Chapter 7:
Site Preparation

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> "Site preparation is the single most important step in the reforestation process"
>
> Professor Michael Newton

Introduction

Site preparation refers to any measure taken to prepare the site for regeneration of a forest stand following harvest or wildfire or reforestation of a brush field or other site in need. To achieve optimal forest stand growth rates, the common objective is to provide the best environment possible for seedlings, with ample root contact to bare mineral soil, adequate sunlight, sufficient levels of organic material to conserve soil moisture, and the reduction in vegetative competition. Other objectives include: reducing fuels to reduce future risk of fire, leaving enough organic debris to control erosion, leaving enough structure in the form of large woody debris (LWD), snags, hardwoods and other elements to provide for wildlife habitat, leaving some residual trees to mitigate visual aesthetics where needed. Balancing the primary objectives of the landowner with the broader expectations, and sometimes contradictory, of other interested parties is a challenge.

Determining Need and Constraints

Determining the need for site preparation involves many factors, some of them considered limiting factors (Hobbs, et. al., 1992) constraining seedling survival and some in need of mitigation, for example hydrophobic soils. It is also important to not create limiting factors in the process of site preparation. These factors revolve around creating the ecological conditions necessary to enable the survival of planted trees and the desired level of natural regeneration. The primary methods include: mechanical, chemical, burning or manual, with best results usually from an integrated combination. Logging in many situations can also assist in site preparation, such as whole tree logging or biomass harvesting and sending sub-merchantable material to cogeneration power plants. Some of the factors to consider that influence the decision on what method to use are discussed below.

Slash Loads and Fuels Loading

Historically the objective of site preparation activities has been to clear logging debris by piling with a brush rake, and sometimes with broadcast burning, to make the site plantable. Ripping (sub-soiling) is done by some landowners to expose mineral soil for the purpose of planting and to reduce the depth of slash through crushing. Heavy loads of logging debris or slash can be difficult to plant through and will add to the fuel load in the case of a future fire. Deciding how much slash to remove from a site for optimum growth and minimal risk to fire can be difficult. Slash loads that prevent proper planting access need to be addressed. For many landowners in fire-prone interior California, leaving a minimal amount of slash is necessary to help facilitate plantation survival to maturity given the future risk of wildfires. Other landowners with less available investment or that attach less importance to optimal stand growth rates may use less intensive treatments. Thompson (2011) found that a plantations risk of loss to wildfire decreases as age and tree size increases, and stand basal area decreases. Removing excess fuels through site preparation activities is the most influential factor in reducing risk of future fire (Weatherspoon and Skinner 1995). Peterson (2007) indicates lower basal area and low levels of surface fuels increases chances of survival. This indicates a need to maintain low fuel levels and control vegetation to increase growth rate to improve resilience. Slash levels for fuel models are generally classified as light, medium and high levels. Light slash is total fuel load of less than 11.5 tons per acre and fuel bed depth of 1 foot. Medium slash is described as being a total fuel load of 34.5 tons/acre and a fuel depth of 2.3 feet. Heavy slash loads are fuel depths of greater 3 feet. The level of slash loading will affect the rate of spread and the potential flame length. Stands of mixed conifer or mixed conifer and hardwood that are clearcut or heavily thinned are all represented by these medium and heavy fuel models. Medium and heavy slash loads should be considered a high priority for site prep treatments that reduce depth of slash and aid in rapid decomposition of residues. In post wildfire situations where high intensity fire has removed a high percent of the small material retention of the remaining organic material should be a priority.

Vegetative Competition

Beyond the need to remove slash to make sites physically plantable, the next most important limiting factor to reforestation success is vegetative competition. In a Mediterranean climate, the potential lack of available water is the most critical factor affecting survival of planted seedlings. The competition for available soil water can come from native species or invasive weeds. After disturbance from logging, fire or other, conditions are ideal for pioneer species to establish or recover and then dominate a site. A common goal to successfully regenerate a site is to control vegetation on a site for the first two years (year of planting and following year) so that most of the water is only used by the planted conifer seedlings. Keeping the vegetative cover below 30% ground cover for 5 years is best for optimal growth. Pioneer species are very adaptable and site preparation will only reduce their extent and water use temporarily. The soil seed bank and re-sprouting ability of many brush and hardwood species assures their long-term presence. Good site preparation will generally reduce the amount and expense of follow up release treatments that will be needed to achieve the desire level of conifer tree growth.

Soil Type

Soils are the foundation of the forest and its long-term productivity. Forest soils warrant our respect and attention to conserving them. Soil texture can influence what type or types of site preparation to use. Soils can range from fine textured heavy clays to very coarse sandy soils. In general, soils in California forests are loams to sandy loams due to the geology being primarily volcanic, sedimentary and igneous. Fine textured soils (clays) can be susceptible to compaction if operated on under wet conditions. Coarse soils are more erosive than fine textured soils. Decomposed granite for example is very erosive. Picking a logging system that minimizes soil disturbance while leaving the site clean enough to plant is preferred to a mechanical or burning site preparation method that can remove much of the organic matter that has a positive role in controlling erosion. On erosive soils, using proper logging and good chemical vegetation management as an integrated approach will usually achieve the best environmental outcomes with respect to soil erosion and negative downstream impacts.

Recent findings from 20 years of results from the North American Long-Term Soil Productivity (LTSP) experimental sites in California (Zhang et al. 2017) provides some guidance on the importance of organic material on the site and the relation between compaction and subsequent growth of the conifer seedlings. The study examined the effect of timber harvest activities on the residual organic material and effect of compaction. Biomass treatments included: 1) Remove tree boles. Retain crowns, felled understory, and forest floor; 2) Boles and crowns removed. Felled understory and forest floor retained; 3) all above ground biomass removed, including forest floor, with bare soil exposed. The three soil treatments were: 1) no compaction; 2) compact to an intermediate soil bulk density; 3) compact to a severe bulk density. Compaction treatments were intentional and over as much of the area as possible, not merely what occurred during logging. Contrary to popular belief, the treatments to the organic material had little effect on the subsequent growth of the planted conifers. Despite indications on several sites that nitrogen availability was reduced in the forest floor removal treatment, it was not limiting growth at 20 years. Compaction was also shown to have an insignificant effect on seedling growth and in some cases (primarily on coarse textured soils) proved to have a positive effect on growth, due to increased water holding capacity. No sites had negative effects of compaction when varying seedling survival was factored in.

These results are similar to 10-year continent wide results (Ponder, et. al, 2012) stating that: “organic matter removal had no consistent study-wide impacts on 10 year planted tree or total above ground biomass”, “soil compaction per se generally increased planted tree biomass on these predominantly coarser-textured soils, particularly in the absence of forest floor removal”, “vegetation control increased 10 year planted tree biomass and in many cases, foliar N concentrations, with positive responses usually occurring consistently across organic matter removal and compaction treatments". These results are contrary to international meta-analysis (Achat, et.al. 2015) of published data worldwide. Soil fertility losses from organic removal were shown to have negative consequences for the subsequent forest ecosystem, with tree growth reduced by 3-7% in the short to medium term (up to 33 years after harvest) in the most intensive harvests (e.g. when branches are exported with foliage). Ponder et al (2012) suggested possible contributing factors to the lack of negative response from organic removal and compaction in LTSP studies were: 1) most LTSP installations were on deep, relatively productive soils where nutrient limitations are less likely because of greater quantities and proportions left on site; 2) the operational nature of the full tree removal treatments on the less productive jack pine and black spruce sites whereby substantial quantities of fine and coarse woody material were left on-site; and 3) the potentially confounding but variable role that soil microorganisms may play in enhancing tree nutrition by utilizing otherwise inaccessible and/or mineral nutrient reserves.

LTSP installations in California and soils in general on most managed timberlands in California have the noted characteristics of mostly loamy and sandy loam to sandy soils that are tolerant of some compaction and with sandy soils there is some benefit to compaction. Many of these same soils are deep providing for a large reservoir of nutrients. We are blessed to have very manageable soils in California. But evidence from older multi-rotation studies (Achat, et.al. 2015) would indicate that we should still be diligent and wise to practice accepted best management practices (BMP's). Some include:

- not operating when soils are wet, especially on clay soils,
- Leave as much foliage as possible on site, especially on sensitive soils, like shallow, highly acidic, highly weathered and coarse textured soils.
- Do not remove the A horizon during operations

It is important to have the results of these studies in mind when trying to determine the method of site preparation appropriate for the site or if site preparation is necessary at all. The fundamental decision of implementing a site prep activity should be creating a positive environment for planting seedlings. Initial success depends on being able to plant the site well and long term optimum growth is dependent on proper planting. Long term growth increases from site prep activities that remove slash or mitigate compacted soils are less predictable, but we should still be cautious and avoid compaction at the time of harvest and retain organic material for optimum soil health.

