time of planting.

5. Protect seedlings from damage by animal and insect pests if necessary

As described in *Chapter 11 – Damage*, there are many control methods to consider depending upon the specific animal and/or insect pest and reforestation site characteristics. It is important to consider that maximizing early tree growth by adherence to the previous four “principles” can greatly reduce the number of years that seedlings would need protection from possible browse damage by livestock and/or other animals.

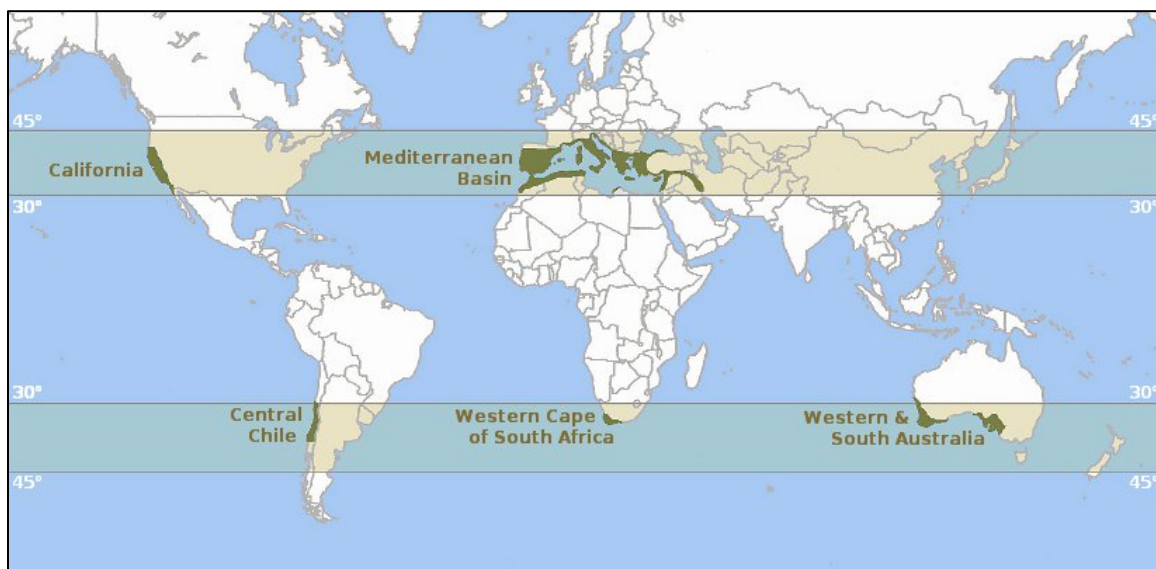


Figure 9.1 A “Mediterranean climate” is characterized by warm/hot, dry summers and mild/cool, wet winters. Therefore, soil moisture is the limiting factor for conifer seedling establishment.

Planting Season

The most appropriate times of the year to plant vary for different ecoregions in California. Even within regions, the optimal planting window varies by elevation, aspect, climatic conditions, soil and ground

Chapter 9: Planting

conditions, as well as planting site access. Depending upon these site-specific factors and the general region, planting typically occurs in California from fall through late spring. Since 2010 there have been a few successful operational-size planting trials conducted in late summer. These successful summer plantings have been completed on sites with good soil moisture due to recent thunderstorms and excellent control of competing vegetation throughout the spring and summer. Additionally, smaller container seedlings are grown in the nursery for a shorter period of time and lifted and packed in proper physical and physiological condition for summer planting. Late summer plantings should be done with caution until continuing success can be demonstrated in your region. The factors in the following sub-section should be considered in selecting the proper scheduling of planting times, especially if the forester has multiple planting projects to complete.

Central and Northern Coastal Area

Ideal planting times are determined by the species being planted, the distance from the coast, climatic conditions, elevation and aspect. Areas not planted in the late fall or winter are typically planted as early as possible in the spring. Since south and west slopes typically dry out before the east and north slopes, these slopes should be planted first.

Planting true fir at higher elevations of the North Coast region typically starts in November and progresses until access to, and planting of the units, is impeded by snow, typically in late December. Planting can then resume in the spring after snowmelt, sometimes occurring as late as May if snowpack persists into the spring. In general, redwood planting within its typical coastal range can start in November and continue into April, sometimes the first part of May, with the majority of redwood being planted January through March. Where redwood is planted at more inland and higher elevation sites at the fringe near the edge or outside of its typical range, commencement of planting typically is delayed until later in the season to avoid desiccation of newly planted seedlings from exposure during the coldest month(s) of mid-winter. Once redwood seedlings at these locations are established at the end of the first growing season with deep roots, winter desiccation is not usually a problem.

West and East Sides of the Sierra-Nevada/Cascade Ranges

The variable elevation, aspect, soil, and climatic conditions dictate the planting schedule for specific locations within this broad region. Latitude can also affect planting timing, with southerly latitudes opening sooner for planting than northerly latitudes at the same elevation. Planting in this region occurs primarily in the spring planting season that occurs from late winter through the advent of drier late spring conditions. However, fall planting has become increasingly common and successful at higher elevations (if seedlings are insulated during harsh winter weather by snow), primarily on the westside, but also in

Chapter 9: Planting

limited situations on the eastside. Typically, spring planting on the westside Sierra/Cascades extends from February to late March or early April at lower elevations (1,500 feet to 3,500 feet), March through April at mid elevations (3,200 feet to 5,000 feet), and mid-April to late June at the higher elevations with late snowpack melt. On the eastside, planting season is typically from April to late May, and any high elevation sites (above 5,000 feet) may not be accessible until a May to late June period. These timeframes will be dependent on local conditions such as aspect and site conditions and can vary from year to year depending on weather patterns. Table 9.1 shows the approximate planting dates by area and elevation.

Table 9.1 Approximate Planting Dates in California Sierra/Cascade Regions

Area	Elevation	Planting dates
Westside “low” elevation	1,500 feet to 3,500 feet	Feb through early April
Westside “mid” elevation	3,500 feet to 4,500 feet	March through April
Westside “high” elevation	>4,500 feet	April through June or Sept. through Oct.
Eastside “low” elevation	3,200 feet to 5,000 feet	April through May
Eastside “high” elevation	>5,000 feet	May through June or Sept. through Oct.

Source: Personal communication with numerous experienced reforestation foresters

For any of the indicated spring planting periods, planting in the Sierra/Cascade and eastside regions should begin as soon after snowmelt as possible and when soil temperatures are at least 38 to 40 degrees Fahrenheit and rising. For large spring planting projects that require several weeks of planting to complete, lower elevations should be planted first and within any particular elevation, south facing aspects should be prioritized, followed by west, then east, and lastly north facing aspects. Also, within these elevational and aspect considerations, soils with relatively lower water holding capacities should be prioritized.

Considerations for Fall versus Spring Planting in the Sierra Nevada/Cascades and Eastside

The principle behind fall and spring planting lies in the fact that most conifer species have two primary root growth periods in a year. The spring growth period is stimulated by climatic conditions favorable for root and shoot growth, including increasing day length, warming atmospheric and soil temperatures, and an abundance of moisture from seasonal rains. This period of conifer growth is characterized by the highest a rapid extension of both the roots and the shoots metabolic activity of the year as seedlings

Chapter 9: Planting

rapidly extend both roots and shoots, with root growth initiating before shoot growth. The other time of year that conifers have the capability of growing roots is in the late summer and early fall when temperatures start to moderate, and the days are becoming shorter. The fall season is also a period of reduction in transpiration of deciduous trees and herbaceous vegetation, which allows soil moisture levels to rise. Planting in the fall has historically yielded unpredictable results, at least in part due to unpredictable winter weather conditions. Wind or exposure to sunlight without adequate snow cover can result in seedling desiccation, particularly since no root uptake occurs in cold soils. All these factors typically made spring planting the safest and most commonly used planting timing in reforestation. However, in recent years, reforestation foresters have developed more expertise on when, where, what and how to plant in the fall. Several factors should be considered when making a decision to plant in the fall and certain strategies will maximize success and minimize risk if it is decided to plant in the fall.

Planning a fall planting project requires focus on the basic reasons for choosing to not plant in the safer spring planting window. Four such justifications include:

1. Planting on high elevation sites that would be covered in winter snowpack until very late spring and/or the onset of summer drought.
2. Planting on sites where access may be blocked by high passes that are normally covered in snowpack until late spring or by snow that persists on significant distances of roads shaded by forest cover. Snowpack on a planting unit(s) exposed to direct sunlight typically melts off weeks before shaded or high elevation access roads are open for travel to the planting site.
3. Decrease extended seedling storage time that is required when planting in late spring. Seedlings must be lifted and packed and put into refrigerated or freezer storage at the optimum lifting time (December or January) which is months before the optimum planting time at higher elevations (May or June).
4. Divide operational challenges of large planting projects between two planting seasons.

Conditions needed for fall planting are the same as any other planting timing, i.e. adequate soil moisture, warm soil temperatures, mild diurnal air temperatures and adequate humidity. Timing is even more critical in the fall. Ideally, seedlings should be in the active root growing phase typical of the late summer and early fall. The fall planting window is generally late August through October for most sites. Ideally, high elevation sites should be planted when enough growing season is left for adequate root growth to occur. Planting in mid to late October may result in very little or no root growth at high elevations. However even if the seedlings are planted this late planting can be successful if the seedlings are covered

with snow during the winter. In this case, the seedlings are essentially being stored under a blanket of snow until spring thaw. If these seedlings are protected from desicating winds and low humidities by winter snow, then they will get an earlier start on establishment and growth in the spring than will similar seedlings planted later in the spring.



Figure 9.2 (left) Significant new fall root growth on white fir within two weeks after planting on October 5, 2010 compared to the white fir in **Figure 9.3** (right) planted a week later (October 12, 2010) with almost no new root growth two weeks after planting, both at 5,500 foot elevation in Plumas County on private land burned in the Moonlight Fire. Although fall planted seedlings that were planted after mid-October did not initiate new growth until the spring after planting, they did survive the winter and initiated vigorous new root growth in the spring much sooner than the seedlings which were planted spring 2011 initiated root growth.

