Magalia Forest Health Plan

Magalia Forest Management Plan

developed for

by
Sierra Timber Services
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Funding provided by the Sierra Nevada Conservancy and Agency of the State of California through the Water Quality, Supply, and Infrastructure Improvement Act of 2014, Proposition 1 as well as the California Department of Forestry and Fire Protection SRA Fire Prevention Fee.

Magalia Forest Health Plan

Contents

Introduction and Purpose

The project is part of an effort by the Butte County Fire Safe Council to apply fuel reduction on a landscape level in the Magalia and Paradise area. The project assesses forest health on 1066 acres of land. Landowners in the project area include Paradise Pines Property Owners Association, Paradise Irrigation District and Paradise Unified School District. The Fire Safe Council's intent for this project is to develop planning and permitting for fuel reduction work during the next ten years that will help protect the area surrounding Magalia and Paradise, including all the natural resources in the surrounding landscape. To accomplish this, field surveys were conducted by a local forestry consulting firm, Sierra Timber Services, on the various land holdings of Paradise Pines Property Owners Association (POA), Paradise Irrigation District (PID) and Paradise Unified School District (PUSD). The project goals were to:

- Provide a guide for landowners and fuels reduction decision makers such as CCC, CALFIRE, USFS, BLM to manage forest for fire safety and watershed health.

- Document the completed shaded fuel break and watershed protection projects.
- Assess the fuels reduction prescription that has been used and determine if it is appropriate and what other silvicultural practices need to be taken into consideration.
- Make a realistic assessment of the risks to the project area from wildfire and tree mortality.
- Develop treatments to mitigate those risks based on the data from the assessment.
- Identify the retreatment intervals necessary to maintain fuel reduction work.
- Obtain the field information required for the Mitigated Negative Declaration covering the fuels work.

This forest management plan has been funded by a grant from the Sierra Nevada Conservancy, an agency of the State of California and a grant from the California Department of Forestry and Fire Protection SRA Fire Prevention Fee.

Forest Health Summary

Field surveys revealed several significant risks to forest heath within the project area. The forest is overstocked on Paradise Pines and Paradise Unified School district lands. There are a growing number of dead trees near homes and roads due to the recent drought and natural mortality. Much of the Paradise Irrigation District's land and small portions of the Paradise Pines and Paradise Unified School district lands have received fuel reduction work, however more recent fuel treatments have been less aggressive and show higher fuel loads than past treatments. Canopy bulk density will need to be reduced in key fire corridors to lessen fire danger to the community. This may require removing trees greater than 10"DBH in some areas. Healthy, well-spaced, smaller diameter trees should be strategically left at a low density (1-5 per acre) to maintain the health of the forest stands while obtaining adequate fuel reduction.

Key Management Points

Fire Modeling and Simulations

- *Middle Butte Creek and Slaughterhouse Ravine, on POA lands, are key fire corridors with the highest risk of crown fire and fire spread into the community.*
- *Little Butte Creek watershed area, on PID lands, is at a lower risk of fire spread into the community.*
- *Pine Ridge Elementary School on PUSD lands is at high risk for crown fire and high intensity fires.*

Water Use

- *Continued Fuels reduction will benefit forest health by making more water available to trees for longer durations.*

Fuels Reduction Prescription

- *The fuels reduction prescription which has been used is an effective method where fuels are concentrated in the understory.*
- *Select 1-5 young trees to replace aging, larger trees and to avoid leaving too many trees in the understory, compromising the integrity of the fuels reduction work.*
- *Retreatment intervals should be every 10 years for areas with less than 70% canopy cover or every 15 years for areas with greater than 70% canopy*

Maintenance

- Where Canopy cover is less than 70% retreatment will need to occur in 10 yr. intervals.
- Where Canopy cover is greater than 70% retreatment intervals can be lengthened to 15 yr. intervals.

Forest Health Risk Assessment

Overview

Current forest stocking levels show a total of approximately 425 trees per acre, ~70% of which are under 10 inches in diameter at breast height (DBH- measured at 4.5 above the ground). Approximately 120 trees per acre are over 10" DBH. There are about 15 snags (standing dead trees) per acre under 10" DBH and 7 snags per acre above 10" DBH. That calculates to about 7,300 snags over 10" DBH across the entire project. There are also approximately 2 diseased trees per acre. Expected conifer mortality is less than one tree 10 inches DBH or greater per acre. Over the project area this data can be extrapolated to show an approximate mortality of over 600 conifers 10 inches DBH and greater throughout the entire project area in the near future.

Current forest stocking levels on the 1066 acres in the project area are shown on the table below.

	Total Trees /Acre	Trees per Acre less than 10" DBH	Trees per Acre 10" DBH and greater	Basal Area	Crown Bulk Density
Current	425	305	120	231	.077kg/m^3
Ideal Range	180-290	120-200	60-90	100-170	.04-.055kg/m^3
Percent Overstocked	147-236%	153-254%	133-150%	136-231%	140-193%

The project area also has 264 acres classified as a Hazard Zone where vulnerable dead and dying trees are within 150 feet of houses and roads and pose a threat to public health and safety. Approximately, 1,845 dead snags over 10" DBH are located within the Hazard Zone and it is recommended that snags which pose a safety hazard in this area be removed. Furthermore, 528 trees are considered diseased, 158 of which are conifers 10" DBH and larger.

There are 1,845 dead snags over 10" DBH located within the 264 acres classified as a Hazard Zone (150 ft. or less from houses and roads).

Treatment objective	Vegetation Types	Recommended Prescriptions	Potential Treatment Methods
Summary			
To create a fire safe community and recreation area, and to protect local infrastructure,	Mixed Conifer Fir/Cedar/Oak Grey Pine/Live Oak Ponderosa Pine Fir/Pine/Oak Ceanothus/Scrub/Opening Serpentine	Remove underbrush, down, and dead fuels. *Remove non-wildlife snags < 10" DBH.* Prune branches under 16 feet or 1/3 of live crown for smaller trees. *Remove suppressed/intermediate trees <10" DBH.* Remove healthy < 10" DBH trees until 70% target canopy cover is reached. *Leave replacement and wildlife trees at 1-5 trees per acre depending on stand conditions (see pg. 21).*	Hand cutting Mastication Prescribed burn (see pages24-25)
Paradise Irrigation District			
Protect watershed and facilities	Mixed Conifer Fir/Cedar/Live Oak Grey Pine/Live Oak Serpentine	Continue with current treatment protocol. *Remove dead/dying trees in Hazard Zone*	Hand cutting Mastication Prescribed burn (see pages24-25)
Paradise Pines			
Fire safe community and recreation area, Removal of hazard liabilities.	Mixed Conifer Fir/Cedar/Oak Ceanothus/Scrub/Opening	Remove dead/dying trees throughout property and in Hazard Zones. *Removal of ladder fuels and some trees +10" DBH.* Retaining of younger trees for future recruitment into overstory. *Middle Butte Creek/Slaughterhouse Ravine should be a management priority*	Hand cutting Mastication Prescribed burn (see pages24-25)
Paradise Unified School District			
Safe aesthetic campus, safety during an evacuation	Mixed Conifer Ponderosa Pine	Remove dead/dying trees in Hazard Zones. *Thinning of unhealthy or damaged trees in 2-8" diameter class.* Pine Ridge School should be a management priority.	Hand cutting Mastication (see pages24-25)

Tree density at the recommended 70% canopy cover. For additional information see the Silviculture section.

Overhead View of 70% Canopy Cover

Horizontal View of 70% Canopy Cover

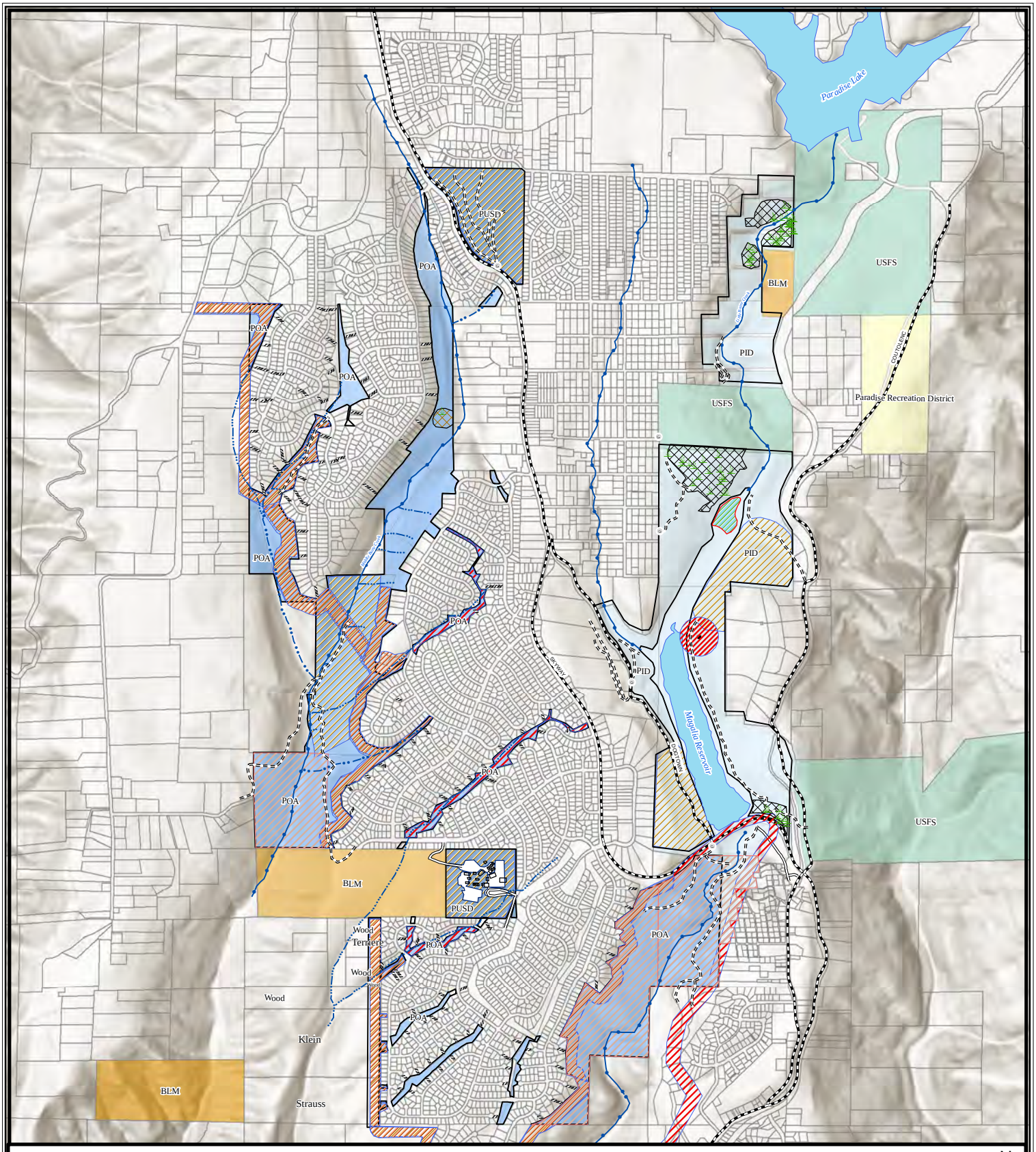
Table 1. Overall Project Area Trees per Acre

Magalia Forest Health Project Stand Table

Trees per Acre

Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Live Oak	70	23	1	<1	<1		
Douglas Fir	83	25	13	4	1	< 1	<1
Incense Cedar	66	11	5	2	<1		
Ponderosa Pine	29	3	5	2	<1		
Pacific Madrone		2	<1				
Big Leaf Maple	24	3					
Black Oak	29	11	2	<1			
Bay Laurel	6						
Sugar Pine		<1	<1	<1	<1	<1	
White Fir		2	<1				
Gray Pine		1					
Totals	**307**	**81**	**26**	**8**	**1**	**<1**	**<1**

Table showing the average amount trees per acre by species and diameter class.



Magalia Forest Health Planning Map- Overview

Legend

- Project Area
- Retreatment Needed
- Access Road
- Gate Access
- Pedestrian Easement

Watercourse
- Class I
- Class II
- Class III

Plant Surveys Needed*
- Serpentine
- Volcanic
- Special Status Plants

Restricted Area
- Bald Eagle Nest Buffer
- Bald Eagle Nest
- Archeaological Sensitive Areas
- Federal Wetland

Ownership
- Private
- PID
- POA
- PUSD
- BLM
- USFS
- Paradise Rec

N

1 inch = 3,300 feet

Sierra Timber Services

Paradise Irrigation District

Paradise Irrigation District has 389 acres within the project area, located around the Magalia Reservoir and Little Butte Creek. The property has multiple vegetation types including: Mixed Conifer, Fir/Cedar/Oak, Grey Pine/Live Oak, and Serpentine. The current stocking level for the property is approx. 385 trees per acre, with about 270 (~70%) being 10" DBH or less. About 108 trees per acre are 10" DBH or larger. There are approx. 8 snags per acre under 10" DBH and 5 snags per acre 10" DBH and larger, which is a slightly less average than the rest of the Magalia plan area. Therefore, throughout PIDs land it is estimated that there are currently 1,945 10" DBH and larger standing dead trees. There are also less diseased trees per acre on PIDs land than the project areas average, with close to 80 trees being diseased. The expected conifer mortality is about 1 tree 10" DBH or larger per two acres. This means that about 195 conifers 10" DBH and larger may die in per year.

Paradise Irrigation District has 59 acres of Hazard Zone in the project, where vulnerable trees are within 150 feet of houses and infrastructure, posing a health and safety risk. This means roughly 295 10" DBH and larger dead trees are located in the hazard areas of their property. There are also approx. 12 diseased trees in the PID Hazard Zone. Expected conifer mortality of trees 10" DBH and larger in this zone is about 31 trees per year. There is an average of 6.4 tons per acre of dead, downed woody debris located throughout PIDs land holdings.

Summary
Acres: 389
Location: around the Magalia Reservoir and Little Butte Creek
Hazard Acres: 59
Down woody debris: 6.4 tons/acre

Objectives
- *Protect watershed and facilities*

Key Issues
- *PID has the lowest fuel loading*
- *Healthy timber stand*
- *Hazard trees*

Recommendations
- *We recommend that they continue their current program of fuel break maintenance and expansion*
- *Large diameter dead and dying hazard trees within 150 feet of houses and roads should be removed.*

Treatment Methods
- *Hand cutting*
- *Mastication*
- *Prescribed burn*

Table 2. Paradise Irrigation District Trees per Acre

Paradise Irrigation District Stand Table *Trees per Acre*							
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Black Oak		17	1	<1			
Douglas Fir	132	22	10	5	1	1	<1
Gray Pine		2					
Incense Cedar	41	6	4	2	1		
Live Oak	104	28		<1	<1		
Ponderosa Pine		2	3	1	<1		
Sugar Pine			1	1	<1		
Totals	**277**	**77**	**19**	**9**	**2**	**1**	**<1**

Table showing the average amount of trees per acre by species and diameter class that are found within PIDs 389 acres.