Topography

Slope can also effect what options are available for site preparation. Steep ground has fewer options than gentle slopes. Options on steep ground are generally more expensive. Site preparation on steep slopes is usually limited to whole tree logging or broadcast burning. The whole tree logging usually leaves a significant slash load along roads, which needs to be burned. Broadcast burning is increasingly being limited by smoke management issues along with liability and cost associated with risk of escaped burns. Manual methods can be used but are very expensive. For mechanical methods, tractors are generally limited to slopes less than 35%. Excavator mounted equipment with self-leveling cabs can work up to about 45% slopes depending on soils. The Spyder can be used on slopes to around 65%. Trends of increased slash loads being left on steep slopes is becoming a fuel loading concern with deteriorating markets for small material and liability concerns.

Hydrophobic soils

Hydrophobic soils are usually the result of high intensity wildfire, often on coarse textured soils, and can generate considerable soil erosion after a wildfire (Certini, 2005; DeBano, 2000). Additional soil disturbance on coarse textured soils is usually not encouraged due to erosion risks. A 4-year study of erosion in sites with different combinations of post-fire logging and contour subsoiling treatments suggests that on moderately sloped sites affected by high-severity forest fires, salvage logging—particularly when implemented immediately post-fire—can substantially reduce erosion (James & Krumland, 2018). As noted elsewhere it is crucial that tractors follow the contour when subsoiling to avoid concentration of water in new ditches that can become gullies.

Compaction

Sub-soiling is the primary form of mitigation for compaction done by mechanical activities such as logging or piling. This is particularly applicable with clay soils. Sub-soiling to mitigate any present or past compaction also adds another mechanical disturbance to vegetation and makes for easier and less expensive planting.

Animals

Vertebrate pests can do significant damage to planted seedlings. These primarily are pocket gophers, deer and elk. Mountain beavers, rabbits, wood rats and voles can also cause damage. Manipulation of habitat is usually the long-term solution. Short term protection and control methods may be necessary. It is important to make sure that during the site preparation process habitat is not created that may encourage some pests.

Disease

When diseases are present or in the near vicinity the best time to deal with these are during harvesting and site preparation. Root rots that exist in stumps can transfer to young seedlings of susceptible species. Chapter 10 provides good guidance on how to deal with root rots and other diseases. Mistletoe is another example that is best dealt with during harvest and site preparation. Getting rid of the source within spreading distance of seedlings to be planted is the easiest solution.

Temperature

High temperature can be a problem especially with Douglas-fir (DF) seedling survival. Southerly facing slopes will always be hotter and should be a major concern. Burned surfaces or organic material generate hotter temperatures than bare mineral soil (Haig et al. 1941). Site preparation can improve conditions by creating bare mineral soil. With DF it is also important to leave LWD where possible to provide micro-sites for planting that provide some dead shade and shelter from afternoon sun. When planting in harsh sites, it is even more important to plant seedlings with small tops, good caliper and a high root to shoot ratio so that they will have a better chance of survival.

Low temperature can also be a problem too in the form of frost. Frost is particularly problematic with DF and the true firs. Higher elevations particularly on eastside flat locations are problematic. Air drainage is very important to providing conditions favorable to fir species. Site preparation activities that block air flow should be avoided. Clearing brush to improve air flow is helpful. DF should be planted on slopes where possible and avoid low lying flat areas particularly on the eastside. Areas that are known to be frost pockets should be planted Ponderosa pine or Lodgepole pine in extreme cases to ensure survival.

Costs

Economics have a significant influence on what types of site preparation are utilized and how much is spent. The time value of money encourages one to spend the least amount necessary up front due to the length of time the costs must be carried. By the same token good site preparation can significantly increase growth, helping to justify proper site preparation. Good site preparation also considerably reduces follow-up release costs. Lack of any site preparation or poor site preparation can also lead to a completely failed plantation and the need for a costly replanting.

Safety and Snags

Snags are increasingly are being left as wildlife habitat. Leaving snags must be done with operator and public safety kept in mind. The quantity, quality and location of snags retained needs to be well planned to minimize safety hazards. Snags should not be left within a tree length of roads due to public safety and to reduce spread of future fires. Roads are often used as fire lines and snags next to roads can cast sparks over fire lines the can speed the spread of wildfires. Snags should also not be left along ridge tops to help prevent spread of wildfire from embers that are carried in the wind. For operator safety, the removal of snags that are judged to be public safety or fire spreading risk should be done as soon as possible after the wildfire while snags are still sound and can be safely cut. As the snags age, they are increasingly prone to falling. Research conducted on Blacks Mountain Experimental Forest with a species composition of primarily ponderosa pine, white fir and incense cedar after the Cone Fire in 2002 calculated that 80% of snags fell within ten years (Ritchie, 2014).

Worker safety for the various forms of site preparation varies. The highest workman's compensation claims in reforestation activities are related to chainsaw work. Burning related activities are followed by equipment operation for frequency of injury. The safest activity related to site preparation was the application of herbicides (Newton and Dost, 1984). With current worker protection safety standards and the application of herbicides that do not affect mammals, the negative impacts of herbicide exposure to humans and mammals is minimal. There is always public concern about the potential of herbicide application to affect non target plants, fish, and animals. The use of hand application along with buffers on streams is a useful mitigation to limit public exposure where recreational users are more common.

Methods of Vegetation Control

There are many different methods for controlling unwanted vegetation, and the selection of the desired method is a keystone in the success of the reforestation project. These various methods that can be used in site preparation are introduced here and more detailed information for use beyond the site preparation phase can be found in other chapters within this book.

Mechanical

Mechanical site preparation includes logging, piling, sub-soiling, mulching, V-blading, terracing, mastication, chipping and other methods. There are many forms of mechanical site prep and many types of equipment that can be used to accomplish the basic objective of making a site plantable. The more complex objective of balancing fuel loading, erosion control, wildlife habitat, aesthetics and other goals including economics can be difficult. Ease of planting and ensuring a favorable environment for the seedlings should be the underlying goal of mechanical site prep.

Logging

Logging disturbance is a basic site preparation activity that can be one of the most cost effective of all the methods. Directing the logging contractor to remove the whole tree to the landing can provide both removal of excess organic material and some level of scarification. Construction of skid trails provides additional scarification. Site preparation achieved by logging may not be evenly distributed across the harvested area and may not achieve desired results.

A commonly used form of logging that can accomplish slash disposal and reduce the need for tractor piling is “whole tree logging”. Taking the whole tree to the landing takes most of the slash too. When markets are strong for biomass and cogeneration power this has been a popular method of logging for commercial and sub-merchantable materials. Leaving the material on site for a while (at least a month) after shearing allows drying time to facilitate chipping and maximizing haul weight to the cogeneration facility. It can also facilitate leaving more of the foliage and nutrients on site as more foliage will fall off during the skidding process when it is dry. It allows for the disposal of tops left on the landing and chipping of small material that is otherwise waste. Removing as much sub-merchantable material as possible can reduce the need or eliminate need for site preparation. Biomass thinning allows for understory thinning for fuels reduction that is a valuable treatment for reduction of fire risk.

There is one variation to whole tree logging that is being implemented due to the limited biomass markets and the diminishing infrastructure. The feller buncher (hotsaw) cuts all of the sub-merchantable material (3 – 10 inches in diameter) along with the merchantable timber (typically up to 23 inches in diameter at the stump) in a harvest unit. The skidding equipment is brought in along with a log processor and log loader at the landing. As the merchantable timber is processed at the landing the exiting skidding equipment grapple the unmerchantable tops and limbs from the processing operation at the landing and pack it back into the harvest unit, evenly spreading out the material. Repetitive turns from the unit to the landing and back additional dispersal and breakdown of the slash.

