

Chapter 3

Planning a reforestation project

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Successful reforestation in California is a complicated undertaking spread over multiple years. The planning process detailed in this chapter is designed to guide landowners, land managers, and reforestation practitioners through the steps necessary to meet their reforestation project goals. Each step serves a specific purpose essential to the project's success. Failure at one step can limit success or result in complete failure, even if all others are properly implemented. In all situations, it is critical to think through and plan out all the steps while being prepared to adjust the plan for unexpected complications, delays, or setbacks. These basic steps are the same whether you are a small or large landowner or public agency, though slight modifications may be needed depending on the project type and purpose.

For planning purposes, the three basic reforestation project types (and purposes) can be categorized as postharvest, postwildfire, and rehabilitation and restoration. Connecting the many time-critical, sequential reforestation activities that occur over a number of years is also key to eventual success. To represent this process, figure 3.1 is a flow chart of the steps for each project type. Figures A1, A2, and A3, found in this chapter's appendix, shows the timing for each step of the three basic reforestation project types and provides references to the appropriate chapters in this book. These examples are for general reference, as each project will develop its own timeline based on site-specific implementation needs.

Developing and implementing a plan: Essential steps for successful reforestation

Reforestation projects in California are implemented on a diverse range of forestlands, ranging from highly productive timberlands to noncommercial forests with mostly aesthetic and wildlife value, and small private woodlands to large public and private forests. For all landowners, the decision to initiate a reforestation project begins with the desire to accelerate positive changes in the forest that they own or manage. Often this decision is forced by timber harvest or wildfire. Despite the differences in motivation and objectives, the best management practices outlined in this chapter and described in this book will lead to a successful reforestation project.

Select reforestation forester

The administrative and biological steps outlined in figure 3.1 (the flow chart) must be executed in a timely manner. It is advantageous to seek the services of a forester with expertise in reforestation. Large, private ownerships often have a professional reforestation staff or consultants under contract, while small landowners may have an ongoing relationship with a local Registered Professional Forester. Within the private sector, Registered Professional Foresters are licensed by the California Board of Forestry and Fire Protection. Contact the California Department of Forestry and Fire Protection (CAL FIRE) for a list of [Registered Professional Foresters](#) available to offer services in a project's general vicinity. Federal agencies have reforestation specialists, and sometimes contract out for specialized skill sets.

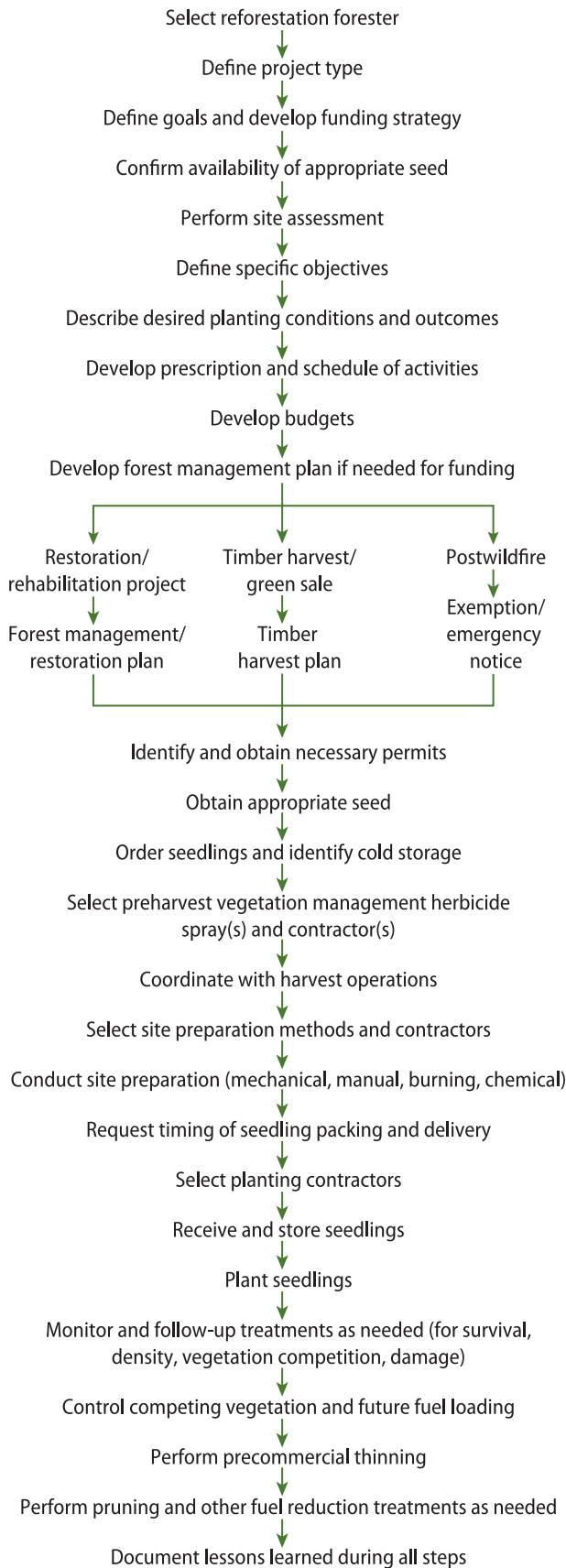


Figure 3.1. Reforestation workflow outlining necessary steps for basic project types.

Landowners should be aware that not all Registered Professional Foresters are experienced in reforestation, due to differences in specialization and previous work experience. A forester experienced in preparing and administering Timber Harvest Plans or salvage logging contracts may not necessarily be experienced in planning and implementing a subsequent reforestation project. The following considerations can help to identify a Registered Professional Forester with expertise in reforestation:

- What reforestation projects have they done and how successful were these projects? Consider visiting some of the project sites.
- Ask for references from other landowners that the Registered Professional Forester has worked with.
- Do they keep up with the most current reforestation practices? Foresters have many excellent opportunities to improve their reforestation skills, such as attending the Forest Vegetation Management Conference and California Forest Pest Council Weed Tour. These conferences also help members network with other reforestation specialists.
- Does the forester have other pertinent licenses, such as those issued by the California Department of Pesticide Regulation? An Agricultural Pest Control Advisor license in the Weeds category allows a forester to make pest control recommendations that are needed for managing competing vegetation. A Qualified Applicators License or Certificate in the Forest Pest category indicates that a forester is knowledgeable in regulations and practices regarding the application of forestry herbicides. Additional information regarding licensing requirements when working with persons or business that are hired to conduct herbicide application may be found in chapter 8 (“Vegetation management”).
- If different Registered Professional Foresters are chosen to manage the harvest and reforestation, can they communicate with each other and coordinate activities as needed? If both harvest and reforestation activities are planned, consider hiring a firm or individual with experience in both.