Figure 1. PID Stand Structure Visual Simulation

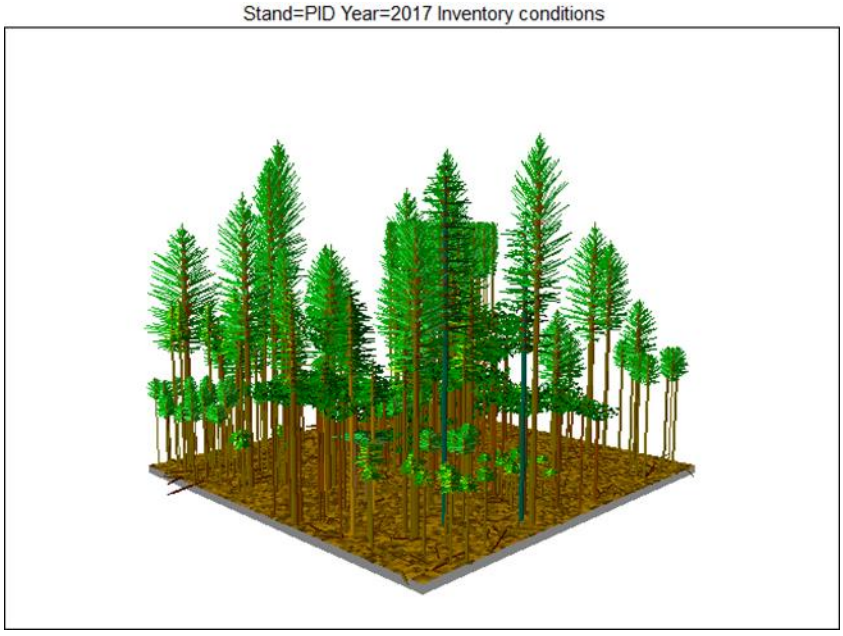


Figure shows various size classes and overall structure of current stand conditions in Paradise Irrigation District landholdings.

Paradise Irrigation Districts has an overall stand structure reflective of a healthy, managed stand. Figure 1 gives a visual representation of the structure and shows various ages and height classes evenly distributed throughout the area. Associated with a well-managed and evenly distributed stand, the canopy bulk density (CBD) of the property is the lowest of all the property holdings (0.062kg/m^3) Graphs 1 and 2 show the influence of the diameter classes on CBD, with 10-16" class having the greatest influence, followed by the 18-26" class, 28-36" class and the 2-8" class. The stand is the closest to recommended canopy bulk densities for fuel breaks of 0.05kg/m^3. Opportunities for new fuel reduction work exist in the less accessible northern portion of PID's ownership. Beyond that, further decreases in CBD will require removal of larger diameter trees. We recommend that they continue their current program of fuel break maintenance and expansion.

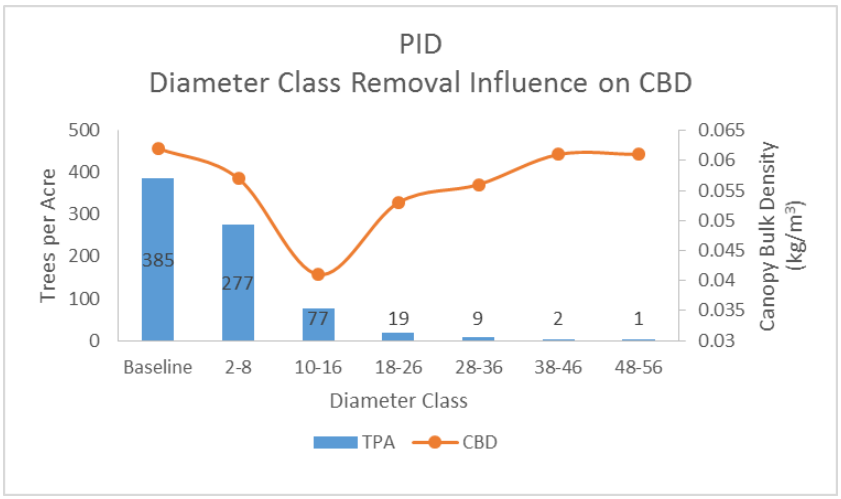
Canopy Bulk Density

n. **The mass of available canopy fuel per unit canopy volume (Scott and Reinhardt 2001).**

Canopy bulk density is used to predict whether an active crown fire is possible. The product of canopy bulk density and rate of spread is mass-flow rate; a minimum mass-flow rate is hypothetically required to maintain an active crown fire.

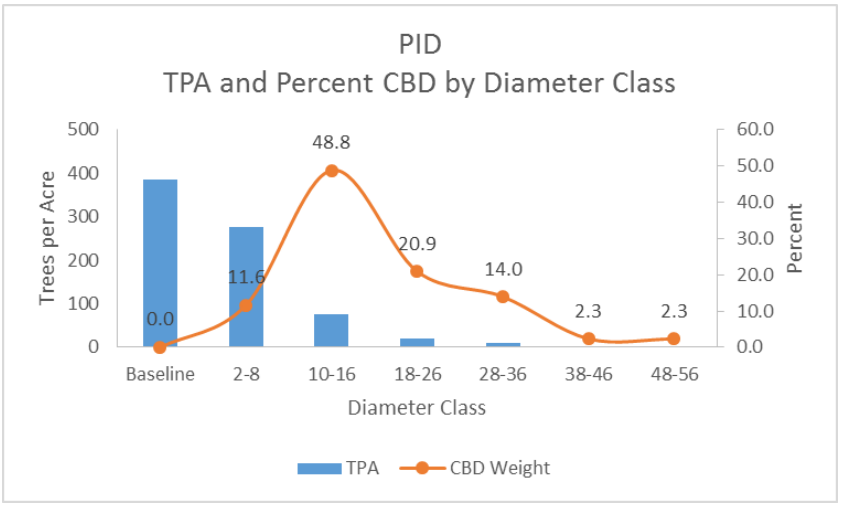
Fire Words-Glossary of Fire Science Terminology **Joe Scott 2007**

Graph 1. PID Removal of Diameter Classes and Influence on Canopy Bulk Density



Graph showing how 100% removal of designated diameter classes will affect canopy bulk density.

Graph 2. PID: TPA and Percent CBD by Diameter Class



Graph showing the percent influence each diameter class has on overall canopy bulk density.

Paradise Pines Property Owners Association

Paradise Pines has 560 acres in the project area, which are located around Middle Butte Creek, Little Butte Creek and Slaughterhouse Ravine. Vegetation types include: Mixed Conifer, Fir/Cedar/Oak, and Ceanothus/Scrub/Openings. The current stocking level of POA property is approx. 401 trees per acre with about 65% being trees under 10" DBH. There are about 140 trees per acre 10" DBH and larger. There are approximately 25 snags per acre under 10" DBH and 10 snags per acre 10" DBH and larger, which is about 3 more snags per acre than the total project average. That calculates to about 5,600 10" DBH and larger standing dead trees throughout Paradise Pine's property. There are an estimated 3 diseased trees per acre; i.e. approx. 1,680 diseased trees. The expected conifer mortality is about 2, 10" DBH and larger trees per 3 acres. This means that roughly 390 conifers 10" DBH and larger may die per year.

Paradise Pines has 165 acres that fall within the Hazard Zones of the project where vulnerable trees are within 150 feet of houses and infrastructure, posing a health and safety risk. This calculates to about 1,650 10" DBH and larger standing dead trees in the Hazard Zones located on their property. There are about 495 diseased trees in the Hazard Zone. Expected conifer mortality in this area is approx. 116 conifers 10" DBH and larger. There is an average of 18.3 tons to the acre of dead, downed, woody debris.

Summary

Acres: 560
Location: around Middle Butte Creek, Little Butte Creek and Slaughterhouse Ravine
Hazard Acres: 165
Down woody debris: 18.3 tons/acre

Objectives

- *Fire safe community and recreation area*
- *Removal of hazard liabilities*

Key Issues

- *Key fire corridors (Middle Butte Creek and Slaughterhouse Ravine)*
- *Hazard trees*

Recommendations

- *The Middle Butte Creek and Slaughterhouse Ravine are key fire corridors and fuels should be aggressively treated in this area.*
- *Trees larger than 10 inches in diameter will need to be removed to create an effective fuel break some areas*
- *Large diameter dead and dying hazard trees within 150 feet of houses and roads should be removed.*

Treatment Methods

- *Hand cutting*
- *Mastication*
- *Prescribed burn*

Table 3. Paradise Pines Owners Association Trees per Acre

Paradise Pines Stand Table ***Trees per Acre***							
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Bay Laurel	11						
Big Leaf Maple	47	5					
Black Oak	7	11	3	<1			
Douglas Fir	51	30	16	4	1	<1	
Incense Cedar	75	10	6	2	<1		
Live Oak	69	29	2	<1			
Pacific Madrone		3	1				
Ponderosa Pine		4	6	3			
Sugar Pine		1			<1	<1	
White Fir		3	1				
Totals	**260**	**96**	**35**	**9**	**1**	**<1**	**0**

Figure showing the average amount of trees by species and diameter class within the 560 acres of Paradise Pines ownership.

Figure 2. POA Stand Structure Visual Simulation

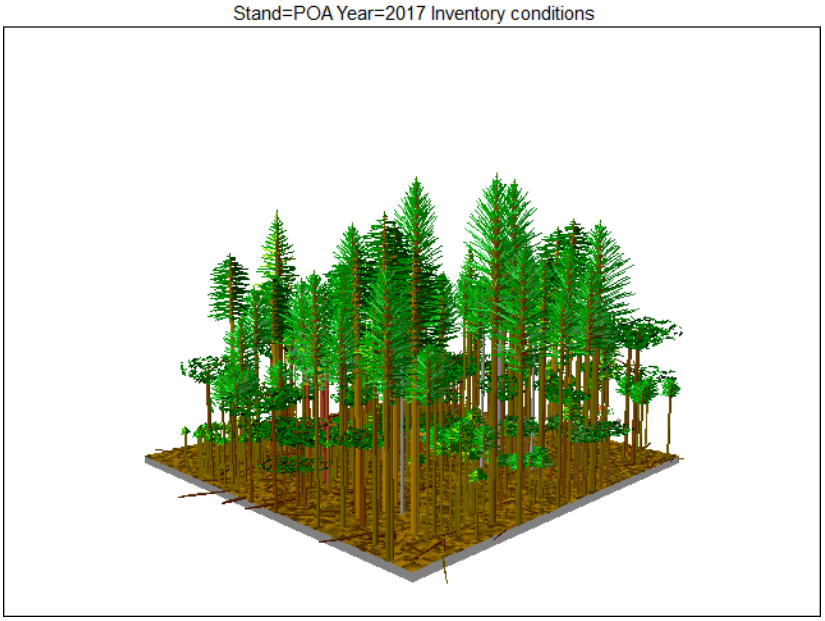
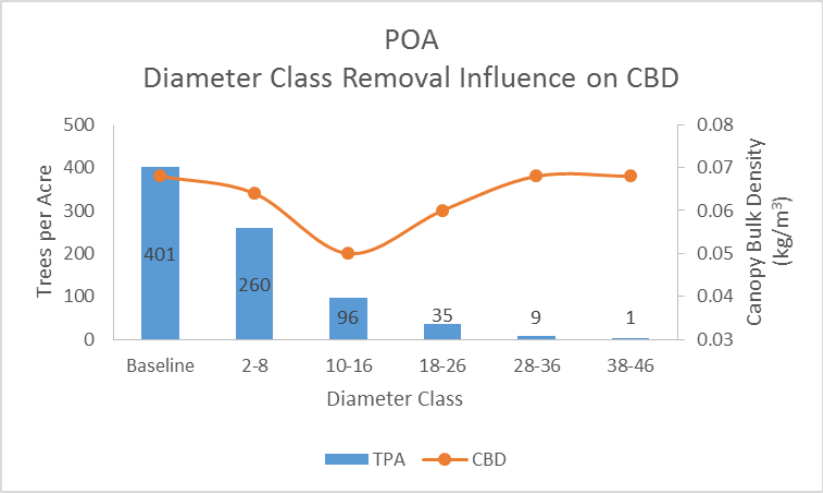


Figure shows various size classes and overall structure of current stand conditions in Paradise Pines Owners Association landholdings.

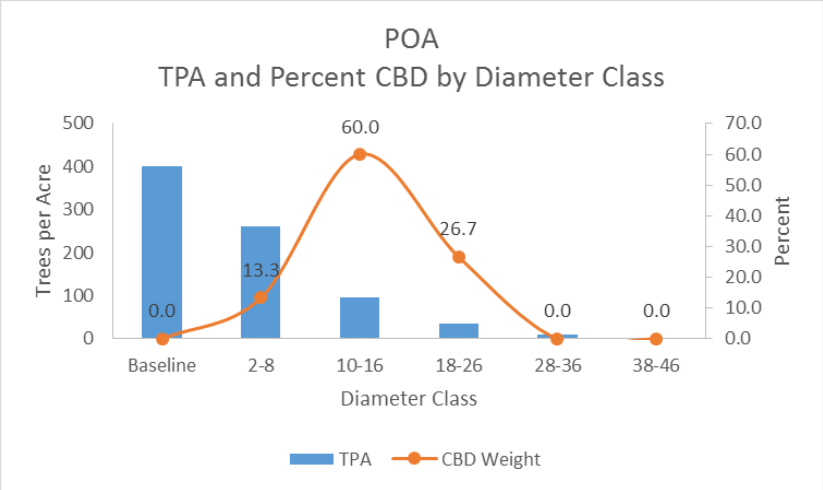
Paradise Pines Owners Association stand structure is a more mature stand than PID or PUSD. Figure 2 shows a very dense upper canopy, with a scattering of smaller trees in the understory that would act as ladder fuel. The current canopy bulk density based on calculated results is 0.085kg/m^3 and is the highest density of all the property holdings by an average of 0.02kg/m^3. Because of the high bulk density and the overall maturity of the stand, removal of lower diameter trees won't have as much effect as it would in PUSD and PID. As Graph 3 shows, 100% removal of the 2-8" diameter class will only reduce CBD by .004kg/m^3. A more effective method to reduce CBD would be to remove larger diameter trees particularly in the 10-16" diameter class. A possible solution for landowners hesitant to remove larger diameter trees could be to take out the larger diameter trees that are dead or dying. As mentioned above, POA has roughly 5,000 standing dead trees and 1,600 dying trees throughout the property. Since these trees should be removed for human health and safety reasons, as well as for the overall health of the stand, it may be possible to help reduce the CBD with the removal of dying trees. Such practices can also be used for recruitment of younger trees into the overstory, which is especially important in mature stands. Strategically opening the canopy in areas with smaller, well-spaced trees, allows them access to water and light so that they rapidly grow into the overstory, creating a healthier forest. This could help achieve desired landowner goals and objectives without compromising stand integrity and overall health. Graphs 3 and 4 show that if removal of larger diameter trees is desired, the 10-16" diameter class will have the biggest effect on overall CBD.

Graph 3. POA Diameter Class Removal and Influence on CBD



Graph showing how 100% removal of designated diameter classes will affect canopy bulk density

Graph 4. POA: TPA and Percent CBD by Diameter Class



Graph showing the percent influence each diameter class has on overall canopy bulk density

Paradise Unified School District

The Paradise Unified School District has 100 acres in the project area that are located in two parcels; 40 acres at Pine Ridge School and 60 acres off of Skyway. The ownership has multiple vegetation types including: Mixed Conifer and Ponderosa Pine. The current stand stocking level is approx. 632 trees per acre, ~84% (532 trees) of which are under 10" DBH. There are about 100 trees per acre 10" DBH and larger. There are approximately 3 snags per 2 acres that are 10" DBH and larger, which is about 5 trees less than the overall project average. That calculates to 150 10" DBH and larger standing dead trees on Paradise Unified School District's section of the property. There are an estimated 3 diseased trees per acre. The expected conifer mortality is less than one 10" DBH tree and larger per acre on the school districts property, averaging about 56 trees total per year.

Paradise Unified School District has 40 acres in the Hazard Zone, where vulnerable trees are within 150 feet of buildings and infrastructure, posing a health and safety risk. Currently there are about 60 10" DBH and larger dead trees in the Hazard Zones. There are also approximately 120 diseased trees in the project area. Expected conifer mortality is about 22 conifers 10" DBH and larger per year. There is an average of 8.9 tons per acre of dead, downed, woody debris.