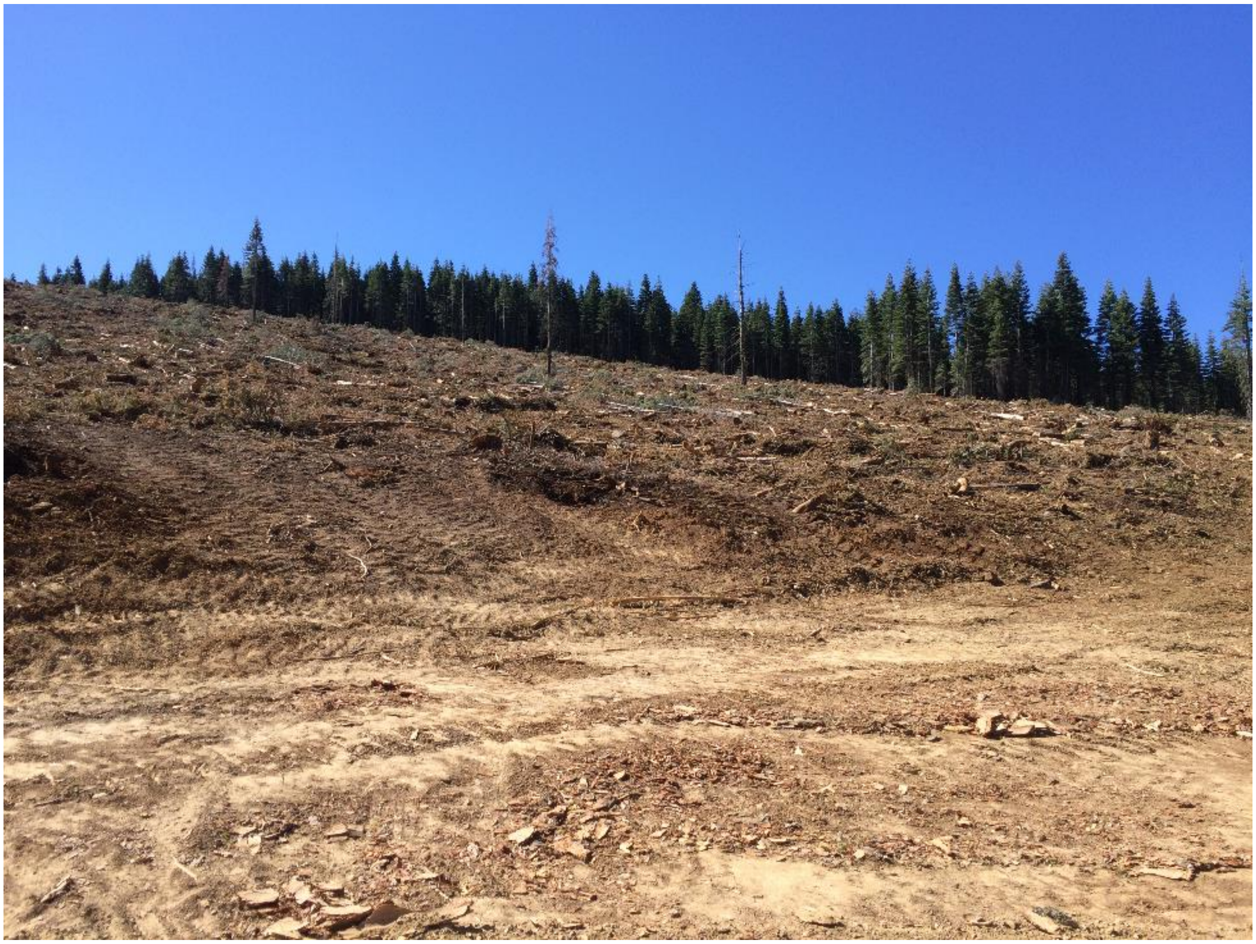

Figure 7.1 Unit with landing slash returned.

In-woods processing is another alternative that is being implemented and similar to the operations mentioned previously. In this operation, the log processor is placed in the unit to process logs previously bunched by the feller buncher. The processor removes the limbs and severs the tops of the merchantable trees from the boles leaving the material more evenly distributed throughout the unit. The skidding equipment grapples and skids a full payload of the processed logs to the landing. The logs can be decked or immediately loaded without any material generated at the landing. The action of the log processor moving through the unit along with the repetitive turns from the skidding equipment, allow additional dispersal and breakdown of the slash.

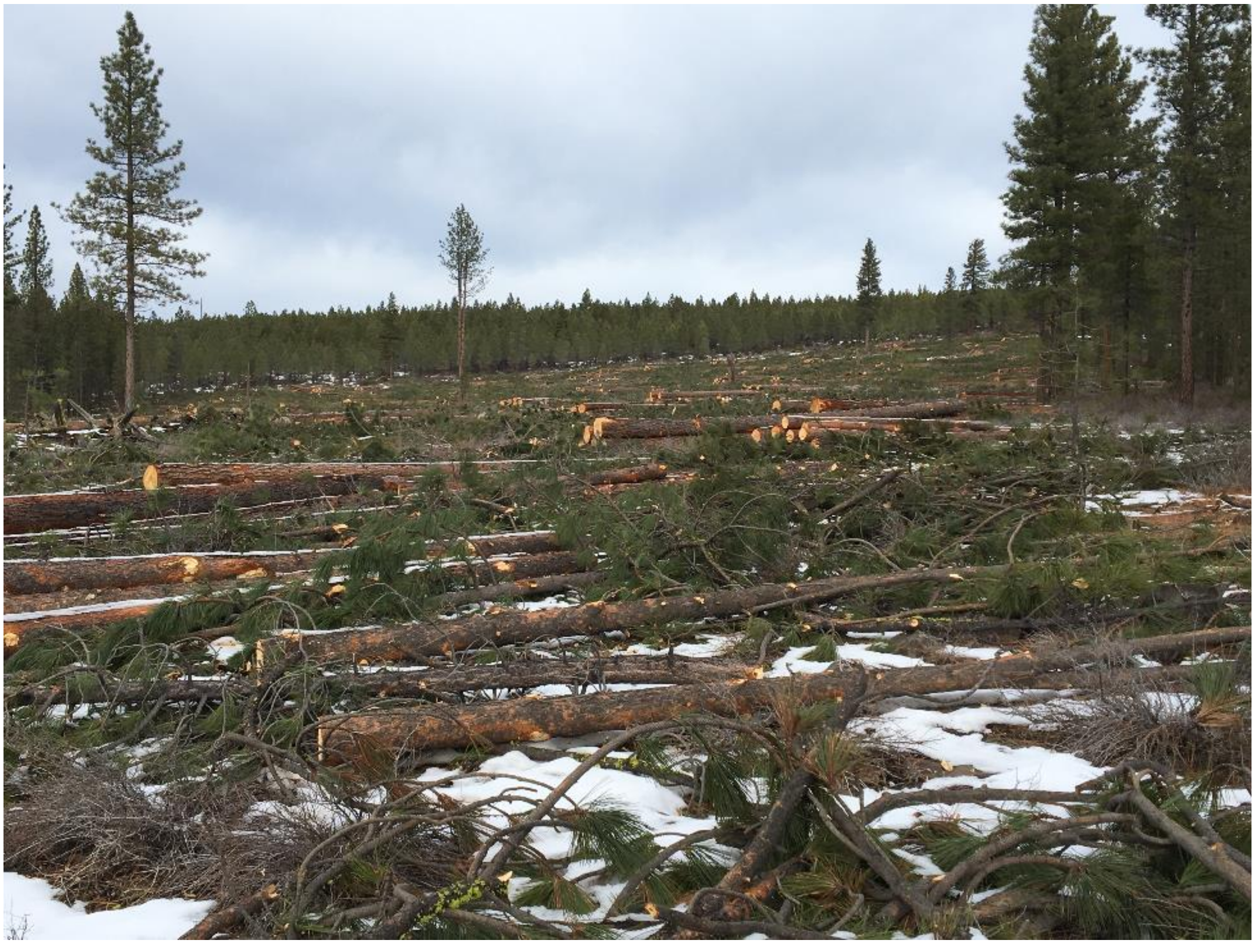

Figure 7.2 "In woods" processed logs.

Piling

Piling involves the gathering of the slash generated from logging activities with a brush rake mounted on a cat or excavator and placing it in piles or wind rows for burning. For the conversion of brush fields, the most common practice is to root out the brush and place it in windrows and after a period of drying, the windrow is rolled into a pile. This helps to remove soil that is being held in the roots. It is important to avoid including soil in the piles for two reasons. First, the top layer of soil or A horizon plays an important role in the initial establishment and growth of the seedlings because it is where the highest level of nutrients resides. When the A horizon is removed completely, the plantation may have poor growth for many years or fail to properly establish. Secondly, when there is soil incorporated into piles that are then burned, there is an increased possibility that incomplete burn consumption will occur in the piled material. This mix of soil and combustible biomass can lead to smoldering material that may reignite when conditions dry in the spring. Nutrient-rich soil in smoldering piles will also have organic matter and nutrient volatilization from heating intensity and duration, losing site nutrient capital. Piling can also be done by hand, but is cost prohibitive in most cases. Slope can be a limiting factor for mechanical site preparation as most equipment can't be used on slopes greater than 35 percent. In areas of high fire risk or subject to dry windy conditions, site preparation methods that don't require burning may be a good alternative.

