APPENDIX C – FUEL REDUCTION

TABLE OF CONTENTS

C. WILDLAND FUEL HAZARD REDUCTION[1]

For thousands of years, Native Americans kept forest fuels in check through periodic burning. This practice created the pre-European Settlement forest landscape. The landscape known today as the "natural" Sierra Nevada is a result of *plant succession*[2] that responded for more than a century to the human practices of fire suppression, road building, logging, the introduction of non-native plants, and vegetation conversion for agriculture and livestock. These activities were needed to grow trees that supported a growing economy and population.

However, the ecological consequences of these practices include increased *forest stand density*[3] with low-level *growth or vigor*[4]; increased susceptibility of forest *stands*[5] to bark beetle attacks and pathogens; changed species composition and structure of forestlands, grasslands, shrublands, and oak woodlands; and habitat alteration of forestlands, shrublands, oak woodlands, and savannahs. These changes have caused an increase in fire hazard, as well as a shift in the intensity and effects of wildfire. Current trends in *silvicultural*[6] and *prescribed fire*[7] practices focus on restoring and maintaining vegetative communities to a more *fire-resilient,*[8] native vegetation condition.

In an effort to *modify fire behavior*[9] and reduce the potential for *crown fire*[10] in the Sierra, federal and state agencies, local fire districts, and private landowners have been taking a proactive approach to reducing extreme fuel hazards. Incorporating ecological considerations into planning and implementing these fuel hazard reduction treatments can be an innovative and exciting task for landowners and land managers.

Fuel reduction activities can give land stewards the opportunity to increase fire safety on their own property, with positive impacts to their neighborhood. Fuel reduction assists in initiating and enhancing the process of restoring health to the forestlands, woodlands, shrublands, and grasslands. Fuel hazard reduction work guided by conservation principles and designed with ecological treatment prescriptions will facilitate long-term positive environmental outcomes.

C.1. WHAT IS ECOLOGICAL FUEL REDUCTION?

Ecological fuel reduction seeks to reduce *surface fuels,*[11] *ladder fuels,*[12] and *crown density*[13] while implementing treatments that work to enhance plant community health and *biodiversity.*[14] Ecological fuel reduction techniques assist the natural environment in becoming healthier and more *productive.*[15]

Treatments are designed to be *site-specific,*[16] taking into consideration vegetation, *soil types,*[17] slope, aspect, forest health needs, and individual landowner objectives. Fuel reduction objectives are best accomplished with an emphasis on ecological treatments that incorporate *forest stand enhancement*[18] and restoration forestry techniques. The implementation of ecologically restorative fuel reduction treatments is guided by the Conservation Principles *(see Appendix A).*

Goals and methods for ecological fuel reduction seek to strike a balance among the following:

Goals

- To make the forest less susceptible to crown fire
- To reduce the intensity of wildfire through activities that separate surface and ladder *fuel continuity*[19] and volume.
- To manage and modify fuels and configurations of trees and plants, to reintroduce low-intensity fire (cool burning), and to contribute in a positive manner to the ecological processes upon which the forest and plant communities of the Sierra depend
- To make fire-suppression efforts safer and more effective because of reduced fuel loads near roads, home sites, and strategic landscape areas.
- To improve the health of the trees most suited to the site.
- To emulate a plant regime similar to what occurred with natural fire
- To maintain and enhance native species diversity
- To maintain and enhance wildlife habitat
- To control problematic, invasive, non-native species
- To provide erosion control where appropriate (e.g. *lop and scatter*[20] and *contour falling*[21]) with materials from fuel reduction activities.
- To utilize byproducts of fuel reduction activities (firewood, poles, and sawlogs) where ecologically appropriate and economically feasible to help offset costs.
- To insure these goals are economically sustainable over time by grants and other revenue producing means.

Methods

We are choosing methods that emulate lightning and *anthropogenic*[22] low-intensity fires that have helped shape the local landscape for thousands of years. These methods include:

- Thinning portions of the understory
- Selectively reducing crown density where it is ecologically appropriate.
- Favoring and retaining the largest, most fire-resilient, and healthiest trees adapted to the location.
- Burning or chipping the smaller fuel loads.

C.1.1 WHAT IS A TREATMENT PRESCRIPTION?

Excessive fuel loads can indicate poor health of the tree, plant, and/or natural community on your property. A treatment prescription as it relates to fuel hazard reduction and ecosystem health is a sequence of steps to bring the forestland, woodland, shrubland, or grassland back to a healthier state. These efforts will ideally increase the area's resiliency to fire as a *natural disturbance*[23] that can occur occasionally without burning the entire landscape to the ground. This is similar to the recovery of a sick person—the doctor will prescribe medicine and a series of steps that a person will follow to return to health.

Prior to beginning work, the first step is an assessment of the property, including fuel hazards and health conditions. This is called an *initial site assessment,*[24] where you walk the property and take a closer look to gather information about present conditions. Using the answers to a series of questions outlined below, you will accumulate the data that will enable you to plan your fuel hazard reduction treatments for homesite safety, community wildfire protection, and the ecological enhancement of the property.

When planning fuel reduction prescriptions, it is important to remember that you are attempting to manage a natural, living system. Whatever your actions, the natural ecosystem will generate a response that will either favor its health and recovery or have negative impacts. Three very important concepts to consider and/or research for planning your prescription are 1) *Present Condition,*[25] 2) *Historic Natural Condition,*[26] and 3) *Future Desired Condition*[27] of the property. In an effort to reduce fuel hazards without creating additional environmental problems, it is important to use these three concepts when planning a treatment prescription.

Site Assessment—Present Condition

Present Condition will describe what conditions occur on your property now. During the planning of fuel treatments, the present condition will enable you to outline the activities you wish to undertake, based on today's starting condition. It will facilitate gathering your initial assessment data for planning your treatments.

The following is a list of questions that will help you plan a prescription for a fuel reduction project.

Site Evaluation Information and Questions

1) What is the elevation of the treatment area? List the variety of elevations from low to high.

2) What are the aspects of the treatment area? What direction does your property face? Explain in some detail.

3) Give a brief synopsis of the topography of the site. Highlight *draws,*[28] ravines, rock outcroppings, and special landscape features.

4) What are the vegetation types and plant associations of the site? What are the *dominant*[29] and *codominant*[30] species on the property?

5) What are the estimated *age classes*[31] of the forest stands on the site? What is the variability (and range) of sizes of the trees? What are the DBHs (diameters at breast height)?

6) Explain the *fuel load conditions*[32] on the site. Describe the density of vegetation and the variety of fuel types. Assess the *ground fuels,*[33] surface fuels, ladder fuels, dead standing wood (snags), widow-makers (large trees with lots of dead limbs), etc.

7) Give an estimate of the number of snags per acre on the site. What species of snags are present? What is the DBH of these snags? Which snag classes are present? Snags are categorized into three structural classes—characterized by the amount of bark and branches, condition of the treetop, and condition of the wood—and these features determine wildlife use. You should document snag height. What may be causing tree mortality? Is there beetle activity present?

- Structural Class 1 represents those trees that have died recently and retain most of their bark and most of their branches; the top is intact. Very little decay has occurred in the wood, unless the tree had heart-rot decay when living. Class 1 snags are typically used primarily for foraging by woodpeckers on bark beetles in and under the bark. Once the bark loosens, bats can roost under the bark.

- Structural Class 2 represents those snags that have been dead for several years and have lost some branches and bark (except grand fir and Douglas fir, which tend to retain their bark after death); tops are often broken; there is some evidence of decay. Woodpeckers use these for nesting, foraging in the bark, and foraging in the interior for carpenter ants.

- Structural Class 3 represents those snags that have been dead a long time and lack branches and bark (except grand fir and Douglas fir). Tops are broken off and the sapwood and heartwood are extensively decayed. The primary use of these trees is by woodpeckers foraging on carpenter ants and wood-boring beetle larvae. Most of these trees are too decayed for woodpeckers to excavate a cavity in them, although secondary nesters may use existing cavities.

8) Describe fuel loads in relationship to homesite, driveway, and other *egress*[34]/access routes on the property.

9) List and explain any special details about this site that should be considered for fuel mitigation and forest stand enhancement treatments. Include information about sensitive zones for plants, wildlife, *slope stability,*[35] etc.

Historic Natural Condition

The Historic Natural Condition will give you the baseline data on how the ecosystem in question functioned prior to fire suppression, urbanization, and industrial activities that may have occurred there. Questions include:

- What trees and plants were dominant on the property and historically present?
- How frequently did fire occur?

- What plant communities were present prior to European settlement that are now gone?