Summary

Acres: 100
Location: Pine Ridge School and off of Skyway
Hazard Acres: 40
Down woody debris: 8.9 tons/acre

Objectives

- *Safe aesthetic campus*
- *safety during an evacuation*

Key Issues

- *safety during an evacuation*
- *Hazard trees*

Recommendations

- *Initial efforts should focus around Pine Ridge School.*
- *Starting fuels reduction now has the greatest opportunity to reduce fuel loading using the Butte County Fire Safe Council's standard prescriptions.*
- *Large diameter dead and dying hazard trees within 150 feet of school buildings, houses, and roads should be removed.*

Treatment Methods

- *Hand cutting*
- *Mastication*

Table 4. Paradise Unified School District Trees per Acre

Paradise Unified school District Stand Table ***Trees per Acre***							
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Black Oak	170	3					
Douglas Fir	82	36	10	2			
Incense Cedar	89	31	6	2			
Ponderosa Pine	191		5	5			
Totals	**532**	**70**	**21**	**9**	**0**	**0**	**0**

Figure showing the average number of trees per acre by species and diameter class that are found within the 100 acres of PUSD ownership.

Figure 3. PUSD Stand Structure Visual Simulation

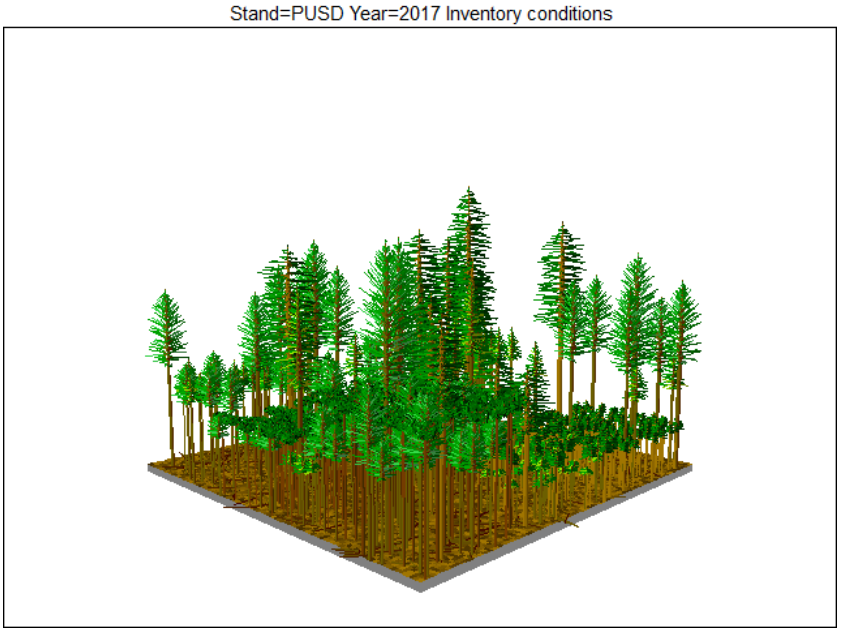
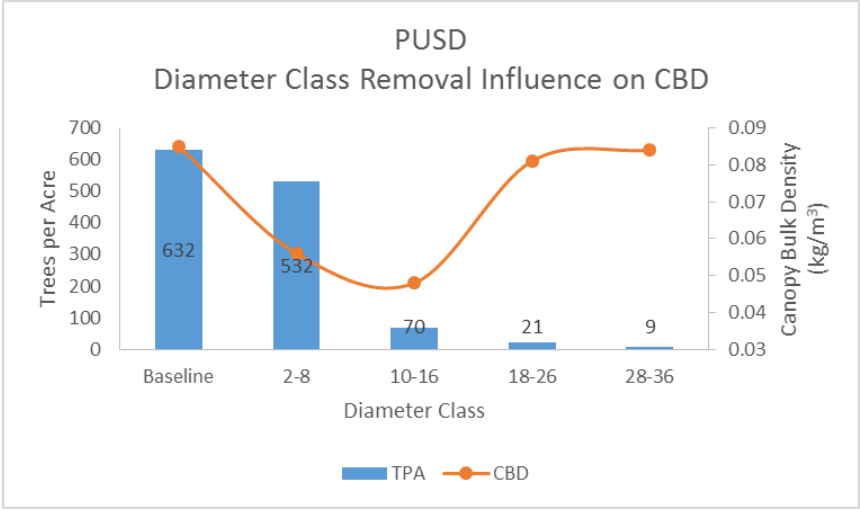


Figure shows various size classes and overall structure of current stand conditions in Paradise Unified School District landholdings.

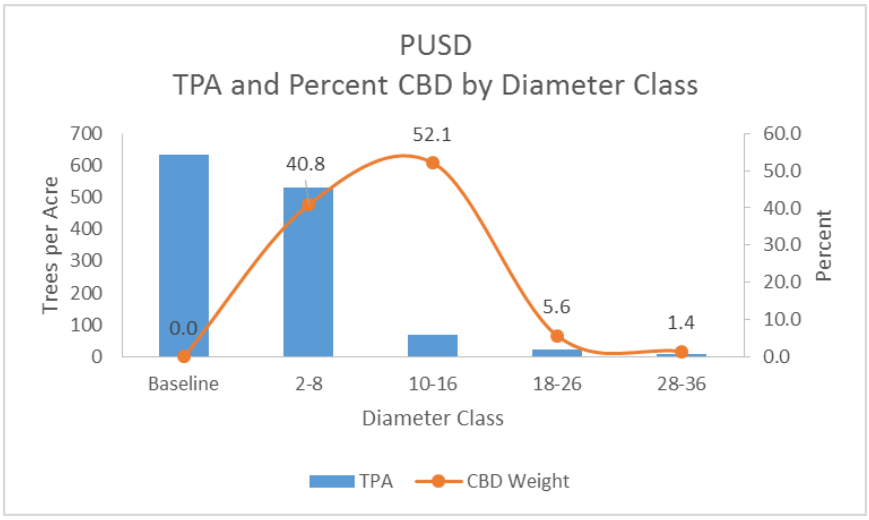
Paradise Unified School Districts overall stand structure is that of a younger stand. As Figure 3 shows above, the understory is overstocked with smaller diameter trees, which would act as ladder fuels in the event of a fire. PUSDs stands currently have the highest canopy bulk density (.085kg/m^3) and the most trees per acre (632) of any other stand. Because this is a younger stand, the lower diameter trees can have a much greater effect on overall canopy bulk density than that of other stands within the project area (as illustrated in Graphs 5 & 6). This is more in line with current landowner goals and objectives, as thinning/removal of trees within the 2-8" diameter class could significantly reduce CBD. As Graphs 5 and 6 show, 100% removal of 2-8" diameter class could reduce CBD by almost 0.03kg/m^3. Treatment of these stands should be considered a priority as they have the greatest opportunity to reduce fuel loading using the Butte County Fire Safe Council's standard prescriptions.

Graph 5. PUSD: Diameter Class Removal and Influence on CBD



Graph showing how 100% removal of designated diameter classes will affect canopy bulk density

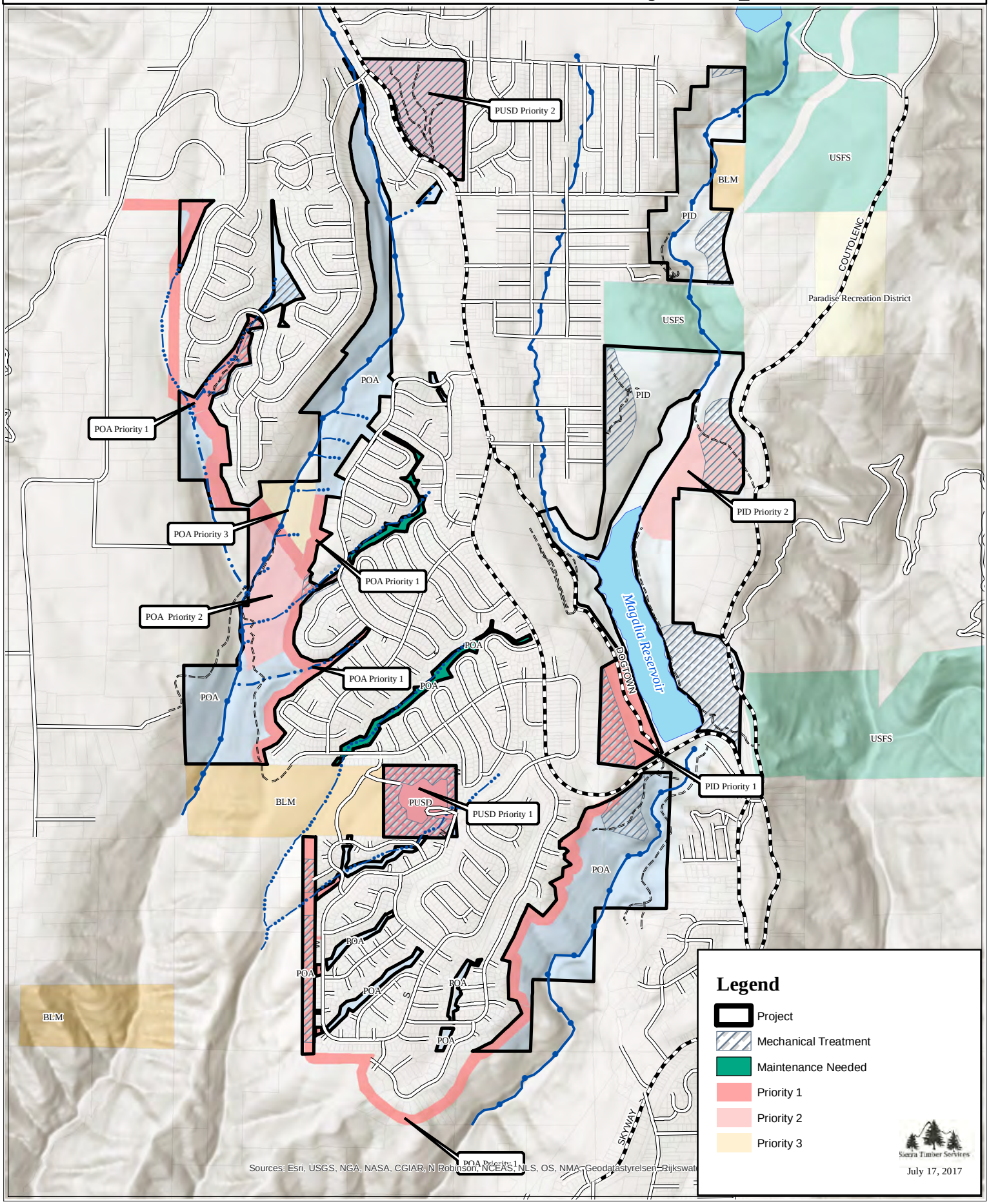
Graph 6. PUSD: TPA and Percent CBD by Diameter Class



Graph showing the percent influence each diameter class has on overall canopy bulk density

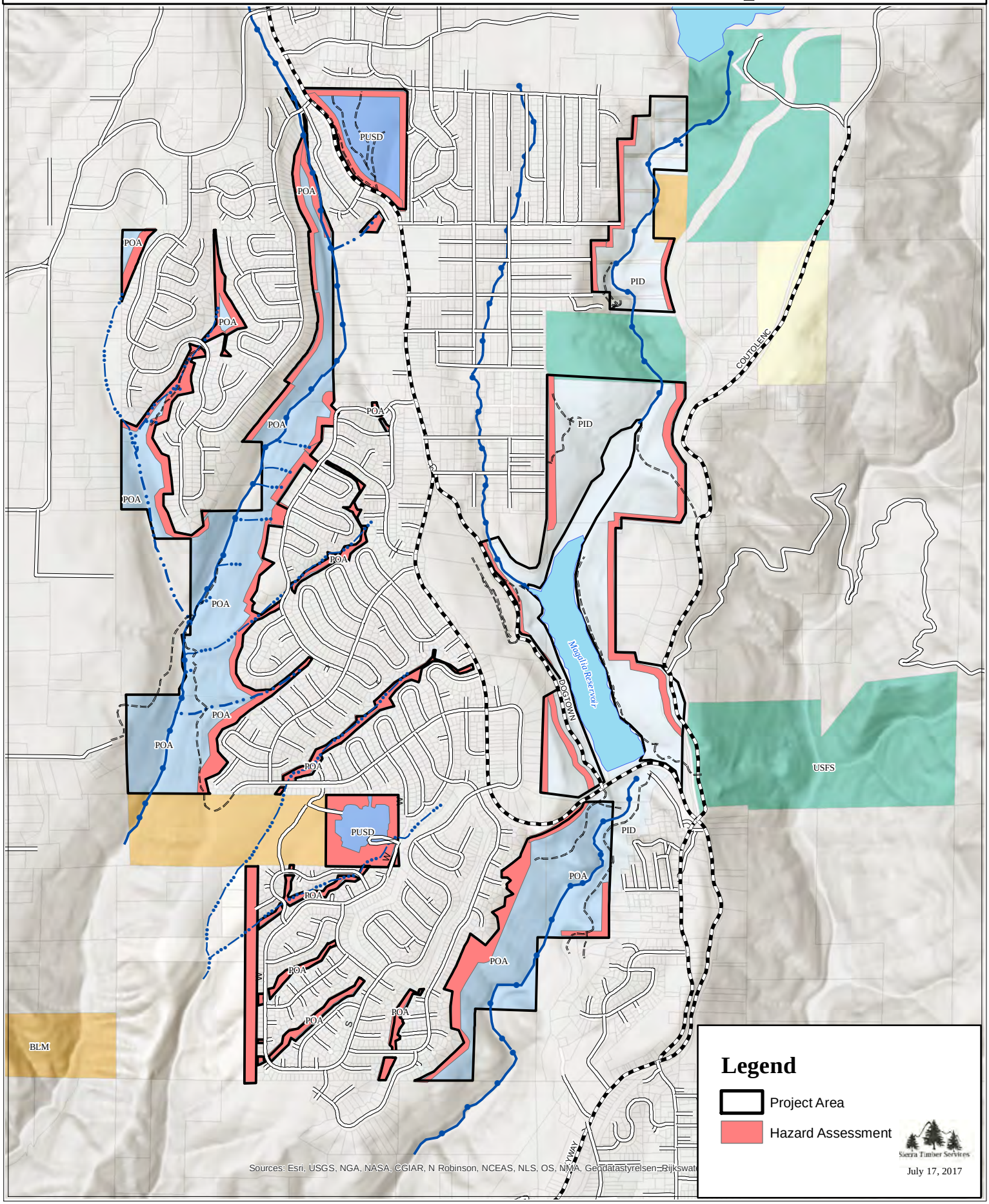
Magalia Forest Health
Fuel Treatment Priority Map