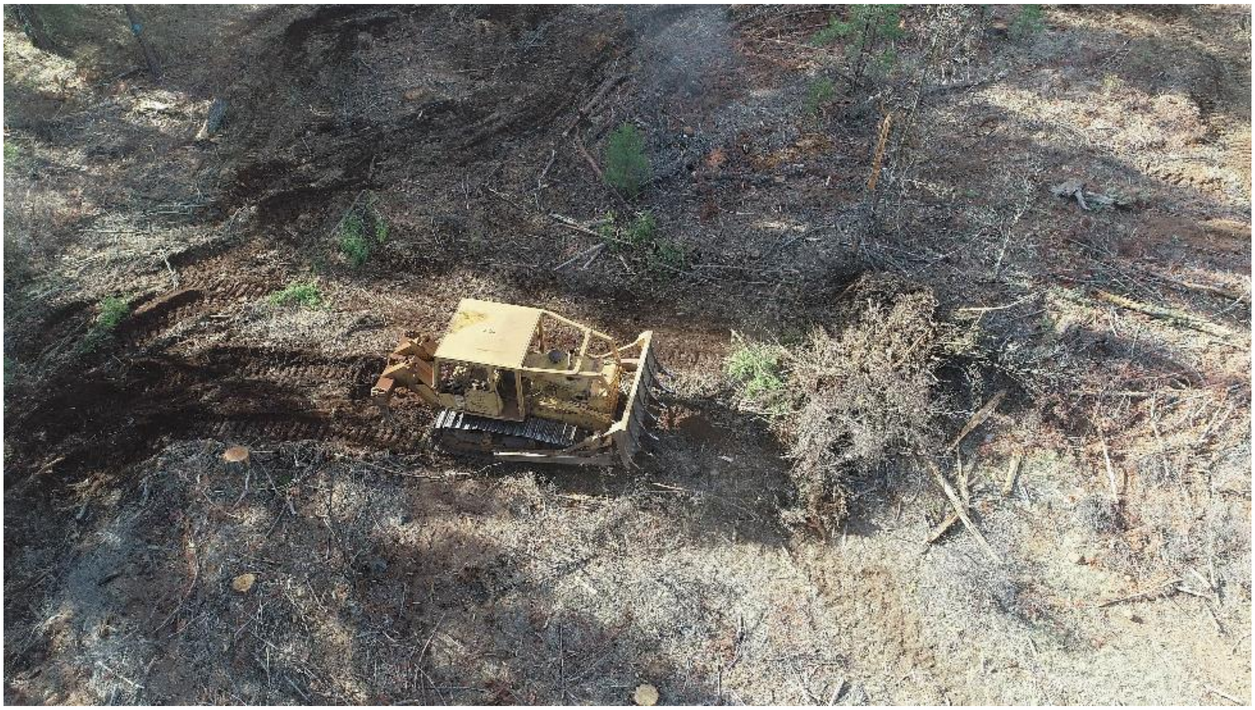

Figure 7.3 Cat with brush rake piling logging slash.

Sub-soiling

Sub-soiling or tilling is most commonly the practice of pulling a single or double set of shanks with winged sub-soilers through the soil with a tractor. Rock ripper shanks are also commonly used but do not fracture nearly as much ground as winged shanks. Wings on shanks should have only a slight angle from horizontal (less than 3 degrees). The objective is to lift and fracture not to plow. Sub-soiling to mitigate compaction primarily on clay and clay loam soils should target a minimum depth of 18 inches. Most compaction caused by mechanical equipment is present within the top 18 inches of soil. Because this method of site preparation causes a linear gully effect, it is extremely important that the feature is made on the contour. If not on the contour, it could lead to concentrated flow of surface water and increased erosion potential. This method of site preparation can be used in conjunction with other methods of mechanical site preparation or used as a single treatment. As discussed previously, this method has been used extensively in reforestation programs as mitigation for compacted soils. While this rationale for tilling may not be supported by scientific evidence for most of California soils, there are other benefits that can be achieved through the practice. Tilling after fire and salvage operations can have a beneficial effect on infiltration rate as it can break up hydrophobic layers that frequently develop in burned sites, particularly with coarse-textured soils. Tilling of coarse textured soils other than for mitigation of hydrophobic soils is not advised because it will reduce the water holding capacity of the soil. Tilling also serves to break up slash and incorporate it into the soil thus speeding up the breakdown of combustible material on the site, and perhaps benefitting soil organic matter (humus) development.

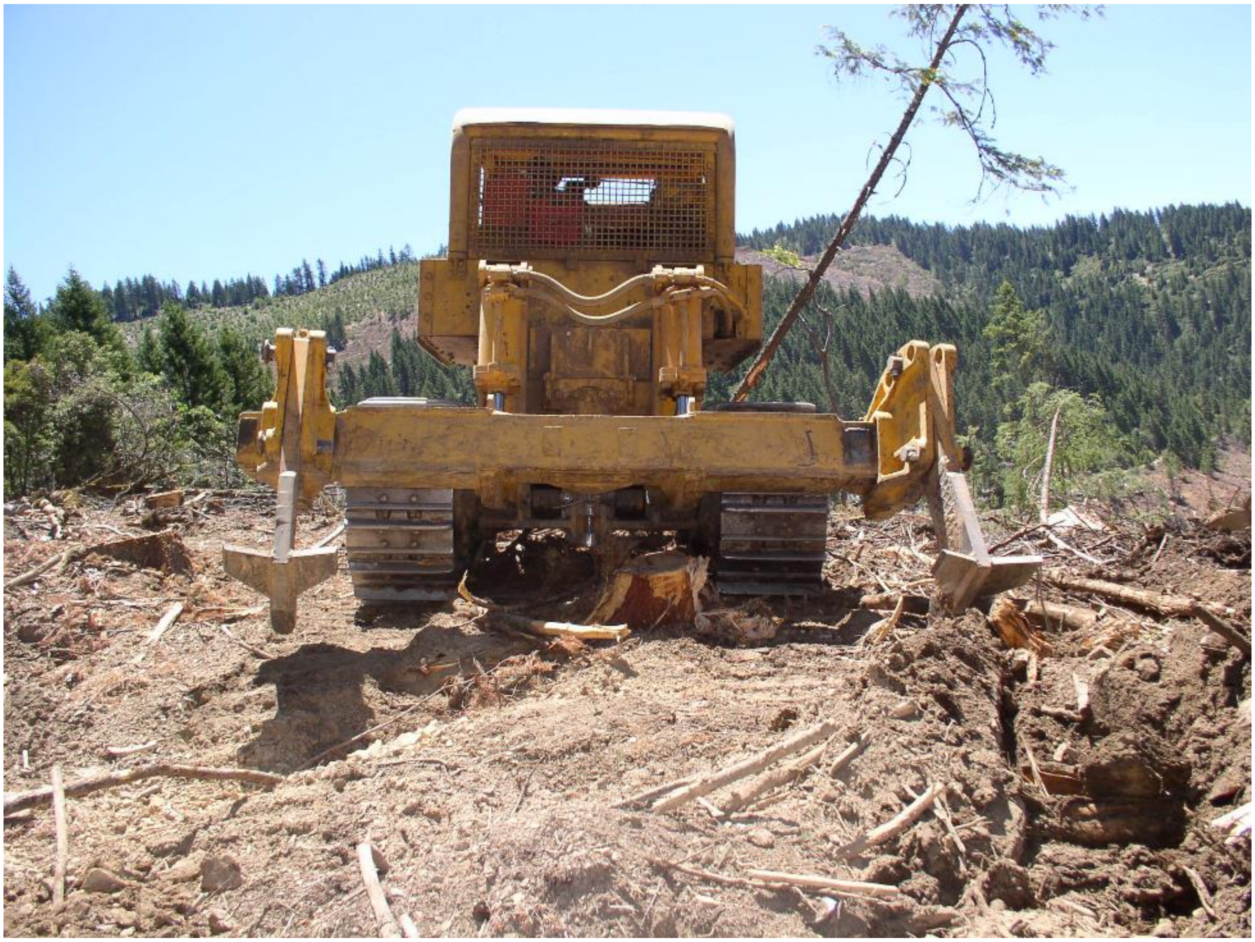

Figure 7.4 D8 with Winged Sub-soiler shanks.

Mastication

Mastication has been used extensively in the effort to reduce fuels at the wildland urban interface. It is an effective way to clear brush along fire breaks and reduce overall fire risk. More recently it has been used to reduce the fuel loads in harvested units and retain some of the benefits of providing a mulch layer to the soil. Mastication involves crushing or grinding vegetation on site with some type of specialized head mounted on a piece of heavy equipment. The type of equipment can range from small bobcat machines to large excavators. This method of vegetation control is expensive, but burning afterward is not necessary. Organic mulch that is left on site may also increase the water holding capacity of the soil (Hudson 1994). It is a good method to use when vegetation is very large hindering reforestation efforts. Masticating the vegetation (figure 3&4) will not kill most species and re-sprouting will most likely occur. It is best used in combination with herbicides for effective control. It is usually used more with release applications where large brush is present, but increasingly as a site preparation to avoid potential liability of burning. Due to risk of starting a fire by hitting a rock and creating sparks, many mastication operators prefer to avoid work during the hot dry summer months or work in areas that are less risky (rocky). Some units have foam units mounted on them to immediately put out a fire if one starts.