Define project type

Reforestation projects generally fall into three categories:

1. **Postharvest:** Planting after a green-timber harvest
2. **Postwildfire:** Planting after a wildfire
3. **Rehabilitation/restoration:** Converting a brush field occupying unstocked or understocked forestland back to forest or reclaiming a site from off-site, exotic, or invasive species

While each project type has its own needs and challenges, most will follow the sequence of steps shown in the flow chart (see fig. 3.1). Timing constraints will differ based on the status of competing vegetation and the time needed to order appropriate seedlings.

Define goals and develop funding strategy

After defining the project type, landowners must identify goals for the property. A goal is a broad, general statement of intent that describes a long-term vision, such as producing income, enhancing wildlife habitat, and protecting soil and water resources (Oregon State University Extension 2023). For example, the USDA Forest Service's reforestation goals are to "foster resilient, healthy, and productive forests that sustain ecosystem services, economic values, carbon sequestration, and stable carbon pools" (U.S. Department of Interior and U.S. Department of Agriculture 2023). Goal setting is also essential to identify the relevant funding necessary to implement a project. Specific objectives to reach these goals should be developed after the site assessment phase, when more details are known about the property.

Reforestation is an expensive, long-term investment, as described in chapter 2 ("Investing in reforestation"). Acquiring the funding needed to complete the many steps of a multiyear project can be challenging, particularly for small landowners. Be aware that underinvesting in activities such as vegetation control, seedlings, and planting will result in failure or the need for additional, even more expensive work to salvage the project. An important early first step is to identify and pursue relevant and available financial grant assistance from state and federal cost-share programs. Grant approval can take from several months to more than a year after an application is received. It is important to plan for the reality that the timing of funding may not coincide with climatic or biological windows that dictate the timing of each step.

Large landowners usually finance projects with a portion of net income from the sale of forest products in the project area as well as other private investment funds. To get initial funding, the forester must document the plan and budget needed for a successful reforestation, and the reforestation team typically submits expense requests for inclusion in annual or multiyear budgets. With government agencies such as the Forest Service and CAL FIRE, funding must be allocated from the general fund through spending bills by the U.S. Congress or state legislature.

Federal agencies such as the Forest Service may have several potential funding options for individual reforestation projects. Timber sales, with planned regeneration harvests, commonly use Knutson-Vandenberg

collections. These funds become available after the purchaser pays for the timber and can be used soon after the harvest is complete. However, current reforestation activity is dominated by reforestation after high-severity wildfires, often without salvage harvest of the fire-killed trees. The Reforestation Trust Fund then may become the major funding source and is available for use. Other funds are sometimes available and may be combined with these more common sources to meet the need.

Typically, funding is requested and allocated for annual accomplishments. Largely due to the geographic extent and number of recent high severity fires, combined with the relative absence of salvage harvesting of fire-killed trees and the need to reduce the adverse effects of competing vegetation, the total cost of reforestation is now much higher than any historical average.

Confirm availability of appropriate seed

Without appropriate seed, a reforestation project cannot proceed. The importance of seed origin and quality to long-term reforestation success is described in chapter 5 ("Seeds"). CAL FIRE's California Tree Seed Zones map, shown in chapter 5 (see fig. 5.1), divides the state into 85 unique zones, the result of many years of research into California's complex tree diversity and ecology. Within each zone, conifer seed collections are catalogued by 500-foot elevation bands and subzones less than 50 miles across. Research currently underway on the impact of climatic change on mature trees may result in guideline changes that adjust seed zones and elevations.

Identify the desired species, seed zones, elevation, and number of seedlings for each project before contacting conifer seed suppliers. Potential suppliers include the State Seed Bank at the Lewis A. Moran Reforestation Center in Davis, private seed companies in California and neighboring states, and forest nurseries. The Forest Service and some large private landowners may also make seed available from their seed inventories if they have excess. Large private landowners typically ask potential seed purchasers if they plan to follow all necessary steps for a successful reforestation project before selling their excess seed.

Finding out how much seed is potentially available for the project is a key step. An inadequate supply of seed can necessitate reducing the project size, planting fewer trees per acre (wider spacing), altering the species mix, or delaying the project until a suitable amount of seed can be obtained. Although determining the approximate quantity of seed needed and its availability is necessary prior to proceeding with the next steps, knowing exactly how much seed to order is

determined later in the planning process (see “Obtain appropriate seed” section below).

Landowners can choose to establish their own seed inventory to ensure a supply of seed for future projects, by purchasing seed from one of the sources listed above or collecting and processing cones from their own or neighboring properties (with permission). Additional information on monitoring cones for collection and processing seed for storage is described in chapter 5.

Perform site assessment

Site assessment is the first step in developing a reforestation project’s specific objectives and schedule of activities. The site assessment begins with an in-office assessment of relevant regional information on climate and fire risks and then focuses down to the project site to identify a wide range of project area characteristics so that all project planning is firmly based on the realities of the site. Most planning efforts use geographic information systems (GIS) and spreadsheets to organize, analyze, and map relevant site information and

identify unit boundaries and conditions. Other digital or manual methods may also be used.

Site information may result in dividing the project area into units with similar characteristics for applying treatments. Unitizing the reforestation area into homogenous subunits is particularly important for large project areas. An on-site assessment provides detailed, site-specific information and aids in ground-truthing information derived from other sources. See also chapter 4 (“Site assessment”) for a detailed explanation of this process and chapter 12 (“Reforestation of areas burned by large wildfires”) for an example of unitization.

Define specific objectives

A broad range of environmental and economic objectives may be possible for each previously defined goal. Objectives should be quantifiable (for example, trees per acre by species) in order to measure success and facilitate postproject monitoring. Objectives like aesthetics are not as easy to quantify as others, but it is always valuable to identify metrics for measuring out-