Some of these questions can be answered from the vegetation type descriptions in Chapter 4. You can also acquire this information from old or historic photos of your property, old settler's journals, the traditional oral descriptions of Native American elders who may be living in your area, or by visiting neighboring lands in your watershed that have not been greatly altered. Additional ways to learn this information are from surveying your land and looking at older tree stumps and their configuration, or by talking to an ecosystem restoration professional.

The site-specific information for your property will create a closer-to-home level that will help in planning your treatment prescription. "Site-specific" is a key concept that will enable you to tailor your treatment prescription to your property, using general guidelines as a basis while taking into consideration detailed site conditions. "Site-specific" describes a unique place and its conditions. Site conditions should be considered in the overall plan.

Future Desired Conditions

Future Desired Conditions will outline both the short-term and long-term goals you wish to accomplish with your activities. For example, future desired conditions for fuel mitigation efforts along a driveway might be outlined as follows:

1. Will be an area with little to no surface fuels, no ladder fuels, and fire-resistant, shade-casting trees without low-hanging branches

2. There will be larger, well-spaced trees with wide spreading crowns. Any shrub or brush patches will be small and isolated.

3. The grasses on the site will be converted over time, from tall, annual grasses that carry longer flame lengths to shorter, native grasses with shorter, flashier flame spread.

Create your concept for a future desired condition based on the conservation principles and other information in this plan.

C.1.2 STRATEGIC LANDSCAPE FUEL TREATMENTS

Strategic Landscape Fuel Treatments emphasize the creation of *shaded fuelbreaks*[36] to increase community wildfire protection. These treatments typically occur along ridge tops that divide sub-watersheds, on slopes above high-ignition sources (such as railroads or dividing ravines), and adjacent to secondary logging roads that will serve as anchor points for this and future work. Fuel reduction activities will aim to create safer and more effective anchor points for fire-suppression efforts, and contribute to the creation of effective *ignition zones*[37] for future prescribed fire activities. The introduction of prescribed fire can contribute to the long-term maintenance of forest fuels and overall ecosystem health.

Strategic landscape treatments, including shaded fuelbreaks, can be creatively designed into an ecological *Variable-Density Thinning*[38] regime that will reduce fuels and maximize structural and species diversity.

Wildland Fuel Reduction Zone Ecological Fuel Reduction Practices

The Wildland Fuel Reduction Zone is the area one hundred feet or more from a house or other structure. This is the place where innovative ecologically fuel reduction treatments can be accomplished, in an effort to begin the restoration process for previously impacted and degraded landscapes.

Although vegetation types vary greatly in the Sierra, and site-specific treatments will need to be developed to take into account this variation, certain silvicultural practices are applicable throughout the different vegetation zones.

Shaded Fuelbreaks

When you remove fuel ladders around your property and leave the tree canopy in place, you are creating a shaded fuelbreak. This break in fuel continuity—a result of treating both surface and ladder fuel—gives firefighters a chance to slow down and perhaps even stop a fire. Shaded fuelbreaks are effective because you 1) reduce the amount of fuel, 2) modify the types of fuel, and 3) improve their arrangement. It is called “shaded” because you leave most of the forest canopy intact. Some of the canopy may need to be removed, however, if conditions are high for a crown fire.

A shaded fuelbreak differs from a firebreak where a bulldozer or other equipment is used to create a bare-ground break with no vegetation. Firebreaks tend to regenerate quickly with flashy fuel and require a lot of maintenance. By contrast, the shade cast by the forest canopy helps to reduce the regeneration of plants on the forest floor, thus keeping the amount of fuel low in these fuelbreaks and requiring less maintenance. Shaded fuelbreaks also improve your evacuation routes, as they provide a place where a fire might slow down or decrease in intensity, making it safer for you to get out (and firefighters to get in).

Their purpose is to reduce the amount of combustible material available so when a fire reaches the shaded fuelbreak, it will decrease in intensity and drop from the canopy to the ground. It is very important that shaded fuelbreaks be created in strategic locations to provide the most benefit. Favorable locations are along ridges, *benches*[39] and other areas of flatter terrain. Shaded fuelbreaks can also be constructed along roads and around WUI communities; however, it is important that these efforts be coordinated with multiple landowners to achieve increased community wildfire safety objectives. Shaded fuelbreaks located at mid slopes can sometimes be ineffective because fire can preheat an area from below, and burning materials from above can roll downhill and ignite fires.

The exact prescription for a shaded fuelbreak depends on your objectives and local (present) conditions. Some landowners want to create as much cleared space (and their perception of fire safety) as possible. Others want to maintain as much privacy as possible, sometimes compromising but usually still improving fire safety. Treatment prescriptions will also vary according to the vegetation type and the aspect in which you are working. Determine your vegetation type and reference its Fuel Modification Prescription in Chapter 4 for site-specific treatments to incorporate into your design.

Typically, trees are spaced so their crowns no longer touch. Lower branches are pruned. Shrubs and dead and downed material are removed to reduce surface fuel. Not all small

trees need to be removed; care should be taken to create horizontal space between small trees and nearby larger trees. Heavy underbrush and fallen limbs are generally removed, leaving mature trees that are more fire-resistant. In forested areas, between sixty and eighty-five percent of the overstory canopy can be left intact, depending on the forest type.[40] Ponderosa pine stands, for example, which are typically less dense forests, tend to be located on arid aspects and resemble more of an open savannah plant community type. Historical canopy percentages for pine were less than sixty and closer to thirty percent on average. However, it is important to recognize that historic canopy percentages were representative of a long-term landscape with larger trees and broad crown ratios. Act cautiously within pine locations by retaining enough canopy to prevent adverse effects from opening things up too much, too fast. Moving any forest stand toward historic conditions can be achieved in intervals over a five- to ten-year period. The method of *sequential entries*[41] can be an effective, cautious way to both reduce fire hazard and restore the stand and associated ecological conditions. Monitoring the response of the forest and ecological community will be the guiding influence on what time intervals to use for further thinning entries. Ecological monitoring can be accomplished by a visual assessment of the stand's response, *photo-point monitoring,*[42] or by establishing permanent monitoring plots to measure closely the ecological benefits or impacts.

Shaded fuelbreaks can be constructed creatively to blend both fuel modification and forest stand enhancement objectives to achieve multiple positive outcomes. Variable-density thinning prescriptions can be incorporated into such treatments. It is important to consider the long-term health of each site, as well as potential adverse impacts on soils, understory plant communities, and forest stands. Species diversity can be retained within shaded fuelbreaks while still achieving fuel reduction objectives, especially if you do not try to do it all at once.

In Douglas fir stands, the canopy can be left more intact to accommodate the desired conditions for plants associated with this forest type. Douglas fir and red fir forests tend to grow on north and east aspects or in shaded draws with the appropriate microclimate. Shaded fuelbreaks in fir stands can still be very effective in reducing fire severity while leaving an average of seventy to eighty-five percent canopy closure.

In chaparral stands, shrub groupings can be left in patches that are spaced apart to reduce fuels while sufficient shade is cast to prevent the ground from drying out and invasive species from getting a foothold.

Varying levels of light on the forest floor will generate different resprouting responses; therefore creating shaded fuelbreaks requires the commitment to maintain them. As in all fuel reduction treatments, regular annual or bi-annual maintenance is often necessary as stump-sprouting plants, invasive species and/or shrubs begin to colonize the understory (although this is theoretically minimized with the shade provided by the intact canopy). Maintenance can be accomplished either by pruning and cutting back regrowth or through use of prescribed fire techniques. Established shaded fuelbreaks provide a good opportunity for prescribed fire applications.

Following thinning and prescribed fire application, restoring and establishing native grasses and forbs along shaded fuelbreaks is a long-term objective for the prevention of non-native species invasion. In situations where private lands border federal lands or wilderness areas,

invasive species can travel into these neighboring public lands and “spread like wildfire”; hence, it is critical that long-term stewardship be a priority for maintaining these sites.

Basic Prescription for First Entry[43]

For the first entry, cut as much of the *one-hour*[44] (0–0.24 inches in diameter) and ten-hour fuel (0.25–1.0 inch in diameter) as possible, i.e., the finer fuel. Remove trees that look brushy (versus a more tree-like form), unhealthy, are lacking in vigor, or are overtopped by larger and/or more vigorous trees that block access to open spaces in the canopy. Eliminate dead vegetation of all sizes. Shade will inhibit the regrowth of the sprouting species, which will not resprout vigorously enough to be a major maintenance problem. Prune up all trees you leave behind as high as you can reach safely, with a chainsaw or pole saw.