1 inch = 3,000 feet



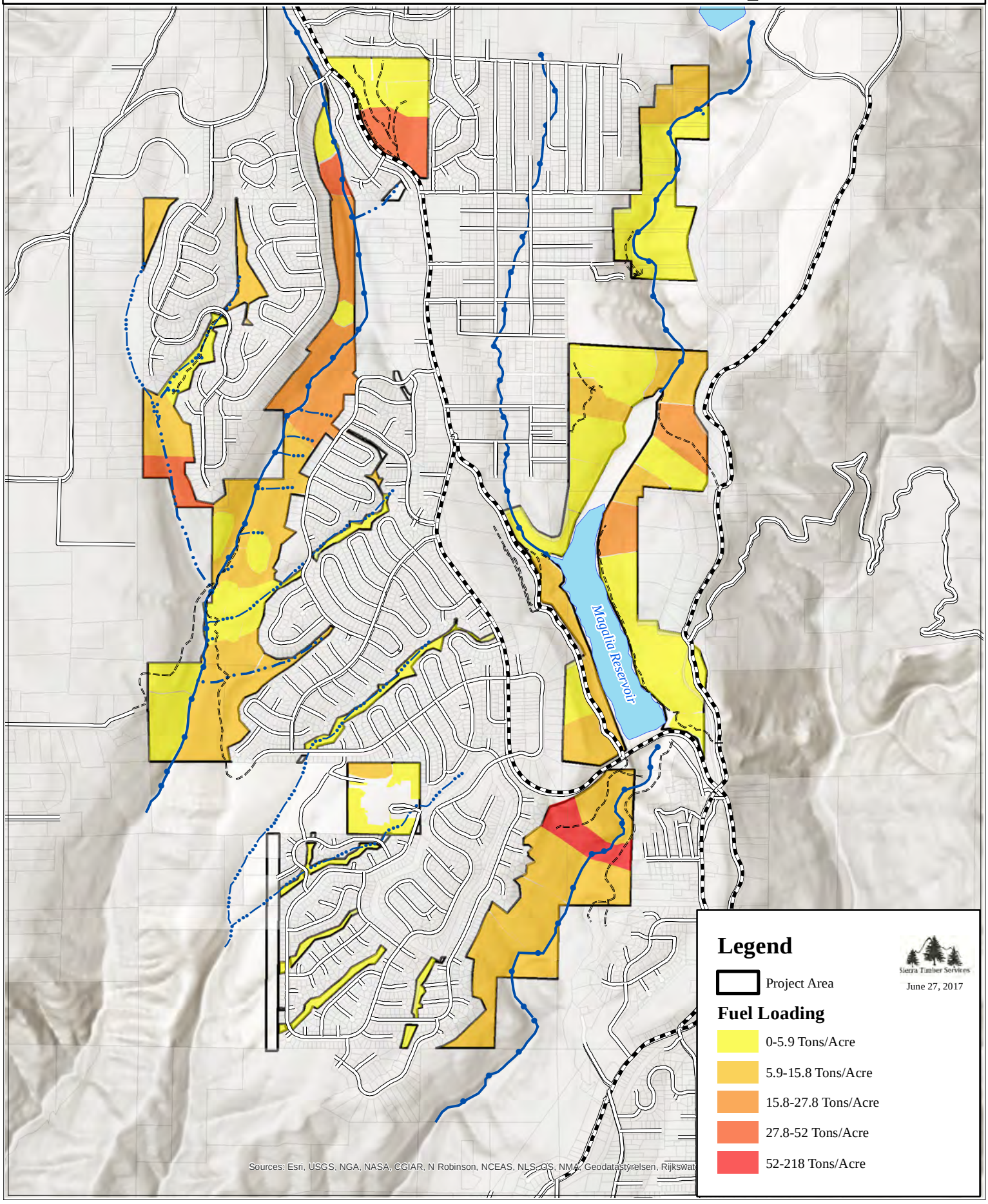
Magalia Forest Health
Hazard Tree Assessment Map

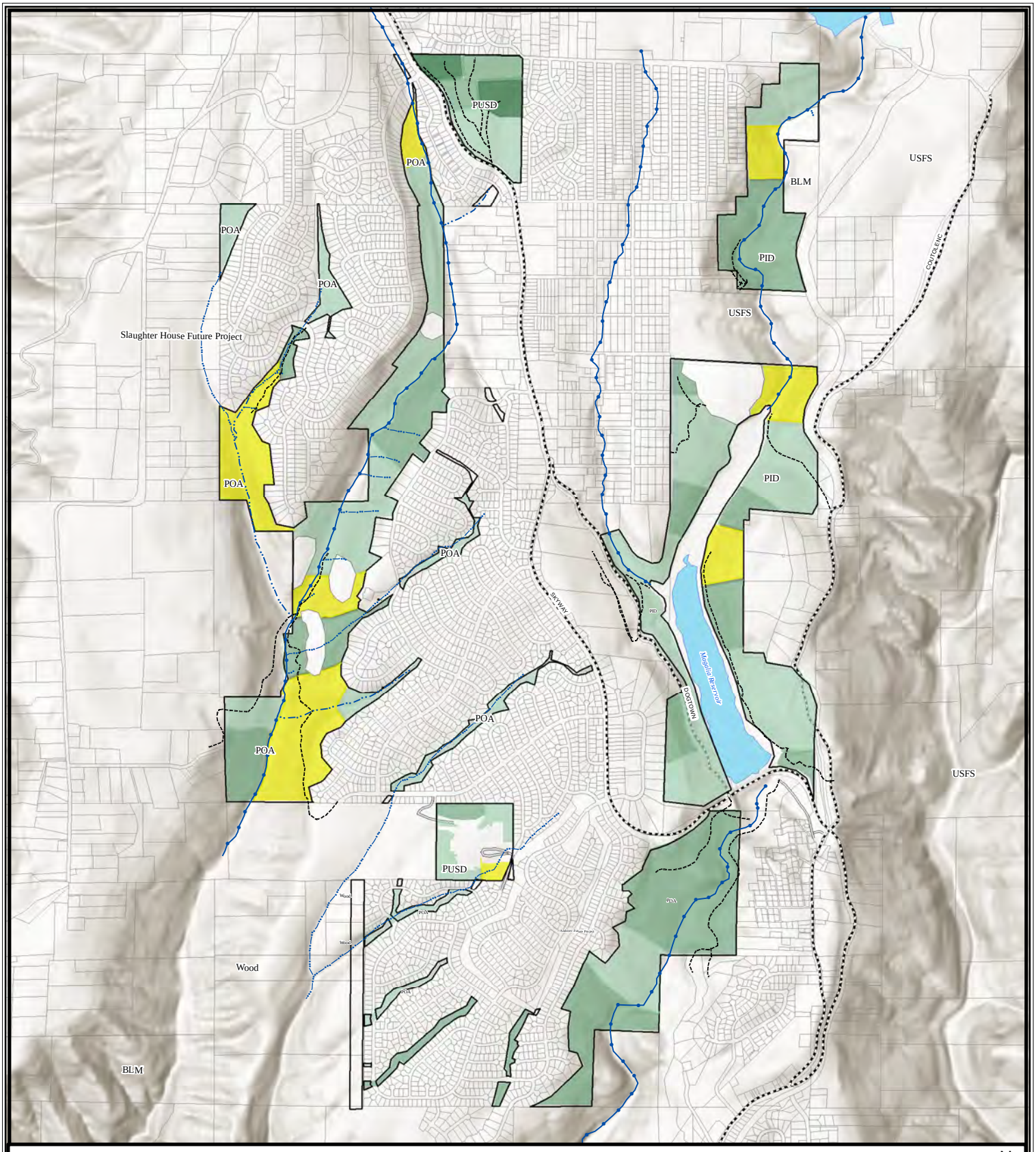
1 inch = 3,000 feet



Magalia Forest Health
Down & Dead Fuel Load Map

1 inch = 3,000 feet





Legend

Project Area

Tree Health

- Serpentine outcrop
- Young/Full vigor
- Immature/Full to Good Vigor
- Mature/Good to Poor Vigor
- Overmature/Fair to Poor Vigor

Magalia Forest Health
Tree Health Map

N

1 inch = 3,000 feet

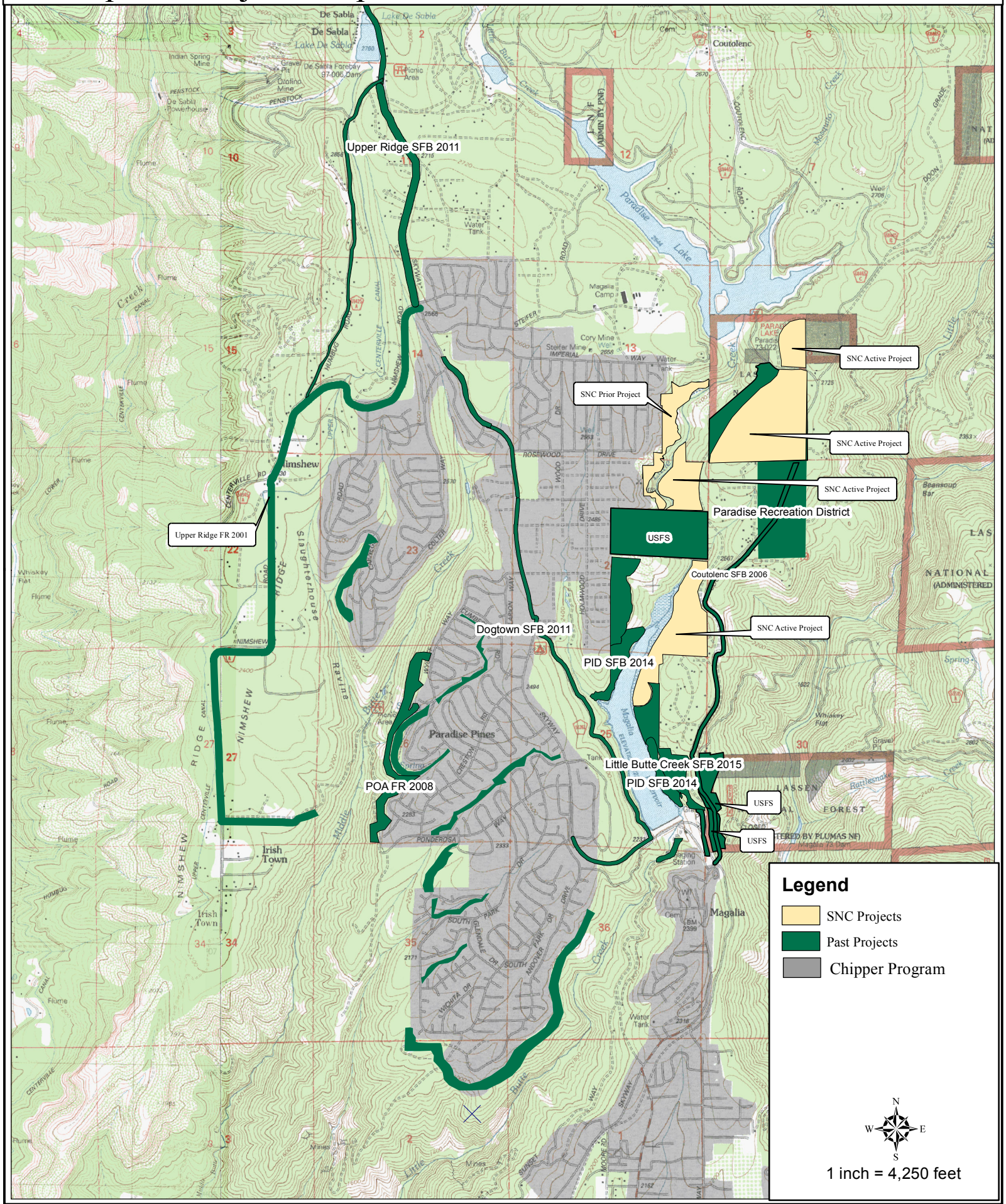
Sierra Timber Services

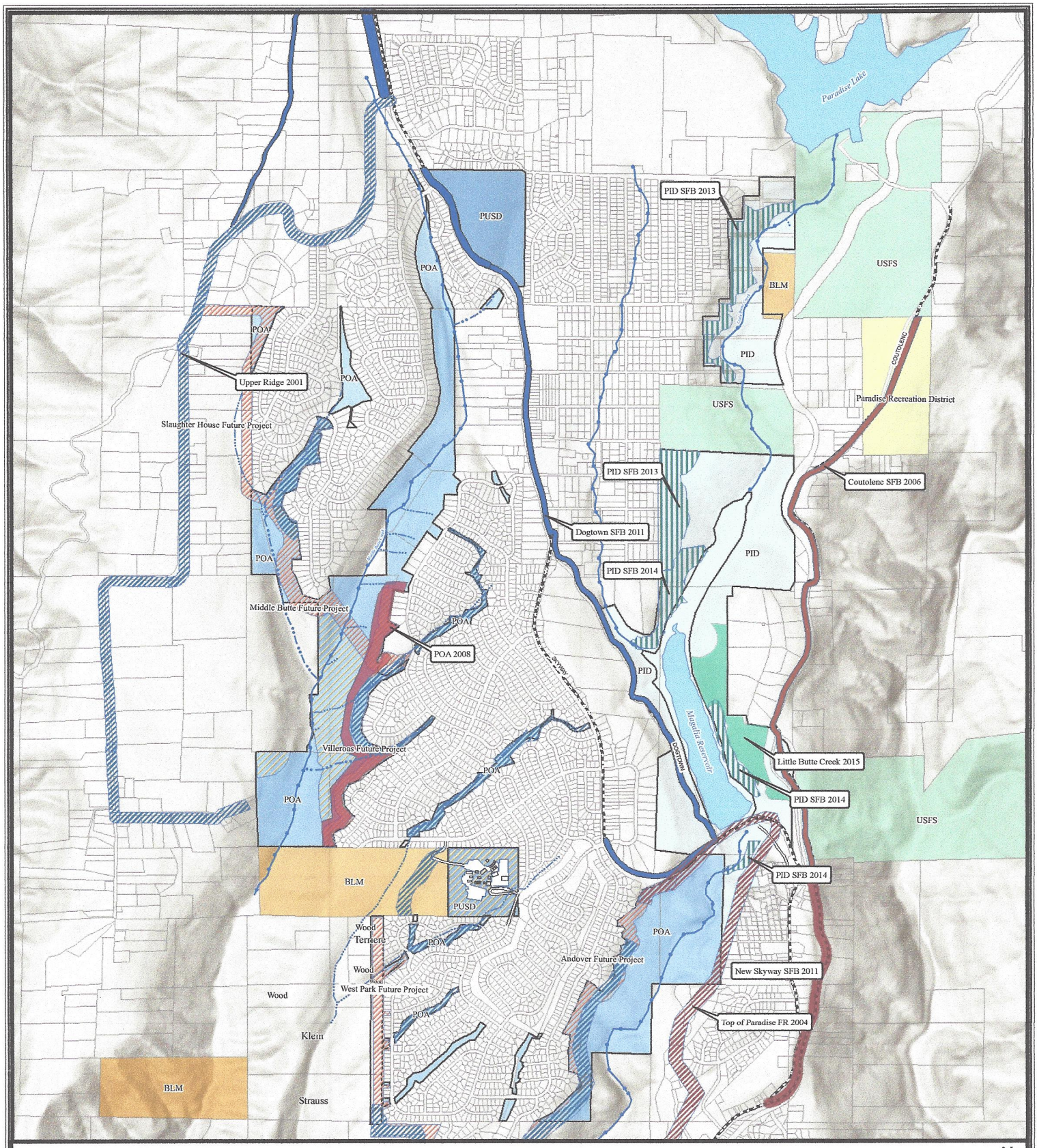
Past Projects- Magalia					
Project Name	**Project Description**	**Treatment Method**	**Land Ownership**	**Acreage**	**Year Completed**
Upper Ridge Fuel Reduction Project	13 Miles of Fuel Reduction around Paradise Pines and along Nimshew Rd. Funded by US Forest Service WUI grant.	Hand Cut	Private Owners and POA	238	2001
Top of Paradise Fuel Reduction Project	6 Mile fuel reduction project in opper Paradise on bott the northeastern and northwestern flank. Funded by BLM	Hand Cut	Private Owners and POA	135	2004
Couotlenc Road Shaded Fuel Break and Watershed Protection Project	4 Miles along Coutolenc Road.Funded by Prop 40	Hand Cut and pile burn	Private owners and County Right of Way	29	2007
New Skyway Shaded Fuel Break	One mile of fuels reduction to complete the last fuels reduction along Skyway between Magalia and Paradise	Hand cut and chip, hand cut and haul.	Private owners and County Right of Way	22	2011
Dog Town Road Shaded Fuel Break	One mile shaded fuel break to protect Magalia residents	Hand cut and chip, hand cut and pile burn.	Private owners, PID, County Right of Way	8.5	2011
Upper Ridge Shaded Fuel Break	Nine mile shaded fuel break along Skyway from Dog Town Road to Lovelock, Humbug Road and Fir Haven community	Hand cut and chip, hand cut and pile burn, mastication, lor and scatter.	PG&E, Private owners, PUSD, County Right of Way	96	2011
PID Shaded Fuel Break	North of Magalia Reservoir	Hand Cut and pile burn	PID	30	2013
PID Shaded Fuel Break	West side of Magalia Reservoir	Hand Cut and pile burn	PID	32	2014
Upper Ridge POA Green Belt	Maintenance of existing fuel breakswithin POA green belt. 7 sites total.	Hand cut, chip and scatter. B.C. Sheriff Dept.	POA	33	2014
Little Butte Creek Shaded Fuel Break, PG&E grant.	Shaded fuel break along east shore of Magalia Reservoit	Mastication, hand cut and stack for chipper. B.C. Sheriff Dept to assist with 5 acres.	PID	30	2015
Total				654	