TABLE 3.1. Objectives for reforestation projects and measures of success

Goal	Objectives	Measures of success examples
Sustainable timber	<ul style="list-style-type: none"> • Manage for a sustainable yield of commercial conifer timber trees. • Manage for broad mix of species for sustainable yield of commercial conifer timber trees. 	<ul style="list-style-type: none"> • Meet postharvest tree stocking needs per acre. • Meet total and per-species stocking needs per acre.
Forest health	<ul style="list-style-type: none"> • Ensure seedling survival, vigor and growth by controlling competing vegetation. • Maintain tree density and species composition that will create a vigorous and healthy forest, including a diverse understory. 	<ul style="list-style-type: none"> • Allow no competing vegetation within 5 feet of seedling for 1 to 2 years after planting and minimal competing vegetation for next 3 to 5 years. • Plant desired species and remove undesired species to reach specific number of trees per acre within specified number of years. • Precommercial thin to desired species and number by age 10.
Fire protection	<ul style="list-style-type: none"> • Maintain condition of property to minimize wildfire risk and allow for effective fire suppression and postfire recovery. 	<ul style="list-style-type: none"> • Create fuel breaks for fire suppression and maintain roads for access. • Maintain brush and dead woody debris at acceptable levels at specified plantation age(s).
Post-wildfire	<ul style="list-style-type: none"> • Replant all productive forest soils in burned areas with appropriate species. 	<ul style="list-style-type: none"> • Achieve specific number of trees per acre per species alive and growing after 2 years.
Wildlife habitat	<ul style="list-style-type: none"> • Retain oak species to provide acorns for wildlife. • Retain pockets of shrubs and small wood debris for small mammal habitat. • Manage non-conifer vegetation to stay within desired conifer/non-conifer mix. 	<ul style="list-style-type: none"> • Retain specific number of oaks per acre during site preparation, preferably large, acorn producing oaks.
Natural diversity	<ul style="list-style-type: none"> • Enhance native plant species by reducing invasive and non-native plant species that can have negative effects on plant diversity and abundance. 	<ul style="list-style-type: none"> • Eliminate or control invasive plants to acceptable levels.
Aesthetics	<ul style="list-style-type: none"> • Consider short and long-term effects on viewshed, especially near houses and high use recreational areas. 	<ul style="list-style-type: none"> • Develop a low density of large trees per acre in the viewshed.
Erosion Control	<ul style="list-style-type: none"> • Provide for effective ground cover on eroding or potentially erodible sites. 	<ul style="list-style-type: none"> • Evaluate site to confirm no visible signs of (sheet, rills, ruts, gullies or mass movement), and no impacts to water quality.
Fuels management	<ul style="list-style-type: none"> • Manage live and dead aboveground biomass to keep fire behavior to manageable levels. 	<ul style="list-style-type: none"> • Keep live and dead above ground biomass to less than 10 tons per acre.

comes. Objectives can be short- or long-term in timing and vision. Examples of goals, objectives, and measurable criteria are in table 3.1.

Wildlife, water quality, recreation, and aesthetics

Wildlife should be protected and encouraged to the degree required or desired, while accommodating necessary forest management activities. Treatments needed for successful reforestation also affect the characteristics of the stand; for example, hardwoods such as oaks provide food for many wildlife species as well as valuable habitat elements for cover, denning, and nesting. It is important to identify oaks, snags, large woody debris, and other elements left on-site that will be helpful to meet long-term objectives for wildlife habitat, recreation, aesthetics, and water quality. Depending on the stand's stage of development, habitat elements important for desired wildlife species include:

- Basal area of stems or square feet of cross-sectional stem area per acre (for example, approximately 2 to 10 percent of total basal area or number of stems in a stand)
- Snags, especially large ones, for nesting and denning sites (for example, number of 20-inch snags per acre)
- Coarse woody debris such as large, hollow logs that can be used for denning (for example, one large log greater than 30 inches in diameter and at least 20-feet-long per acre)
- Large-diameter oaks for denning or nesting (for example, one oak greater than 30 inches in diameter every 5 acres)

An example of a long-term objective could be to develop over time a habitat for game species at a forage-to-tree cover ratio of 60 percent to 40 percent. After ensuring seedling survival with treatments to control competing vegetation, this could be accomplished by managing vegetation and tree spacing over time. Another example of a long-term objective could be to develop a mature, mixed-conifer or ponderosa pine stand with 10 percent oak cover. To achieve this objective, the forester would need to leave much less than 10 percent oak cover at planting to account for the significant difference in early growth and site occupancy between newly planted conifer seedlings and resprouting hardwoods with existing, well-established root systems. A rapidly expanding oak canopy cover can significantly diminish conifer growth and site occupancy if it exceeds the manager's initial hardwood target.

Brush and hardwoods are valuable wildlife habitat elements, but they also compete with conifers for valuable resources and are ladder fuels for fire. Another

long-term objective could be to leave a small, specified percentage of the total project area in brush and hardwoods for wildlife habitat.

Tree density

The number of mature trees per acre is the most widely used metric for assessing the success of a reforestation project after the first decade. The initial number of seedlings planted often exceeds the projected number of mature trees, to account for expected mortality and in some circumstances to promote more-vertical tree form and provide early revenue, if there is a market for small-diameter trees. California and other Western states also have tree-per-acre requirements after green-timber harvests on private lands, which can be met with a combination of newly planted seedlings and residual trees.

In 2020, the California Board of Forestry and Fire Protection reduced the minimum trees-per-acre requirement from 300 trees per acre to 200 trees per acre on high sites, and 150 trees per acre to 100 trees per acre on low sites. This rule update brought California's reforestation requirements closer in line with those of other Western states. Planting higher densities of seedlings can result in more total biomass growth, but unless precommercially thinned, the trees will have smaller diameters and take significantly longer to reach the necessary diameter for commercial sale, wildfire resilience, or mature forest habitat objectives. In regions without a strong market for small-diameter trees, forests that are planted at higher densities and not precommercially thinned can stagnate and become prone to insect-caused mortality. Within any area, it is also common to leave some pockets of noncommercial species, snags, designated residual trees, and clumps of understory vegetation for wildlife habitat.

At planting, the number of trees per acre will vary depending on the species planted or whether the reforestation is a green harvest where minimum stocking standards must be met on private lands, voluntary reforestation after wildfire, or part of a restoration effort. The number of trees per acre remaining after precommercial thinning is the most important consideration for the long-term financial and ecological value of a stand. Foresters can aim for an initial planting density that is the desired final density or plant more seedlings based on vigor, species, and spacing characteristics, as well as wildlife habitat elements. As long as competing vegetation is not significant, wider tree spacing will result in faster diameter growth. At wider spacings, each tree has more access to water and other resources and is therefore more resistant to insect attack, disease, drought, and climate change.

Fuels

Choices made during the implementation of a reforestation project can have a major influence on the site's future fire risk. Site preparation and vegetation management methods, the retention of woody material for wildlife habitat, and tree density objectives should all be evaluated for their potential to increase fire risk. A fuel-loading target of less than 10 tons per acre can help to keep fires more manageable. The Rocky Mountain Area Coordination Center website includes photos of [common fuel models](#) for California. This link along with other information is available on the [Fuels and Fire Danger page](#).

Describe desired planting conditions and outcomes

Describing desired conditions applies to two time-frames: 1) the physical and vegetative conditions at time of planting for successful survival and growth of the target seedlings, and 2) a series of postplanting conditions over time, leading to successful future outcomes. Long-term results could be from 10 to 70 years or more.