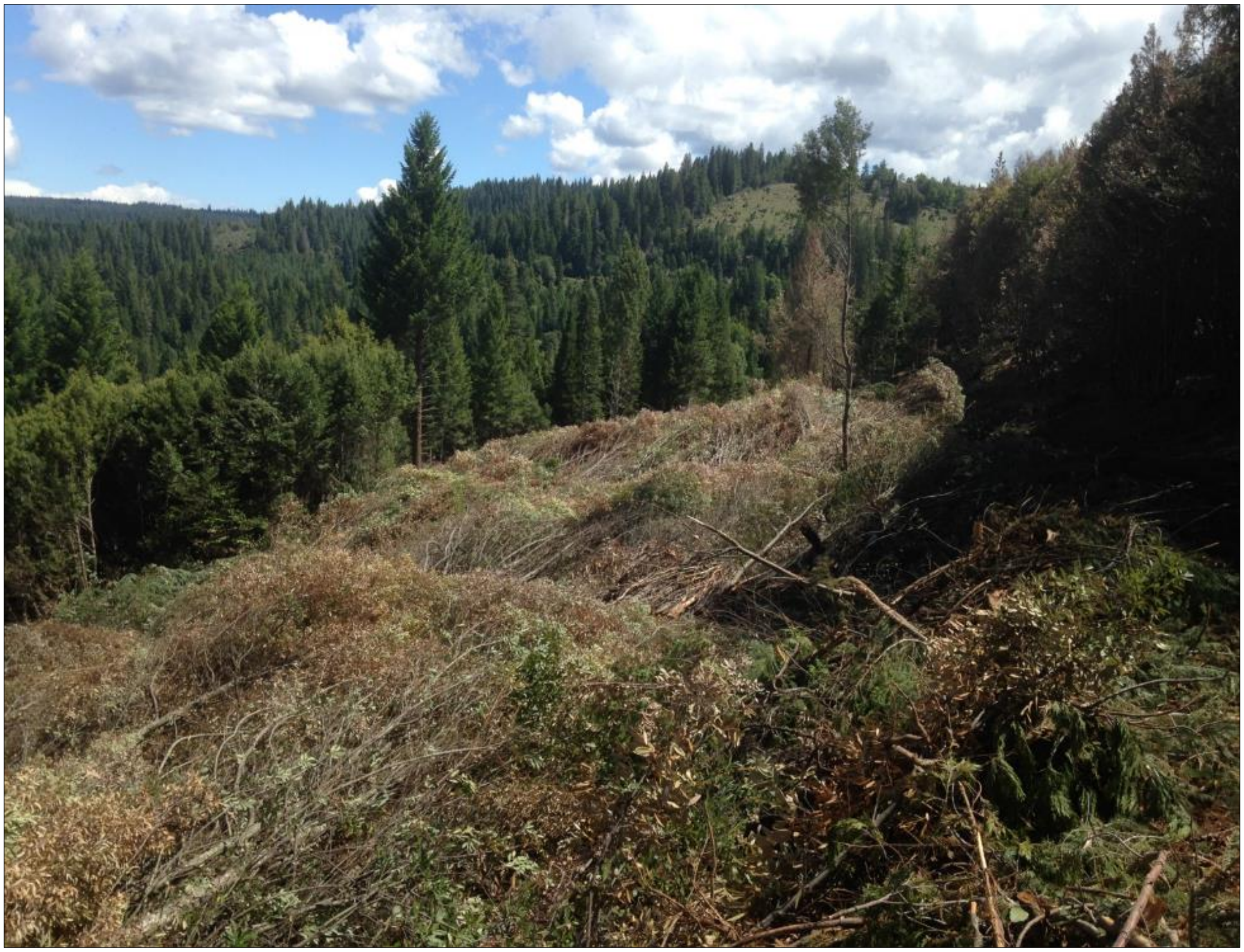

Figure 7.5 Before mastication.

Figure 7.6 After mastication.

Chipping

Chipping sub-merchantable, or unmerchantable, material prior to harvesting is a method to reduce the overall impact of having too much biomass on the harvest unit. The process is to cut all unmerchantable trees of all sizes for use as woody biomass. Typically, the biomass is cut and bunched with a feller buncher and then skidded to the landing where it is chipped into a van for shipping to a co-generation facility, this can be done as a pre-harvest like with a clearcut or as a post-harvest. Post-harvest chipping includes the cutting of the remaining unmerchantable material that is left standing after harvest and skid to the landing where it is chipped along with the top piles. Post-harvest logging debris can also be skid to the landing for chipping, further reducing the amount of organic material left in the harvested unit. Removal of biomass does not benefit the growth potential of the site as previously discussed, but it does facilitate the ease of planting and reduces the fuel load. Using biomass thinning can be a stand-alone site preparation treatment or it can be used in conjunction with other mechanical site preparation activities such as sub-soiling and/or with chemical treatment. Biomass chipping usually eliminates the need for piling and leaves more organic material on site to act as mulch that is particularly beneficial to Douglas-fir. Having more organic debris on site also reduces risk of erosion.

With small landowners one needs to distinguish between biomass chipping and small hand chippers. Most small landowners visualize chipping with a small chipper and do not understand what biomass chipping is. The difference between commercial biomass chipping for power cogeneration and small chipping for example defensible space around a structure needs to be recognized.

V-Blading

Tractors mounted with a V blade can be effective in mitigating high slash loads or for facilitating making planting sites in brush field conversions. The V blade casts the brush to the side exposing bare mineral soil that is ready to plant. In brush field conversions, it is best to kill the brush with an aerial application of an appropriate herbicide at least a year in advance of V blading as large green brush can be difficult to root out. It is possible to pull a single ripper shank behind the tractor if sub-soiling is a desired treatment. This method of site preparation is limited to level terrain and is difficult, if not impossible to do where there are many tree stumps.

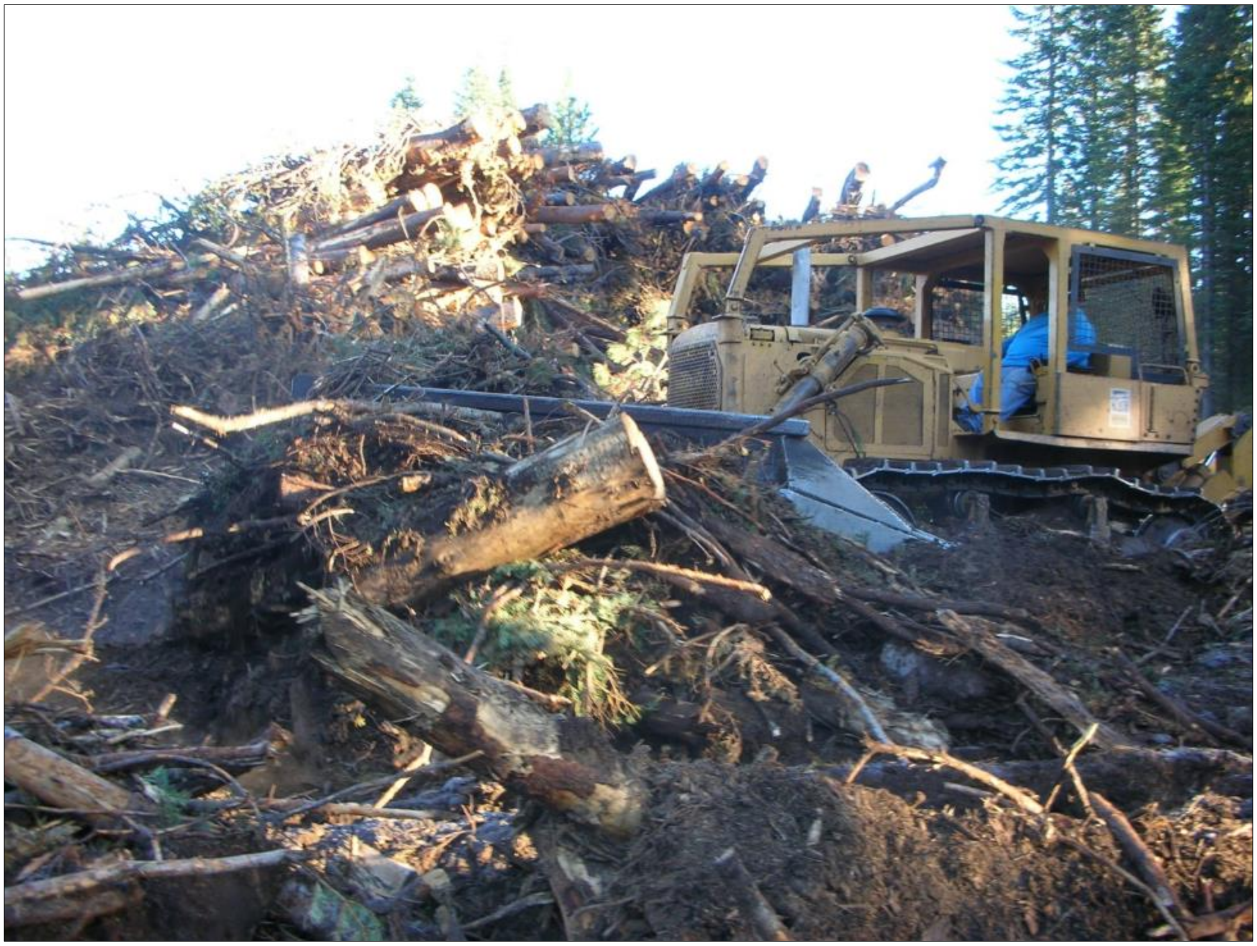

Figure 7.7 V-Blade clearing landing slash for planting.

Spot Cultivator

One site preparation tool that has been used in California with some success is the VH Mulcher. This machine utilizes a spinning head with angled blades that not only crushes vegetation in a circular area about four feet in diameter, but mitigates compaction and creates planting spots for seedlings by tilling the soil. It is expensive and can run between $150 and $400 per acre depending on the number of planting spots created, density and size of brush, slope and rockiness. It crushes and grinds the vegetation creating fairly small spots, so it usually must be used with another form of vegetation control to be successful. The planting spots created are depressions in the soil that have been vigorously disturbed. Vegetation is usually slow to come back in the holes themselves, but encroachment from the edges is fairly rapid.