Start low in the area and work gradually uphill. Also, start with the lowest-growing plants and work up the fuel ladder. This will help keep you from burying your work, and the result will be cleaner and more thorough.

When creating shaded fuelbreaks, you should work in teams with a sawyer and a brush hauler. This can result in a more thorough job with less effort once safety and logistical issues have been worked out. The sawyer can make a small to moderate mess in one spot and then move to the next spot while the brush hauler cleans up the mess in the first spot. They then flip-flop and the sawyer returns to the first spot to expand upon what has been done, while the brush hauler cleans up the mess in the second spot. While this method requires teamwork and awareness, it will enable the sawyer to cut with more ease. Meanwhile the brush hauler is cleaning things up but is not in danger from falling trees and limbs because the cutting occurs in a separate area.

Second Entry, or Advanced First Entry

Go to those trees and shrubs that you were not sure about on the first pass. Look at the leader (the new growth at the top of the tree) and the overall health and vigor of the tree in relation to other trees of the same species. The leader reveals the annual growth. How is the tree growing in relation to other trees? Is the leader longer or shorter? Does it look healthy? Leave the healthiest trees. Is there space for them to grow in the upper canopy? If not, can you create that space by removing the less healthy or suppressed trees? If not, the tree is a good candidate for removal regardless of health and vigor. Imagine the same place in ten or twenty years. Will there be room for all the trees you have left? If not, remove some of the unhealthiest and smallest ones, or those in the way of your largest and most dominant trees. Keep in mind that the denser the canopy, the less regeneration (maintenance) you will have to address next year.

Think about species composition. You will generally want to favor rarer species. The type of forest you have on your property will determine what species to leave, and the appropriate percentage of canopy and understory density. For example, certain mixed-conifer forest types and their associated plants require more of a *closed-canopy*[45] forest with a woody shrub understory plant community. These forest types are usually located on north or east aspects, along riparian areas, and dominated by Douglas fir at lower to mid elevations and red fir at higher elevations. Other forest types such as ponderosa pine, pine-oak woodland,

or mixed-pine forests will generally have less canopy percentage and be located in drier sites on south- or west-facing aspects. They have more herbaceous plants consisting of native grasses and forbs, with an average of thirty percent woody shrubs present in the understory.

The Sierra Nevada region is quite diverse with many different forest and vegetation communities present. Determine what plant community exists on the property and make allowances for the varying percentages of canopy and understory thinning needed for fire behavior modification. This is explained in further detail in Chapter 4. Think about what you are leaving behind more than what you are removing. You can deviate from these general guidelines if you are doing so consciously, keeping in mind the overall principles mentioned above, foremost being the creation of breaks in fuel continuity and the Conservation Principles identified in Appendix A.

How to Decide which Trees to Leave or Take

First, look for the vigorous, healthy trees. One way to decide which trees to cut is to look at how much crown is on a tree. Trees with less than twenty-five percent live crown may be candidates for removal because they will have a hard time being *released*.[46] Choose trees with healthy crowns as the trees to leave. Create space around them by removing less vigorous trees. Look for existing space in the canopy. Is there space for the tree to grow into the upper canopy? If so, leave it. If not, consider removing it. There may be trees that you will eventually want to remove—often intermediate – trees that are not cost-effective on the initial entry, but could be on subsequent entry. Some of the intermediate trees may have enough size or volume for lumber production. Therefore, if your removal costs are not high you may be able to offset some of the expense with lumber for commercial or personal use. *(See Section C.2 below for details.)*

After you have created your shaded fuelbreak, take a final pass through the area. How does it look? Do you need to remove any branches or small fuels that were left behind? Did you miss some trees or shrubs that obviously can be taken out now? Remember, you do not need to remove everything. You can leave clumps of vegetation for wildlife habitat.

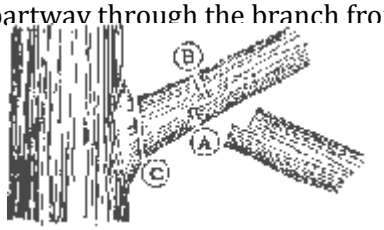
Pruning Individual Trees

Prune as high as you safely can with a chainsaw or a pole saw, given your available time and financial resources. The more you prune the more slash you will have to remove. Costs for this will vary widely, depending on the size of pruned limbs. Leave at least one-half of the tree height in live crown. Only remove one-third of the total foliage at one time. Do not bother pruning anything that is shorter than you are (unless it is right next to your house, then it should probably just be removed). Make sure to follow proper pruning techniques or you will create health problems in your landscape. Pruning is one of the most difficult skills to master but it is also one of the most important. For tips on proper pruning techniques, see the following table and the text entitled “Prune trees for better health and higher value,” by the California Forest Stewardship Program, ceres.ca.gov/foreststeward/html/prune2.html.

FIGURE 1. PROPER PRUNING TECHNIQUES[47]

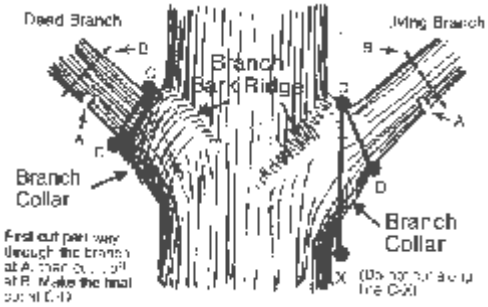
Prune correctly. The object of the operation is to remove the branches as close to the tree stem as possible without leaving any stubs.

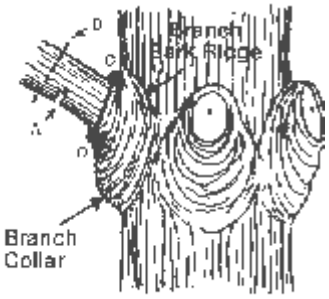
A. Cut partway through the branch from beneath at a point one or two inches from the trunk.



B. Make a second cut on the top of the branch, at a distance of 1/3 to 1/2 the diameter of the limb from the first cut. This should allow the length of the limb to fall from its own weight and be safely removed.

C. Complete the job by making a final cut next to the trunk, just outside the branch collar, with the lower edge farther away from the trunk than at the top.





Using the illustrations above, final cuts should be made from points C to D. Do not cut along C–X, which is an imaginary vertical line to help you locate C–D. First cut partway through the branch at A, then cut it off at B. Make the final cut at C–D.

Drip-Line Thinning

In forests and woodlands, the technique of drip-line thinning can be used to reduce ladder fuels and release desired leave-trees from competition for nutrients, sunlight, and water by removing the nearby small trees and shrubs.

The drip line is the area at the end of the longest branches of a tree or shrub where water drips vertically to the forest floor. The technique for drip-line thinning is accomplished by clearing away the ladder fuels within the drip-line circumference around the desired leave-tree. The best place to begin is by picking out your healthiest, largest, desired leave-trees and drip-line thinning around them. Following this technique, you can reevaluate what vegetation is left and plan how you will shape the remaining plants and stands of trees. For example, trees may be left more isolated as individual specimens, or standing in groups.

Mosaic Thinning and Adaptive Management

To accomplish fuel reduction objectives and provide ecologically sound treatment results such as enhancing site biodiversity, a *Mosaic Thinning*[48] approach can be used. Mosaic thinning regimes work to emulate the structural composition created by wildfire. Although thinning will not achieve the same ecological results as a natural fire, the openings and patches of vegetation that are created can increase the potential for a variety of habitat types. Mosaic thinning takes into consideration the site-specific conditions of the plant community type in order to choose the best prescription for a given area and to make allowances for a variety of ecological concerns that may arise during treatments where on-site direct *adaptive management*[49] will need to be practiced. For example, in certain portions of a treatment area, thicker vegetation and tree cover may be left to provide *thermal cover*[50] for deer and other wildlife, while in other locations canopy cover may be reduced to provide sunlight to the forest floor in order to favor struggling native grasses and associated herbaceous understory vegetation.

FIGURE 2 MOSAIC TREATMENTS IN CHAPPARAL

Mosaic thinning consists of treatments that reduce the abundance of dense vegetation, thus encouraging herbaceous understory and overstory growth. Such thinning results in a diversity of habitat types beneficial to wildlife by creating islands, corridors, thickets, open understory forest stands, and small grassy openings of random shape, size, and occurrence.

Variable-Density Thinning Practices: Reducing Fuels and Creating Diversity

In an effort to meet the desired outcomes for maintaining and enhancing plant communities and to reduce fuel loads and the threat of catastrophic wildfire, a Variable-Density Thinning, or *uneven-aged treatment,*[51] may be considered.