Determining the desired planting conditions requires a thorough understanding of how planted conifers and competing vegetation will behave on a site. Factors to consider include:

- Soil moisture, air temperature, humidity, wind speed, and frost conditions during establishment
- Shade tolerance of the preferred conifer species
- Species present in the understory
- Responses of potential competing vegetation after harvest, site preparation, or fire; and how competing vegetation responds to treatment
- Species of competing vegetation present or likely to germinate on-site

Regenerated stands include a combination of species that have been planted, resprouted from root stock, and germinated from seed. Decisions must be made about which actions or prescriptions are necessary to achieve both the desired planting conditions and future forest outcomes. Conditions at planting to ensure seedling success vary for different species. For example, ponderosa pine is shade-intolerant, and residual trees that shade pine should be removed. Pine-dominated units are typically more than 1 acre in size. Douglas-fir has intermediate shade tolerance and its young stems are sensitive to heat damage, so large logs, stumps, small debris, and an intact organic layer provide favorable microclimates for their establishment. Douglas-fir and white fir are susceptible to frost mortality, and damage can be reduced by leaving some

overstory trees, utilizing a shelterwood harvest, allowing smaller group openings, or designating some leave trees as protection in frost-prone locations. Larger leave trees will effectively use soil moisture and sunlight and limit the growth of the new seedlings, especially those closest to the leave trees.

Develop prescription and schedule of activities

The prescription process incorporates site assessment, objectives, and desired conditions into a series of treatments designed to achieve the project goals. The timing of these treatments is described in a schedule of activities. See appendix 3.1 for examples of activity schedules (figs. A1, A2, A3), which can be used as outlines for different project types. Depending on the landowner and the need for disclosure, prescriptions can be as brief as these schedules or lengthy documents detailing each step. Each activity on the schedule may also have its own detailed timeline as well as a separate budget.

Develop budgets

Dividing the project area into smaller and more homogenous units, called unitization, helps to facilitate the budgeting process. Providing accurate acreage for each unit in mapping and spreadsheet data allows the forester to accurately estimate the cost of supplies, labor, timing, duration, and other activities. Small landowners can use this information to justify funding when applying for grants, while large landowners and agencies can use it for annual budgeting. If reforestation costs are being paid for with income from annual logging revenues, it is useful to know the timing of future costs so the land manager can retain income in the appropriate years. Landowners who do not budget well for postplanting release treatments, precommercial thinning, or other treatments may not have the resources to invest in future activities that are critical to long-term success. A spreadsheet covering at least 10 years of estimated costs from initial site preparation to precommercial thinning can help to identify budget needs and avoid future funding constraints.

The primary purpose of budgeting is to identify the amount and timing of funding needed throughout the project's scope. Skipping or even delaying a particular activity due to lack of funds can jeopardize the success of the reforestation project, wasting money spent on prior activities and requiring even higher treatment costs in the future. If funding is limited, the budgeting spreadsheet developed for each unit during the site assessment can be used to establish priorities among the units and allocate available funding appropriately. A spreadsheet with all units from the mapping system also helps ensure that a unit is not overlooked. When

the budgeting process is complete, the spreadsheet can aid in prioritizing which units will be treated with available funding. Similar lists developed within an agency can be used to prepare proposals for bidding.

Develop forest management plan if needed for project funding

Written forest management plans help guide reforestation planning on private property or units of public agency land. The plan's geographic scale is usually the landowner's entire forest property, while the time frame for planning and expenditure is at least 5 years, with goals and objectives for much longer. The plan includes site assessment information relevant for long-term forest management. In addition to guiding reforestation planning, a completed forest management plan speeds up the prescription process.

Forest management plans can also facilitate reforestation funding. CAL FIRE requires a forest management plan as a condition of receiving cost-share grants from the California Forest Improvement Program, which can fund 90 percent of the cost for Registered Professional Foresters to prepare project plans following a disaster such as a wildfire. Similarly, the Natural Resources Conservation Service requests that a conservation plan be completed as a condition of its Environmental Quality Incentives Program (EQIP), while the Forest Service requires a plan for funding from its Forest Stewardship Program.

The [California Cooperative Forest Management Plan](#) is a common template used to meet the requirements of agency assistance programs and American Tree Farm Association grants. In addition, CAL FIRE offers a nonindustrial timber management plan option to promote long-term management and planning on forest ownerships of 2,500 acres or less, with landowners agreeing to manage their forests through uneven-aged management and long-term sustained yield (California Public Resources Code §4593). The nonindustrial timber management plan can also be used to qualify for California Forest Improvement Program project funding.

Implement reforestation by project type

The three basic reforestation projects—postharvest (green timber sale), postwildfire, and restoration/rehabilitation (brush-field conversion)—primarily differ in the timing of activities to control competing vegetation, order seedlings, and secure necessary permits. Once seedlings are delivered to the site, the implementation of most projects will follow a similar path, with the timing or methods in some steps modified, added to, or eliminated.

Identify and obtain necessary permits

Federal, state, and local agencies require permits for a number of reforestation project activities. Permitting processes are ever-changing; check with appropriate agencies to determine the latest requirements. Some permits will require a timber harvest plan signed by the landowner, timber owner (typically the landowner), and Registered Professional Forester. The forester typically prepares them in consultation with the landowner and other professionals and agencies and submits them for the landowner.

Green-timber and salvage harvesting permits

Reforestation activities related to green-timber harvest on private land cannot begin until a timber harvest plan that complies with the state Forest Practice Act and California Environmental Quality Act (CEQA) is approved by CAL FIRE. The preparation and approval of this permit can take from 1 to 3 years, depending on the location and issues involved. Site assessment for a Timber Harvest Plan requires numerous surveys, including botanical, fish and wildlife, geological, and archeological. Reforestation activities should be planned well in advance of harvest so that they can be conducted at the appropriate times once the plan is approved.

Salvage harvest permits are not usually required for postwildfire reforestation activities on private and state lands in California. Postwildfire salvage logging operations may be conducted after filing a notice of emergency timber operations (or notice of exemption) with CAL FIRE, which may allow logging to commence within 5 days after CAL FIRE accepts the notice for filing. Harvest operations conducted pursuant to exemption and emergency notices must still comply with all operational requirements of the Forest Practice Rules.

An archeological records check and other assessments may not be required for operations under an exemption, but the landowner and Licensed Timber Operator are still responsible for protecting those sensitive resources. Prior to operations under a notice of emergency, the Registered Professional Forester must conduct an archeological record check and survey along with other assessments to protect sensitive resources including botanical, fish and wildlife, and geological.

On federal lands, all timber sale operations must comply with federal laws such as the Multiple-Use Sustained-Yield Act, National Environmental Policy Act (NEPA), Endangered Species Act, Clean Water Act, and Clean Air Act. Projects going through the NEPA process can take 2 years or more before approval and longer if appeals and litigation are filed. This

uncertainty can complicate project planning and lead to operational delays.