Magalia Forest Health
Completed Projects Map

Sierra Timber Services

Date: 11/1/2017





Magalia Forest Health Projects Map - Overview

Legend

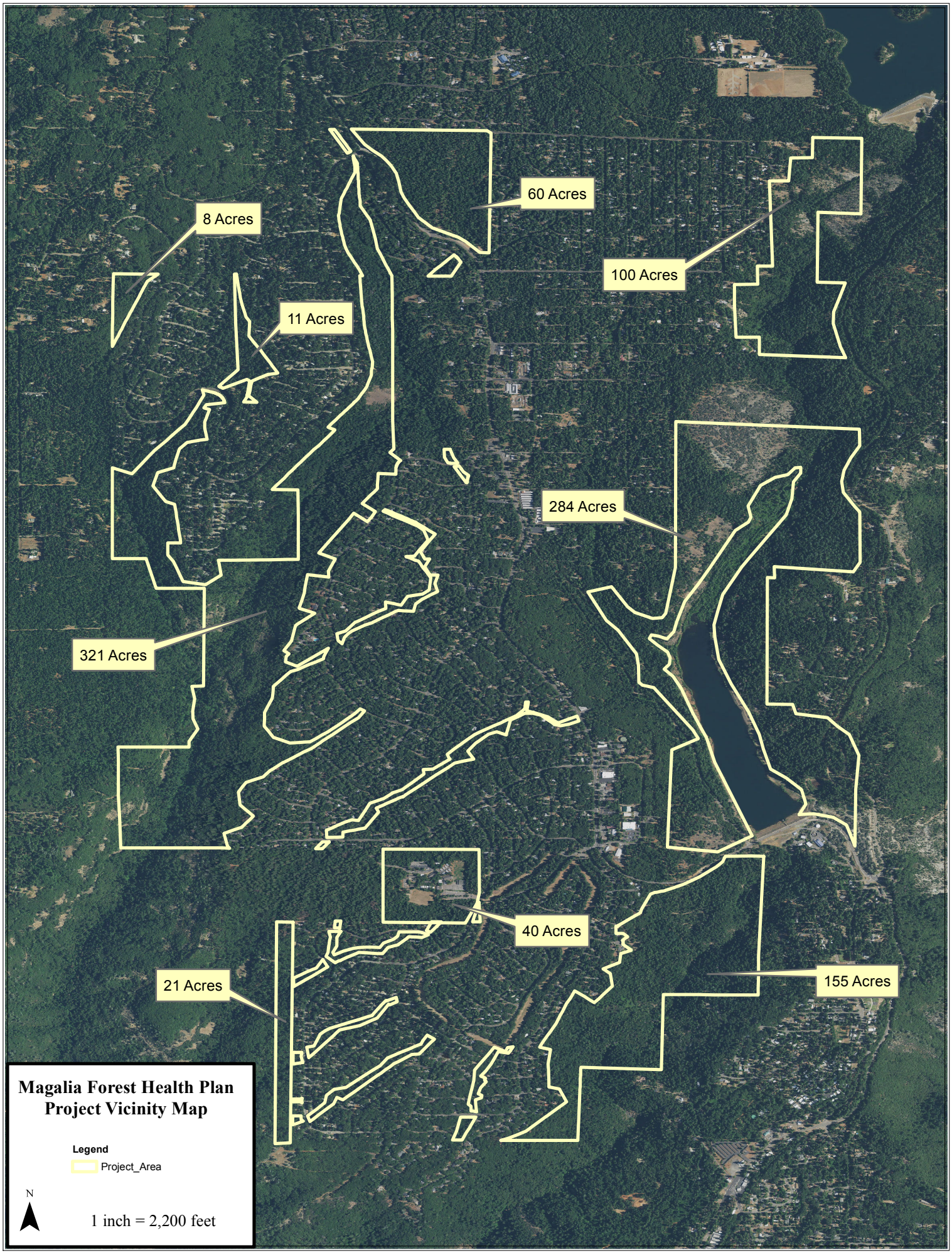
Ownership
- PUSD
- BLM
- USFS
- Paradise Rec
- PID
- POA
- Private

- Upper Ridge FR 2001
- Top of Paradise 2004
- Coutolenc SFB 2006
- POA FR 2008
- Upper Ridge SFB 2011
- New Skyway 2011
- DogTown SFB 2011
- PID 2013
- PID SFB 2014
- Little Butte Creek SFB 2015
- Project Area

N

1 inch = 3,300 feet

Sierra Timber Services


8 Acres
60 Acres
100 Acres
11 Acres
284 Acres
321 Acres
40 Acres
21 Acres
155 Acres
Magalia Forest Health Plan
Project Vicinity Map
Legend
Project_Area
N
1 inch = 2,200 feet

Silvicultural Recommendations

The goal of this project is to manage the forest in a way that can increase its resilience to wildfire and aid fire suppression crews in their ability to do their job safely and efficiently in the event that a wildfire occurs. This can be done by reducing the amount of biomass in the understory as well as reducing the number of trees per acre, which will help keep a fire from reaching the canopy.

Currently, the forest infrastructure of the Magalia/Paradise area is generally overstocked with over half of the trees being less than 10" DBH. The dense shrub understory averages 35% cover at 1.5-2 feet tall with patches of very dense brush scattered throughout the project area. On-the-ground observations have also shown that some stands are beginning to age, with trees of various diameters becoming decadent and losing vigor. Approximately 39% of the project area (408 acres) has been treated with 120 acres or 11% of the project area having regrown to the point of needing retreatment. Data collected during the retreatment surveys show an unexpected increase in canopy density for the recent treatment units over the older ones. There are two causes of this. Initial fuel breaks were often located in brushy open areas which never had a dense tree canopy. Secondly some of the more recent fuel break prescriptions have focused on retaining a larger number of wildlife trees and other plants causing an increase in ladder fuels and canopy bulk density in the treatment areas when compared to the earlier treatments. (See discussion on selection of wildlife and leave trees.)

Areas with a denser understory need to have ladder fuels (trees/shrubs that will ignite from a surface fire and cause the fire to move into the surrounding overstory, creating a crown fire), removed via hand cutting or mastication. Areas with light fuel loads may be treated with lop and scatter or prescribed burning.

Fuel reduction treatments should remove trees and snags below 10"DBH until the canopy cover reaches 70%. Smaller diameter trees that are in a suppressed or intermediate crown position (the tree is being overtopped by taller, more mature trees and doesn't receive direct sunlight throughout the majority of its crown) should be targeted first. Leave trees should be pruned up to 12-16 feet or until 1/3 the live crown has been removed for smaller trees. With the stand aging it is vital to make sure there are trees available to regenerate the overstory once mature trees start dying. 1-5 smaller diameter replacement trees with the following characteristics should be retained for regenerative purposes:

- Healthy crown with a pointed top
- > 50% Live Crown Ratio
- 20 feet spacing from other leave trees
- No signs of damage and free from infection or disease
- Located in an opening at least 10 feet outside the dripline of mature trees

Replacement trees should be outside the drip line (the edge of the crown) of mature trees in order to allow them room to grow and to prevent them from acting as ladder fuels. Selecting healthy trees in already existing open areas with ample sunlight will give the tree the resources necessary to grow into the overstory quickly and reduce the possibility of it becoming a ladder fuel. When limbing up the lower branches on replacement trees no more than one third of the live crown should be removed.

Recommended Fuel Break Silvicultural Prescription

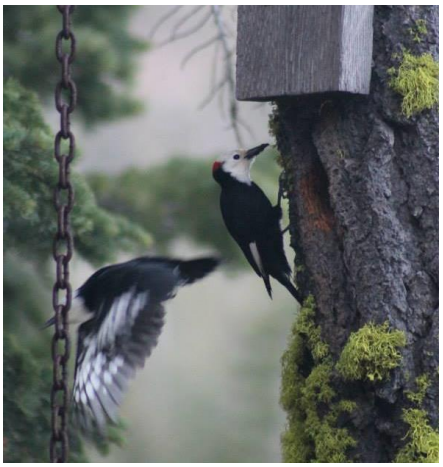
- Remove underbrush, down and dead fuels.
- Snags less than 10" should be removed unless they show signs of wildlife use.
- Prune all low hanging branches up to 16 feet or 1/3 of the live crown for smaller trees.
- Remove all suppressed and intermediate trees less than 10" DBH
- Remove additional healthy trees less than 10" DBH until the overstory canopy cover reaches the target level of 70%, Lower canopy cover may be needed in high risk corridors or steep terrain.
- Areas such as portions of the Paradise Pines ownership contain a dense overstory canopy and may require removal of trees over 10" DBH to lower the canopy bulk density enough to provide an effective fuel break. Such work is outside of the scope of the Mitigated Negative Declaration associated with this management plan and is not addressed here.

Replacement Trees and Small Diameter Wildlife Tree Retention Rates

We are recommending that replacement trees and wildlife trees be left a rate of 1-5 per acre depending upon the stand conditions.

- **If over 50% of the overstory trees are healthy leave the lower rate of replacement trees per acre.**
- **If there are several mature trees with characteristics of value to wildlife leave the lower rate of wildlife trees.**
- **5 trees per acre is approximately 90ft. spacing between trees.**
- **2 trees per acre is approximately 150 ft. spacing between trees.**

Wildlife Tree Characteristics



- *Broken tops*
- *Forked tops*
- *Nests*
- *Mistletoe clumps,*
- *Substantial cavities*
- *Dogwood Trees*
- *Large Oaks*

Treatment Methods

Hand cutting: cutting branches, bushes or trees with hand equipment such as a chainsaw or hand pruners. The plant material can be disposed of using a number of methods: **Scattered**, where it is spread evenly over the ground, **Chipped** when plant material is fed into a machine chopping it into "chips" which are then scattered or can be used for mulch, **Piled and Burned** when plant material is removed by piling and burning.

Mastication: mechanical chopping and grinding of plant materials by a rotary head mounted on tracked or wheeled equipment. The material remains on the ground in various shredded sizes.

Prescribed burn: (or controlled burn) when the understory plants are burned off using set guide lines to ensure public safety and completion of the fire's purpose.

Canopy Density

Our research showed that a 70% canopy cover allowed us to reduce fuels while still maintaining enough shade to suppress regrowth. Higher canopy closure poses greater risks of crown fire while lower canopy cover than 70% had accelerated regrowth needing retreatment within 10 years instead of 15 years.

Mixed Conifer Vegetation Type

Overhead View of 68% Canopy Cover

Horizontal View of 68% Canopy Cover

Fir, Cedar, Oak Vegetation Type

Overhead View of 70% Canopy Cover

Horizontal View of 70% Canopy Cover

Ponderosa Pine Vegetation Type

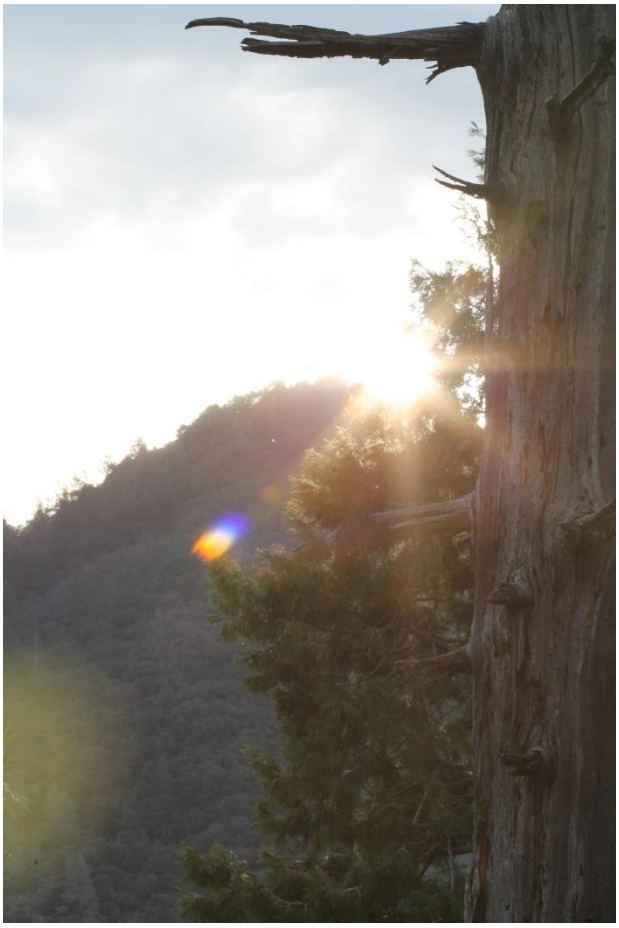
Overhead View of 70% Canopy Cover

Horizontal View of 70% Canopy Cover

Fir, Pine Oak Vegetation Type

Overhead View of 72% Canopy Cover

Horizontal View of 72% Canopy Cover



Snags and Bark Beetles

Under the Butte County Fire Safe Council's Fuel Reduction prescription trees over 8" DBH are not cut, however there are several instances where this would be necessary. As mentioned earlier in this assessment, the high volume of standing dead and dying trees throughout the Hazard Zones can pose a threat to the forest health and community safety. These trees should be removed and it's recommended that the Hazard Zones are evaluated yearly for any new mortality or disease. The compounding effects of overstocked stands, drought and bark beetle outbreaks could cause dieback throughout the project area on an annual basis, compromising the overall health of the stand, increasing risk to human safety and increasing the risk of wildfire.

Bark beetle infestations result in tree mortality and top killing. They reproduce in brood material composed of green pine slash and logs. Adults then re-infest additional trees. During suitable weather, their life cycle may be as short as five weeks. Timely treatment of infested trees and brood material is essential to control bark beetle populations. Piling of brood material is more hazardous than slash that is lopped and scattered. **Hazard is highest when pine brood material is produced from February through June.** Young, drought stressed, suppressed, and overstocked timber stands are the most susceptible to damage. Diseased, damaged, and over-mature trees are also at risk. High beetle populations have the potential to damage more than just low vigor trees. Chronic pine mortality in the area should be evaluated to determine if high beetle populations are present.

(BOARD OF FORESTRY TECHNICAL RULE ADDENDUM NO. 3 Accessed 6/21/17 http://calfire.ca.gov/resource_mgt/downloads/2017%20Forest%20Practice%20Rules%20and%20Act.pdf)

Maintenance

Key Management Points

- *Retreatment*- No maintenance is done and the fuel break is retreated when it regrows to pretreatment levels.
- Where Canopy cover is less than 70% retreatment will need to occur in 10 yr. intervals.
- Canopy is greater than 70% retreatment intervals can be lengthened to 15 years.
- *Maintenance*- Treating regrowth annually or biannually to maintain the fuel break.
- Deciduous re-sprouts can be treated by several methods.
    - Retreat within 2-3 years, 3-5 times either by hand cutting or prescribed fire.
    - Apply herbicide using cut-stump treatment.
    - Prune problem species to tree form instead of cutting.
- Prescribed burns in areas with high downed fuel loads result in significant tree mortality even if fuels are raked away from the trees prior to burning.
- Burns should be conducted when ambient air temperatures are low to minimize tree mortality.
- Evaluate Hazard Zones yearly for dead and dying trees in danger of falling into houses and roads.