In general, the best time for fall planting is as early as the soil moisture is present provided that soil temperatures are still high enough for root growth or an insulating winter snowpack is imminent. The uncertainty in California's climate for suitable late summer or early fall rains during any given planting year can be significantly mitigated with effective weed control. Although late summer or early fall rains can provide the necessary soil moisture, complete control of competing vegetation during the entire growing season prior to planting is an effective strategy to retain the necessary soil moisture to begin planting. Most forest soils, especially at higher elevations, can maintain adequate soil moisture within the lower rooting zone of seedlings even by the end of summer if transpiration from competing vegetation has been completely controlled on the planting site. If vegetation control has not been completed throughout the entire growing season, then sufficient late summer or early fall rains are necessary to ensure adequate soil moisture for early fall planting.

Chapter 9: Planting

Areas prone to drier conditions should be avoided for fall planting because of risk of desiccation. Eastside sites, especially at relatively low elevations (less than 5,000 feet) can be very risky due to the high probability of very low humidity (less than 20%), high winds, or soil temperatures that become too cold for water uptake by existing seedling roots. These conditions can desiccate the seedlings before they have the time to grow new roots. When planting at higher elevations, consideration of aspect is important because south facing aspects and/or windswept areas may become void of adequate snow cover in the winter period, exposing the newly planted seedlings to extreme low temperatures and drying winds. North facing slopes that are likely to be snow covered all winter are generally safer for fall planting. Small regeneration units with surrounding mature trees that provide winter shade on most of the unit will retain more snow than large units that are open to direct winter sunlight.

Other areas where fall planting should be avoided are areas that have high populations of deer or elk during the late fall or winter that historically browse on conifer seedlings. Areas that are traditional wintering grounds for these herbivores should not be fall planted, since the only succulent green vegetation during this time of year may be the newly planted conifer seedlings.

When planning a fall plant, it is important to communicate to the nursery manager when placing the sowing order, that you plan to lift the seedlings for a fall planting program if site conditions are suitable. The nursery manager should make sure that the seedlings are sown early enough to achieve a suitable maturity to lift between late August and very early October (depending upon species and elevation of planting site) if the project conditions are favorable. The nursery will also have to plan ahead to accommodate fall packing, and this needs to be discussed with them early in the growing season. At the time of lifting in the nursery it is important to remember that the trees need to be actively growing roots and be kept in that condition until planting time. This type of planting is considered “hot planting” and seedlings are not to be put in cold storage. Storage temperatures should not be less than 40 degrees Fahrenheit or the trees may be pushed into dormancy and not grow roots. As planting time nears, the nursery should be instructed to only lift and pack the number of seedlings that can be planted in one week or less. The nursery should not put liners around the boxed seedlings, as carbon dioxide (CO₂) may build up very rapidly due to the high rate of respiration of the trees. All seedlings that are lifted and packed for fall planting must be planted at that time, because they are not capable of surviving long term storage when lifted and packed at that time of the year. This is because seedlings do not reach a high level of cold hardiness and low metabolic rate, which are necessary for long term storage, until mid November, which is the start of the normal lifting window for long term storage. Container stock is preferred over bare-root stock for fall planting due to the ability to lift and ship one week’s production or less on short

Chapter 9: Planting

notice and also because it is very difficult to lift bare-root seedlings while the roots are actively growing without damaging the roots (e.g. stripping the cambium layer away from the root).

Summary of Advantages of Fall Planting

- Seedlings planted in the fall will initiate root growth before winter if planted in September or early October. However, even if seedlings are planted later in the fall they will initiate spring root growth sooner than seedlings planted in the spring.
- Fall root growth can occur immediately after planting if the seedling and site conditions allow planting in September or early October.
- Costs of plowing snow and/or long seedling storage are eliminated, as are the risks of late spring-early summer planting. Also more time to conduct the entire annual planting program is available if needed.

Summary of Challenges and Risks with Fall Planting (especially east of the Sierras/Cascades)

- Coordination and scheduling with nursery and planting contractor for seedling packing, transportation and planting is more complex due to “hot planting”, with no more than one week’s production for each pack out.
- Sometimes on the eastside, the normal summer dry season extends into the fall with the first significant precipitation coming in the form of snow, especially above 5,000 to 6,000 foot elevations.
- Low relative humidities on the eastside in the fall can exacerbate transplant shock and/or subsequent stress on seedlings.
- Wind or extreme temperatures with no protective snow pack after fall planting can damage or kill newly planted seedlings.
- On sites where mechanical sub-soiling or ripping has been conducted, planting should not occur until significant precipitation has settled the disturbed, loose soil. Reforestation projects have experienced higher than acceptable mortality rates when fall planting has been preceded by such mechanical treatments in the summer of the same year. So, it is now standard practice to either avoid sub-soiling/ripping on sites scheduled for fall planting, or to schedule fall planting at least one full winter after sub-soiling/ripping in order to allow the disturbed soil to properly settle prior to planting. Or if it is necessary to sub-soil/rip and it is necessary to schedule it for the same year

as fall planting, then seedlings are planted in the undisturbed, firm soil inbetween the sub-soiled/ripped rows.

- Unanticipated delays in the timely completion of scheduled logging or site preparation activities presents a risk that a scheduled fall planting program might be reduced in scope or cancelled. This can be mitigated by scheduling fall planting a year or more after logging. Although this might delay planting a year, it provides more certainty for scheduling the prescribed reforestation steps. Completing logging or mechanical site preparation in the year prior to fall planting allows for the scheduling of a spring herbicide treatment which can result in the retention of adequate soil moisture throughout the summer and early fall regardless of the amount of late summer or early fall rains.

Species, Stock Types, and Spacing across California

Seedling species and stock types are discussed in detail in *Chapter 5 – Seedlings*. These sections provide some practical lessons from decades of experience with reforestation plantings in these regions of Northern and Southern California.

Sierra/Cascades and Eastside

Species

Species selection by landowners/managers is more variable in these interior sites than in the coastal redwood dominated areas. Generally, landowners and managers want to plant a mix of species that are adapted to surviving and growing well on the site. Diversity of adapted species increases forest stand health since most pests are “host species specific” and it also diversifies future marketing options for the trees that will take several decades to grow. On many sites throughout this region the percent of shade tolerant species far exceeds the pre-settlement, more fire-adapted mix with a higher proportion of shade intolerant species, especially at low to mid elevations on the westside and most of the eastside. Decades of partial harvesting, the ingrowth of more shade tolerant species, and fewer wildfires that result in relatively more mortality to thin barked species such as white fir often result in a distribution of current species that are not necessarily well suited to future climatic conditions. Although seed disseminated from adjacent shade tolerant species, such as WF and IC, typically become established in group selection and clearcut size regeneration units, natural regeneration may not occur in the event of a large, stand replacing wildfires. DF is much more susceptible to late spring frost damage than other conifer species, so other suitable species should be planted in frost pockets that might occur within a planting unit.

Chapter 9: Planting

Where natural regeneration of shade tolerant species, such as white fir (WF) and incense cedar (IC) can be expected to seed in over time, less shade tolerant species such as PP, SP and DF are the focus of planting. This is especially true for landowners and managers that primarily practice single tree selection silviculture which favors the natural establishment of IC and WF over PP, SP, and DF.

Based on informed expectations of future site-specific climatic conditions, species should be selected that are accordingly adaptable to be resistant/resilient to drought, fire, pests and pathogens. In some areas, this can mean a shift towards a species mix of more drought tolerant pine species even if the site is currently dominated with white fir and incense cedar trees.

Soil type characteristics such as Available Water Holding Capacity (AWC), depth to bedrock, and texture can also influence the best mix of planted species. Although a site might be within the general location and elevational range where one might normally plant a 50:50 ratio of PP and DF, a soil type with relatively low AWC is a reason to increase the percentage of more drought resistant PP, especially on south aspects or sites with relatively low average annual precipitation.

Size of regeneration unit in proximity to adjacent seed sources. At lower elevations (i.e., below 3,000 feet and eastside up to 4,500 feet) a typical seedling mix of 50 to 100% PP (and/or JP where appropriate on the eastside and ultramafic westside soils) with some DF and IC seedlings on suitable sites may be appropriate, depending upon objectives. A typical seedling mix from 3,000 feet to 4,000 feet on the westside is 50% PP and 50% DF, with some IC if appropriate. A mid-elevation (4,000 to 5,000 feet) westside species mix commonly planted is 35 to 50% PP, 5 to 20% SP, 5 to 20% IC, 20 to 35% DF, and 10 to 20% WF. At elevations above 5,000 feet, increasingly more WF or RF are planted with RF replacing WF as elevations increase above 5,500 feet and JP replacing PP. Ponderosa pine and/or JP are often not included in the species mix at all above 6,000 feet depending upon the specific location. Some landowners have not only planted giant sequoia (GS) within its current narrow range but have also planted up to 5% GS on suitable sites in the Northern Sierras well outside its current range but where GS grows really well and where it may be better adapted to future climates. Such sites selected for planting GS typically are characterized by relatively high site class and high water holding capacity soils.

Stock Type

The selection of stock types in this region are based on several factors, including the following considerations to ensure seedlings can survive the critical first year of establishment during the long dry and hot summers typical of these regions:

- Minimize foliage height to reduce transpiration stress.

Chapter 9: Planting

- Maximize first-year root growth (to below depth of late summer soil moisture).
- Small enough to plant with hoedads.
- Sturdy stem, buds, and healthy foliage.

To reduce transpiration stress and promote rapid, deep root growth during the critical first growing season, almost all seedlings planted in interior California are relatively small one-year-old container grown stock that have vigorous, juvenile roots. Styro 5's are the most common ponderosa pine (PP) stock planted with some foresters in recent years planting even smaller, Styro 4 PP. Styro 6 PP are also planted to a far lesser degree than in the past, and even much less frequently Styro 8 PP are planted. Styro 6 is most commonly planted sugar pine (SP) seedling. Styro 6 and Styro 8 are the most commonly planted DF, true fir and IC stock sizes because these species, especially DF, are more susceptible to sun scald on the basal stem compared to PP. Although more expensive, the slightly larger stem diameter and more pronounced lateral branching of Styro 8 DF provides more shade on the stem, which is especially important at lower elevations. If a larger DF seedling with even more lateral branching is needed then more expensive Styro 10-77's, which are grown in styrofoam containers that have only 77 cavities, are planted. On eastside ponderosa pine sites in northeastern California, some landowners still plant two-year old bare root PP seedlings using shovels or hoedads with relatively long, wide blades.