Water quality and fish and wildlife permits

Water quality permits, or more typically conditional waivers of those permits, along with fish and wildlife permits, may be required for timber harvest activities that potentially affect the beneficial uses of water or threaten fish and wildlife. Examples include Regional Water Quality Control Board waivers of waste discharge permits, California Department of Fish and Wildlife lake and streambed alteration permits (under section 1600 of the California code), and, where needed, surveys for specific plant and wildlife species. Conditional waivers and 1600 permits may be obtained within a month but can take longer. Surveys often are season-dependent and can take a year or more to be scheduled and completed. For example, surveys for the northern spotted owl, which is protected under the state and federal Endangered Species Acts, can take up to 2 years. Such permits and surveys may also be required for salvage logging after a wildfire.

Know what permits or waiver conditions are required and allow plenty of time to get them processed. Permits may also be required by the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Army Corp of Engineers, or other federal agencies, most often for timber harvest activities that could impact listed species or stream habitats. Some of these permits can take months or years to obtain.

Pesticide application permits

Pesticide application permits are issued and enforced by local county agricultural commissioners under authority of the California Department of Pesticide Regulation and must be obtained before pesticide spray operations begin. An operator identification number and a restricted materials permit for the application of certain herbicides or insecticides is required for reforestation projects (California Department of Pesticide Regulation 2019). The permit identifies sites where applications can be made and lists specific conditions that must be followed during applications. If the permit applicant is not the landowner, the applicant must have written authorization designating them as the landowner's representative, and they must possess a valid Pest Control Advisor license issued by the Department of Pesticide Regulation.

Unless they are working on their own property, applicators must also be licensed as a pest control business, have a qualified applicator licensee on staff in order to apply pesticides for hire, and must annually register with the county agricultural commissioner in each county where work is performed. After

applying any pesticide, the landowner or applicator is responsible for reporting the use to the commissioner online or on approved forms. A written pest control recommendation by a licensed Pest Control Advisor is required when the person making a recommendation on the use of pesticides is not the landowner or an employee of the landowner. For more information on pesticide licensing, permits, and reporting, see chapter 8 ("Vegetation management")

Burn permits and plans

Burning as a site preparation method may require a smoke management plan from the county or regional air quality district, depending on the size of the project, quantity of emissions, and proximity to smoke-sensitive areas. Some districts may also require an air pollution permit, and fees may apply. California's 35 air pollution control districts are responsible for regional air-quality planning, monitoring, and stationary-source and facility permitting; these districts are the California Air Resource Board's primary partners in efforts to comply with the federal Clean Air Act. Due to a declining number of burn days, acquiring approval for smoke management plans that include burning in a reforestation project has become more difficult in recent years.

Private landowners may also need to obtain a project burn permit (LE5) from the agency responsible for fire suppression in the project area (usually CAL FIRE). The LE5 permit is required to burn during fire season, which varies annually and throughout the state as determined by CAL FIRE.

Obtain appropriate seed

Since seed adapted to the project site is not always available, a source for seed should be located prior to the start of project planning. The project prescription should include estimates of the quantity of seedlings needed by seed lot, which is typically grouped by seed zone, elevation, and species. The best way to obtain the proper quantity of seed is to contact the selected seedling nurseries and have them calculate how much seed will be needed based on the forester's plan for the quantity of seedlings per seed lot and each seed lot's attributes, including seeds per pound and germination rate in combination with the nursery's oversow factor and other nursery-specific attributes. How much seed the nursery needs also depends on the quality of seed and how efficiently the nursery uses it (see chapter 6, "Seedlings"). If a reforestation forester knows that a particular seed lot is in short supply, informing the nursery of the situation can result in more efficient seed use.

Order seedlings and identify cold storage

Seedlings should be ordered by the first week of December at the latest (see “Ordering seedlings” section in chapter 6 for more details). If ordered in November or December, 1-year seedlings will be available for planting the following fall (10 to 11 months later), winter (12 to 14 months later), or second spring (14 to 18 months later). Timely seedling orders allow the nursery to optimize seed treatment and sow dates and therefore provide the best quality seedlings. If you haven’t grown a particular species or contracted with a nursery before, be sure to contact them well in advance.

The project prescription identifies the species and seedling stock types (container size or bare-root age) that are best-suited for the project and lists the quantities of each needed. If seed for the project has already been obtained, the nursery needs to know the quantity and quality of that seed to determine how much they will need to grow the requested number of seedlings. If no seed has been obtained, the nursery may be able to secure it (if any is available). The seedling purchaser is responsible for the cost of the seed as well as the seedlings. Chapter 6 (“Seedlings”) offers extensive information on selecting species, seedling stock types, and a forest nursery, and more detail on how to order seedlings. Chapter 9 (“Planting”) has more detail on species and stock types commonly used in various regions of California.

Packing windows for seedlings are getting shorter, making cold storage more critical. This is a particular problem for small landowners and consultants with relatively small and often periodic reforestation projects. Try to line up cold or freezer storage, if applicable, when seedling orders are placed. Often the nursery can provide or arrange for cold or freezer storage. If not, identify an alternative storage location. Do not wait until the seedlings are packed and ready for delivery and then try to find storage as nurseries usually have limited storage capacity. See chapter 9 (“Planting”) for more information on cold storage.

Select preharvest vegetation management herbicide spray(s) and contractor(s)

Preharvest chemical site preparation before a green harvest, if done well, can substantially reduce the need for treatments to release planted trees from competing vegetation after planting, known as release treatments, and related costs. Herbicides to control competing woody and other vegetation may be applied before a site is logged so that the planted seedlings are not damaged. Such treatments are particularly effective for controlling resprouting brush and hardwood species. Depending on the species to be planted and location,

spraying should be done a minimum of 3 months prior to logging and 1 to 2 years before planting.

The need to spray before logging means that timber harvest or sale plans must be completed well in advance. Completing and receiving approvals for plans 2 years before logging is scheduled allows flexibility to conduct vegetation management treatments, even if logging plans change. Road construction or reconstruction that provides access to the project harvest area should be completed prior to this preharvest site preparation treatment to reduce labor costs and allow spray crews and equipment suitable access to harvest units. Find a contractor equipped and experienced in preharvest chemical site preparation. This should occur at least 6 months if not a year before the planned application to give contractors time to schedule the work and secure a labor force. Permits for chemical use may also take time to obtain. For more information, see chapter 8 (“Vegetation management”) and the examples of project timing in appendix 3.1 (see figs. A1, A2, A3).

Coordinate with harvest operations

Green-timber harvest schedules often affect the timing of reforestation treatments, and treatment plans may need to be adapted to account for changes in harvest timing. Harvests are often scheduled to accommodate a mill’s processing capacity or the availability of a logging operator. Being involved with the scheduling process as much as possible will allow for timely reforestation treatments. Harvesting can take place any time of the year depending on the location and weather, but most logging is done from April through November. Some logging occurs on the eastern side of the Cascade or Sierra Nevada mountains on snow or frozen ground from December through February. Logging can occur year-round on the California coast where roads are well-rocked.