Variable-density thinning regimes are an integrated approach to the management of forest stands and vegetative communities of different sizes and densities. The silvicultural practice of variable-density thinning can be applied to the diversity of vegetation types throughout the Sierra, with site-specific adjustments made to accommodate the favored species historically suited for each plant community location.

The main goal of variable-density thinning is to restore maximum repeating variability or redundancy to a forested landscape.[52] Since we do not know exactly how much of what kind of habitat to restore or maintain, it is good to vary the treatments and apply them in small areas. This is in line with the *Precautionary Principle.*[53]

This kind of thinning will reduce crown fire hazard and can be combined with biomass utilization, surface fuel treatments, and prescribed fire activities. Low- to moderate-severity fire (the kind experienced historically in the Sierra) will then tend to select naturally for fire-resistant species.

Variable-Density Thinning to Create Structural Heterogeneity

"Variable-density thinning regimes in which thinning intensity and tree marking rules are varied within the stand of interest (Carey and Johnson 1995; Carey and Curtis 1996) are a useful approach to increasing heterogeneity in stand density and canopy cover. Variable-density thinning is sometimes referred to as a 'skips and gaps'" approach. In such a prescription, some portions of a stand are left lightly or completely unthinned ('skips'), providing areas with high stem density, heavy shade and freedom from disturbance, while other parts of the stand are heavily harvested ('gaps'), including removal of some dominant trees, providing more light for subdominant trees and understory plants (Carey et al. 1996). Intermediate levels of thinning are also applied in a typical variable-density prescription."[54]

These goals can be accomplished by the following practices: creating and maintaining variable or uneven spacing, with clumps of trees and canopy gaps; maintaining the largest trees of the stand; reducing the density of *ingrowth*[55]; maintaining early-seral species on the landscape; and reducing the fuel loading by removing ladder fuels.

In addition to providing fire safety, ecological fuel reduction provides many other benefits. Some of these are:

- Improved forest health and productivity: There will be less stress and mortality from reduced competition, and this translates into lower fire intensity. In addition, by removing the lower branches of your trees, you will have higher quality lumber (less knots) should you ever choose to harvest those trees for wood products.
- Improved wildlife habitat: Opening up the lower canopy and forest floor provides habitat for some of the species that prefer to dwell in larger trees or older forests.
- Improved aesthetics: Many landowners comment on how much nicer their view is after doing fire hazard reduction, as they can see out into the forest again.
- Creation of firewood, biomass, and sawlogs

For additional information on fuel hazard reduction, please see Appendix D, Fire Safety Information.

C.2. WHAT TO DO WITH THINNED MATERIALS

Because of your fire safety work, you will likely accumulate a lot of branches and other materials that you have cut. There are a few main options for dealing with thinned materials: burning, chipping, lop and scatter, some combination of these, small-diameter wood products, and biomass.

You can only use commercial wood products from your forestry operations on your own property. To sell most commercial wood products from a forest operation requires a Timber Harvest Plan (THP) approved by the California Department of Forestry and Fire Protection (CAL FIRE). THPs are generally too cost-prohibitive for fuel hazard reduction in most young forests. However, the Forest Fire Prevention Exemption provides an alternative; see Section B.1.1.5 for more information. The Mattole Restoration Council has a great summary

and comparison of fire hazard reduction exemptions you can use for your fire-hazard-related forestry operations. See their "Forest Practice Rules for Thinning Exemptions," at mattole.org/pdf/Exemption_thinning_requirements.pdf, and "Comparison of Thinning Exemptions," at mattole.org/pdf/fire_hzrd_exemption_comparisons.pdf. They have also developed a model cost-share program to facilitate fuel hazard reduction on non-industrial private forestlands. For more information on that program, see mattole.org/program_services/forestry/fuelsreduction.htm.

Firewood is also a great by-product of fuel hazard reduction. To sell firewood, you need a firewood exemption from CAL FIRE. Always contact CAL FIRE before removing large trees.

C.2.1 BURNING

Burning is the cheapest and usually the easiest method to remove thinned materials, as long as it is done safely. Burning does require permits. The Amador County Air District requires burning permits for all burning except for residential burning of a single pile of vegetation less than 4 feet by 4 feet in size. Residents wishing to burn larger piles or multiple piles need to obtain a burning permit from the Amador Air District. These permits vary in cost depending on the type of burning. Some burn permits can be purchased on a multi-year basis. In addition to burn permits issued by the Amador Air District, CAL FIRE requires burn permits from May 1 to the end of fire season.

Following is a list of suggestions for safe burning adopted from the California Forest Stewardship Program:

- Arrange the material to be burned so that it emits minimum smoke. Place material of various sizes in the pile for adequate airflow.
- Amador Air District requires burn permits for most open burning. Check with CAL FIRE and the Amador Air Quality Management District regarding necessary permits while planning—and before starting—any burning.
- Except for large trees (six inches DBH or greater), ignite only the amount that can reasonably be expected to completely burn within the following 24 hours.
- Only ignite outdoor fires with ignition devices approved by the local Air Quality district and CAL FIRE.
- Ignite material to be burned as rapidly as practical within applicable fire control restrictions.
- Curtail, mitigate, or extinguish burning when smoke is drifting into a nearby-populated area or creating a public nuisance.
- Don't burn material unless it is free of tires, rubbish, tar paper, and construction debris; is reasonably free of dirt, soil, and moisture; and is loosely stacked in such a manner as to promote drying and ensure combustion with a minimum of smoke.
- Some air districts and/or counties may limit the amount of needles and leaves within a pile, as well as enforce burning hours throughout the day.[56]

Getting a group of friends together in the winter to thin and burn can be an enjoyable or at least satisfying way to spend a day outside.

Prescribed Burning and Slash Disposal

Prescribed Burning is the controlled application of fire to forest and woodland fuels in either their natural or modified state. It is done within site-specific environmental conditions to confine the fire to a predetermined area. The objective is to produce the fire behavior and characteristics required to attain fire treatment, ecological restoration, and resource management objectives.

Prescribed fire methods vary and include *hand pile burning,*[57] *swamper burning,*[58] *broadcast underburning,*[59] and *patch burning.*[60] All of these methods can be used to reduce fuel hazards and improve the ecological health of Sierra Nevada wildlands.

When choosing the right prescribed fire activity for your property it is very important that you consult fuel management and forestry professionals, especially when considering broadcast underburning. Prescribed fire methods are very site-specific. Not all methods are appropriate for every location. Prescribed fire prescriptions must be determined on a unit-by-unit or section-by-section basis. The details you will need for burning will develop as on-the-ground work progresses along with your knowledge of site conditions.

PRESCRIBED BURNING METHODS AND TREATMENTS

Swamper Burning

Swamper burning is a prescribed fire method in which fuels are gradually added (usually over the course of a day) to a hand or machine pile. In Sierra Nevada areas with a high concentration of homes, swamper burning for slash treatments may be a good option. This method is highly recommended within denser vegetation zones, following an initial *first-entry thinning treatment*[61] where high concentrations of slash will be generated. Swamper burning is also a first step of preparation prior to broadcast underburning activities.

Since 1993, Lomakatsi Restoration Project[62] (a restoration forestry contracting organization based in Southern Oregon) has used the swamper burning method on thousands of acres of private, state, and federal land throughout Southern Oregon and Northern California for fuel reduction. Lomakatsi believes the swamper burning method not only accomplishes fuel reduction goals, it also provides an extra degree of protection for nearby residences. This method is favored for the following reasons:

1. There is less smoke at any given time when you drag and burn downed slash than when lighting many hand piles at once.

2. More fuels are consumed because of this method. There is little opportunity for piles that are lit to extinguish in the center.

3. Swamper burning minimizes the scorching of leave-trees and sensitive vegetation zones. Slash can be dragged away from leave-trees and transported to burning piles in more open locations.

4. The danger level of crown scorching and the potential for runaway fire is lessened because piles are more manageable in a swamper burn situation than in a larger *touch-off*[63] hand pile burn.

5. The visual appearance of hundreds of hand piles burning at one time can be frightening for residents. Swamper burning is a good tool to educate landowners about working with and becoming more comfortable with fire, and the fire-adapted landscape in which they live.

6. Swamper burning methods are safer and more manageable, in both appearance and execution. In light of recent prescribed-fire disasters in the Southwest, this factor cannot be overstated in terms of developing and maintaining community trust for landowners, contractors, and agencies involved in the application of prescribed fire.

7. In a swamper-burning situation, materials for special forest products and small-diameter utilization can be more efficiently sorted by hand crews than during the standard industrial forestry approach of stacking larger hand piles where good materials are wasted during burning.