Spacing

Seedling spacing in the Sierra/Cascade/Eastside regions depends on many factors including the landowners' objectives and commitment to follow-up with pre-commercial thinning (PCT), site quality and conditions, risk, seed availability, level of competing vegetation, funding availability and window, and anticipated first-year seedling survival rates by species. When harvesting healthy trees on private land, compliance with the minimum stocking standards of the California Forest Practice Rules (FPR) must be considered. As of 2020, the stocking standards in the California Forest Practice Rules (FPR) vary by site quality and are in line with stocking standards on private lands in other western states.

Table 9.2 2020 Resource Conservation Stocking Standards for Minimum Stocking (trees per acre)

CA FPR Site Quality	Coast	Norther / Southern
I	200	125
II	200	125
III	125	125
IV	100	100
V	100	100

Source: California Department of Forestry and Fire Protection. 2020. California Forest Practice Rules 2020. Pages 306: State of California.

Chapter 9: Planting

Currently, there are no reliable pulp markets in the Sierra/Cascade/Eastside regions of California and wood fuel chips and small logs are low (or negative) value by-products of final harvests or intermediate forest thinning projects. As a result, sawlog or peeler size trees that are 12 to 18 inches diameter at breast height are the primary objectives of most private forest landowners when determining seedling spacing at planting or at PCT. Although ideal density will vary by species and site, it should generally be at 100 to 180 trees per acre by age 10 to 15 years to reach desired tree sizes for the first commercial thinning at age 35 to 50. This was historically accomplished by planting at higher densities of approximately 258 to 436 trees per acre, depending on species mix, followed by a PCT in 7 to 10 years. However due to improved seedling survival rates, some landowners planted seedlings at wider spacing, often from 135 to 222 trees per acre after wildfires and other catastrophic stand replacing events that did not require restocking under the FPR. The 2020 California Forest Practice Rules stocking standards have been revised to reflect the experiences of successful reforestation after wildfires that did not require extensive precommercial thinning and the management of the additional fuel load they created.

It was common in California to plant fewer trees per acre after wildfires when the forest practice rule of 300 trees per acre did not apply. Planting fewer initial trees per acre can reduce immediate costs as well as some or all of PCT costs to achieve the desired density of commercial trees. However, in low elevation Sierra/Cascade ponderosa pine, as well as eastside pine sites where excellent survival is anticipated, planting 135 TPA (18 feet by 18 feet) to 170 TPA (16 feet by 16 feet) is becoming more common. This is due to exceptionally high survival rates of PP and JP, the desire to minimize seed use, and to reduce seedling, planting and future PCT costs and fire hazard from PCT slash.

North Coast Region

Species

The larger redwood companies typically plant 75% redwood and 25% Douglas-fir (DF) mixes on upland sites and pure redwood on flat alluvial sites. Factors reforestation foresters consider when determining the species mix for a particular reforestation project must always consider the availability of suitable seed by species, climate, soil types, site elevation and aspect, appropriate species, and unplanned natural ingrowth. Sites where the soil types have lower Available Water Holding Capacity (AWC) or south facing aspect have more moisture stress on seedlings and may do better with more Douglas-fir and less redwood. Conversely, sites that consistently have more fog can support more redwood.

Stock Type

For many years, redwood seedling production consisted of two-year old bare-root or plug-1 stock. These stock types have a woody stem that is far more resistant to damage from animal browse than seedlings

Chapter 9: Planting

with green succulent stems. However, it is now difficult to find a bareroot nursery in a location where the minimum winter temperatures are mild enough for redwood production. Improvements in container nursery technology have allowed foresters to shift much of the production to two-year old containerized Styro 15s. These large container trees do not sustain as much damage to the fine root systems when lifting as bare root seedlings. Since the coastal climate results in relatively less soil moisture loss and transpiration stress than interior climates (where much smaller stock types are preferred) the larger foliage does not create as much transpiration stress on seedlings during the first growing season in coastal redwood climates. However, it is common practice to mow the tops of containerized redwood seedlings to keep the crown from getting too large in order to reduce transpiration stress after planting.

It is fairly common to see redwood seedlings turn reddish brown the first few years after planting, particularly on colder sites. Sometimes the tops will even die off. However, even if the top appears completely dead, the trees will often resprout from the root collar the next season. In these situations, foresters typically dig up a few such seedlings to inspect and determine if the seedling is still alive below ground. Inspection is done by scraping the cambium at the base of the stem and looking for moisture and/or creamy color to see if the seedling is alive. It is important to take the time and monitor whether or not foliage dieback is fatal to the seedlings or if they are still viable before investing in a replant.

Common stock types for DF in the Coast Region are one-year old Styro 8 and Styro 10 container seedlings. These are commonly grown at a greenhouse nursery in interior Northern California where colder temperatures, and careful control of temperature and light within the greenhouse, condition these seedlings to withstand planting site conditions. Douglas-fir stock types as small as Styro 6 have also been successfully planted by some landowners. Container nurseries can provide much more flexibility in the timing of lifting and packing seedlings than bare root nurseries, which is important when scheduling a planting project around specific planting site conditions. Also, DF can be forced into dormancy by the use of dark-out technology in the greenhouse. This method of inducing dormancy does not stress the seedlings, unlike the method of withholding water and nutrients. Two-year-old bareroot and plug-1 transplant DF seedlings are still used on the coast, especially on sites where sunscald or animal damage is a problem. Although plug-1 stock is more expensive than 2-0 bareroot, there is less damage to the fine roots when lifting and packing.

Spacing

Since planted seedlings often times get outnumbered by the redwood sprouts, it is more cost effective on units that are sufficiently stocked with sprouts to not plant redwood or plant as few as 50 redwood seedlings per acre. Approximately 5% of regeneration units can meet redwood stocking objectives solely

with coppice regeneration. However, in redwood units with few sprouts, typically as many as 200 redwoods are planted per acre with up to 150 redwood clones and 50 redwood seedlings totaling 200 planted trees per acre (TPA). Although the range of planting density varies with the level of resprouts, on average within redwood units, approximately 120 seedlings per acre are planted. Redwood planting has been expanded into some areas of DF/tanoak timber type at higher elevations than redwood occurs naturally, but still generally within the redwood region. Outside of the redwood range, DF is commonly planted in the coast region at 300 to 435 TPA depending upon ownership and site.

Southern California Mountains

Due to the lower latitudes of Southern California, the dry season is longer, and temperatures are generally higher than in Northern California forests. These considerations along with Southern California's generally lower average annual precipitation, means the timing of planting projects in this region is even more critical and usually involves shorter planting windows. If the "Five Principles of Successful Reforestation" described in the introduction to this Chapter are followed, especially the elimination of competing vegetation to extend the window of suitable soil moisture during seedling establishment, a suitable planting window should be available to complete a successful planting project.

Planting in this region occurs primarily from December through February but at higher elevations can extend later into spring. Ideal planting times are determined by distance from the coast, climatic conditions, elevation and aspect. Since south and west slopes typically dry out before the east and north slopes, these slopes should be planted first. In addition to the factors listed for other regions, the periodic occurrence of extremely dry, warm spells and especially east winds known as "Santa Ana's" must be considered in scheduling planting operations and avoided.

Receiving Seedlings from Nursery and/or Cold Storage

The importance of monitoring the growing, packing, and storage practices at the nursery is mentioned in *Chapter 5 – Seedlings* along with a description of what a forester should look for in visits to the nursery. Then seedlings should be inspected upon receipt from the nursery and placed into a cold storage facility and monitored periodically until the day of planting. Upon receipt from the nursery a forester should inspect the following seedling conditions:

- Identification. Boxes or bags are properly labeled with name of forest owner/manager, seedlot number, species, stock type, seed zone, and elevation. The quantities of each seedlot should be verified against the nursery's packing list. In addition to a label on the outside of each seedling

Chapter 9: Planting

box, it is important to have the nursery place a label on the inside of the box in case the label on the outside of the box detaches during later transport or handling.

- **Morphological standards.** Seedlings should meet the morphological specifications in the nursery growing contract (i.e. stem height and caliper and root length). Note that there are rare occasions when accepting seedlings that do not meet specifications, particularly stem height, is preferred to delaying planting for a year or more, which usually also creates the need for an additional site preparation treatment.
- **Acceptable root pruning.** Roots of bare-root seedlings should be consistently pruned to specified lengths and the root cambium should remain intact (not stripped away or otherwise damaged during lifting and/or packing).
- **Moist but not waterlogged condition.** If seedling roots and/or shoots appear to have dried out, the plant moisture stress should be measured. Seedlings and roots should be moist but not immersed in standing water within bags or boxes.
- **Signs of physical damage.** This includes examining foliage, terminal buds, stem cambium and roots. Careful inspection of bareroot seedlings should be made to make sure stem and/or root cambium of seedlings were not stripped during lifting, pruning and/or packing.
- **Signs of destructive molds/fungi.** It is critical that seedlings are inspected for destructive molds/fungi upon receipt from the nursery and also periodically during cold storage. Botrytis and other such destructive fungi can severely weaken or kill seedlings regardless of how well seedlings are subsequently planted and cared for. Destructive molds or fungi may appear dark and/or “slimy” and/or cause the bark and cambium to easily dislodge from the stem. However, some fungi that typically show as a whitish fuzz connected to the foliage of seedlings that have been in long term cold storage are not harmful. Mycorrhizal fungi that appear on roots are even beneficial. When in doubt, it is important to immediately consult with an experienced reforestation forester and/or nursery manager to properly determine if fungi appearing on seedlings are destructive or harmless. Planting seedlings with destructive molds or fungi such as Botrytis is putting “good money after bad” and not worth the cost and effort even if the seedlings otherwise appear alive and green. After receipt from the nursery and inspection, seedlings must be placed in cold storage facilities immediately and monitored periodically until the day of planting, unless the seedlings were lifted and packed to be kept out of dormancy for fall planting. Seedlings lifted and packed for fall planting should be kept in shaded storage above 40 degrees