Select site preparation methods

Site preparation refers to any measure that prepares an area for the regeneration of a forest stand, and many reforestation practitioners consider it the single most-important step. Vegetation management is a primary controlling factor in any successful reforestation. Chapter 7 (“Site preparation”) describes how to determine the need for site preparation and covers three common non-chemical methods: mechanical, manual, and burning. Chapter 8 (“Vegetation management”) focuses on the chemical (herbicide) methods of forest vegetation management used in the different steps of reforestation. Each method, or more likely an integration of methods, should be evaluated on a unit-specific

basis in terms of comparative cost and effectiveness in meeting project objectives.

Mechanical site preparation

Common reasons for mechanical site preparation include slash removal, vegetation control, reduction of soil compaction, and breaking up hydrophobic soils after a fire. Mechanical site preparation should be done in the summer or fall before planting. In places where chemical preharvest site preparation did not happen, it may be necessary after harvest. In this case chemical and mechanical treatments should be scheduled to allow for maximum efficacy of the chemical treatment while still accomplishing the objectives of any mechanical treatment.

Manual site preparation

Manual labor to prepare a site includes grubbing, applying mulches, and hand-piling. It is much more expensive per acre and tends to be used on sensitive sites such as steep slopes close to sensitive water sources or at the urban-wildland interface, where chemical use might be too controversial.

Burning

The use of burning under prescribed conditions, including pile and broadcast burning, is an option, although its use on private lands has declined significantly in recent years due to smoke management and liability issues.

Chemical site preparation

Postharvest foliar chemical site preparation may be necessary if preharvest chemical site preparation was not done or was not effective on all target weed species. Depending on the vegetation present, units may need to sit fallow for a season to allow woody vegetation to resprout and grow foliage leaf area large enough to absorb sufficient herbicide for effective chemical control. This usually occurs with difficult-to-control species such as snowbrush, tanoak, or golden chinquapin. However, if imazapyr is used, planting should be delayed for an entire year because it is a foliar herbicide with residual soil activity that is harmful to conifer seedlings.

Following pre- or postharvest foliar site preparation treatments, a soil-active residual herbicide application may need to be scheduled for the fall or spring before planting, depending on the elevation, to control competitive grasses and forbs. Depending on the herbicide mix used, this may occur before or as soon as practical after planting.

Select site preparation contractors

Anticipate all labor contracts well in advance of when site preparation work needs to be done. Experienced crews and essential equipment operators are typically booked early. It is wise to get a commitment from contractors several months prior to the project. Seasonal availability varies by the type of site preparation method. The summer season is busy for equipment contractors, so the previous winter is a good time to locate and commit, for example, to a contractor for mechanical site preparation. Spring is generally the busy time for herbicide application contractors. Prescribed fire crews, who have different skills than firefighters, will be needed during the spring and fall burn windows. Plan ahead and be ready when your prescription window opens.

Conduct site preparation (mechanical, manual, burning, chemical)

Site preparation is the most important step for a successful reforestation program. Good control of competing vegetation prior to planting will save land managers a lot of time and money in the long run. It is far more expensive to release established seedlings from competing vegetation after planting than it is to treat it prior to planting during site preparation. Relying solely on release treatments to control competing vegetation limits the land manager's choice of chemicals and forces them to use higher volumes of chemical and significantly more expensive application methods.

It is also important to coordinate the proper sequence and timing of the different site preparation treatments. For example, foliar chemical site preparation applications must be completed prior to mechanical treatments to allow enough time for the chemicals to translocate from the sprayed foliage to the meristems and roots before any mechanical, manual, or prescribed-fire disturbance. Also, planned, mechanical, and prescribed-fire treatments must be completed prior to any soil-active herbicide application for controlling herbaceous vegetation.

Request timing of seedling packing and delivery

Contact the nursery in the fall, at least a month before seedling packing is expected to begin, to discuss its timing for spring planting. Packing requirements for units scheduled for fall or winter planting should be discussed during the summer prior to planting. The approximate date that seedlings are expected to be planted will affect their packing window and the type of cold storage to use. Get requests in early and plan cold storage accordingly. See chapter 6 ("Seedlings") and chapter 9 ("Planting") for more information.

Select planting contractors

Planting contractors can be very busy with existing commitments, so contact them as soon as 6 to 12 months before their services are needed for your project. Government agencies that have lengthy contracting procedures, especially those with complicated bidding processes, may need even longer lead times to ensure that planting contractors will be available for planting. See chapter 9 (“Planting”) for more details.

Receive and store seedlings

Seedlings packed for immediate planting, such as in the fall, will need to be picked up as soon as they are packed and then handled properly and planted within 1 to 2 weeks (see chapter 9, “Planting season” section). Seedlings that will be stored and planted later are packed from November through January. Without proper storage, packed seedlings can develop mold. If storage at the nursery has not been arranged, seedlings should be picked up immediately after they are packed and transported to cold storage. If the travel distance is long and the region is warm, it may be necessary to transport seedlings in a refrigerated truck or van. The type of cold storage required near the planting site depends on the length of time the seedlings will be in storage (see chapter 9, “Cold storage” section).

Plant seedlings

Planting is the culmination of this multistep process. Seedlings must be properly handled with adequate transportation from the cold storage to the field and then by the planters onto the site. Having an experienced planting crew and good planting-quality inspectors helps to ensure success. Doing all the other steps well will not guarantee success if the seedlings are not planted correctly. See chapter 9 for more information about planting and storage.

Monitoring and follow-up treatments as needed

It is essential to follow up any planting project with periodic evaluations of seedling survival and density, vegetative competition, and damage from insects, disease, and animals. Monitoring after planting in a manner and at intervals described in chapter 9’s “Planting follow-up” section allows for timely diagnoses and responses to problems that can otherwise lead to poor performance or project failure. Animal damage is sporadic, making scheduling of labor difficult. If needed, some prevention of animal damage can be done in conjunction with planting if monitoring and diagnoses are timely.

Effective monitoring is based on knowledge of the planting area and habitat that pests thrive in. Facilitating healthy, vigorous tree growth with good

vegetation management and tree spacing significantly reduces the need for direct control of insects, significantly minimizing or eliminating the use of insecticides on most project sites. Early identification of pest species allows for timely treatment. For diseases, particularly root-based fungal rots, knowledge about pathogens in the area is helpful. For animal damage, knowledge of migration patterns or habitat issues can lead to successful preventative programs. Entomologists and pathologists employed by CAL FIRE and the Forest Service’s Forest Health Protection program are available to provide valuable assistance in forest pest identification and management.

If possible, schedule labor for any required treatments well in advance. Aerial applications may be needed for insect infestations that occur over large areas, and lining up aerial contractors can be difficult on short notice. Disease treatments are usually preventative and often occur at harvest. See chapter 9 (“Planting follow-up” section) and chapter 11 (“Damage”) for more information.