The swamper burn method is site-specific; one size does not fit all. For prescribed fire activities in montane chaparral, sagebrush-bitterbrush, and foothill woodland where fuels burn hotter than conifer forests, the swamper burning approach will achieve positive results, provide a safer burn, and prepare site conditions for the future reintroduction of low-intensity fire.

Swamper Burning Prescription

- Burn-pile locations will be placed at a minimum of ten feet outside the drip zones of the largest overstory leave-trees.
- Place burn piles in the most open areas to avoid damage to surrounding trees.
- Construct small piles (comprised of mainly smaller fine fuels such as live and dead branches) approximately every fifteen to twenty-five feet to serve as *pilot ignition piles.*[64] These piles can be constructed roughly three feet high and covered with *slash paper.*[65] After stacking enough material for the base of the pile, place a sheet over the material then stack about 1/3 more on top to hold down the protection sheet—this will keep things dry for when you come back to light the pile.
- Leave the remainder of slash on the ground until you burn. Swamper burning will likely need to be conducted prior to fire season, so check with your local fire department or CAL FIRE for permitting details. Desired sub-merchantable materials will be sorted for special forest products, small-diameter poles, and firewood. *(see section C 2.4 for more information*) These products will be yarded to roadside locations.
- When the burning is executed, ignite pilot piles in smaller sections (ten piles at a time), with the remaining slash dragged to the burning piles in a rotational fashion. Add slash to the piles while keeping flame lengths reasonable. When those piles have become manageable, crewmembers with hand-carried *drip torches*[66] can move ahead to ignite other piles, while a mop-up crew will stay behind and clean up the remaining slash and burn out the surrounding slash in the piles.

- Depending on the time of year, a *scratch line*[67] or *scalping*[68] down to *bare mineral soil*[69] may need to be placed around the piles in an effort to prevent the fire from burning outside the pile ring.

- After visible flames have burned down, hot embers will remain in the burn ring. Depending on what fuel type you are burning, these hot embers may remain for several days. It is important to inspect the area where you were burning several times throughout the following days until the fires are dead out. In regions like the Sierra, fuels on the ground can dry out rapidly even after several days of rain. Pay close attention to this to prevent fire from escaping.

Following burning, a good restoration practice is to sow native grass seed into the mineral-rich ashes of some of the burn locations in an effort to restore the native grass community. Native grass can establish itself well in disturbed locations like burn spots. It may be possible to acquire native grass seed for your specific location from the US Forest Service or a local nursery in your area. You can sow these seeds by hand and experiment with how much seed to sow. Seeding rates will vary, so check where you buy the seed as to how much to use per location. The best time to sow native grass seeds is November thru March during their dormant time, depending on elevation. Sowing native grasses not only restores herbaceous plant communities to your site, it is a good preventative measure for noxious weed mitigation.

Remember: do not strip the ground of all woody material in your burning operations. Be sure to leave some coarse woody debris. Do not burn every stick. Decide what to leave on the site based on slope percentage, aspect, and location.

Hand Pile and Burn

Following thinning operations, you may consider the method of *hand pile and burn,*[70] whereby slash can be gathered into piles located in open areas and burned. Slash is piled soon after it is cut, then covered with slash paper. Some people use plastic to keep piles dry and then burn the plastic. However, burning plastic is toxic especially to those doing the burning. If you decide to use plastic in your preparations, be sure to remove the plastic sheets before burning.

Slash piles are usually burned in the fall and winter during moist days. At this time, the piles will be relatively dry while surrounding vegetation will be damp, minimizing the spread of fire beyond the pile.

Slash Piling Specifications

- Pile debris ranging from two to eight inches in diameter, at least two feet or more in length. On slopes greater than 55%, small-diameter (greater than eight inches) coarse woody debris may be left for soil stability. Some favorable small-diameter materials may be yarded for special forest product utilization (*see section C 2.4 for more information*).

- Piles should be placed away from old stumps and fallen logs to minimize their ignition. In an effort to prevent holdover fire potential (i.e., a fire not burning out completely), make sure piles are not located on top of old stump holes or decomposing

logs. Be sure to place piles a sufficient distance from the drip lines of trees to prevent scorch.

- Construct piles up and down slopes and create a secure base to prevent the rolling of materials.

- Smaller fuels form the initial core for later ignition, with larger fuels placed on the top and sides.

- Piles ideally range from a minimal size of four feet high[71] by four feet in diameter to a maximum size of five feet high by seven feet in diameter, except when insufficient slash is available in the area.

- Make piles as compact as possible. Limbing, aligning the material, and placing heavier material on top of the pile will obtain compaction. Air space between logs and limbs is not to exceed three inches in cross dimension after piling.

- Place slash paper on the piles such that the covering does not go beyond half the length of each side of the piles, as measured from the top (or center/mid-point). Your goal is to have the center core of the pile covered (not the entire pile) for successful ignition when lighting the pile later.

- Secure slash paper on piles by placing heavy materials on top of the paper. Place it to provide the best protection from rain and snow, in order to enable later ignition.

For piles that may cause unavoidable scorch to residual trees upon combustion, burn them during periods of rain or snow to minimize damage. Each pile should be *chunked*[72] at least once during burning operations. Include any creep in the chunk to keep the fire confined to the piled area. Chunk piles after they have had sufficient time to burn down. Check piles daily, and more often in windy conditions. Escaped burn piles are responsible for numerous wildfires in the Sierra**.**

Broadcast Underburning

Broadcast underburning is a method that allows a prescribed fire to burn in the understory over a designated area within well-defined boundaries. It is done to reduce fuel hazards and/or as a silvicultural restoration treatment.

In order to effectively and responsibly reintroduce fire (i.e., to ensure it will burn on the ground and not in crowns), thinning and brushing must first take place. These actions reduce stand densities, ladder fuels, and the build-up of brush and excessive surface fuels.

Before burning in forested stands, a few preventative measures should be taken to ensure the survival of overstory trees. Often a thick layer of duff or thatch will accumulate beneath mature trees. In many cases, feeder roots will grow into the duff layer close to the surface of the ground. The loss of these roots due to extreme heat and/or fire can cause tree mortality. Thus, duff should be raked back several feet with a McLeod to prevent unwanted impacts. Such treatments are especially important beneath large pines, which often accumulate thick mounds of debris, colonized by sensitive roots.

Favorable conditions for igniting fires include low winds, moderate humidity, moderate temperatures, and a small amount of soil moisture to protect soils from baking. Aboveground fine fuels should be dry enough to ignite and carry fires. The idea is to reduce fine fuels in the form of duff or grasses without compromising or impacting soils, fungal associates, sensitive tree roots, etc. Burn intensities will vary depending on the vegetation type, the amount of ground and surface fuels, and the restoration objectives on the site.

In certain locations, flashy underburns are the desired outcome where surface fuels are less and grasses persist in the understory (e.g. oak woodlands and savannahs). Flashy underburns are best accomplished in the fall. Burning in the fall enables safer broadcast burning of a larger area. This can be achieved usually the second dry day following a rain. You want the top several inches of the surface of the fine fuels to be dry, and the moisture content below sufficient to safely carry the fire quickly (flashy) and consume the top layer of the surface fuels leaving some organic material to protect the soil.

In other locations where surface fuels consist of deep, heavier leaf litter mixed with duff (e.g. Ponderosa pine and mixed conifer forests); a slower-creeping fire may be more appropriate. During Sierra Nevada mid-winter periods, an annual window of an extended dry period often occurs following heavier periods of earlier winter rain. This is a good time to accomplish this type of underburning to consume more of these abundant surface fuels. The slow creeping fire will consume more depth of surface and ground fuels. The native people of northern California and southern Oregon referred to this type of burning as 'cool burning'; the fire creeps along and consumes fuels without getting hot and out of control.[73]

Prior to execution of any broadcast underburning activities, it is recommended that a *burn plan*[74] be drafted on a unit-by-unit basis. During any underburn operation, it is necessary that a fire engine and a certified *ignition specialist*[75] and wildland firefighters be present to conduct the burn. If you decide to execute a broadcast burn, you will need to work with the local fire department and CAL FIRE in the development of the burn plan. A burn plan will describe the layout of the property and determine locations for firebreaks (skid roads, spur roads, and main access roads), *fire ignition,*[76] *escape routes*[77] (in case the fire becomes a wildfire, a reality to consider in all levels of prescribed fire activities), water *pump chance,*[78] and adjacent properties. Prior to considering broadcast burning be sure to contact CAL FIRE and the Amador Air District to obtain all the necessary permits and legal requirements.

For ecosystem health and the long-term maintenance of fuel levels, broadcast burning is an important and recommended activity. Although there are many risks involved, it is critical that landowners, agencies, and communities not only learn to live with fire, but also become accustomed to using it.