Chapter 9: Planting

Fahrenheit to prevent root dormancy. Such seedlings must be planted within one week after lifting to maintain good health and vigor and to prevent *Botrytis* infestation. Key elements of cold storage for seedlings that should be kept dormant until winter or spring planting are:

- Storage facility temperature should be 33 to 35 degrees Fahrenheit. If the facility does not have a functioning commercial hydro-thermograph, then a strategically placed “Hi-Low” thermometer(s) or a continuous digital recording device is helpful in daily monitoring of the cold storage unit. A long probe thermometer(s) is useful to monitor temperatures inside the seedling boxes or bags. Modern digital data recorders are small enough to be placed inside seedling box and are capable of recording temperature data remotely for many days.
- Seedling boxes or bags should not be open in order to avoid drying out the seedlings.
- There should be proper air circulation in the storage facility with seedling boxes at least 4 inches away from walls, stacked on pallets (if feasible), and at least one side exposed to circulating air.
- If diesel-powered refrigerated vans are being used for temporary cold storage, then the oil and fuel levels of the motor supplying power to the refrigeration unit should be monitored, along with the refrigeration coils and fan. The temperature in both diesel and electrical powered refrigerated vans should be checked daily as refrigeration unit break downs occur periodically and should be repaired within 24 hours. Foresters using refrigerated storage, especially vans, routinely arrange for mechanic(s) skilled in refrigeration to be ready and available for repair work on short notice. Caution should be used in placing seedling boxes immediately in front of the refrigeration unit where colder temperatures from the air blown by fans can sometimes leads to frozen seedlings.
- Refrigerator coils should be checked daily for excessive frost as it could impair proper functioning, especially in refrigerated vans. The higher the relative humidity in a cooler, the more likely excessive frost can occur. It has been observed that icing of the refrigerator coils occurs more frequently after wet seedling boxes have been loaded into cold storage on rainy days. Although electric defrost coils installed in storage units can reduce icing problems, the coils still need to be monitored as icing can still occur. With the use of container seedlings and/or current packaging techniques for all seedling stock types, excessive drying of seedlings in cold storage rarely occurs. However, it is important to make sure seedlings, especially bareroot seedlings, are not directly exposed to drying air. Once seedling roots dry out, they are dead. If packaging and seedling stock type do not keep seedlings sufficiently moist, bucket(s) or barrel(s) of water can be

placed in the cooler with burlap sacks placed over the sides to soak up and wick the water, to increase humidity.

- Although long-term storage is not ideal, when the planting site is not ready until late spring, seedlings that were cooler stored and never frozen can last for 3 to 4 months if lifted and packed at the proper time and stored properly. Alternatively, as discussed in *Chapter 5 – Seedlings*, seedlings can be put in freezer storage if a longer storage period is anticipated. However, once freezer stored seedlings are thawed they do not cooler store as well as seedlings which were never frozen. So, after thawing and placed in cold storage, seedlings should be put planted as soon as possible, preferably within a week.

Transport, Handling, and Storage in the Field

Importance of Seedling Care

As described in *Chapter 5 – Seedlings*, the proper handling and cold storage (refrigerated or freezer) of seedlings at the nursery and transport to, and storage at, a temporary refrigerated or freezer storage facility (if not available at the nursery) is critical. Conifer seedlings must be in the best physiological shape to survive and thrive in the harsh field conditions that may be encountered during establishment in the first growing season.

Physically damaged seedlings expend resources to repair the damage. Seedlings exposed to temperatures above 35 degrees Fahrenheit are subject to undue respiration which depletes carbohydrate reserves that are otherwise used for survival and growth after being planted into a harsh environment. Foresters need to plan, communicate, and coordinate well with nursery and storage facility manager(s) and planting crews to ensure that seedlings are packed, stored, transported, and planted at the best time and under optimum conditions. Although it is critical to maintain container grown stock free from physical damage and at proper storage temperatures, bare-root seedlings are even more susceptible to climatic stresses during field transport, handling, and planting. Without soil media surrounding the roots, bare-root stock is especially susceptible to root damage or death by desiccation.

Seedling health and vigor must be carefully maintained from the time seedlings are transported from the nursery (and/or local refrigerated or freezer storage facility) to planting in the ground.

Transportation from Nursery and/or Storage to Planting Site

To minimize seedling stress and loss of vigor, only the number of seedlings to be planted that day should be picked up and transported to the planting site. Seedlings scheduled for planting later are best left in

Chapter 9: Planting

cold storage. Seedling boxes and bags should be handled with care (e.g. no dropping, excessive sliding or impacts) to avoid damage to seedlings. Seedlings are typically transported from cold storage to the planting site in the bed of a pick-up truck or trailer. In situations where there is no road access to the planting site, seedlings may need to be further transported using yarders, helicopters or all-terrain vehicles (ATV's). Since planting crews typically start planting at first light in the morning, the seedlings need to be picked up and transported to the planting site before sunrise.

However, if transportation occurs while the sun is shining or in low relative humidity (i.e. less than 30%), the seedling boxes or bags should be within an insulated tree box with reflective outer surface. Absent such a storage compartment, the boxes or bags should be covered with a "planting tarp". A typical "planting tarp" consists of a silver reflective layer on the inside (placed against the seedling boxes or bags) and a white reflective layer on the outside (facing away from boxes and bags). Never cover seedlings with a regular plastic or canvas tarp that is not constructed specifically for planting (i.e., a "planting tarp") as that could increase rather than decrease ambient temperatures around the seedling containers by absorbing rather than reflecting radiant heat. Seedling container temperatures should be checked upon pick-up from the cooler and monitored throughout the day until seedlings are placed in the planting bags. Particular care should be taken if the weather is sunny, hot, windy, and/or dry, especially when planting bare-root seedlings.

Handling Seedlings at the Landing or Daily Storage Site

Tree seedlings should be kept sealed in their container boxes or bags until placed in the planting bags. Seedling containers must be kept out of direct sunlight at the planting site and stored under secured "planting tarps". If shade is available, it is advisable to park the pick-up truck or trailer in the shade even if an insulated, seedling trailer or storage box is used. If a pickup with a reflective "planting tarp" is used and cannot be parked in the shade, then the seedling boxes or bags should be removed from the pickup and placed in the shade of tree(s) or the pickup and covered with the protective "planting tarp".

Planter Handling at the Landing or Other Daily Storage Site

Planters should use planting bags to carry seedlings that are specifically made for planting small conifer seedlings.

Container Seedlings

Container grown seedlings are often packed in small plastic bags containing 15 to 20 seedlings which are then packed together in a larger container, usually a box that is lined with a large plastic bag. Seedlings should be placed in the planting bags either with or without their plastic seedling bags such that the roots

are protected from sunlight and dry air. Avoid packing seedlings in the planting bags so tightly that they are damaged and/or prone to accidental spillage when an individual seedling is pulled out for planting. Seedling roots must not be allowed to dry out. Planters should not “bag up” until they are ready to plant including after, not before, taking a break. Planters should only pack planting bags with enough seedlings that can be planted within one hour on days that are warm, dry, windy, or sunny.

Bare-Root Seedlings

Consider packing fewer trees per “bag up” when planting bare-root seedlings on hot and/or dry and windy days. Bare-root seedlings should be dipped in water prior to placing them in bags. On warm, dry days some foresters mix vermiculite or another additive such as Terra-Sorb® Planting Gel (manufactured by Lebanon Seaboard Corporation) in the water to retain moisture. However, the literature is not conclusive on the benefits of additives to the dipping water. It is important to drain excess water from the bottom of planting bag so that roots are not immersed in water long enough to be damaged by asphyxiation.

Seedling Handling During Planting

Each seedling should be pulled gently from the planting bag one at a time and only after the planting hole has been prepared using a planting tool for placement of the seedling. Holding multiple seedlings in one hand outside of the bag or holding a seedling while preparing the planting hole (i.e. holding it and planting tool in same hand) is a common cause of cambium damage and weakening of seedling vigor. In addition to risking stem or root cambium damage, holding seedlings outside of the planting bag any longer than the time necessary can expose the roots to desiccation and possible death. Planters should not prune individual seedling roots in the field. Although all bare-root seedling roots should be pruned to the proper length at the nursery just prior to packing, if some seedlings were not properly pruned, then any subsequent root pruning should be done under the supervision of the forester at the landing (site where boxed or bagged seedlings are stored for the day and distributed into planting bags). Heavy-duty paper cutters or sharp machetes have been used on the rare occasions that pruning at the landing was necessary. Seedling roots should then be dipped in water and immediately placed in the planting bags for planting as soon as possible.

Planting Methods

Essential Steps

Proper planting methods must be followed to ensure success. The following steps are essential to any reforestation project:

Chapter 9: Planting

- Store trees prior to planting in an area selected by the landowner's representative and under conditions specified and monitored by landowner/manager's representative.
- Keep the root system of all planting stock, between storage and planting, moist at all times. Only remove one seedling at a time from planting bag immediately prior to planting (i.e. only after opening planting hole with the planting tool).
- Plant the area in an organized manner so that systematic inspection can be maintained.
- Scalp each planting spot down to bare, moist mineral soil to remove dry soil, slash, snow, and other dead and live vegetation. No duff or debris shall be allowed to enter the planting hole. Prior to starting the planting hole, the edge of the hoedad or shovel should be used to "scalp" an area of sufficient size (i.e. approximately one-foot diameter) down to moist mineral soil such that only moist mineral soil will fall into the planting hole when it is opened and then closed around the seedling roots. If not instructed otherwise, sometimes planting contractors (and some reforestation foresters) do not require crews to spend the extra time to scalp when the surface of the soil is wet or when it's raining. However, besides making sure no dry soil or snow can fall down into the planting hole, scalping is also used to clear away woody debris, grasses, forbs and/or surface rocks that could potentially fall into the planting hole around the seedling roots. Also, scalping live grasses and forbs prior to planting facilitates protection of tree seedlings during a follow-up release spray treatment. Grasses and forbs rooted at the base of planted seedlings are likely to be missed when seedling protectors are placed around the seedlings to protect them during release spray. Heavy, deep accumulations of slash can make it difficult to plant with hoedad, so this needs to be considered when planning and implementing site preparation activities.
- "Break out" each planting hole by opening it to the extent necessary to assure that only friable soil is packed around the roots of each seedling.
- Plant each tree in an erect/vertical position so that the tops and roots are perpendicular to the horizontal plane. Ensure that the roots are not twisted, tangled, matted or curled at the ends (i.e. no "J" or "L" roots) and only moist soil is placed against the roots. The total root system must be covered with moist soil.
- Plant each tree so that the root collar is at the natural undisturbed ground line of the planting spot. When container grown nursery stock is used, the top of each "plug" must be covered with soil to prevent exposure of the potting mix to the atmosphere. Allow the planting hole

Chapter 9: Planting

to backfill with moist soil and minimal rock, without woody debris or snow and leaving no air pockets.