Control competing vegetation and future fuel loading

Treatments to control vegetation after planting, known as release treatments, usually occur within 5 years after planting, but can occur later. Target weeds will vary by site, and the appropriate treatments used to control them will depend on the species, stage, and condition of vegetation present. Depending on objectives, release treatments may or may not be necessary. If herbaceous vegetation is present at the time of planting or soon after, a timely release treatment is typically done to assure seedling survival and vigorous first-year growth. Release treatments if needed in later years primarily target woody vegetation to maintain or enhance sapling health and growth and reduce the growth of brushy wildfire fuels. If monitoring after planting indicates the need for follow-up release sprays, plan ahead to secure properly trained and equipped spray crews. Securing a crew that is experienced in protecting seedlings from the herbicide treatment is a must. See chapter 8 (“Vegetation management”) for more details.

Perform precommercial thinning

Precommercial thinning is any activity where the density of trees is modified to facilitate growth of the residual trees into desired sizes over time. Timber stand improvement also refers to treatments that involve pruning, branch removal, or other activities to reduce potential wildfire fuels. Although precommercial timber-stand improvement activities do not generate net revenue, they promote the health and growth of trees and/or reduce the risk of loss from wildfire,

insects, and diseases. When the primary long-term objective is to generate timber revenue or otherwise grow relatively large trees, factors to consider when thinning include the size of tree required for commercial viability and how the treatments will reduce potential wildfire losses.

The timing for completing precommercial thinning varies from site to site. Precommercial thinning typically occurs 5 to 10 years after planting depending on tree growth and site productivity. Thinning should occur when trees are well established but before they get too large and expensive to thin and create an unacceptably hazardous fuel load. Spacing must be wide enough for the trees to grow at an acceptable rate for the next 20 to 30 years until the first commercial thinning. Delaying thinning past the optimum time not only slows the growth rate of crop trees but also increases the level of fuels from thinned trees. Thinning late also increases the cost of thinning projects because larger trees take longer to cut.

When making decisions about when and how much to thin it is important to understand and consider the information in chapter 10, but precommercial thinning ultimately boils down to accepting the number of feet between trees that the forester prescribed and the thinning contractor was hired to achieve. Foresters sometimes have a difficult time watching thinning crews cut down trees that they have planted and cared for, which are growing well. They must overcome a common tendency to focus on the short-term spacing needs of tree sizes at the time of precommercial thinning instead of spacing needs as the trees grow for the next 20 to 30 years. Otherwise, they will want to leave stands too dense. Spacing must be wide enough for trees to grow larger and compete with each other for the next 20 to 30 years and not simply wide enough to manage inter-tree competition for the next 5 to 10 years, when the forester sees much younger, smaller trees at the time of precommercial thinning. It is important to follow through with this crucial step at the right time with proper spacing for the long-term health and productivity of the stand.

For example, a common prescription for productive sites in Northern California starts with planting 200 to 260 seedlings per acre, followed by the precommercial thin to 18-by-18-foot spacing (135 trees per acre) at year 6 or 7 (or perhaps later for lower quality sites). Thinning will happen earlier for very productive sites and a year or two later for drier, less productive sites.

It's important to avoid conducting precommercial thinning between early May and the end of July during the flight of bark beetles in ponderosa pine stands, because the beetles are attracted to freshly cut trees. As

with all other treatments, lining up labor ahead of time is critical.

Deciding which trees to cut and which to retain is a relatively simple task in single-species plantations—the preferred trees are the ones retained at the prescribed spacing. The preferred tree to retain could be the one that is tallest or without defects but thinning to the prescribed spacing is ultimately the most important consideration. Mixed-species plantings are much more complicated due to significant growth differences between species in the first 5 to 10 years after planting. For example, although Douglas-fir and true firs are typically much smaller than ponderosa pine at the age of precommercial thinning, by age 15 to 20 they often catch up and sometimes exceed pine in height. Within the spacing guidelines, species preference should take precedence over relative height in order to retain the desired species mix. Targeting to retain a well-spaced species mix that is naturally adapted to the site should provide protection from insects, diseases, and drought in the decades to come, along with the widest range of market options in the future. See chapter 10 (“Precommercial thinning”) for more information.

Perform pruning and other fuel reduction treatments as needed

A fuel reduction treatment may be considered as a plantation matures or if funds are limited in strategic portions of a plantation, such as within 200 feet of roads and ridgetops. Pruning lower limbs to increase wood quality is no longer a common practice, but it can reduce the probability of surface fires getting up into the branches and facilitate fire suppression efforts under some circumstances. Fuel reduction treatments to manage brush are also important, such as spraying small brush before it grows into the crowns of young plantation trees or becomes hazardous ladder fuels in the understory of an older plantation. If brush has been allowed to grow into ladder fuels in an older plantation, it can be piled and burned or masticated as feasible. However, it is much more cost-effective and safer to treat the brush early before it grows into hazardous wildfire fuel.

Document lessons learned

Learning lessons from the reforestation project should be continuous and not necessarily the final step. It is important to document what worked well, what could have been done better, and what failed—and why. Understanding what happened during a reforestation project may not always be obvious but documenting the steps taken (or not taken) with text and pictures contributes to a better understanding of the project's

success or lack thereof. Over time, documenting lessons learned can substantially improve success rates.

Conclusion

Properly completing the time-critical steps described in this planning chapter addresses the five key principles that should be addressed in a successful reforestation project in California's Mediterranean climate:

1. Plant native species from known, appropriate seed sources that are adapted to the reforestation site.
2. Use quality seedlings that are vigorous enough to grow roots down to permanent soil moisture during the first growing season of establishment and are able to withstand sun, wind, cold, and any other environmental conditions that might be encountered.
3. Prepare the planting site by providing complete control of competing vegetation, access for planters, and management of hazardous fire fuel loads.
4. Properly handle, transport, store, and plant seedlings.
5. Monitor and protect planted seedlings from damage by animal and insect pests, and manage competing vegetation, hazardous fuel loading, and intertree competition.

Positive progress with reforestation over the past several decades has led to many changes in the details of planning projects. However, these common-sense planning recommendations and principles from an Oregon reforestation guide still ring true for California today (Hobbs et al. 1992):

- The region's environment and its well-adapted non-conifer vegetation interact to create often-hostile conditions for the survival and growth of seedlings. Such conditions require the careful and timely execution of well-thought-out plans for reforestation.
- In order to succeed, managers must work to identify long-term objectives.
- Regardless of management objectives, the sustainability of forest productivity must be a primary concern, with a major component of sustainability being reforestation after natural disturbance or harvest. An understanding of ecological principles, management practices, and analysis capabilities pertinent to the reforestation process is relevant to managing lands for all of the listed purposes.
- Managers must make monitoring of reforestation efforts by technically competent people a high priority.
- Actions must be biologically sound, economic sensible, socially acceptable, and operationally feasible.