Figure 7.8 VH Mulcher Mounted on an Excavator.

Spyder

The spyder is another specialized form of mechanical site preparation equipment designed for piling slash on steep slopes. This equipment is capable of operation on slopes over 65% but gets more expensive as the slopes steepen. To keep the costs under control one must be careful to just make the site plantable and not overly clean the site. If piles created are burned, one must be very careful with the burning prescription. If one is not careful burning piles on steep slopes that are not cleaned they can easily turn into a broadcast burn. If one does plan to burn these types of units, it is highly recommended to put a fire line around them just in case the ignition turns into a broadcast burn.

Figure 7.9 Spyder site preparation machine.

Terracing

In the case of steep terrain, terracing has been used historically to primarily clear brush and occasionally logging debris to make planting sites. Terracing is done by using a tractor with a straight or angle blade to dig into the hillside and side cast organic material and soil downhill creating a nearly level surface. The terrace must be slightly out sloped and on the contour to facilitate proper drainage and minimize erosion potential. Creating terraces can be extremely expensive and cause adverse effects when topsoil is displaced and mixed, and the flat terrace surface may be less hospitable subsoil that can have long-term detrimental effects on productivity. For these reasons this once common site preparation method is rarely used in California.

Mounding

Mounding is used in high water table situations to create planting spots that are well-drained. This can be done with a VH Mulcher or an excavator. This is a very common practice in Canada but rare in California, usually used in areas around meadows or flats with high water tables. The problem is opposite in California, with planting usually in the bottoms of holes or sub-soil furrows to get closer to water.

Other

There are many forms or systems of equipment that can be used to accomplish various site preparation objectives. There is old equipment modified for various objectives and new equipment being developed all the time, be creative and give operators a chance. Some examples include: the tree planting excavator in Canada used to create mounds and plant trees at the same time, farm tractors mounted with large heavy-duty roto-tillers.

Manual

Manual vegetation control involves cutting, grubbing, pulling or some other method of physically removing vegetation by hand. These are usually associated with sensitive sites including; steep slopes, highly visible, urban-interface or other areas of concern.

Vegetation control using these methods is usually of short duration and application costs can be very high (Knowe 1992), and as a result, they are commonly used in combination with another method of vegetation control. Manual control of vegetation is particularly useful in areas that chemical application is not feasible, such as projects in close proximity to residential areas or in areas that may be sensitive to herbicide application due to multiple water courses and associated buffer zones. Other uses might be in very remote areas with limited access by application equipment where grubbing crews can provide a release treatment by hiking into the treatment site. Manual treatments are frequently used by the United States Forest Service (USFS) in their reforestation activities, at least, in part, due to the complex authorization process required prior to use of chemical treatments.

Grubbing

Grubbing is often used as vegetation control as an alternative to herbicides. Most often it is used as a release treatment but can be used as a site preparation method. Research done as part of release studies gives direction on the minimum and effective sizes of treatment. McDonald, Oliver and Fiddler with the Pacific Southwest (PSW) Research station have conducted many studies in northern California from the 1970's to the present focused on woody competition and effects on survival and growth. Early studies were summarized (McDonald and Oliver, 1983) comparing various grubbing techniques to herbicide treatments. It was statistically significant that when woody shrubs were greater than 20 to 30 percent of cover seedling and sapling growth is retarded. From early studies (Fiddler and McDonald 1984, McDonald and Fiddler 1989) the minimum effective radius is 5 feet, any lesser radius does not give the conifer seedlings time to develop the deep and extensive root system necessary to secure adequate soil moisture for growth at the potential of the site. These same studies found, the first 3 years are important; the first year is critical. Seedlings must be free to vigorously expand their root systems in an ever-increasing volume of soil. Results from Tesch and Hobbs (1989) with Douglas-fir showed roots expanded greatly in biomass and volume of soil occupied in the near-absence of competing vegetation, but developed scarcely at all if roots of competing species were present. McDonald and Fiddler (1990, 2010) found, grubbing 4 foot radii around ponderosa pine seedlings did not appear to be effective biologically and was expensive. Applying treatments at an early age led to statistically significant differences among treatments earlier than in other studies, and suggested the worth of treating competing vegetation as soon as possible. The two most intensive treatments in this study, Velpar herbicide and increasing the radii to 6 feet were the most effective. McDonald and Oliver (1984) found, the best treatment is one that not only effectively controls competing vegetation, but does so when conifer seedlings are becoming established.

A clear conclusion from these studies is that the minimum cleared radii for effective treatment is 5 feet. For smaller distances, the roots of the adjacent vegetation was able to access enough of the water and nutrients in the cleared area to impede the growth of the seedlings. Treating entire plot areas whether by grubbing or herbicide produce the best survival and growth. From a cost perspective, the grubbing is exponentially more expensive than herbicide. McDonald and Fiddler (1990) showed effective grubbing to 6 foot radii had labor costs $578/ac vs. a total cost of $152/ac ($38/ac for labor, $113 with chemicals) for Velpar. McDonald, Fiddler and Myer (1996) showed grubbing a 4 foot radii for 3 years was $420/ac and Velpar $102/ac. (the labor component was $27/ac.) McDonald and Fiddler (1995) found grubbing entire plot twice was $1,696/ac. compared to the labor cost of spraying Velpar of $27/ac.

Mulches and Mulching

Mulches used as a site preparation tool for the regeneration of conifers have been tested and applied commercially in many different forms. Paper, polypropylene fiber mats, plastics and many other sheet form materials have been used with varied results. The rational for applying mulch in these forms is to control competing vegetation and create a more favorable moisture environment for the seedlings. Studies have shown that the size of the mulch mat needs to be 10’x10’ to significantly enhance conifer seedling growth. (Fiddler and McDonald 1987) When using large size mats, it is important that the mats are made of a permeable material that allows moisture through to the soil below. These types of mulches have proven to be very expensive from a material and installation standpoint and generally less effective for control of weeds than chemical or manual weeding. Gophers and voles often find the mulch material a good place to take up residence and can cause damage to the seedlings. In high value areas such as in campgrounds or in park settings where use of herbicide may not be an option, these types of mulches may be a viable alternative. In large scale projects that generate slash and other organic debris, use of machinery to convert that material into organic “wood” mulch form may be feasible.

Hand Piling

Hand piles are often associated with slash disposal and fuels treatment in difficult areas like along roads and around structures particularly in the wildland urban interface (WUI). Small piles oven associated with defensible space are limited to 4'x4'x4' to allow rapid burning and control adjacent to structures. They can be used in small landscape areas where it's not cost effective to move in equipment or on steep slopes that will not allow equipment. Hand piling and burning is very expensive and risky due to liability of fire and usually limited to high value sensitive areas.

Biological

Biological control is achieved utilizing a naturally occurring organism or substance to control vegetation. Successful examples of biological control include control of tansy ragwort (*Senecio jacobaea*) using the Cinnabar Moth (Fuller 2002) and control of St Johnswort (*Hypericum perforatum*) with the Klamath weed beetle (Holloway 1964). Pathogenic fungi are also under investigation to control certain types of vegetation, but to date the results have not been as successful (Wall 1996, Wall & Shamoun 1990). Biological control methods are usually limited to very specific pests, which does not make them applicable to broad spectrum vegetation control. They are usually also restricted to certain geographic ranges or elevations. In most cases, biological controls are a small part of a larger management program (Newton & Dost 1984).

Burning

Fire is of the most common cultural treatments historically used to manage vegetation in forestry. But today with increasing constraints and regulations regarding air quality and smoke management along with general liability concerns, this practice is used much less frequently. Smoke management plans have also made burning more difficult in recent years. The number of burn days available are fewer to comply with Clean Air Act requirements. Historical uses of fire revolved around reducing post-logging slash and residual vegetation on site. Substantial gains in vegetation control have also been shown when burning is used in combination with herbicides (Powell 1992). Burning without the use of herbicides can actually release some fire adapted species such as deerbrush, snowbrush, blue blossum (*Ceanothus thyrsiflorus)* and knob cone pine (*Pinus attenuata*) (Weatherspoon 1987, Newton & Dost 1984).

Fire has been shown to increase conifer survival and growth, especially in combination with herbicides (Taylor et al. 1991). The authors looked at piling, broadcast burning and spraying, burning alone, all treatments with and without disking. Two years after treatment, the spray plus burning treatment had greater consumption of fuel compared to burning alone, and better vegetation control and seedling growth than either burning alone or the piling treatment.

Fire Behavior and Prescriptions

There are several disadvantages to using fire for vegetation management. The liability associated with burning is substantial. There is always the risk of escape and associated suppression costs. The importance of developing and following a detailed prescription for any planned fire is essential. Ten-hour fuel sticks are a valuable tool for monitoring fuel moistures to monitor fuel moisture inside and outside of units, an important prescription factor being the difference inside and outside the unit. Burn bosses must have a thorough understanding of fire behavior and weather. Weather conditions prior to during and after a fire are critical to success. Weather after a burn is not always adequately considered. Many problems with fires escaping are in the days after a fire when strong winds cause fires to escape before they are extinguished. Patrolling a fire and mopping up after fire is essential prior to any forecast wind events. The forester must also have the experience and ability to call off a potentially high risk burn when conditions are not right.