- Compact the soil around the root system by lightly tapping the ground (do not use a hard stomp that would cause too much compaction) so that the tree does not pull loose by a tug strong enough to detach a group of needles.
- Maintain the desired spacing and TPA.
- Do not plant seedlings in a road drainage facility or within 8 feet of any road. Consider leaving the log landings and other selected areas unplanted to facilitate equipment and personnel access and safety for future management activities and fire suppression efforts.
- Field culled seedlings should be laid on the ground alongside a planted tree so planting inspectors know they were intentionally left unplanted because they were considered cull and were not otherwise intentionally or accidentally abandoned. If feasible, requiring the planter to tie the stem of the field culled seedling in a knot ensures that it was placed on the ground intentionally as a cull.
- Root pruning should be allowed only at the time when trees are being placed in the planting bags and should be done under the direction of landowner/manager's representative.
- Plant seedlings of each species uniformly throughout planting area or as directed by landowner/manager's representative. This is especially important when planting mix species at wide spacing, as planting contiguous areas solely with less hardy species may result in an unacceptably large hole, should the less hardy species experience low survival.
- Micro-site: Where feasible, true fir and Douglas-fir should be planted on the north side of snags, tree stumps, slash, dead brush skeletons and other shade producing objects if available and close to the spot that fits into the spacing pattern. Ponderosa pine can be planted in full sunlight. Examples of micro-siting are shown in Figures 9.4, 9.5, and 9.6.



Figure 9.4 One year after micro-site planting Douglas-fir in the shade of a dead tree (right) and a nearby ponderosa pine planted in full sunlight (left).



Figure 9.5 One year after micro-site planting a Douglas-fir on the north side of a tree stump that provided enough shade during a portion of the day in the previous summer of the first critical year of seedling establishment.



Figure 9.6 Dead brush skeletons also provide suitable shade for Douglas-fir (DF) and white fir (WF) seedlings during the critical first summer growing season after planting. Crews are instructed to plant ponderosa pine in openings and DF and WF in partial shade of dead brush where feasible to reduce direct solar radiant heat on the sensitive basal stems of these species. By the time winter snow crushes down the brush skeletons, the DF and WF seedlings will be sufficiently developed to withstand direct sunlight.

Planting Tools

There are various tools used to plant seedlings with proper methods specific to the tool, seedling stock type and site conditions (i.e. soil, slash, snow, and other dead and live vegetation). Regardless of the tool used, proven methods summarized in Section 8.6.1. must be followed to make sure seedlings are properly planted. Almost all operational reforestation projects in California now use some form of hoedad or shovel to plant seedlings.

Hoedad

By far the most common planting tool used in California is the hoedad (see *Figure 9.7 and 9.8*). This tool is almost exclusively used for planting in the Sierras, Cascades and eastside where relatively small, container grown seedlings are the preferred stock type to plant. When used by well trained and experienced planters on most sites in interior California, the hoedad is the most productive, cost effective, and productive tool for planting seedlings. An experienced planter can average planting more than 1,000 seedlings per day using a hoedad on prepared sites. A hoedad consists of a metal blade typically 3 to 4 inches wide by 16 to 19 inches long that is attached to a 36-inch long wooden handle with a metal bracket that is either angled at 90 degrees (“straight blade”) or at slightly wider bracket angle of approximately 100 degrees (“angled blade”). Due to hand position and mechanics of holding and swinging a hoedad

Chapter 9: Planting

downward when making a planting hole on relatively flat ground, using an “angled blade” makes it easier for the blade to enter the ground at a 90-degree angle (see *Figure 9.7 and 9.8*). This angle facilitates planting the seedling with the roots straight down and deep rather than at an angle. On steeper slopes however, using a “straight blade” hoedad when planting uphill makes it easier to make a 90-degree hole that facilitates proper placement of the roots. The blade of a hoedad can come in various lengths and shapes, which are selected depending upon the size of the planting stock and/or rockiness of the soil. The effective length of the blade (distance between the tip of the blade and the location of where it is attached to the bracket) should be at least a few inches longer than the length between the root collar and bottom of the roots of the seedlings being planted. It should be long enough such that it can loosen the soil in the planting hole a few inches deeper than where the bottom of the seeding roots will be planted. It should be wide enough to properly break up the soil and open a planting hole that can accommodate the seedling roots. In friable, relatively rock-free soil a longer and wider blade can be used without negatively affecting planting quality, but it could slow down individual planter production or increase fatigue compared to a shorter, narrow bladed hoedad.

A hoedad with a relatively short, narrow blade can be used in surprisingly rocky soil to plant small container grown seedling or even a compact one year old bare-root seedling (see *Figure 9.8*). This is done by holding the “butt” of handle with one hand, or sometimes both hands, very close to the blade and applying pressure to wiggle the blade down between the rocks, deep enough to open a small planting hole. Even if the ground is not too rocky, the use of a shorter, narrower bladed hoedad can facilitate better production without a reduction in quality provided that it can still open a planting hole of sufficient width and depth to properly plant the seedling stock type/size being planted.



Figure 9.7 When planting flat or relatively gentle slopes, the 100-degree angled bracket hoedad (foreground picture on left) facilitates setting the blade into the ground at a right angle easier as shown by the hoedad in the left hand vs. the hoedad with a 90-degree angle bracket causing the planter's right hand to contact the ground when setting the blade at a right angle.



Figure 9.8 Hoedad with a relatively short, narrow blade (left) can be used in surprisingly rocky ground to plant small container grown seedlings (middle). Although the surface is covered almost 100% with rock scree, survival and growth can be excellent due to proper planting technique with the right tool and quality seedlings as shown (right) 2 years after planting on the Moonlight Fire in Plumas County.



Figure 9.9 Hoedad planting starts with using the long side of the blade to “scalp” away (upper left) dry soil, competing vegetation, woody debris, snow, and any other material that must not fall into the planting hole. Next, the hoedad blade is inserted into the ground at right angle (upper right) to a depth at least a few inches below where the end of the seedling roots will be placed; then “breaking out” the planting hole (middle left) by pressing the blade while lifting the top of the handle up and away from the planter such that only the soil between the planter and hoedad blade is loosened and the soil against the bottom side of the hoedad blade is undisturbed. Depending on the soil, sometimes the process of inserting the blade and breaking out the soil is repeated until the blade reaches sufficient depth. Breaking up only the soil between the planter and the hoedad blade allows the planting hole to remain open upon pulling back the hoedad blade in order to place the seedling in the hole properly (middle right). After the seedling is placed in the opening, the hoedad blade is removed so the loosened soil falls back into the planting hole enclosing the seedling in moist, bare mineral soil. The hoedad blade is then inserted at a slight angle approximately 6 inches away from the seedling with the blade tip angled slightly towards the seedling roots so that a slight straightening of the blade as it is pushed towards the seedling will then secure the soil against the seedling leaving no air pockets (lower left). Only a gentle step with the toe of the planter’s boot is done to level out the soil around the seedling and make sure there is no loose soil or air pockets around the seedling roots (lower right).

Shovel

A short-handled shovel specifically designed and manufactured for planting or a regular long-handled shovel with footpads of sufficient size and strength can be used in certain situations (see *Figure 9.10*). It can be used for planting in soil that is relatively friable and free of rocks and on well-prepared sites that consist of sufficiently exposed mineral soil such that scalping is not needed. On sites with a lot of slash that limit the effectiveness of hoedad planting, the shovel can be used to plant without scalping. Although rarely used in the Sierra/Cascades/Eastside, shovels are commonly used on the Coast where larger seedlings are typically planted, and sites may consist of heavy slash. In suitable soils shovels can be used to properly plant large two or three-year-old bare-root or plug-1 seedlings more easily than hoedads. However, shovel planting is often less productive and therefore costlier than hoedad planting when the seedling stock type is small and where slash loads are relatively low. In some circumstances, shovel planting might require more site preparation to loosen and expose the soil, such as mechanical “ripping” or sub-soiling, or the use of a separate labor step and tool to scalp to bare mineral soil prior to opening the planting hole.

Commonly used planting shovels are all steel, short handled with “D” shaped grips and handles ranging from 26” to 29” long and attached spades or shanks that are from 12” to 15” long and 6” to 7” wide, and bolt on foot pads that are usually sold separately.



Figure 9.10 Shovel planting steps are similar to hoedad planting which include inserting the shovel blade at right angle to the ground (upper left) to a depth at least a few inches below where the end of the seedling roots will be placed; then “breaking out” the planting hole (upper right) by pressing the top of the shovel handle away from the planter such that only the soil between the planter and shovel blade is loosened and the soil against the front of shovel blade is undisturbed. Breaking up only the soil between the planter and planting spot allows for the planting “hole” to be kept open for proper placement of the seedling upon pulling back the shovel blade (lower left). Then once the shovel is removed, the loosened, friable soil falls back into the planting hole enclosing the seedling in moist bare mineral soil with no air pockets lower right).