Broadcast Burn Fire Preparation Example

- Thin and remove ladder fuels and *jackpots,*[79] and prune to head height. Separate ground-to-crown and crown-to-crown live and dead fuels.
- Lop and scatter tree branches and tops; cut to twelve- to eighteen-inch lengths on the ground for broadcast burn.

- Pile all other slash three to four feet high, five to six feet at base.
- Use flagging to mark all desired leave-species like seedlings and native shrubs, and create a *blackline*[80] around them (slowly burning out from desired leave-species so they will be retained when the main broadcast burn is initiated).
- Blackline (backburn) all retained doghair thickets and gulches before broadcast burning.
- Pull back heavy duff from leave-trees to prevent root steaming and possible mortality. Use a McLeod tool for this task.
- Leave slash less than two to three inches in diameter on the forest floor.
- Put slash of two to three to eight inches in diameter in piles or near roads for firewood.

Patch Burning

Following initial thinning and slash treatment by either hand pile burning or swamper burning, patch burning may be used in site-specific locations. Patch burning is performed by defining and isolating a small area of fuels that you want to burn and applying fire only to that area. This method is sometimes used in the management of invasive blackberries where the area around the patch is thinned, a scratch line is created around the thinned area, then the inside patch is ignited.

This method can also be used to burn surface fuels within a variable-density treatment where unthinned areas are retained but you want to achieve the diversity of mosaic burn conditions.

If performed properly, patch burning can be a very effective method of reducing fuels and reducing costs. In the right conditions, it works well in chaparral and sagebrush, as these plant types often have lots of dead fuel, and patches can be isolated and burned.

Similar to all prescribed fire methods, only perform the activities by consulting and hiring skilled fire or forestry professionals.

Considerations for Burning Activities within Riparian Corridors

Some variation may occur during burning operations due to the change in vegetation, slope, and aspect.

- Burning should be carried out carefully along slopes above riparian draws, especially in *headwalls,*[81] or where loose boulders may be found. Lop and scatter coarse woody debris in these locations to protect the soil and enhance slope stability.
- Burn on stable benches within upland riparian areas. Thinned slash may need to be transported by hand crews to these locations.
- Take extra care while burning is being conducted to protect vegetative diversity. Burn slash away from *mesic*[82] vegetation.
- Underburn in a patch burn fashion.

C.2.2. CHIPPING

Chipping is another method for treating thinned materials, and like all options, it has both advantages and disadvantages.

Advantages to chipping are:

- You can work on days when burning is prohibited.
- The chips created can be used for landscaping on paths around your homesite.
- Chips spread along roadsides will suppress the growth of vegetation, thereby keeping down fire hazards. Disadvantages to chipping are:
- Chipping can be expensive.
- Chippers break down and need to be serviced.
- Chippers require use of fossil fuels to operate.
- Production levels for slash disposal are slower.
- Chippers have limitations to where they can be staged to accomplish fuels work.
- Chipped material can be used for biomass

If you do not have a chipper of your own, contact your local Fire Safe Council (FSC) or CAL FIRE unit. Many FSCs have community chipping programs or funding to help you chip instead of burn, especially in areas where air quality grants are available. If these programs are not available, you can either hire a forestry contractor who has a chipper or rent one. The chipper should be able to process material up to ten inches in diameter. Even if the material you are chipping is six inches, having a ten-inch chipper will make things go faster because sometimes you will want to put three branches (each three inches in diameter) in the chipper simultaneously. With a chipper that takes larger-diameter material, you will prevent the potential problem of jamming the machine. There are many good brands, so do some research and ask around. It is very important that you get a good chipper, since it can be frustrating to rent a chipper that does not serve your needs.

Chippers are best suited for use close to roads, landings, or where access to thinning slash is convenient. The best fuel types to use in a chipper are softwood conifer species. Chippers can be used on hardwood and chaparral, but you will need to pre-process these materials before putting them into the chipper. Broad, branchy fuels like chaparral (e.g. manzanita or buck brush) can cause a chipper to jam if you do not first limb the branches with a chainsaw. These fuel types are time-consuming but workable. Limit dirt from getting into the chipper, as this will quickly dull the blades. Remember to stack all your branches in the same direction so you can easily feed the chipper.

Use extreme caution when operating a chipper; always wear safety glasses and ear protection. Pay special attention to the feed control; watch that your clothes (especially shirtsleeves) are not caught on branches as they are pulled into the chipper. Many counties

have roadside chipping programs where the service is free. You can contact CAL FIRE and the Amador Fire Safe Council for further information on this. Be safe, be cautious, and happy chipping!

C.2.3. LOP AND SCATTER

Lop and scatter is a method whereby thinned materials are spread about to rot on the forest floor—taking care not to form large piles (jackpots) of slash. Lop and scatter can be very cost-effective but is definitely a site-specific treatment.[83] This is the best method for improving the soil fertility of the forest and hence the forests' long-term productivity. By removing the ladder fuels and scattering them low to the ground, you are improving the chances of your forest surviving a wildfire. However, because of short-term increased hazard this is not a method to do near structures within the Defensible Space Zone. Rather, it is more appropriate in the forested landscape, in the Wildland Fuel Reduction Zone (see Appendix B for Zone definitions).

Material should be cut down to an ideal height of one foot above the ground. However, lopping to less than or equal to twelve inches above ground is likely beyond the skills of most, so eighteen inches is sufficient to strive towards. Remove all large pieces of wood (makes for great firewood). Dedicate some larger, heavier pieces to sit on top of the slash and weigh it down. Conifer slash "lies down" much easier and requires less lopping than most hardwood slash due to its growth habit. Green slash of all species lies down easier than dry slash (if you are thinking of coming back later to lop). Make sure none of your material on the ground is touching the base of any trees or shrubs you have left standing (your leave-trees). Think about this in terms of creating defensible space around leave trees just as you would around structures.

The risk with lop and scatter is that fire may occur within your treated area before the fine fuel falls to the ground and decomposes. Even so, lop and scatter does reduce your fuel hazard because the fuel is no longer part of the fuel ladder, and there is vertical clearance between the surface fuel and the bottom branches of the trees (ideally a minimum of eight feet of space). However, your surface fuel hazard may increase in the short term—from three to ten years—depending on the forest types on your property and the length of time it takes for the fuel to decompose.

C.2.4. SMALL-DIAMETER WOOD PRODUCTS

Much effort has been made in California and throughout the Pacific Northwest to develop markets for small-diameter wood products, especially hardwoods. It is possible to use these materials commercially, and they often produce beautiful lumber. Small, suppressed Douglas fir—a softwood—often has a tight grain that makes for attractive trim and tongue-and-grove flooring. Local hardwoods such as tanoak and Madrone are used by woodworkers to create stunning furniture, cabinets, and floors. To be merchantable, the logs need to be straight and between six to ten inches in diameter. Two great sources for more information on this subject are the Institute for Sustainable Forestry (www.sustainablehardwoods.net) and the Watershed Center (www.thewatershedcenter.org).

The principal issues limiting small-diameter wood products are lack of infrastructure and marketing. The following text from *Small-Diameter Wood Utilization in Sierra Nevada Forests, A Situation Analysis and Assessment of Opportunities for Expanding Existing Markets* (a study commissioned by the Sierra Forest Legacy), summarizes existing small-diameter wood product market issues in the Sierra:

- Stronger markets for small-diameter wood would help reduce the net cost of restoration treatments, thus encouraging more landowners to undertake restoration work.

- Throughout the Sierra, small-diameter wood is underutilized when compared to other regions in the US. A large volume of small-diameter wood is piled and burned, a costly treatment that exacerbates air quality issues, particularly in the southern Sierra.

- The existing infrastructure for small-diameter log utilization in the Sierra is relatively weak as compared with other regions in the US. Exceptions to this exist in areas in close proximity to sawmills capable of processing small-diameter material, or a biomass energy facility, as well as the relatively robust market for small-diameter incense cedar.

- Beyond that, a handful of examples of small-scale, small-diameter wood utilization facilities exist or are in development. Most of these are in need of outside funding or political support in order to thrive.

- Strong potential exists to develop new markets based on the amount of material potentially available, but many barriers exist to creating sustainable markets. Among the most vexing barriers is the lack of consistent and stable supply of small-diameter material. The long-term nature of stewardship contracts makes that tool a potentially attractive avenue for addressing supply issues.