Broadcast Burning

Broadcast burning on steep slopes is one of the primary methods of burning to reduce fuel loads to make site plantable and facilitate follow up planting and spraying. One significant advantage of fire is adaptability to steep slopes where heavy equipment use is infeasible. The use of fire reduces difficulty for hand crews during subsequent planting, spraying and thinning, thereby, reducing costs (Newton & Dost 1984). Once the prescription is done it is important to prepare the unit for burning. A key step is creating an adequate fire line to contain expected fire behavior. Often this is best done by the logger while on site if they have the proper equipment rather than moving equipment in just to build fire line. Sometimes there is slashing work or chemical application to kill brush that helps create conditions that allow fuels to dry faster than adjacent fuels to allow a fuel moisture differential that facilitates burning the unit while it is dry and adjacent ground is still wetter. This helps prevent fire spotting and escapes. Another practice to reduce risk of escapes is “black lining” the top of the unit before lighting the rest of the unit. By burning a strip off the top of the unit and letting it cool down, it effectively widens the fire line at the top of the unit.

Figure 7.10 Broadcast burning.

Another key factor to facilitate safe burning is access. It is essential to have good access for equipment especially water tenders and fire trucks to the top of a unit in case of an escape. Getting personnel and equipment to a spot fire in a timely manner facilitates control in a timely manner. This is another instance when working with the logging administrator is advisable. In preparation for burning it is important that the logger does not block off roads or water bar them so extensively that a water truck cannot access the unit.

During ignition operations, it is imperative to have adequate personnel and equipment available to accomplish ignition and containment. One way to limit the number of personnel needed is to do ignition with a helicopter. This can be riskier from the perspective of generating too much fire too fast and increase the risk of escape. The benefit is not having to expose burners to the risk of lighting the fire by hand and its risks to rollers, falling, and dehydration. There are additional logistics involved but if there are several burn units in a localized area this is a way of getting more done to take advantage of narrow and infrequent burn windows.

Pile Burning

Burning piles can take on many forms such as hand piles, tractor piles or windrows and landing piles. Each has its own pros and cons. As with all fire, liability is becoming a greater concern and limitation. Like broadcast burning it is important to monitor piles after they are burned until they are out and mop up if necessary, if high winds are forecast and piles are not out. A wise tactic for preparation of all burn piles is to cover them or at least a portion of them with some waterproof cover. This is especially true of small hand piles and landing piles. This facilitates burning piles during wetter, safer conditions by creating a dry portion in the pile to assist with ignition. The temptation can be to wait until things are very wet, but usually it is better to burn a little earlier (but after adequate precipitation) to get more complete consumption. Poor consumption can lead to hold over piles that rekindle in the spring. Large landowners are more acceptable of marginal fuel consumption. If burning on small landowners, they normally expect much cleaner sites upon completion. If there are large units to burn with large piles it is advisable to contain the piles with a fire line prior to burning to help avoid escape.

Hand piles have the advantage of being small, burn down rapidly and go out faster. But if one lights too many piles and they are not out before a major wind event they can still be a problem. Tractor piles are large and can burn for days, weeks or months depending on how much dirt ends up in the piles that may bury large fuels that can smolder for a long time. When piling brush, it is often difficult to avoid getting dirt in the pile, especially with species like chinquapin that has an extensive root system. The best way to try and reduce dirt in a pile is uproot the brush throughout a unit and then go back and finish the piles. This allows the brush and soil some drying time to enable some dirt and finer foliage to fall off as the material is moved into completed piles. This accomplishes getting less dirt in piles and leaving some of the nutrient rich vegetation on site, providing some organic material for erosion control. Avoid the temptation to create completed piles as you go.

A technique being used for logging slash in conjunction with whole tree logging is to shear the material with hot saws and then skid sheared bundles to landings for concentration or to scattered piles in a unit. Compared to pushing sub-merchantable material into pile with a brush rake, this technique has the advantages of fewer piles to burn, cleaner piles with less dirt in them, and s cleaner and faster pile burns. Excavator type loaders from logging are used to stack the piles to facilitate larger and fewer piles. Individual sheared bundles usually do not burn that well, so it is better to combine the bundles to get better burn conditions and consumption.

With whole tree type logging landing piles can be very large if biomass markets do not exist. To provide for a safe burn it is critical that the piles not be pushed up against green residual trees that are meant to be saved. Since these piles can generate tremendous amounts of heat, a wide fire line around the pile is essential to contain large piles while burning and from radiant heat. It is most efficient to build the fire lines when the appropriate logging equipment is on site. Working with the logging administrators is critical to getting the appropriate fire lines constructed economically.

Large landing piles generated from chipping residue can be particularly problematic. These piles potentially have a lot of small organic debris and soil in them and not much air space making burn consumption poor. If they are built with a landing cat instead of a grapple loader they can have a lot of dirt in them, which reduces the degree of burn consumption. Large landing piles take a long time to burn and need to be monitored in the spring to make sure they are out. An alternative is to skid this residue material back out and scatter in the harvest unit as it is being generated. This material is often nutrient rich and good for long-term productivity. It's important that it is not spread to thickly so it can be planted through and spread to areas beyond the landing.

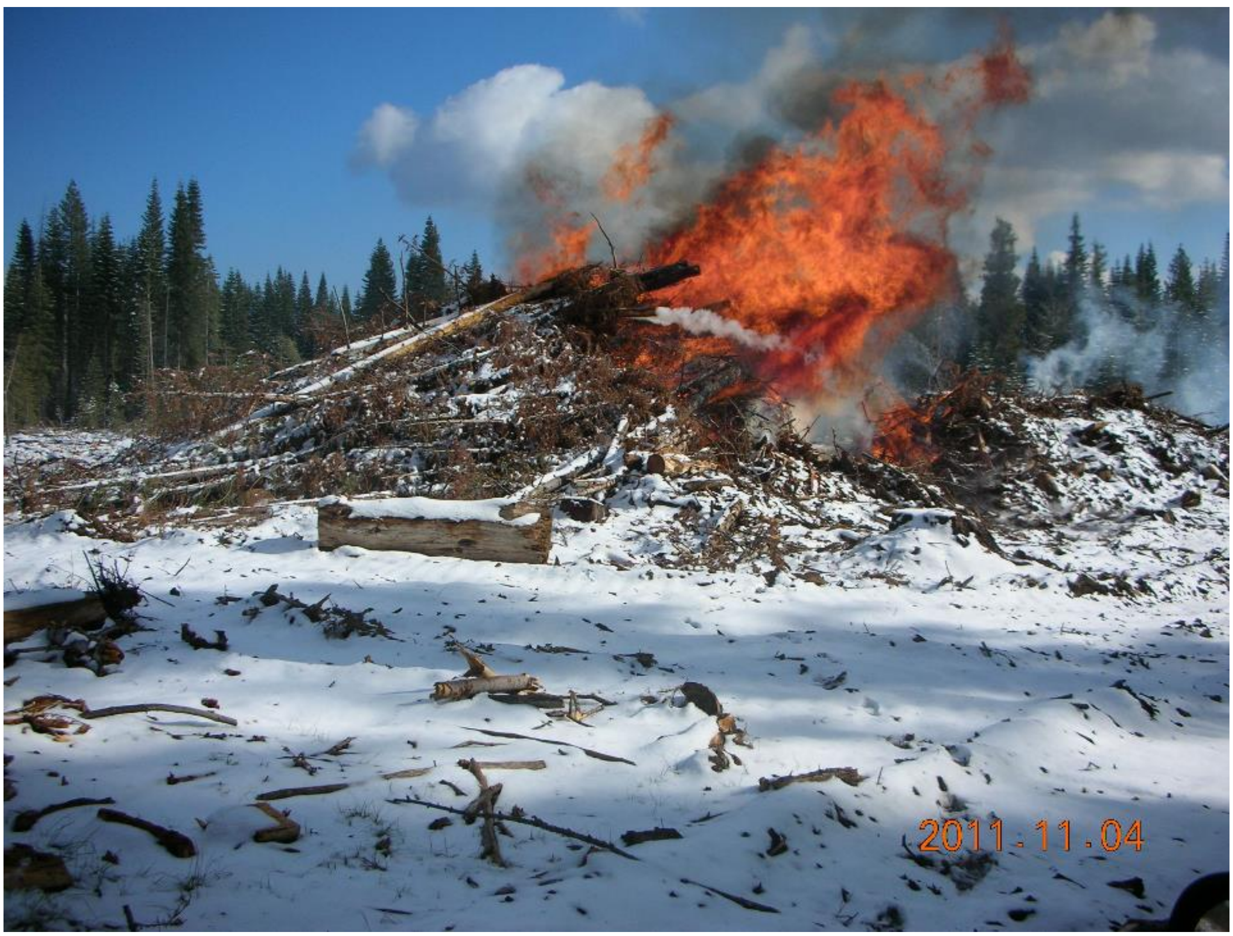

Figure 7.11 Top and Landing pile burn.