Power Auger

Although rarely used in operational reforestation projects, power augers have been used in limited situations such as planting in hard packed soils or soils with a very shallow and thin hardpan layer. Typically, an auger is mounted to a chainsaw type power head and can dig a 4 to 6-inch diameter hole to any depth needed for tree planting (see *Figure 9.11*). However, augers cannot operate on areas with many large rocks and roots. Operator fatigue and maintenance time is typically much higher with a power auger than hoedad or shovel. Also, in heavy clay soils augering can “glaze” the walls of the planting hole restricting future lateral root growth. Thorough scalping prior to making the auger hole is critical to keep dry soil, woody debris, rocks, vegetation and snow from falling into the planting hole. After bare moist mineral soil has been exposed by scalping, it is important to auger the hole perpendicular to the ground surface and in the middle of the scalped area. Care must be taken to power the auger slow enough so that the moist soil is mounded close around the top of the planting hole and not thrown too far away from the

hole. After the augered hole is made, the seedling must be planted before any portion of the mounded soil surrounding the hole becomes dry. Therefore, on sunny or dry windy days, the auger operator should do not get too far ahead of the planter. Following these steps will facilitate planting of the seedling with its roots straight down and allow for only moist mineral soil to be placed back in the hole around the roots.



Figure 9.11 Auger Planting Redwood Cultivars.

Machine Planter

Many thousand acres of gentle terrain were machine planted from the 1980's through about 2010 with very good success on private lands in Siskiyou and Modoc counties, California. These projects were primarily on relatively flat ground in areas destroyed by wildfires in the 1970's where stumps had decayed enough so as not interfere with the planting machine. However, with the reforestation backlog caught up on these old burns, this method has not been used in California for several years.

A properly modified machine planter pulled by a small crawler tractor equipped with a V-blade (see *Figure 9.12*) was a very cost-effective method of planting on relatively gentle terrain with suitable soils in old burn sites that had few solid, fresh stumps remaining. Since soils on these sites consisted of live brush roots and decaying tree roots instead of bare plowed soil, the most critical modification made to the manufacturer's planting machine was to replace the trenching tool, i.e. a coulter wheel, with a custom-made cutting blade. This modification allowed for a much cleaner and debris free opening of a planting trench which was critical so that each seedling fed into the trench could be planted properly as the packing wheels then closed the trench. The V-blade attached to the front of the crawler tractor would

Chapter 9: Planting

scalp away a 5 to 6-foot-wide band of grass, brush and woody debris down to moist mineral soil allowing the planting machine attached to the back of the tractor to plant 5,000 to 8,000 seedlings per day. It was a cost-effective method because site preparation of grasses, forbs, and light to moderate sized brush could be accomplished in the same operation as the planting. Unlike piling brush into piles or windrows a substantial distance away from where the trees would be planted, the V-blade left the scalped material within the future rooting zone of the planted trees, providing organic matter to the soil as it broke down. The planting machine, however, was not very efficient at planting wide spacing within a row, as only 8 to 9-foot spacing between seedlings within a row was feasible. Therefore, after early machine planting at high densities resulted in excellent survival rates, typical planting by the mid 1990's consisted of 8 to 9-foot spacing within a row, with rows located 16 to 18 feet apart. Pre-commercial thinning 7 to 10 years later consisted of thinning out every other tree in each row for a resulting density of 135 to 170 trees per acre.



Figure 9.12 A “V Blade” attached to the front of a crawler tractor scalps away grass and brush making a level surface of moist mineral soil (left) in preparation for planting 2-0 bareroot ponderosa pine seedlings by the planting machine attached behind the crawler tractor.

Contracting

Contractor Selection

The selection of the planting contractor is a critical step in the implementation of a successful reforestation project. The increasing importance of having skilled, experienced planters available during a relatively short timing window coupled with increasing reliance on the time sensitive work visa process, means that foresters now plan and secure agreements with planting contractors from several months up to a year prior to planting. Also, experienced reforestation foresters do not limit their criteria in selecting a planting contractor simply to the lowest bidder with the cheapest labor. Compensation necessary to retain skilled, highly motivated planters is critical to ensure careful, proper seedling handling and planting that

Chapter 9: Planting

is necessary for good survival and growth. In addition to cost, the selection of the planting contractor should consider the following: crew, foreman, and contractor experience.

Crew

Successful reforestation foresters have the attitude that the person who actually handles and plants each tree seedling has a very critical role in the reforestation program. They look for indications that members of the crew have expertise, a good work ethic and take pride in their role in a successful reforestation project. Although inexperienced planters periodically join a planting crew and require one on one training, it is important that the majority of the crew consists of experienced, proven planters. It is important to select a planting contractor with a low turnover rate and crew members that are highly motivated. Although training new planters occurs, minimizing turnover and maximizing the use of experienced planters allows the planting contractor's foreman or foremen to focus on the details necessary for the proper organization and oversight of the handling and planting of several thousand seedlings each day. Important questions to ask of a potential planting contractor include:

- What percentage of the planting crew has one full season or more of experience planting?
- What do you do to motivate your planters to produce efficiently and with care and pride in their work?
- What is the average tenure with your company?

Responses to these questions can provide an indicator of how well a planting contractor retains employees that have the expertise and motivation to do quality planting and take pride in their work.

Foreman

The planting crew foreman is critical to a successful reforestation project. Good foremen communicate well with each member of their crew as well as with the reforestation forester, take pride in the work of their crew, and pay attention to detail. They are highly organized and are eager to implement all of the steps necessary for a successful reforestation project. A foreman should be transparent and open with the reforestation forester about problems or potential problems that might arise during planting operations.

Experience, Reputation, and References

This information can be obtained from other experienced reforestation foresters that have used the planting contractor you are considering. A list of reforestation projects completed in the past 5 years can be requested from prospective planting contractors, with a description including the number of seedlings, stock types, planting methods and a list of references (landowners/forest managers/reforestation

foresters). Those references should be contacted, and inquiries made as to how they would rate the planting contractor in terms of the criteria listed in this section.

Production & Timing

The planting contractor should have adequate personnel to meet the daily production goals needed to comfortably complete planting within the planting window. Also, the planting contractor must be available to commence planting with sufficient crews and foremen by the date needed. This is very important and should not be overlooked because postponing completion of a planned planting project until the next season usually results in wasted seedlings and the need for additional site preparation of the unplanted area that was scheduled for planting. If one otherwise qualified contractor quotes a cheaper price but cannot guarantee that they will be able to start and complete planting within a suitable timeframe, preference should be given to selecting another qualified contractor that commits to completing on time even if they quote a higher price.

Contractors should be willing to execute a written planting agreement, indemnifying the landowner and/or manager and have adequate commercial general liability and auto insurance naming the landowner and/or manager as additional insured. Contractors should also have workers compensation and employer liability insurance and comply with all state and federal laws and regulations, including but not limited to employment practices, Occupational Safety and Health Administration (OSHA), and environmental laws and regulations. A written agreement should also include terms and conditions that meet the landowner's objectives including enforceable inspection guidelines.

Enforceable Inspection Guidelines

Although enforceable inspection guidelines should be developed based upon the methods and objectives of each specific planting project, the planting contract should list enforceable inspection items that address the steps listed in the 'Essential Steps' subsection in the preceding 'Planting Methods' section.

Production Targets

- Minimum average daily number of trees per crew to comfortably complete the project within the scheduled timeframe. It is understood weather conditions, access, or harsh conditions on particular portions of the planting area might justify planting less than the minimum on some days. However, there should be an overall average daily production target.
- Maximum number of seedlings that can be planted daily per planter to maintain planting quality by minimizing fatigue and short cuts on proper handling and planting techniques. This number depends upon the seedling stock type/size, planting tool, spacing, site, and soil conditions.

Penalties and Incentives

Typical planting agreements specify a minimum percent of seedlings inspected that must have a “satisfactory” rating for all planting criteria, below which the contractor is docked payment. However, if the percent of seedlings inspected that do not pass as satisfactory goes much below this minimum, then the contractor could be held in breach of contract and assessed more severe penalties and possible loss of contract. The forester’s daily inspection report can serve as the basis for any payment reduction computed on a daily basis, should such reductions be necessary. Penalties and possibly a breach of contract could also apply to non-compliance with contract terms not related to the inspection of individual seedlings such as improper storage and handling of seedlings in the field, poor distribution of species, failure to meet production targets, and abandonment of seedlings. The excessive abandonment of seedlings (dropped or “stashed” trees) should result in stiff penalties. For example, some planting agreements specify that any tree that is stashed will be paid for by Contractor at 10 times the landowner's purchase price, and that the contractor will not be paid for planting that tree. Tree stashing may be cause, at the sole discretion of the landowner’s representative, for immediate suspension of work for the day or termination of the planting contract.

Payment Methods and Rates

There are three general methods of payment to planting contractors. By far the most common method is to pay the contractor based upon the actual number of seedlings planted, usually calculated daily and subject to reduction depending upon contract penalty specifications. This form of payment requires very careful monitoring and documentation of seedling inventories, deliveries to the planting site and seedlings planted on a daily basis. Another method is to pay the contractor based upon the number of acres satisfactorily planted. This requires an accurate calculation of actual acres planted in compliance with the spacing and planting specifications as determined by a sufficient number of sample plots. Although the latter, less common payment method, is a more “turnkey” form of payment, it can cause some logistic challenges in application that could lead to delays in payment, disagreements or uncertainty on the amount of payment. These potential issues may create more risk of uncertainty for the contractor and therefore could lead to higher bids and costs. A third method involving hourly payment is useful in situations where there are significant variables that make it difficult to estimate and then bid or negotiate on a fixed cost per seedling or acre basis. For example, sometimes the planting contractor is paid by the hour each laborer works on a project with many small units and significant travel time required between units. Use of this payment method should be reserved for trusted contractors and agreement on a “not to exceed” amount in the contract, with clear knowledge of crew performance and production levels.