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Web addresses

CAL FIRE roster of Registered Professional Foresters
caltreesplans.resources.ca.gov/Caltrees/customization/common/rpflicenselist.aspx

Common fuel models for California
gacc.nifc.gov/rmcc/predictive/Fire%20Behavior%20Fuel%20Model%20Descriptions.pdf

National Interagency Fire Center, Fuels and Fire Danger
gacc.nifc.gov/rmcc/fuels_fire_danger.php#

CAL FIRE's California Cooperative Forest Management Plan
fire.ca.gov/what-we-do/grants/california-forest-improvement

Appendix 3.1. Schedule of activities: Examples

The following schedules of activities provide general examples to facilitate the critical thinking necessary to develop and implement complicated biological, operational, and administrative reforestation processes. The left column in figures lists the series of activities necessary for successful execution of the project, which matches activities in the workflow chart (see fig. A1). A description of each of these activities is found in the related sections of this chapter. The second column lists the chapter in this book with detailed information about the topic. The rest of the figure shows when throughout the year activity is likely to occur for the type of project.

Each reforestation project should have its own schedule of activities with a timeline developed for the specific needs of the site. Reforestation includes numerous time-critical steps. Think through your reforestation project and develop a schedule of activities (prescription/plan) that works for your particular situation.

Schedule of activities 1: Postharvest (planting after green timber harvest)

Figure A1 illustrates a project where planting occurs after the harvesting of live trees, such as under even-age forest management, which is often practiced on large industrial ownerships. It can also apply to replanted group selection units that are considered uneven-age management under California regulations. Planting usually occurs in spring in the year or two after harvest if commercial conifer stocking levels are inadequate in the harvest area. However, many harvested sites can also be planted in the fall or winter if conditions are right. See chapter 9 (“Planting season” section) for details.

A post-green-timber harvest reforestation project has the benefit of a longer planning horizon because harvest planning must meet detailed regulatory requirements that result in a timber harvest plan. The schedule indicates this long lead time in the third and fourth columns, with 1 to 3 “minus” years showing the time frame of preharvest activities prior to the reforestation phase. Although many steps are the same as for the other two reforestation project types, post-green-timber harvest reforestation often benefits from preharvest spray treatments, which typically are more difficult to schedule in the other project types.

Schedule of activities 2: Postwildfire

While the need for postwildfire projects is increasingly common, reforestation success can be improved when planning begins immediately after a fire (Zhang et al.

2008) and proper steps, as described in this book, are followed. The planning and implementation timing of salvage activities and reforestation after a wildfire (see fig. A2) is considerably compressed. Quick action with the salvage process can increase income to help offset reforestation costs. Wildfires tend to occur from June through November with later wildfires further compressing planning timelines.

The first activity for a successful and cost-effective response after a wildfire is usually salvage harvest. The objectives are to salvage deadwood, capture as much value as possible before the wood deteriorates, and prepare the site so that residual and newly planted trees reach their growth potential. Salvage harvests are usually performed within a year of a fire, especially for smaller fire-damaged areas. On private land, a notice of emergency operations can be filed with CAL FIRE and logging can start within 5 days of its acceptance. The salvage operation must still comply with all relevant Forest Practice Act requirements, as well as secure and follow the conditions of the required water-quality and fish and wildlife permits. Archaeological record checks and surveys must be done prior to harvest operations.

Large landowners have the advantage of staff who can immediately get started, and most have experience with salvaging after wildfires and know what needs to be done. However, large landowners who do not have manufacturing facilities, along with small landowners, must take the extra step of marketing salvage timber and executing contracts with mills and logging contractors. The decline in the number of sawmills in California in recent decades has made it more difficult and expensive to get logs to market. If other landowners also have fire damage, nearby mills may not have the capacity to process all the trees killed in the region. It is important to start the process of looking for potential log buyers and transporters as soon as possible after a fire loss.

Smaller landowners can be at a disadvantage when planning a salvage harvest after a severe wildfire, especially if they do not have an existing relationship with an experienced forester or a forest management plan in place. Many landowners have lost not only their forestland but also their homes, so finding a place to live and dealing with insurance companies takes priority. Many are in shock, don't know who to trust, and want to wait before making decisions about reforestation, even though quick action will reduce costs and improve success.

Landowners who have the capacity to deal with salvage and reforestation should hire an experienced Registered Professional Forester as soon as possible, preferably one with reforestation experience. After a big fire, foresters and loggers are usually in short

supply. Loggers can quickly become committed to the larger projects of larger landowners. To find trustworthy, professional advice, ask to see the licenses of foresters and loggers and check with CAL FIRE about any violations. Small landowners who don't know the process or who to trust can call CAL FIRE and speak with the forest practices staff about salvage logging or contact a county forestry assistance specialist about California Forest Improvement Program funding for reforestation funding (see chapter 2, "Investing in reforestation," for more information). Be patient: Connecting with agency personnel can be difficult during and immediately after a fire.

Salvage logging and reforestation funding applications should be worked on concurrently. Applications for funding should ideally be filed by October 1 for approval before December 1, so that seedlings can be ordered. If reforestation is delayed for a year, brush and grass may become established, making reforesting more expensive and success more difficult. Federal reforestation projects can take much longer due to National Environmental Policy Act requirements, which can take 1 to 2 years, assuming there are no further delays from lawsuits and appeals. Federal agencies do not have any emergency processes for expediting postfire reforestation. Once salvage logging is complete, the sequence of reforestation activities is similar to other project types.

Schedule of activities 3: Rehabilitation/restoration (brush-field conversions)

Rehabilitation projects involve restoring conifer species to land previously forested but now dominated by other vegetation. The reforestation steps for this brush-

field conversion example vary from the other two schedules primarily regarding site preparation (see fig. A3). It is also key to prevent the return of heavy brush after site preparation with pre- and postplanting vegetation control. Brush-field conversions require less permitting related to harvestable trees than other reforestation project types. The permitting requirements are constantly changing, so landowners and foresters should check prior to any project. Pesticide-use permitting is required for all project types. Brush-field conversions are similar to green-timber harvests in terms of timely (rather than emergency) planning, but they typically have much higher costs for mechanical site preparation. Funding is a big obstacle with conversion projects, regardless of who owns the land. Small landowners may be able to receive funding from federal and state cost-share programs.

Tractor piling followed by burning is a common practice for brush-field conversions. Where feasible the brush is sprayed with foliar herbicides prior to piling to kill the root systems and facilitate piling. Spraying beforehand greatly reduces piling time and costs, limits topsoil disturbance, facilitates the burning of dirt-free piles, and eliminates the resprouting of brush that otherwise would be costly to control after planting. Whether spraying before or after piling, piling and burning is usually followed by herbicide spraying before planting to control vegetation. When herbicides are not applied, manual control of competing vegetation via scalping to bare mineral soil is used in conjunction with planting.