Maintenance or Retreatment?

There are two methodologies for maintaining fuel breaks. One is to not manage the fuel break and retreat the area when it has reached a predetermined fuel load. The other is to patrol fuel breaks annually and treat the regrowth each year.

Retreatment Intervals

Pre-treatment base levels of understory vegetation are on average 1.5 to 2 feet in height at 35% density. The data shows that with a canopy cover of less than 70% it takes approximately ten years for understory vegetation to return to pre-treatment levels and with a canopy cover of over 70% it takes approximately 15 years. This is due to an increase in light availability on the forest floor, which will facilitate understory regeneration and growth. It is important to note that opening up the canopy will increase the effectiveness of the fuel breaks; however, the retreatment intervals will need to increase in frequency in order to maintain the fuel breaks effectiveness.

Fuel Break needing maintenance along Coutolenc Road

Maintenance Methods

Vegetation types containing oaks and other deciduous trees can quickly re-sprout from the stumps creating a need for secondary treatment. There are three methods of dealing with re-sprouts. Retreating within 2 to 3 years for three to five times will deplete the root reserves on re-sprouting vegetation and eventually control most of the plants. Herbicides may be used for sprout control. This would be the lowest cost and most effective control method. If herbicides were to be used a cut stump treatment may be the best option as it is more targeted with the herbicide painted directly on the freshly cut stump as opposed to spraying the re-sprouts, and the chemicals used emit less odor than the ones used for basal frill injection treatments. The other option to deal with re-sprouting vegetation is to prune it into a tree form during the initial treatment. This method is simple but leaves a larger amount of ladder fuel within the fuel break.

Prescribed Fire

Prescribed fire presents some unique benefits and challenges as a maintenance tool. It is a very effective way to remove down and dead surface fuels. Controlled burning helps release nutrients tied up in woody debris back into the soil and is effective in restoration projects seeking to restore natural open stand conditions and ecosystem processes.

Challenges include preventing the spread of noxious weeds, minimizing tree mortality and protecting rare plants and animals. Prescribed fire units with Scotch Broom infestations will require follow up treatments since prescribed fire typically stimulates sprouting of scotch broom seeds. Multiple burns have been successful in eradicating it but repeated burns usually severely set back recovering native vegetation as well (2). Alternative control methods such as spot spraying should be considered after the initial prescribed fire.

The US Forest Service has documented 50-90 % conifer mortality in prescribed burns following fuels treatment where chips and down fuels were several inches thick. Mortality was still close to 50% when fuels were raked away from the trees prior to ignition. Where down fuels were sparse following treatments the prescribed burns had much lower rates of tree mortality. Other studies have documented live oak species being more susceptible to fire than true oaks. Mortality rates from prescribed fire among California Oaks were 1-11% for mature Oaks, 2-10% for sapling oaks (Note: there was 70-90 % top kill among the surviving saplings which survived to re-sprout) and 17-52% mortality among seedling oaks. Mortality among oaks was minimized when burns were conducted when the ambient air temperature was low and fuels were removed around the base of the leave trees. (5)

There are 3 plants listed with the California Native Plant Society as rare present within the serpentine and volcanic outcrops in the project area. One of them, *Carex xerophila* is documented by Lawrence

Janeway to be extirpated by fire (1), Fritilaria *Eastwoodii* is not harmed by prescribed fire when it is done under moist conditions, and the effects of prescribed fire are unknown for the *Eriogonum umbelatum var. ahartii* (3). *McNabb Cypress* is very flammable and fire typically kills individuals within a stand however its serotinous seed will often sprout following a fire (4). Prescribed fire should only be used in McNabb Cypress stands where 100% mortality of the existing trees is acceptable and seedling emergence needs to be promoted.

Sources

1: Carex xerophila, A new sedge from Chaparral of Northern California Madrano Vol.61 No. 3 pg. 302 by Peter Zika, Lawrence Janeway, and Barbara Wilson

2: Zouhar, Kris. 2005. Cytisus scoparius, C. striatus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2017, July 27].

3: Final Environmental Impact Statement Concow Hazardous Fuels Reduction Project Appendix C-1 pgs. 12 and 13.

4: Jenifer Gibson. McNabb Cypress, Shasta CNPS.org 2016, February 13.

5: California Oaks and Fire: A Review and Case Study—Holmes GENERAL TECHNICAL REPORT PSW-GTR-19x

Hazard Zones

The hazard Zones are defined as areas within 150' of houses and roads. There are currently 2005 dead trees larger than ten inches in diameter within the hazard zones in the project area. Many of these trees are a public safety hazard and are a liability to the landowners. A qualified professional should evaluate the Hazard Zones each year and dead or dying trees in danger of falling onto houses or roads should be marked for removal. Once the current backlog of hazard trees is dealt with and tree mortality slows down it may be possible to lengthen the time between inspections.

Hazard Zone Statistics

Owner	Area within the Hazard Zone	Current Snags larger than 10" DBH	Expected Annual Conifer Mortality within the Hazard zone.
PID	59 acres	295	31
POA	165 acres	1650	116
PUSD	40 acres	60	22

Vegetation Types

Mixed Conifer

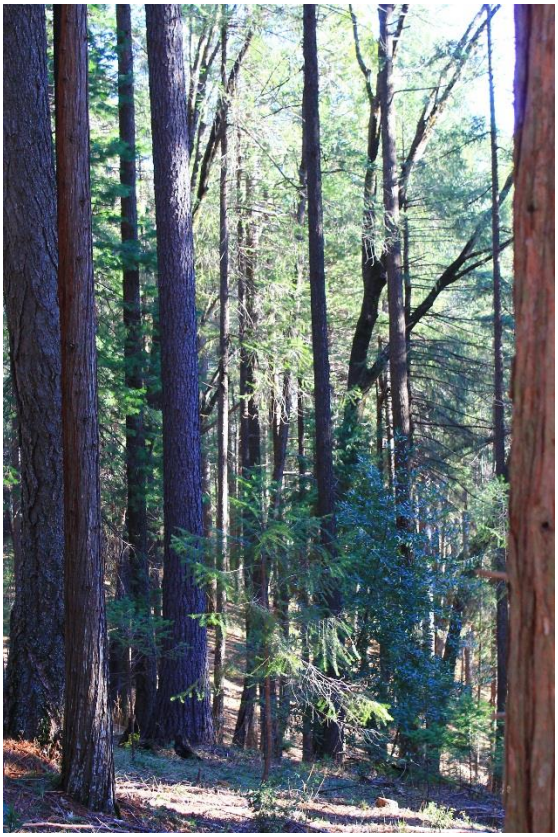
The mixed conifer vegetation type is located in the northern portion of the Slaughterhouse Ravine, the northern tip of Middle Butte Creek, and on the top of the ridge in the greenbelts. It contains the following plant species: Douglas Fir, Incense Cedar, Big Leaf Maple, California Nutmeg, Western Houndstongue, Pacific Dogwood, and Bleeding Heart. The current stand has approx. 430 total trees per acre; 319 trees per acre under 10" DBH and 111 trees 10" DBH and larger. There are about 7 standing dead trees per acre and 2 diseased trees per acre all over 10" DBH. The main soil type is Tusccoll-Schott series, which is a loamy, deep soil with a moderately high water holding capacity.

Table 5. Mixed Conifer Vegetation Type Trees per Acre

Mixed Conifer Stand Table *Trees per Acre*							
	Diameter						
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Bay Laurel	16						
Black Oak	14	4	3				
Douglas Fir	82	49	18	8	1	<1	<1
Incense Cedar	125	6	7	3	<1		
Live Oak	4						
Ponderosa Pine	78	2	6	1	<1		
Sugar Pine			<1		<1	<1	
White Fir							
Total	**319**	**61**	**34**	**12**	**1**	**<1**	**<1**

Table showing the average trees per acre by species type and diameter class for the mixed conifer vegetation type.

Fir, Cedar, Oak



The Fir/Cedar/Oak vegetation type is located throughout the majority of the Middle Butte Creek ravine, at the South and east sides of the Magalia Reservoir. It contains the following plant species: Douglas Fir, Incense Cedar, Canyon Live Oak, Tanoak, Bay Laurel, Western Bracken fern, Black Oak, Indian Warrior, Soap Plant, Himalayan Blackberry, and Cut Leaf Blackberry. The current stand has approximately 357 total trees per acre. There are approx. 241 trees per acre under 10" DBH and 116 trees 10" DBH and larger. There are an estimated 9 standing dead trees per acre and 1 diseased per acre all over 10" DBH. The main soil type is Schott-Rock outcrop, which is a very gravelly soil with a moderate depth and moderate water holding capacity.

Table 6. Fir, Cedar, Oak Vegetation Type Trees per Acre

Fir, Cedar, Oak Stand Table *Trees per Acre*							
	Diameter						
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Bay Laurel	20						
Black Oak		4	4				
Douglas Fir	93	46	18	10	1	<1	<1
Incense Cedar	123	4	8	4	1		
Live Oak	5						
Ponderosa Pine		2	6	1	<1		
Sugar Pine			<1		<1	<1	
White Fir		6	1				
Total	**241**	**62**	**37**	**15**	**2**	**<1**	**<1**

Figure showing the average amount of trees per acre by species and diameter class that are found within the Fir/Cedar/Oak vegetation type.

Ponderosa Pine

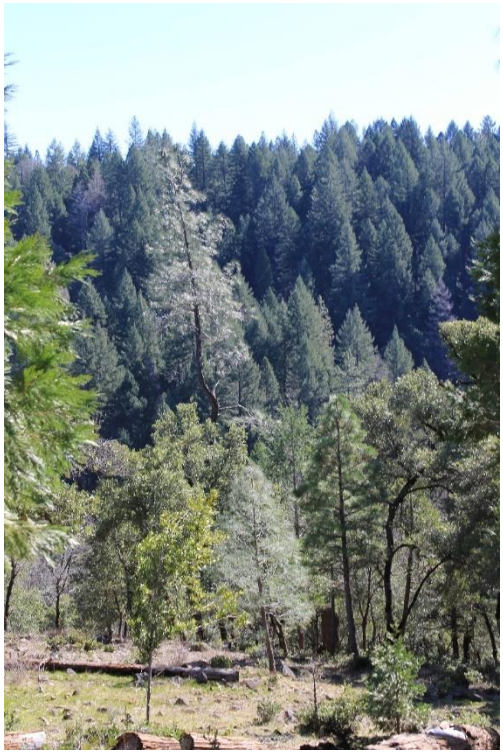
The Ponderosa Pine vegetation type is located at the south end of the ridge between Middle Butte Creek and Little Butte Creek. It contains the following plant species: Ponderosa Pine, Incense Cedar, Douglas Fir, Black Oak, Blackberry, Oregon Grape, and Mosquito Bills. The current stand has about 484 total trees per acre. Approx. 374 trees per acre are under 10" DBH and 110 trees 10" DBH and larger. There is an estimated 1 standing dead tree per acre over 10-inch diameter. The main soil type is Paradiso Loam, which is a deep loamy soil with great water holding capacity.

Table 7. Ponderosa Pine Vegetation Type Trees per Acre

Ponderosa Pine Stand Table *Trees per Acre*							
	Diameter						
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Black Oak	244	11					
Douglas Fir	99	10	6				
Incense Cedar	31	44	9	4			
Ponderosa Pine		4	8	10			
Sugar Pine		4					
Totals	374	73	23	14	0	0	0

Table showing the average amount of trees per acre by species and diameter class for the Ponderosa pine cover type.

Grey Pine, Live Oak



This vegetation type is located north west of Magalia Reservoir. It contains the following plant species: Gray Pine, Canyon Live Oak, Black Oak, Indian Manzanita, and California Yerba Santa. The current stand has an estimated 74 total trees per acre at 10" DBH and larger. There are approximately 7 dead trees per acre over 10-inch diameter. The main soil type is Typic haploxeralfs, Magnesic-Earal-Cerpone-Rock Outcrop Complex. This is a gravelly soil with a moderate depth and low water holding capacity.

Table 8. Grey Pine Cover Type Trees per Acre

Gray Pine Stand Table ***Trees per Acre***					
Diameter					
Species	**12**	**16**	**18**	**22**	**38**
Incense Cedar	19				
Live Oak	19	11	9		2
Gray pine			8	6	
Grand Total	**38**	**11**	**17**	**6**	**2**

Table showing the average trees per acre by species and diameter found within the Gray Pine cover type.

Fir, Pine, Oak

This vegetation type is located in the Little Butte Creek Drainage south west of Magalia Reservoir. It contains the following plant species: Douglas Fir, Black Oak, Ponderosa Pine, Indian Warrior, Oregon Grape, and Mosquito Bills. The current stand has approximately 700 total trees per acre. An estimated 568 trees per acre are under 10" DBH and 133 trees 10" DBH and larger. There are approx. 3 diseased trees 10" DBH and bigger per acre. The main soil type is Griffgulch-Surnuf-Spine taxadjunct, which is a gravelly soil that is moderately deep and has a moderate water holding capacity.

Table 9. Fir, Pine, Oak Cover Type Trees per Acre

Fir, Pine, Oak Stand Table *Trees per Acre*							
	Diameter						
Species	**2"-8"**	**10"-16"**	**18"-26"**	**28"-36"**	**38"-46"**	**48"-56"**	**58"-66"**
Black Oak	8	18	15				
Douglas Fir		36	15			1	
Incense Cedar	102	18	3	2			
Ponderosa Pine	458	7	8	2			
Sugar Pine		7					
Totals	568	86	41	4	0	1	0

Table showing the average trees per acre by species and diameter class that are found within the fir/pine/oak cover type.

Ceanothus, Scrub, Opening

This vegetation type is located on volcanic rock outcrops in the Middle Butte Creek Drainage. It contains the following plant species: Buck Brush, Indian Manzanita, Scotch Broom, Poison Oak, Kellogg's Monkeyflower, Seep Monkey Flower, and Butte County Fritillary. Many wild flowers and some of the endangered plants in the area can be found within this vegetation. The main soil type is Typic haploxeralfs, Magnesic-Earal-Cerpone-Rock Outcrop Complex. This is mainly the rock outcrop portion of this soil type.

Serpentine

This vegetation type is located north of the Magalia Reservoir and at the south east corner of the Reservoir. It contains the following plant species: MacNab Cypress, Chaparral Sedge, California Yerba Santa, Gray Pine, California Fawnlily, Butte County Fritillary, and Buck Brush. This vegetation type is known for its rare plants, there have been many sightings just to the east of the project on the Forest service property. The main soil type is Cerpone typic Hapoxeralfs, Magnesic-Earal Complex. This is a shallow soil with low water holding capacity.

Riparian

Streams, rivers and small ponds

Riparian areas along streams, rivers and small ponds occur in thin strips along the banks of these waterbodies and contain plants typical to wetland areas, such as Red Alder, California Dogwood, Big-leaf Maple, and blackberry.