Organizational Needs

Inspectors

If the reforestation forester is overseeing multiple planting projects or a large planting project that requires more than one 10-person crew, trained planting inspectors should assist the forester in administering the planting contracts and in conducting systematic daily planting inspections. A general rule of thumb is to have at least one inspector for every 10 to 14-person planting crew, but in many situations an additional inspector is helpful. If enough inspecting personnel are available, it is a good practice to have one inspector in the field with the crew at all times and one on the landing. The inspector at the landing can also assist in field inspection as the landing duties allow. There are generally two types of inspections (hot v. cold), with “hot” inspection being more common in California, especially on property of small non-industrial landowners. “Hot” inspection involves taking random plots of planted seedlings immediately behind a planting crew and interacting directly with the crew supervisor while the crew is planting. This allows for problems to be corrected in a timely manner and also provides timely direction to the crew supervisor for other matters or questions that might come up. This type of close inspection is preferred when a forester contracts with a planting contractor to plant on several small units and/or several small landowners. The other general type of inspection involves taking “cold” plots after the crew has completed planting a unit with no direct interaction with the supervisor as the crew is planting. The ideal type of inspection and number of inspectors depends upon specific site conditions, size and number of units planted each day, access, and caliber of the planting contractor and planter to foremen ratio. The reforestation forester should conduct a pre-operational meeting with the planting inspectors to train them in the contracted planting techniques, including actual field planting if needed, and to go over all aspects of the planting project including those described in the Seedling Deliveries, Inventory, and Field Considerations sections below.

Seedling Deliveries

Seedling deliveries from the storage location to the planting site via pickup trucks and/or trailers and, if needed, further transport via ATV’s, yarders, and/or helicopters must be scheduled and coordinated.

Inventory

It is essential to monitor the rate at which the seedling inventory in the storage facility is being depleted by planting. Sometimes seedlings for a project are not stored at the location from which daily seedlings are loaded. In this situation, seedlings would need to be transported from a separate storage facility to replenish the inventory in the on-site or local cold storage. Planning ahead to anticipate the time required to ship seedlings to the local storage must be factored in to avoid running out of seedlings. A planting

contractor without seedlings is not a good situation and may result in losing the contractor to another job during the already short planting window.

Field Considerations

Unit Layout

It may be necessary to identify unit boundaries with flagging, or other suitable means, prior to commencement of planting. Situations where this may be useful include units in which the vegetation control of the site preparation spray is not yet clearly evident, areas where planting will be deferred, and special treatment areas. Identification of unit boundaries ensures that planting crews will not waste time trying to determine the planting area and that seedlings will not be planted outside of the designated planting area.

Maps

Project and unit maps should be readily available on site that show the planting area as well as all access roads. Maps are essential for clear communication with the planting contractor. These maps should be used to document the daily planting progress, unplantable areas, areas requiring additional treatment, etc.

Detailed Unit by Unit Planting Plans

Oftentimes, there may be a different seedling species mix, spacing, or other constraints prescribed for a specific planting unit or within a particular aspect of a planting unit. Consideration of the issues that may be involved with each unit prior to planting and conveying this information to the planting contractor will streamline the planting project. If the planting project has more than one unit or is a large project that can be divided into units, the number of seedlings for each unit should be calculated. Seedlings should be allocated and reserved for each unit to ensure that an adequate number of seedlings are available for the last units to be planted.

Unit Planting Folders

A folder should be available at the cold storage area and landings that include such documents as instructions, unit maps, daily planting inspection and summary forms, and inspection cards.

Trash Disposal

The collection, storage, loading, transport, and disposal of refuse generated from planting should not be underestimated. Often on large planting projects, a substantial quantity of empty seedling boxes, pallets, seedling bags, banding material, and general trash is accumulated. Some seedling nurseries will accept the return of seedling boxes and pallets. The remaining trash must be disposed of by taking to a refuse

facility or burned on site if it can be done under safe conditions and if local regulation allows burning of seedling boxes, bags, and pallets.

Pre-operational Meeting

A pre-operational meeting with the reforestation forester, planting inspectors and the planting contractor to discuss the terms of the planting agreement and the logistical and organization aspects relevant to the planting contractor is critical. These pre-operational meetings facilitate much smoother operations because once planting starts, inspectors will be spending long, fast-paced days (often starting a few hours before sunrise and ending well after dark) keeping the planting crews supplied with seedlings, inspecting planting operations, maintaining accurate daily records, and periodic reports.

Planting Inspection

Number of Inspectors per Crew

A minimum of one inspector per 10 to 14-person crew, but in many situations an additional inspector to handle landing duties and assist in field inspections is helpful, especially during the first few weeks of a planting project or planting with a new or inexperienced contractor.

Inspection Procedures

It is important to conduct timely inspections such that problems can be corrected, and adjustments made as soon as possible. Besides the general observations to monitor the planting crew's proper handling of seedlings as previously described, the inspectors should conduct sampling to check on seedling health, spacing, species distribution, micro-siting, and planting techniques (e.g. scalp, depth, root placement etc.). Inspectors should run transects perpendicular to the direction the planting crew has traveled in order to randomly check all planters instead of following one or two planters as the crew progresses. At least 1% of the seedlings should be inspected by first measuring for spacing and then checking to make sure seedlings are not too loose (should not pull up by tugging on a few needles), scalping was adequate, the seedling was planted at the proper depth, and proper planting micro-sites have been selected (if applicable). After checking these items, the inspector should carefully dig up the seedling and check for proper planting angle, roots straight down and not stuffed, no "J" or "L" rooted seedlings, and that all roots are surrounded by moist mineral soil. Dry soil and woody matter that dropped into the planting hole indicates there was no, or poor, scalping prior to opening the planting hole. Air pockets near seedling roots indicate either snow fell into the planting hole (i.e. poor scalp) or the planting hole was not properly closed around the seedling roots.

Documentation

Documentation is critical, such as the use of daily inspection forms (e.g. *Figure 9.13*) made on waterproof paper (if wet conditions are anticipated) with boxes to fill in with symbols indicating satisfactory or unsatisfactory results for each seedling checked. For example, this might be a “0” for satisfactory and if unsatisfactory then a symbol for what criteria was not met (e.g. poor scalp (“S”), loose seedling (“L”), poor angle (“A”), J-root (“J”)). The header of each form should include the names of the inspector, contractor, foreman, planting project, and landowner, as well as the date and any other information the forester deems important. There should be a line at the bottom to fill in the number of trees inspected, the number satisfactorily planted, and the percent planted satisfactorily. A place should also be included at the bottom of the form for both the inspector and the crew foreman to sign acknowledging the daily inspection result. Weather proof electronic devices are increasingly being used that document this information along with mapping of daily planting progress.

Tree Information

Daily seedling information should be on the daily inspection form or on a summary form if multiple daily inspection forms are filled out in one day. This should include the number of seedlings planted by nursery/stock type/seedlot and species. Planting inspectors should take the time when loading trees in the morning to count and record the number of seedlings of each lot loaded (by number of boxes and number of seedlings per box). Although it is good practice to plant all seedlings removed from the cooler and transported to the planting site, if there are unplanted seedlings at the end of the day, they should be counted so the net number of seedlings planted is carefully recorded at the end of each day. Of course, any unplanted seedlings should be returned to the cooler at the end of the day and be the first seedlings removed from the cooler and planted the next day. Even though days can be long and hectic, taking the time to accurately keep daily records can greatly benefit accounting later and can be used in tracking progress to schedule timely seedling shipments if more are needed.

Chapter 9: Planting

DAILY PLANTING INSPECTION FORM								
Project _____				Ownership _____				
Date _____				Contractor _____				
				Inspector _____				

*Nursery	*Species	*Lot	Seedling Owner	# of Boxes	#/Box	# Seedlings Removed from Cooler	# Seedlings Returned to Cooler	*# Seedlings Planted
Total Planted Today:								

Report results daily to project manager

-----fold here-----

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Legend:

O – good tree (ok)

J – "J" root

L – loose tree

H – high tree

S – poor scalp

A – bad angle

Lat – high laterals

T – twisted roots

TD – Too Deep

Other:

Spacing _____

Abnd. Trees _____

Field Storage _____

Bag Storage _____

trees planted satisfactory = _____ = _____ % acceptable

trees sampled

Notes: _____

Contractor's Signature _____

Figure 9.13 Planting Inspection Form.

Installing Protection Measures in Conjunction with Planting

Although animal pest control measures and mulching are covered more fully in Chapter 8 *Vegetation Management* and Chapter 11 *Damage* respectively, there are a few measures were installation occurs in conjunction with or soon after planting operations, often by the same crews. So, the installation of these materials along with the installation of artificial shading devices are briefly discussed in this sub-section.

Artificial Shading Devices

With proper species and stock type selection, seedling handling and planting practices, including micro-siting, and other methods previously described in this Chapter, the use of artificial shading devices are rarely used. However, occasionally there are certain specific site and species situations where installation of artificial shading devices can improve seedling survival and/or health. For example, shade cards were effectively used in reforesting portions of Cuyamaca Rancho State Park in the arid mountains of southern California after the 2003 Cedar Fire.

The purpose of artificial shading is to protect susceptible seedlings of sensitive species from solar radiation on one or more of the following surfaces:

- The main stem of the seedling that can damage young developing stem surface and kill the underlying cambium.
- The soil surface material that is in direct contact with the seedling stem and root collar and/or close enough to radiate damaging levels of heat.
- The foliage of the seedling that can lead to excessive transpiration, especially on hot, dry sites during the first summer's growing season while the seedling roots are getting established into the soil profile.

In addition to protection from solar radiation, artificial shading devices can also provide protection from the desiccating effects of wind in certain, limited situations.

Ponderosa pine seedlings, even on when planted on harsh sites, are very resilient to the effects of solar radiation and so artificial shading devices are very rarely, if ever, necessary. On certain sites, especially south or east facing aspects, the stems and underlying cambium of Douglas fir (DF) and to a lesser degree, true firs, are susceptible to direct solar radiant heat damage or damage from excessive soil surface temperatures, especially smaller one-year old containerized stock sizes. Relatively larger one-year old DF and fir container stock (Styro 15 or greater) and two or three-year-old bareroot or plug-1 stock not only have more developed, hardened stems but also have more lateral branch foliage to shade the seedling stem and so less need of artificial shading. However, larger stock with more foliage are subject to much

more transpiration stress during the critical first year root establishment season on hot, dry sites typical of Southern California and much of interior California, especially on south facing aspects at relatively lower elevations.

Artificial devices are generally comprised of photodegradable, black polyolefin mesh envelope and a wire wicket. They can provide a shade factor of approximately 80% and mesh allows for air passage. The mesh degrades in approximately 5 years and the wire wicket will begin to degrade in approximately 5 years. In most situations where shading devices are used, shading is only needed for the first, and maybe second, year of seedling establishment, when the seedling is developing a root system that is deep and extensive enough to reduce transpiration stress and a hardened stem to protect the cambium and/or lateral branching to shade the seedling stem from direct sunlight. If the devices are only used during the first year or two of seedling establishment, they can be reused until they degrade.