Current small-log utilization in the Sierra

What is the fate of small-diameter logs that are harvested in the Sierra today? The vast majority of small logs will move down one of three primary chains:

Several Sierra sawmills have the capacity to process logs down to six inches and, depending on haul distances, will purchase some proportion of the small-diameter logs generated from traditional timber sales or from hazardous-fuel reduction projects. Incense cedar logs, in particular, have a high value for use in outdoor applications such as fencing and garden stakes, and several of the region's mills are actively seeking out more supply.

In locations near a biomass energy-generating facility, a proportion of the small-diameter log stream is chipped in the woods and hauled to the biomass plant. The rule of thumb is that costs begin to outweigh return about fifty miles' haul distance from such a facility.

Finally, a percentage of small-diameter logs are left in the woods, either scattered or piled and burned. Such treatments are frequently seen along roads throughout the range where the Forest Service and private landowners have increased the number of hazardous-fuel reduction projects in response to greatly increased federal and state funding in recent years….

The infrastructure for distributed, small- and medium-sized wood utilization that currently exists in the Rocky Mountain states (MT, ID, CO) and the Southwest (AZ, NM) does not exist in the Sierra. These states have lost much of their large-scale industrial infrastructure and long ago began the transition to a new forest economy based on smaller-scale operations. Fledgling efforts to develop such an infrastructure in the Sierra will be described in further detail later in the report, but perhaps the most important finding of this study is that after an extensive search for small-diameter wood utilization efforts in the Sierra, only a handful were found. Throughout most of the range, small logs continue to be underutilized compared to other forested regions in the West, and significant value continues to literally go up in smoke as small logs are piled and burned rather than converted into lumber products or energy.[84]

C.2.5. BIOMASS

Due to policies to suppress fire, the forests of the Sierra Nevada have accumulated an unnatural amount of forest biomass that we need to remove by both mechanical means and by returning controlled prescribed burning to the landscape.

Biomass refers to organic material from living things such as trees, shrubs, grasses and other plants. The temperate forests of the Pacific Northwest contain the highest amounts of biomass per acre of any forests in the world, far exceeding tropical forests. Biomass is commonly used as lumber, firewood, and paper. Biomass can also be used for energy production.[85]

In its simplest form, biomass is used to create heat. One of the most efficient ways is through a process called gasification. This technology is increasingly being used in schools in rural areas (see www.fuelsforschools.org for more information). Gasification uses woody materials as a source of energy to produce methane and hydrogen gases. These gases are then used to create additional heat or as fuel to power an engine that creates electricity. Biomass can even be used to replace our dependence on fossil fuel, and can be significantly better for the environment, assuming the production and collection of the original biomass is done in an ecologically appropriate and sustainable manner.

One of the noteworthy challenges associated with biomass as a source of energy is transportation costs. In order for biomass utilization to be economically feasible, the distance for the biomass to travel should not exceed twenty-five to fifty miles. In some of the remote communities in the Sierra Nevada, some transport routes could present trucking challenges. However, solutions are being developed, as woody biomass utilization is becoming more of a federally mandated emphasis for public land management agencies. The alternative is to bring the biomass plant to the woods. Portable biomass facilities are

being developed but are not yet commercially viable. Developing community-scale biomass alternatives that distribute the benefits (and the risks, such as over-exploitation of forests and air pollution) while reducing transportation costs and limiting large-scale impacts are most desirable and advantageous for the Sierra Nevada.

There is a host of creative possibilities for using biomass, including combining community fire hazard reduction and electricity generation using a mobile generator on-site. The University of Washington has invented a process that converts small trees to methanol. They have found that even the smallest trees and branches can be utilized as a power source for fuel cells. Funding is available for biomass projects from the USFS and BLM under Title II of the Healthy Forests Initiative and Healthy Forests Restoration Act. Title II authorizes these agencies to overcome barriers to the production and use of biomass and to help communities and businesses create economic opportunities. Funding is available for research.

A number of promising biomass-related projects are moving forward in the Sierra. These include:

- The Cedar Mills Eco-Farm in Amador County, where a wood-fired boiler provides heat for a greenhouse on an abandoned sawmill site.
- The South Lake Tahoe High School is working to site a biomass boiler as the first Fuels-to-Schools project in California.
- Placer County has embarked on an innovative biomass strategy to reduce catastrophic fire risks, reduce energy dependence on fossil fuels, and promote local economic activity.
- The city of Truckee demonstrated small-scale heat and power from biomass. Their demonstration concluded that there is a need to scale up to a slightly larger output system.
- Buena Vista Biomass in Amador County is in the planning stage and will produce 18.5 mega The renewable energy will provide a sustainable energy resource to approximately 16,000 homes in California and assist the State with achieving its renewable portfolio standard goals. The significant capital investment will create 90 new jobs and tax base to the rural community and Amador County

The California Forest Biomass Working Group, which includes numerous agencies, consultants, and conservation organizations, has developed the following mission statement:

> "Every forest community in California has the capacity to address and utilize the excess biomass in their area that is appropriately scaled to be economically and ecologically sustainable so that local jobs are created that help restore the environment and reduce fire risk."

To learn more about the Working Group, contact US Forest Service Region 5, 707-562-8910.

[1] Much of this section was written by Marko Bey and is based on his work with Lomakatsi Ecological Services. (www.lomakatsi.org).
[2] Plant Succession: In ecology, progressive change of the plant and animal life of an area in response to environmental conditions.
[3] Forest Stand Density: The amount of trees in a forest per unit area. Can be measured in terms of basal area and crown cover.
[4] Growth or Vigor: The ability of plants to exhibit healthy natural growth and survival.
[5] Stand: A group of trees with similar species composition, age, and condition that makes the group distinguishable from other trees in the area.
[6] Silvicultural: The practice of caring for forest trees in a way that meets management objectives. For example, foresters may control the composition and quality of a forest stand for goods such as timber and/or benefits to an ecosystem.
[7] Prescribed Fire: A forest management practice that uses fire to improve habitat or reduce hazardous fuels. A plan for the prescribed burn must be written out and approved, and specific requirements must be met.
[8] Fire-Resilient Landscape: A natural landscape featuring plants that have adapted to local wildlife conditions, or a domestic outdoor space where appropriate actions have been taken to make it less vulnerable to wildfire and certainly less prone to causing one.
[9] Modify Fire Behavior: Using fire-safe practices such as fuel treatments, thinning, creating firebreaks, etc., to change the way a fire will behave, with a goal of slowing it down and/or suppressing it more easily.
[10] Crown Fire: A fire that spreads from treetop to treetop, and is characteristic of hot fires and dry conditions. Crown fires are generally more complex to control than fires on the surface.
[11] Surface Fuels: Materials on the ground like needles or low-growing shrubs that provide the fuel for fires to spread on the ground. Surface fuels are generally considered all fuels within six feet of the ground.
[12] Ladder Fuels: Materials such as shrubs or small trees connecting the ground to the tree canopy or uppermost vegetation layer. In forests, this allows fire to climb upward into trees.
[13] Crown Density: A measurement of the thickness or density of the foliage of the tree crown in a stand.
[14] Biodiversity: The abundant variety of plant, fungi, and animal species found in an ecosystem, including the diversity of genetics, species, and ecological type.
[15] Productive: A term used for land or forests that are growing efficiently and in a vigorous manner.
[16] Site-Specific: Applicable to a specific piece of land and its associated attributes and conditions (e.g. microclimate, soils, vegetation).
[17] Soil Types: Refers to the different combinations of soil particles and soil composition. Soil can vary greatly within short distances.
[18] Forest Stand Enhancement: A combination of both silvicultural thinning practices and other forest restoration activities such as prescribed fire, which aim to increase the health, resiliency, and vigor of tree communities within a forest ecosystem.
[19] Fuel Continuity: The amount of continuous fuel materials in a fire's path that allows the fire to extend vertically toward the crowns of trees or horizontally into the forest or other fuels.
[20] Lop and Scatter: The act of cutting and evenly spreading branches over the ground to reduce fire hazard and erosion potential while promoting the decomposition of branches via their close proximity to the ground.
[21] Contour Falling: Cutting and placing trees along the slope contour. This is a treatment that utilizes positioned logs to control erosion from water flow. Logs are offset on the slope contour to slow water by creating a meandering travel path.
[22] Anthropogenic: The result of human activities or the influence of humans on nature.
[23] Natural Disturbance: Disturbances, like fire and floods, which occur in the environment without the intervention of humans.
[24] Initial Site Assessment: The preliminary steps of an evaluation of a piece of property to determine fuel hazards and health conditions. Information is gathered to help plan a fuel hazard reduction treatment.
[25] Present Condition: The environmental conditions that occur on a property at the present time.
[26] Historic Natural Conditions: The natural condition of a property or area that occurred in the past, before fire suppression and industrial activities. Old photos, settler's journals, elders' oral history, and clues on the property such as old stumps may be helpful in identifying the historical natural condition of an area.
[27] Future Desired Condition: The short-term and long-term goals desired from management activities on a property. It is important to keep the Conservation Principles in mind when designing these.
[28] Draw: A topographic channel that is generally shallower than a ravine.
[29] Dominant: The species that is the most abundant or influential in an ecosystem. For example, a dominant tree is one that stands taller than the rest and receives full sun.
[30] Codominant: Species that share dominance or are of equal importance. For example, a codominant fir-pine forest would be dominated by both firs and pines.
[31] Age Classes: A way of classifying the age range of trees or forests, usually divided into 20-year units, e.g. 0-20 years.
[32] Fuel Load Conditions: The amount of combustible material (both dead and live fuels). It relates to the site's fuel model *(see Appendix 3)*, slope, and aspect, and the fuel moisture content.
[33] Ground Fuels: The layer of combustible material that exists below the surface litter. This layer includes plant roots, duff, etc. These materials can burn when embers drop from above.
[34] Egress: The act of going out, or right to leave or exit a property.
[35] Slope Stability: The degree to which a slope is susceptible to erosion and slides, or the measure of its overall stability.
[36] Shaded Fuelbreaks: A fuel-reduction technique for forested areas. Vegetation is reduced and/or modified to reduce fire hazard, but an adequate amount of crown canopy remains intact, thus inhibiting weedy undergrowth.
[37] Ignition Zone: The place where combustion is initiated.
[38] Variable-Density Thinning: Thinning or selectively cutting trees in a manner to restore repeating variability or redundancy in a forest. This technique ensures diversity in stand density and canopy cover.