Federally Protected Wetlands

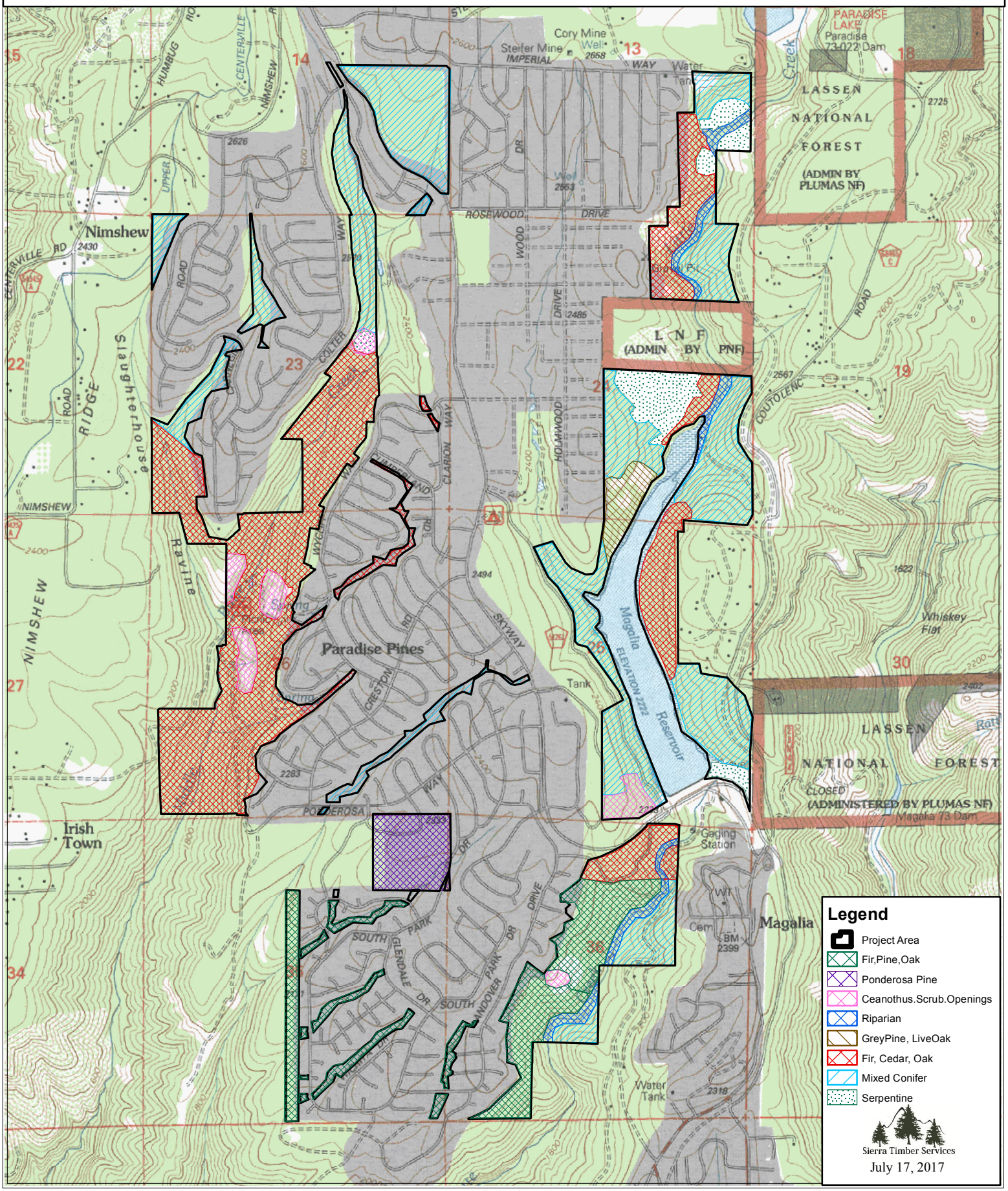
The federally protected wetlands are located just north of Magalia Reservoir.

Vegetation Type Map

Overveiw

N

1 inch = 2,167 feet



Sierra Timber Services

July 17, 2017

Fire Modeling and Simulations

Two fire modeling programs were used for this project; FlamMap and FARSITE. Both programs were downloaded from the USDA/USFS operated website www.firelab.org. The base data (GIS layers) necessary for the initial execution of the simulations and modeling was obtained from www.landfire.gov. All subsequent data necessary for simulations based on post-treatment conditions was hand-drawn in FARSITE and used for the simulations and modeling in both FARSITE and FlamMap. FlamMap was primarily used as a broad descriptor for potential fire behavior over the entire landscape.

It took the entirety of the landscape file (.LCP) and showed how the fire is likely to behave (i.e. flame height, fire intensity, likelihood of crownfire, etc) should it occur in that area. FARSITE was used to indicate the pathways, size and intensity of a fire as it moves through the project area in "real time".

Environmental conditions were based on extremely dry, summer conditions. Average diurnal temperatures, precipitation and wind speed and direction for the end of July was used for each simulation and data was obtained from online US Climate Data sources. All model parameters were set for these conditions. Furthermore, fire behavior parameters on FARSITE were set to allow for spot fires to occur 2% of the time. The duration of the burn was set from 7am on 7/21 to 7pm on 7/24 for all simulations.

No Treatment conditions were based on the base landscape file downloaded from landfire.gov. This file had pre-determined levels of forest variables relevant to fire behavior (Canopy Bulk Density, Canopy Base Height, Canopy Height, Cover % and Fuel Type). Post treatment conditions were based on proposed and existing treatment conditions and locations. Based on the intended treatments within the project area, Canopy Bulk Density (the amount of biomass in the canopy per unit volume) and Ground to Crown Base Height (the amount of empty space between the forest floor and the canopy) values were changed to give an average representation of the proposed conditions within the planned fuel break zones. The Extra Treatment simulation had bigger fuel breaks and further decrease to canopy bulk density. Ground to crown height remained the same for the extra treatment simulation. It's important to note here the importance of canopy bulk density in wildfire behavior and wildfire modeling. Canopy bulk density is a measure of the weight and density of crown fuels within a timber stand and is measured in kilograms per square meter. Fire modeling software uses these values to predict whether an active crown fire is possible, which affects rate of spread, fire intensity and fire movement.

Essentially, the greater the canopy bulk density, the more intense a crown fire will be and the faster it will travel. We determined the average canopy bulk density of Paradise Irrigation District, Paradise Pines Owners Association and Paradise Unified School District landholdings using the Forest Vegetation Simulator available through the United States Forest Service. Data from the 60 individual sample plots located throughout the entire project area and input into the software. FVS then uses allometric equations to determine average crown bulk densities for individual trees and then extrapolates that data to determine the average canopy bulk density of each stand.

Fires were modeled starting in five locations: Southwest at the Middle Butte Creek/Little Butte Creek Junction, West at the Paradise Unified School District/BLM Property line, Northeast near Paradise Lake,

East near the West Branch of the Feather River and East near the USFS property along Coutolenc Road adjacent to the Magalia Reservoir.

The fire modeling software indicated several locations throughout the project area that are high risk for crown fires and extreme fire behavior. These areas are characterized as having higher crown bulk densities, lower ground to crown base-height, and steeper slopes. Particularly susceptible to large scale fires appear to be locations throughout the Middle Butte Creek Ravine and Slaughterhouse Ravine, located to the west of Magalia/Paradise. See Figure 4 below.

Figure 4. No Treatment: Fire Intensity along Middle Butte Creek and Slaughterhouse Ravine

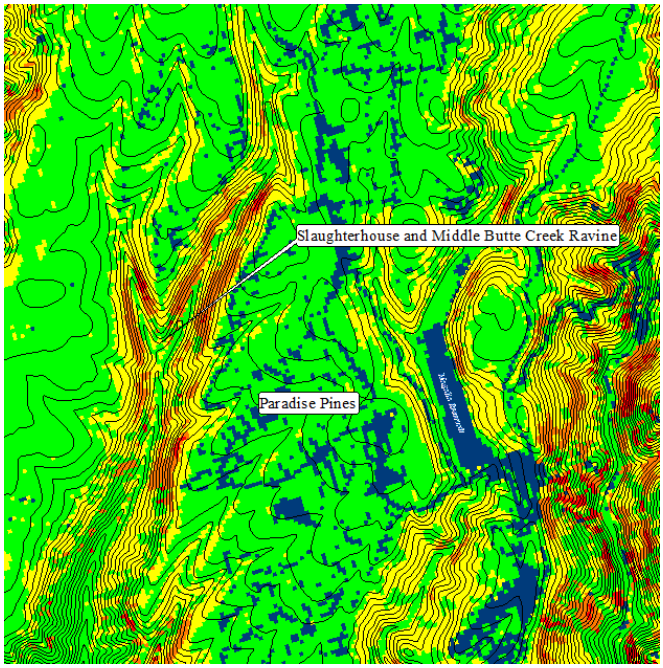


Figure showing fire intensity along Middle Butte Creek and Slaughterhouse Ravine under no treatment conditions. Intensity ranges from low to high: Green, Yellow, Orange and Red, respectively. Blue indicates areas of No Burn.

Simulations indicate that this area acts as a major corridor for wildfires, allowing a wildfire to increase in strength as well as directing the fire towards the more human populated areas of Magalia, specifically Paradise Pines (POA) and Nimshew area. These areas remained important fire corridors throughout all the simulations, even when conditions were changed to reflect current and future treatment options. Although post-treatment simulations do show a decrease in overall fire intensity it was only in areas where the actual treatments occur.

Figure 5. Post Treatment: Fire Intensity along Middle Butte Creek and Slaughterhouse Ravine

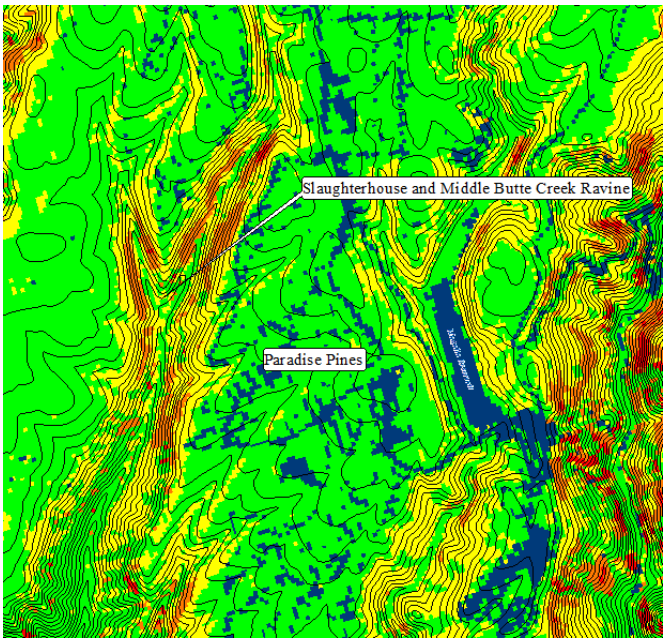


Figure showing fire intensity along Middle Butte Creek and Slaughterhouse Ravine under treated conditions. Intensity ranges from low to high: Green, Yellow, Orange and Red, respectively. Blue indicates areas of No Burn.

The biggest decrease in fire intensity came with the Extra Treatment, where the treatment areas were expanded to include a larger area than that which is currently proposed. This treatment area extended further up and on both sides of Middle Butte Creek and Slaughterhouse Ravine (See Figure 6). The results show a larger downgrade in fire intensity throughout the area, indicating that the treatment (reduction of canopy bulk density and increasing distance between the ground to base crown height) can ultimately reduce the intensity of a fire. This doesn't mean that the fire will go out or fail to pass through these areas in the event that one occurs, but rather highlights the fact that less available fuel will reduce the fire severity, slow the front and allow for a more efficient attack by fire personnel and resources. However, it is important to note that the reduction in fire strength and intensity is subject to the area being treated.

Figure 6. Extra Treatment: Fire Intensity along Middle Butte Creek and Slaughterhouse Ravine

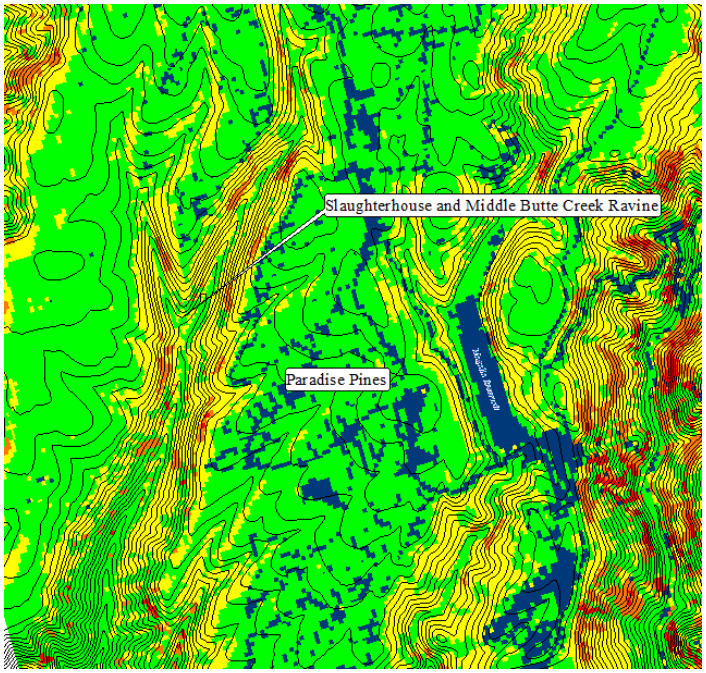


Figure showing fire intensity along Middle Butte Creek and Slaughterhouse Ravine under expanded treatment areas (treatment area increases up Middle Butte Creek and Slaughterhouse Ravine and occurs on both sides of the draw). Intensity ranges from low to high: Green, Yellow, Orange and Red, respectively. Blue indicates areas of No Burn.

The greatest effect the proposed treatment areas have on an advancing fire along the west side of Magalia/Paradise is the ultimate reduction in size of the fire. The treated areas along the west side of Magalia/Paradise and through the Middle Butte Creek and Slaughterhouse Ravine reduced the overall fire size on average, by ~10%. This can be contributed to the reduction of fuels in the treated area slowing the overall burning of biomass, which would in turn reduce the size of the fire simulation that was always set to run for 3.5 days. This effect was found to be true in areas with a greater percentage of treated areas, in particular the west side of the project area. Simulations starting down in Middle Butte Creek and near the Paradise Unified School District/BLM land both had greater reduced areas in the Post Treatment simulations than the No Treatment simulations. Simulations run on the east side of the project area did not see as large of a reduction in burn area possibly due to a moving eastward through Griffin Gulch, USFS lands and the West Branch of the Feather River, which allowed the fire to burn away from our fuel breaks. The fuel breaks in conjunction with natural and man-made barriers (Magalia Reservoir, serpentine rock outcrops and human infrastructure) along the eastern portion of the plan did appear to reduce the chances of the fire reaching the west side of Skyway. There was a further reduction in fire area in the northeastern extent of the project area, which could be attributed to Paradise Lake and the fuel breaks proposed by Sierra Pacific Industries, north of Paradise Lake.

Table 10. Area Burned based on No Treatment and Post-Treatment Simulations.

Simulation Area	No Treatment Area Burned (acres)	Post-Treatment Area Burned (acres)	Percent Reduction
SW; Middle and Little Butte Creek Junction	11000	9900	10%
West; PUSD/BLM Area	10490	9570	8.75%
NE; Paradise Lake	8360	7830	6.3%
East; West Branch Feather River	12430	12335	<1%
East; USFS/Coutolenc Rd	No Change		

Table showing total area burned based on simulations run under extreme dry conditions, July 21 @7am – July 24 @ 7 pm, at different starting locations throughout the project area. Post-treatment simulation is based on proposed/existing fuel break treatments.

Crown Fire Activity analyses were also run in FlamMap. The cell by cell analysis allows the viewer to see the likelihood of a crown fire in a given area, independent of adjacent areas. This is helpful when analyzing certain areas for its level of safety during a fire. In particular it is important to note that the proposed staging / assembly area adjacent to the Paradise Unified School District/BLM parcels is susceptible to a crown fire. If this area is to be used for a staging area it is recommended that treatments to reduce the likelihood of a crown fire be undertaken.