Mulch Materials

Mulch mats manufactured from synthetic fiber, sod, or paper are commercially available or a mulch can be created using bark, pine needles, straw, etc. These mulch products can reduce evapotranspiration from the soil and control competing vegetation. Except in areas where competing vegetation is otherwise controlled or in areas that receive sufficient summer rainfall, mats should cover approximately a 5-foot diameter area around planted seedlings for adequate effectiveness. Mulch mats must be secured to the ground with rocks, stakes, spikes, woody debris, etc. It is very important to periodically monitor mats, especially after significant wind events, to ensure that seedlings are not subject to being covered by a mat dislodged by the wind for a period of time sufficient to damage or kill a seedling. The material and installation costs are typically much greater than chemical vegetation control methods and can be cost prohibitive. Mulch mats deteriorate naturally over time but should be removed once they are no longer needed in order to eliminate the risk of wind or other events dislodging the mat and covering the seedling.



Figure 9.14 Properly installed mulch mat.

Animal Pest Protection Materials & Methods

Sometimes in conjunction with planting operations rigid (solid or mesh) protection tubes, mesh netting and/or bud caps are installed if needed to protect newly planted seedlings from animal damage.

Installation of seedling protection is generally only used in areas with known pest problems. The cost of the materials and labor are typically as much, or more, than the cost of seedlings and planting. When visiting a planting site to see if it is ready for planting in order to schedule planting crews, a forester can plant several “test” seedlings and monitor them to see if animal damage occurs. Then the forester can be better prepared to arrange for installation of seedling protection devices in conjunction with planting operations. The two most common types of animal damage that can be mitigated by installing protection devices are rabbits which clip small seedling stems at about an inch above ground level and deer that browse the seedling foliage and/or main stem bud and sometimes tear off a very tender main stem:

- Rabbits: Damage is easily diagnosed because rabbits will make a very clean cut of the main stem at a 45-degree angle about an inch above ground level. Since this is done not for consumption of the seedling but simply to keep their teeth from growing too long, the clipped seedling is typically laying close to the tiny “stump”. Mostly just small one-year-old container stock early in the growing season are attacked and rarely older seedlings or newly planted two-year old bareroot stock are attacked. One of the most cost effective and maintenance free methods for protecting newly planted seedlings from rabbits (as long as deer browse is not also an issue) is installing plastic mesh buried a few inches below ground level and extending 4 to 6 inches above ground.

- **Deer and Elk:** The least expensive method to discourage deer browsing is by installing mesh netting, but unlike installation for rabbits, the netting must cover the tops of the seedlings and still allow for seedling growth and/or monitored and maintained through the growing season. This method works best when deer browse is not too heavy and/or temporary for just a few months. For elk or heavy deer browse, plastic mesh tubes anchored with bamboo stakes are more effective. Although more expensive this method is longer lasting and require less maintenance, especially during the first growing season. Although not commonly used in California, the installation of bud caps is a relatively inexpensive treatment for the protection of terminal buds if browsing pressure is limited to the winter and early spring when more palatable forage is not available to deer or elk that might be present on the planting site. Bud caps can be applied prior to spring flush, or in fall after the growing season for overwintering and the following spring. Proper installation can allow for early terminal growth, approximately 2 inches, inside the cap when it is most desirable for the browsing animal. Bud caps should be monitored and removed if terminal growth is negatively impacted by them later in the growing season. Lightweight, degradable mesh bud caps, such as Pacforest Supply Company's "Breathe Easy" bud cap can be left to breakdown in most situations but should still be monitored.

Seedling protection tubes and mesh netting are generally not effective against gophers and other burrowing animals.



Figure 9.15 One of the most cost effective and maintenance free methods for protecting newly planted seedlings from rabbits clipping the seedling stems is installing plastic mesh buried a few inches below ground level and extending 4 to 6 inches above ground as shown after planting (left) and at end of first growing season (middle). To protect seedlings from deer browse, the netting must be anchored in soil and extend over the top of the seedling (right) and monitored for maintenance needs.



Figure 9.16 Plastic mesh “tubes” are typically buried a few inches below ground level anchored by bamboo stakes.



Figure 9.17 Solid bud caps installed at a nursery prior to lifting and packing (left). Lightweight, semi-rigid, poly mesh slip on “Breathe Easy” bud cap from Pacforest Supply Company applied after planting (middle) to protect seedling from winter deer & elk browse and typically do not need to be removed as shown in second growing season (right).

Planting Follow Up

Stocking Survival Surveys

Systematic, statistically useful surveys to determine first-year seedling survival and vigor and an estimate of seedlings per acre, should be conducted after the first late summer or fall rains. The person conducting the seedling survival surveys should also record conditions of competing vegetation by general type (grass, forbs, and brush) and species of brush and whether or not brush is a germinate (approximate age) or a re-sprout. Also, notes should be taken on any herbicide, insect or animal damage observed in each plot or while travelling between plots. Typical first-year surveys consist of 1/100-acre plots (11.78-foot plot radius) established at 2-chain (132 feet) intervals on 5-chain (330 feet) transects (about 1% of area sampled). The intensity of the sample depends upon the funds and time available and the degree and uniformity of survival after a brief overview. A good first-year stocking survey will aid in scheduling inter-planting, release treatments, or other pest control treatments if needed the following year.

Depending upon the results of the first-year stocking surveys and the reforestation forester's experience with the general site and planting stock, a second-year survey might be necessary. Although a systematic survey is not warranted until the end of the first growing season, ocular walk-throughs should be conducted about 2 to 4 weeks after planting which include digging a few trees of each species and stock type to monitor root growth. Additional ocular walk through inspections should occur monthly thereafter until the year-end stocking survey is conducted. These periodic brief inspections are necessary to monitor the health and vigor of seedling foliage, stem, buds, and roots, to evaluate competing vegetation, and to aid in diagnosing any problems if they occur. For example, if seedlings that looked morphologically good were physiologically dead or severely weakened at the nursery or during cold storage they usually will show signs within 2 to 4 weeks after planting. Also, most animal damage problems occur within the first month or two of planting. If there are problems with seedling survival or vigor and if the reforestation forester waits until the end of the season stocking survey to look at the out-planted seedlings, it is much harder to diagnose the myriad of potential causes and at what step it occurred (i.e. at the nursery, storage facility, or after planting on site). Also, early detection and diagnosing could facilitate more timely decisions and actions that could reduce damage and costs.



Figure 9.18 Fall planted WF seedling dug up to check for root development at beginning of next growing season (left). New root growth on PP seedling a few weeks after planting (right).



Figure 9.19 New root growth on Styro 5 containerized Ponderosa Pine seedling two weeks after spring planting in Modoc County with 24" average annual precipitation.

Interplanting

Ocular or systematic stocking surveys may reveal areas that are understocked or non-uniformly stocked. These areas may need to be interplanted to achieve the desired level of stocking and uniformity. The need for interplanting should be carefully considered before committing to it. Sometimes a unit or project may appear understocked and be interplanted only to discover that in 5 to 10 years that the unit is actually

overstocked. In this situation, the interplanted trees are often just cut later in the pre-commercial thinning to achieve the desired TPA. Interplanting is more expensive than standard planting due to the time required to find the holes or gaps where seedlings need to be planted. Additionally, the seed transfer, seedling growing, packing, transport, and storage must be accounted for. If interplanting is delayed, an additional site preparatory or release treatment may also be necessary to ensure survival of the interplanted seedlings.

Vegetation and Pest Problem Surveys

As mentioned, plantation surveys can determine the extent of competing vegetation and pest damage. Often a few dead seedlings or competing vegetation can be alarming and lead to the conclusion that treatment is needed. Systematic surveys can be invaluable to quantify the extent and spatial distribution of the damage and aid in determining if treatment is warranted. These surveys can be used as a follow-up to earlier stocking surveys that may indicate the occurrence of problems.

Diagnosing Problems

Periodic monitoring during all phases of the project, including lifting and packing at the nursery, cold storage, transportation to the site, planting and post planting conditions will greatly aid in diagnosing problems that might occur. In addition to monitoring planted seedlings above ground (i.e. seedling stems, branches, needles and buds and presence of competing vegetation) it is very important to dig some seedlings within a few weeks to a month after planting and then in the late summer or early fall excavate the soil around some seedling roots to check on root growth depth and soil moisture availability at rooting depth. In addition to checking on root growth, examining the depth to soil moisture and presence of competing vegetation roots within the seedling's rooting zone in the late summer is a very good indicator of whether or not the competing vegetation was adequately controlled. Even during periodic drought cycles on relatively dry conifer sites, proper vegetation control should provide at the end of summer for sufficient soil moisture within the rooting depth of quality conifer seedlings. What might appear on the surface to be an insignificant amount of competing vegetation and/or an adequate radius of a spot spray or mulch mat treatment, needs to be checked for the presence of adequate soil moisture available to the seedling roots if there is a problem with seedling survival or vigor. The main key to seedling survival in a Mediterranean climate is vigorous root growth down to soil moisture available at the end of the summer. Therefore, checking early season root growth and later checking end of summer root depth and soil moisture are important monitoring techniques for diagnosing problems and prescribing possible treatments. A useful and relatively inexpensive technique to monitor and diagnose potential problems is to plant short "monitoring" rows of each seedling lot at a few different elevations and soil types with

Chapter 9: Planting

labeling that can last at least a few years. Generally, these monitoring rows are planted at convenient locations on the project area, in side-by-side rows of about 20 seedlings of each and at approximately 4 or 5-foot spacing. This can provide a quick, although simple, check for vigor, top, and root growth by seedling lot periodically as the summer progresses. Although a more thorough survey might be needed if problems with a particular stock type, species, and/or nursery arises, the ease of monitoring these rows might alert one earlier to any problem with a particular lot and give a very rough indication of seedling health and vigor by lot. Also, although samples of these trees can be dug up and replanted early in the first season to check for root growth, the close spacing allows for “destructive” sampling to measure root growth at the end of the first and second growing seasons.

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