Worker Safety during Fires

Prescribed fire can also expose workers to a wide variety of toxic byproducts such as methanol, acetic and formic acid, dioxins, terpenes, tars, xylene, benzene and others (Newton & Dost 1984). Another safety factor is the exposure of workers to rolling debris coming out of a fire that may not be seen coming out of the smoke. Rollers can also be a danger during holding and mop up operations. Walking through thick slash with a drip torch is a risk to tripping and falling and getting hurt, hydration is also a risk during hot and strenuous conditions.

Cutting, clearing and walking fire-lines on steep slopes can also be dangerous, although, Kauffman (1992) demonstrated that the incidence of worker injury and worker's compensation claims during post burning activities such as planting, backpack spraying and thinning was less on units that had been broadcast burned compared to units with heavy slash and brush loads.

Cultural

Cultural treatments are management practices that have a direct or indirect effect on vegetation control and can take on many forms. They can be land management activities such as burning (already covered in depth in this chapter) or grazing that can affect competing vegetation itself, or seedling development programs such as seedling nutrition or stock type selection to enable seedlings to outcompete the vegetation. There are many concepts and ideas that can be incorporated into a management program to minimize vegetation management inputs. Like some of the other methods of vegetation control, cultural treatments are only a part of an integrated approach for vegetation management.

Chemical

Chemical site preparation is focused on controlling competing vegetation by treating it prior to planting. There are two main types of chemical site preparation: pre-harvest and post-harvest. Each can be accomplished with a variety of methods either broadcast or directed, using hand applications or aerial. More detail is covered in chapter 9. Chemical vegetation control involves the use of herbicides, desiccants or growth regulators to control unwanted vegetation. The overwhelming majority of chemical vegetation management is done with herbicides and therefore will be the predominant method discussed in this text. Herbicides are generally the most effective and efficient method of vegetation control. Herbicides and their application methods have been the focus on decades of technological improvement as well as state and federal regulations to ensure a very high margin of safety and methods to mitigate specific concerns (Newton & Dost 1984).

Pre-Harvest Site Preparation

This has become very common in recent years because it is so effective since imazapyr was registered in California. It is a particularly effective method and chemical for hard to control woody species. Due to conifer tolerance issues, there are many more chemicals that can be used in a site preparation situation than in a release. Treatment cost in a site preparation circumstance is much cheaper than in a release when trees must be protected. The need for follow up release treatments is also reduced, which is an additional cost savings. The added benefit of reduced release expense is an overall reduction in chemical use. The two primary methods of site preparation application are 1) foliar for applications to brush species and 2) hack and squirt application for hardwood tree species. Hack and squirt is particularly helpful with hard to control hardwoods, such as tanoak on the coast. Logistical planning and coordination with Timber Harvest Plans (THP's) is important. Plans need to be done at least a year before logging to allow time to do pre-harvest treatments soon enough before logging to allow for chemical to work and to allow loggers and other non herbicide applicators to freely work on the site without special post herbicide application requirements. Treatments should be done at least two months before logging and ideally at least one year, or through one winter, after treatment. Safety of fallers in heavy hardwood stands is a concern. Some fallers will not work in stands that have been treated too long before cutting as dead and brittle trees can experience considerable limb breakage during falling that can be dangerous.

Post-Harvest Site Preparation

Prior to the registration of imazapyr in California postharvest chemical site preparation sprays were the most common type of application and for post-wildfire it is still widely used. A problem with post-harvest treatments is that the vegetation is frequently damaged during the logging process and goes into shock making the application less effective. Sometimes with hard to control woody species it can be advantageous to wait and control them after they have had time for crowns to recover as foliar herbicides are most efficacious on actively growing plants. It may be necessary with re-sprouts to wait two-three years for re-growth to occur for above ground leaf area to match the below ground root system to allow for better chance of control. If using imazapyr to control hard to kill woody species post-harvest, it may mean waiting at least one year depending on soil types and precipitation, to avoid root uptake of imazapyr by seedlings, ponderosa pine is particularly susceptible to damage.

No matter whether you treat the woody species pre or post-harvest, the grass and herbaceous species still need to be treated. In the first year after planting it is the grass and forb community that poses the biggest risk to survival of seedlings. Treatments for herbaceous weed control include pre-plant broadcast treatments and post plant directed sprays. Broadcast treatments of hexazinone, oxyfluorphen, penoxsulam or other soil active herbicides can prevent emergence of competing herbaceous species and are the best alternative available. If no pre-plant application is made and grasses emerge after planting, a directed spray will be necessary for survival. See chapter 9 for more in depth discussion on chemical site preparation options.

Brushfield Conversion

Converting brush fields that result from old burn scars can be a unique challenge for preparing the site for planting. Because of the presence of large amounts of living brush on the site a combination of treatments are necessary. Removing the brush can be done mechanically by rooting out the green brush with a Cat tractor equipped with a brush rake. The most common way to achieve this is to push the brush into windrows and allow it to dry for a few weeks. After this drying time, the brush will need to be moved in a way that releases the soil held by the roots and the clean brush piled in burn piles.

Another method of conversion is to spray the brush well ahead of the anticipated planting date. Herbicide applications will need to be done with a helicopter or fixed wing aircraft because ground access will be impeded by brush. Fixed wing applications are only suited for flatter terrain and herbicide options are more limited than with helicopter applications. Once the brush is dead and brittle, many mechanical options are available to prepare the site for planting. Good results can be achieved through crushing/tilling, mastication, v-blading or broadcast burning.

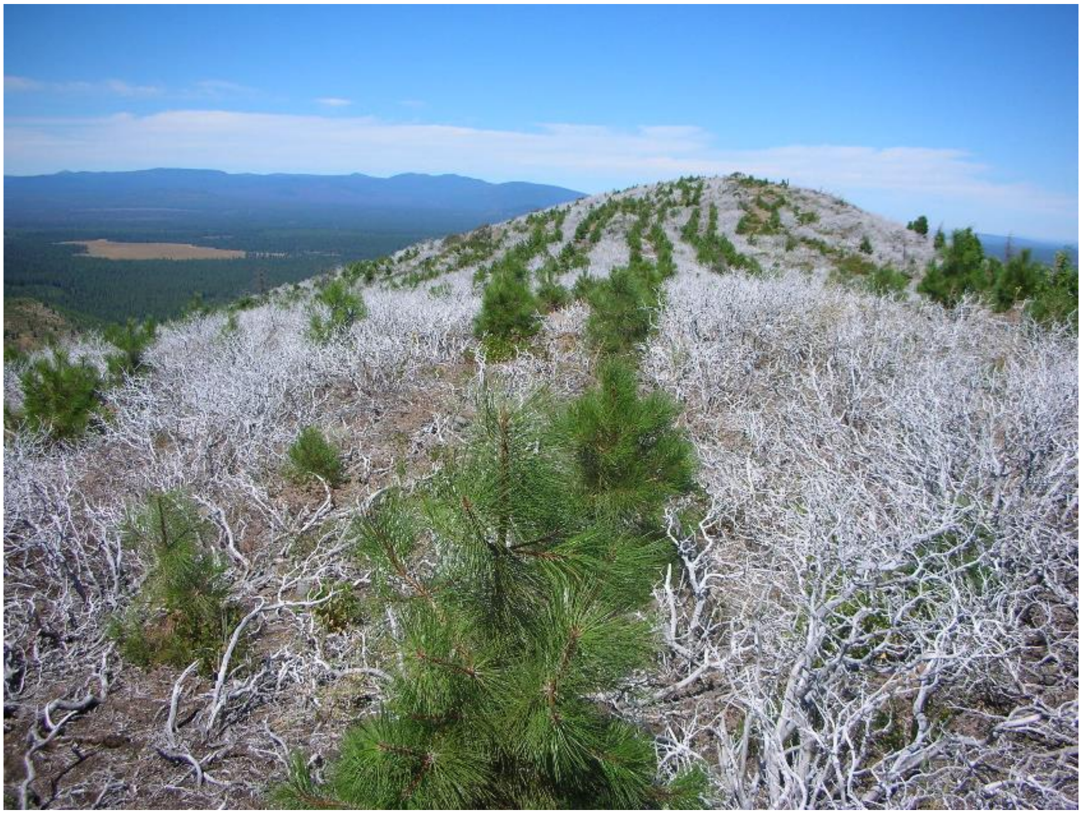

Figure 7.12 Sprayed brush crushed and planted in dozer tracks.

Summary

Good site preparation is a critical step to establishing a successful plantation. Evaluating the site as discussed in chapters 3 and 4 is imperative for identifying potential limiting factors on site and develop a prescription to create desired conditions to encourage survival of planted seedlings. Applying a combination of site preparation methods in a timely combination is necessary to achieve the best results. Effective and economical site preparation is an integration of science and experience to anticipate problems and mitigate them in a timely manner. Prevention is more effective and economical than having to do additional treatments after a problem develops. Years of experience have shown that the best money spent in reforestation is on good site preparation.

Figure 7.13 Well prepped unit with retention islands and cedar seed trees.

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