[39] Benches: Flat landscape areas that occur along foothill and mountainous slopes. They can be the result of natural land formations through slope movement and sluffing, or land alteration by previous resource extraction activities such as logging.
[40] Salmon River Fire Safe Council, www.srrc.org/, Fuel Reduction Plans and Maps; Dennis Martinez, "Canopy Retention for Fuel Modification Treatment in Douglas Fir Stands," Boulder Dumont Late Successional Reserve (LSR) Vegetation Management Project. Tiller Ranger District, Umpqua National Forest.
[41] Sequential Entries: Entering a forest stand or other vegetation type several times over the course of years to spread out the impacts of treatments.
[42] Photo-Point Monitoring: Using a specific, identifiable point on a property from where photos are taken over time using the same view to compare and monitor changes.
[43] This prescription is based on the work of Dave Kahan, Full Circle Forestry, Redway, CA.
[44] One-hour timelag fuels are less than ¼ inch in diameter and respond very quickly to changes in their environment. These fuels will only take about an hour to lose or gain two-thirds of the equilibrium moisture content of their environment … Moving up in size, a fuel will lose or gain moisture less rapidly through time. Ten-hour fuels range in diameter from ¼ inch to 1 inch, 100-hour fuels from 1 inch to 3 inches, and 1,000-hour fuels from 3 inches to 8 inches. 10,000-hour fuels are greater than 8 inches in diameter. Obviously, the 1,000- and 10,000-hour fuels do not burn easily. However, if they do burn, these fuels will generate extreme heat, often causing extreme fire behavior conditions. From: National Weather Service, Fire Weather Definitions, Dead and Live Fuel Moisture, www.crh.noaa.gov/fsd/firedef.htm.
[45] Closed-Canopy: Occurs when the canopies of trees touch and blend together enough so that light does not reach the floor of the forest
[46] Release: Using thinning techniques to free a tree or group of trees from competition for nutrients, sunlight, and water by removing the competing small trees and shrubs.
[47] California Forest Stewardship Program, *Forestland Steward* Newsletter, "Prune trees for better health and higher value," Winter 2002, ceres.ca.gov/foreststeward/html/prune2.html.
[48] Mosaic Thinning: A style of thinning that creates openings and patches of vegetation to increase the potential variety of habitat types.
[49] Adaptive Management: An approach to managing the environment that is based on a "learn by doing" technique. Adjustments in management change over time as new information is learned.
[50] Thermal Cover: Vegetative cover that modifies unfavorable effects of weather for animals. For example, elk may move to a fir forest with trees at least forty feet tall and with seventy percent crown closure to protect themselves from harsh weather.
[51] Uneven-Aged Treatment: A treatment that deals with three or more age classes of trees.
[52] Lindenmayer, David B., and Jerry F. Franklin (2002). *Conserving Forest Biodiversity: A Comprehensive Multi-Scaled Approach.* Island Press. Washington, D.C. See in particular the "Risk Spreading" chapter.
[53] Precautionary Principle: A principle that promotes a careful approach to developing and managing the environment when information is uncertain or unreliable. Erring on the side of caution and conservation is encouraged, along with a "better safe than sorry" attitude.
[54] Lindenmayer and Franklin, 2002, p. 184.
[55] Ingrowth: Trees that grow large enough in a season to be considered a sapling or pole timber.
[56] California Forest Stewardship Program, "How to Burn Piles Properly," www.ceres.ca.gov/foreststeward/html/burnpiles.html
[57] Hand Pile Burning: Hazardous fuels piled by hand for burning in a manner that will not damage surrounding trees or soil.
[58] Swamper Burning: A method of prescribed fire where fuel is added gradually and continually to a burning pile over the course of a day.
[59] Broadcast Underburning: A method of burning where a prescribed fire is allowed to burn in the understory of a designated area to reduce fuel hazards and/or as a silvicultural treatment.
[60] Patch Burning: A method of prescribed burning where patches are burned to prepare an area for planting or to reduce fuels.
[61] First-Entry Thinning Treatment: The first stage of tree thinning performed in a fuel reduction treatment.
[62] www.lomakatsi.org
[63] Touch-Off: A prescribed fire operation performed by a forestry or fire crew where large quantities of slash in hand piles are ignited simultaneously with drip torches.
[64] Pilot Ignition Piles: Small piles made up primarily of small fine fuels such as branches.
[65] Slash Paper: Paper used to cover slash piles before ignition with the intention of keeping or allowing the slash dry. Paper is considered more environmentally appropriate than plastic.
[66] Drip Torch: A hand-held device used to ignite fires by dripping flaming liquid fuel on the materials to be burned.
[67] Scratch Line: An incomplete control line in the beginning stages that is constructed as an emergency backup for spreading fires.
[68] Scalping: The act of removing the surface layer to expose the bare mineral soil.
[69] Bare Mineral Soil: The layer of inorganic earth below the litter and duff layer that is composed of sand, silt, and clay and has little to no combustible materials.
[70] Hand Pile and Burn: The act of gathering slash into piles by hand and then burning the pile.
[71] Piles greater than four feet by four feet require special permits from CAL FIRE and the Air District
[72] Chunk: To complete the pile-burning process by turning in or placing the unburned woody material ends into the fire ring.
[73] Pilgrim, Agnes Baker. Confederated Tribe of Siletz, Takelma Tribe of the Rogue Valley, Southern Oregon. Personal communication.
[74] Burn Plan: Detailed document with specific information on prescribed burns. Used by the burn boss for implementing specific prescribed-burn projects.

[75] Ignition Specialist: A trained professional who specializes in ignition, prescribed fire techniques, and management. Ignition specialists are certified through the National Wildfire Coordinating Group and have years of experience in wildland fire suppression and prescribed fire use. They have met all necessary requirements to perform firing applications.
[76] Fire Ignition: The act of setting on fire or igniting a fire.
[77] Escape Route: A path or road that has been preplanned to get out of harm's way in a fire situation. The route should be well understood by all participants. If there is any unclear direction, the path should be marked.
[78] Pump Chance: An area where water can be pumped from a pond or creek for fire-suppression purposes.
[79] Jackpots: Generally, small pockets of dense fuels which could allow a fire to flare up and burn more intensely.
[80] Blackline: Preburning of fuels adjacent to a control line before igniting a prescribed burn.
[81] Headwall: Steep upper sides of a drainage where fire can move quickly.
[82] Mesic: The condition of being normally moist, as in vegetation or ecosystems.
[83] Jones, Tim. Fire Management Officer, Arcata Bureau of Land Management. Personal communication, July 12, 2004.
[84] Holst, Eric (2006). *Small-Diameter Wood Utilization in Sierra Nevada Forests,* A Situation Analysis and Assessment of Opportunities for Expanding Existing Markets.
[85] Institute for Sustainable Forestry, *Safeguarding Rural Communities: Fire Hazard Reduction and Fuels Utilization, Final Report,* September 2001 to December 2002, p. 23.