Figure 7. Current Treatment: Potential Crown Fire Activity

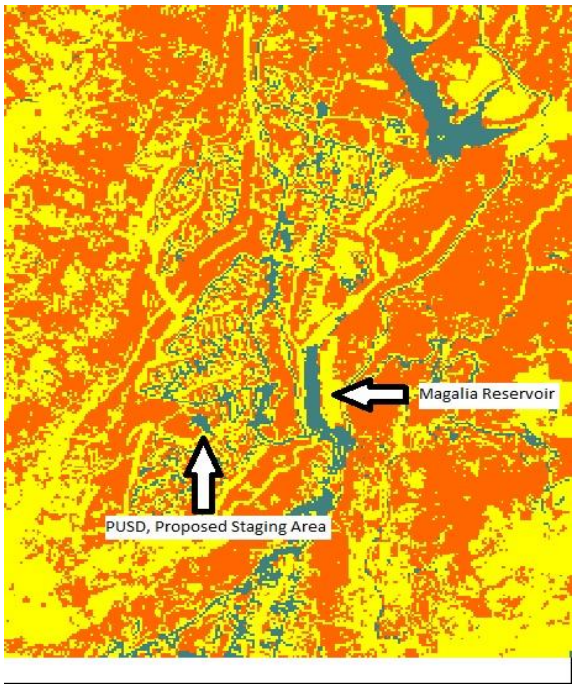
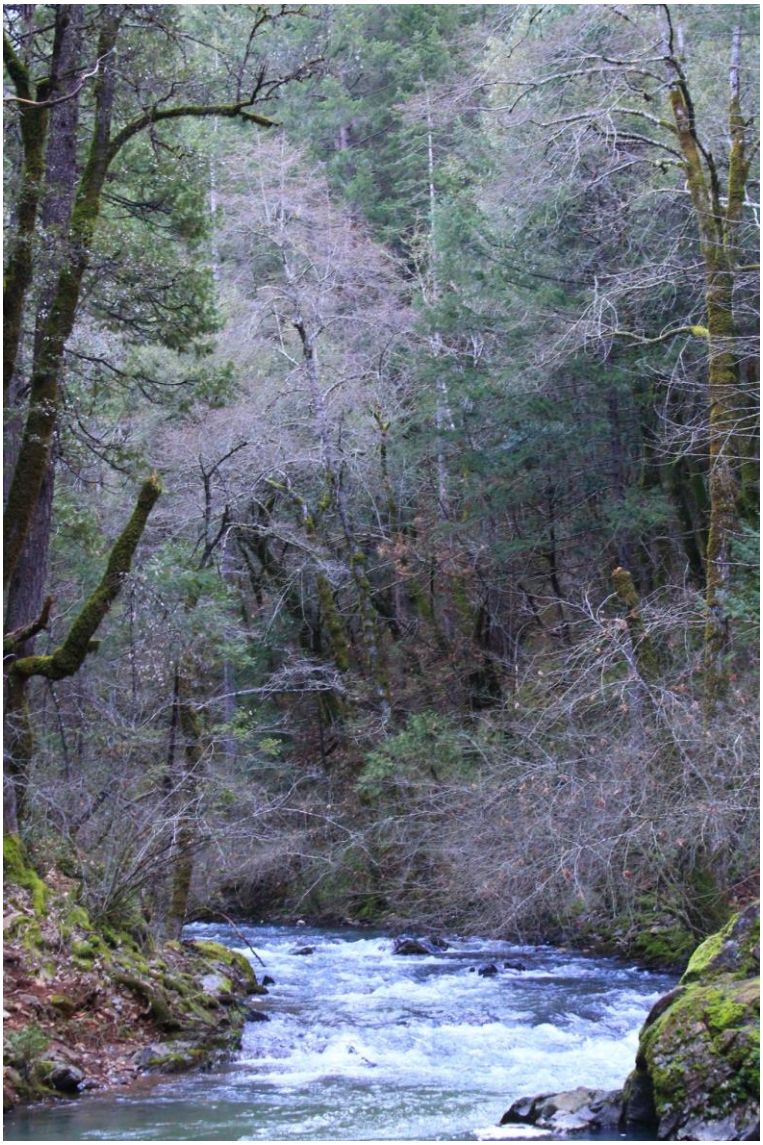


Figure shows potential for surface fire (yellow) and crown fire (orange) across the project area. Blue is No Burn.

Water Use

Landscape Coefficient



Water use by vegetation type was calculated using the landscape coefficient method developed by the UC extension and DWR. The Landscape coefficient is used to calculate plant water use from actual evapotranspiration. It is only intended to provide enough water to maintain the health and appearance of the landscape. This is the same goal as this project the only difference is that irrigation is not feasible but reduction in water use by removing plants is. Evapotranspiration is the amount of evaporation from the soil and transpiration from plants. Reference evapotranspiration is recorded at weather stations across the United States and is the amount of water used by a 4- to 7-inch tall cool season grass growing in an open-field condition. Because it is recorded the same way at each station it can be converted to any plant species. Evapotranspiration is a standard method used in agriculture for calculating water use. “Since growers and turf managers are not equipped to measure plant water loss in the field, a formula was developed which allows water loss to be calculated. (Source 1)”This formula is written as follows: Crop Evapotranspiration equals the Crop Coefficient Multiplied by the Reference Evapotranspiration. This formula states that water loss from a crop (crop evapotranspiration) Equals the Evapotranspiration recorded from weather station (reference evapotranspiration) multiplied by a factor determined for the crop (crop coefficient).

Calculating water use in a forest system is more complicated because it contains multiple plant species with different populations and densities. The landscape coefficient method is effective because it considers multiple factors. Unlike a crop or turf grass, landscapes are composed of more than a single species crop. Coefficients suitable for landscapes need to include some consideration of the mixture of species. Unlike crops, landscapes vary widely in density (Source 1). Landscape coefficient Method estimates water loss from landscape plantings using three variables: species coefficient, density

coefficient, and the microclimate coefficient. The species coefficient is determined by using the Water Use Classifications of Landscape Species (WUCLS) ratings. Information on species population and density were taken from the timber cruise and used to calculate the coefficient using a weighted average based on the WUCLS ratings. Thanks to the use of native plants in drought resistant landscaping, most of the plants in the area were included on this list and the others were extrapolated from similar plants and location to determine the rating. The density coefficient was determined using the combined canopy and shrub cover. Research has shown that when trees have a canopy cover of 70 percent an increase in the canopy cover does not significantly increase water use. This puts 70 percent or higher canopy cover as an average density rating. While shrubs and ground cover are considered average at 90 to 100 percent. "When canopy cover is full for any vegetation type then increases in density result from increases in the number of plants of other vegetation types. (Source 1)" This means that while the typical canopy coverage for the trees on the project was just over 70 percent giving an average rating, the shrub cover added, pushed it to a high density rating. However areas with only one vegetation tier, such as the Ceanothus/Scrub/Opening vegetation type, were given an average density rating. The microclimate coefficient was also average for areas where no external factors increasing evapotranspiration were present. Places like the Ceanothus, Scrub, Opening vegetation type were given a slightly elevated microclimate coefficient due to heating effects of exposed rock in the area. The calculated water use coefficient was then multiplied by the measured evapotranspiration* and the result is the expected water use for the current vegetation. The percent water supplied was calculated by taking the water needed (evapotranspiration) and subtracting that from rainfall for a drought year and an average rainfall year. The excess rainfall was then added to the soil water but not exceeding the soil water holding capacity. Any deficit in plant water needs was taken from the soil water. Percent of needed water supplied was calculated by adding the soil water from the month before and the current months rainfall and dividing by the water needed for the current month.

Example: (Soil Water Past Month + Rainfall Current Month) ÷ Water Needs Current Month = Percent Water Supplied.

(Source 1) A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California, University of California Cooperative Extension California Department of Water Resources, August 2000, Accessed 3/31/2017, http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf

*Evapotranspiration data was drawn from local weather stations and California Irrigation Management Information System (CIMIS) data.

Water use by Vegetation Type

Overall

Average total rainfall for this area is 68 inches per year. Average total evapotranspiration is 54.3 inches (not adjusted for vegetation type). Average soil water holding capacity is approximately 7 inches. The data shows that a reduction in the density in most of the vegetation types would help prevent vegetative drought stress.

Mixed Conifer

Average total plant water needed for the Mixed Conifer vegetation type is 35 inches per year. In an average water year, plant water needs are 100% supplied for 9 months of the year. Only 70% of plant water needs are supplied in July, 3% in August, and 31% in September. As an example of a drought year, in 2015 the total rainfall was 32 inches. The plant water needed was 33 inches. Plant water needed was only 100 percent supplied for 8 months. June supplied only 90 percent, July supplied no water, August supplied 2 percent, and September 11 percent. If a reduction in stand density from the currently high stand density to that of a moderate stand density occurred it could result in an additional month of 100% supply of water.

Table 11. Water Supply and Use for Mixed Conifer Vegetation Type

Mixed Conifer Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	2.11	0.81	0.56	0.79	1.33	2.44	3.25	3.89	4.97	4.96	4.41	3.34	32.86
Soil water	0.44	3.92	9.50	8.83	9.50	7.65	7.33	3.70	0.00	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	90%	0%	2%	11%	
Average Rainfall Year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	2.41	1.17	0.60	0.80	1.27	2.01	3.11	4.22	5.05	5.83	5.02	3.69	35.19
Soil water	1.33	8.03	9.50	9.50	9.50	9.50	9.50	8.19	4.05	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	70%	3%	31%	

Mixed Conifer Vegetation Type (*if treated to a moderate stand density*)													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.76	0.68	0.46	0.66	1.11	2.04	2.71	3.24	4.14	4.14	3.67	2.78	27.38
Soil water	0.80	4.41	9.50	8.96	9.50	8.05	8.28	5.29	1.92	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	46%	2%	14%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	2.01	0.97	0.50	0.67	1.06	1.67	2.59	3.52	4.21	4.85	4.19	3.08	29.32
Soil water	1.73	8.63	9.50	9.50	9.50	9.50	9.50	8.89	5.59	0.78	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	22%	37%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for the Mixed Conifer vegetation type during an average rain year and the 2015 calendar year.

Fir, Cedar, Oak

Average total plant water needed for this vegetation type is 28 inches per year. In an average water year, plant water needs are 100% supplied for 11 months. September is only supplied 75%. As an example, during the 2015 water year the total rainfall was 32 inches. The plant water needed was 25 inches. Plant water needed was only 100% supplied for 10 months. August only supplied 43% and September 18%. If a reduction in stand density from the currently high stand density to that of a moderate stand density occurred it could result in an additional month of 100% supply of water.

Table 12. Water Supply and Use for Fir/Cedar/Oak Vegetation Type

Live Oak, Fir, Cedar Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.60	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	24.77
Soil water	0.95	3.14	6.80	4.81	6.80	5.28	6.12	4.26	2.93	0.82	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	43%	18%	
Average Rainfall year													

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.83	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	28.35
Soil water	1.91	6.80	6.80	6.80	6.80	6.80	6.80	6.80	5.30	2.93	0.68	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	

Live Oak, Fir, Cedar Vegetation Type (*if treated to a moderate stand density*)													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.33	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	20.64
Soil water	1.22	3.75	6.80	5.17	6.80	5.64	6.80	5.30	4.31	2.56	0.88	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	72%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.53	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	23.62
Soil water	2.21	6.80	6.80	6.80	6.80	6.80	6.80	6.80	5.70	3.73	1.88	1.01	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for Fir/Cedar/Live Oak vegetation type during an average rain year and the 2015 calendar year.

Ponderosa Pine

Total plant water needed for this vegetation type is 34 inches per year. In an average water year, plant water needs are 100% supplied for 9 months of the year. July is only supplied 90%, August supplied 3%, and September is supplied 32%. As an example, during the 2015 water year the total rainfall was 32 inches. The plant water needed was 32 inches. Plant water needed was only 100% supplied for 9 months. July only supplied 13%, August supplied 2%, and September supplied 12%. If a reduction in stand density from the currently high stand density to that of a moderate stand density occurred it could result in an additional month of 100% supply of water.

Table 13. Water Supply and Use for Ponderosa Pine Vegetation Type

Ponderosa Pine Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	2.03	0.78	0.54	0.76	1.29	2.35	3.13	3.74	4.79	4.78	4.24	3.21	31.64
Soil water	0.52	4.03	10.10	9.46	10.10	8.34	8.15	4.65	0.63	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	13%	2%	12%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	2.32	1.12	0.58	0.77	1.22	1.93	3.00	4.06	4.87	5.61	4.84	3.56	33.88
Soil water	1.42	8.17	10.10	10.10	10.10	10.10	10.10	8.95	4.99	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	90%	3%	32%	

Ponderosa Pine Vegetation Type (*if treated to a moderate stand density*)													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.69	0.65	0.45	0.63	1.07	1.96	2.61	3.12	3.99	3.98	3.54	2.68	26.37
Soil water	0.86	4.50	10.10	9.59	10.10	8.73	9.06	6.19	2.97	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	2%	14%	

Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.93	0.94	0.48	0.64	1.02	1.61	2.50	3.39	4.06	4.67	4.03	2.96	28.24
Soil water	1.81	8.74	10.10	10.10	10.10	10.10	10.10	9.62	6.48	1.84	0.00	0.00	
Percent of Needed Water Supplied	100 %	100 %	100%	100%	100%	100%	100%	100%	100%	100%	50%	38%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for Ponderosa Pine vegetation type during an average rain year and the 2015 calendar year.

Grey Pine, Live Oak

Average total plant water needed for this vegetation type is 25 inches per year. In an average water year, plant water needs are 100% supplied for 9 months of the year. July is only supplied 35%, August is supplied 4%, and September supplied 43%. As an example, in the 2015 water the total rainfall was 32 inches. The plant water needed was 24 inches. Plant water needed was only 100% supplied for 8 months. June is only supplied 54%, July supplied no water, August supplied 3%, and September supplied 16%. If a reduction in stand density from the currently high stand density to that of a moderate stand density occurred it could result in an additional month of 100% supply of water.

Table 14. Water Supply and Use for Grey Pine/Live Oak Vegetation Type

Gray Pine, Live Oak Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.52	0.59	0.40	0.57	0.96	1.76	2.35	2.81	3.59	3.58	3.18	2.41	23.73
Soil water	1.03	4.30	4.30	3.85	4.30	3.13	3.72	1.16	0.00	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	54%	0%	3%	16%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.74	0.84	0.44	0.58	0.92	1.45	2.25	3.05	3.65	4.21	3.63	2.67	25.41
Soil water	2.00	4.30	4.30	4.30	4.30	4.30	4.30	4.16	1.42	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	35%	4%	43%	

Gray Pine, Live Oak Vegetation Type (*if treated to a moderate stand density*)

Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.27	0.49	0.34	0.48	0.80	1.47	1.96	2.34	2.99	2.99	2.65	2.01	19.78
Soil water	1.28	4.30	4.30	3.94	4.30	3.42	4.30	2.21	0.00	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	3%	19%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.45	0.70	0.36	0.48	0.76	1.21	1.87	2.54	3.04	3.51	3.02	2.22	21.18
Soil water	2.29	4.30	4.30	4.30	4.30	4.30	4.30	4.30	2.17	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	63%	5%	51%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for Grey Pine/Live Oak vegetation type during an average rain year and the 2015 calendar year.

Fir, Pine, Oak

Average total plant water needed for this vegetation type is 35 inches per year. In an average water year, plant water needs are 100% supplied for 9 months of the year. July is only supplied 38%, August is supplied 3%, and September supplied 31%. As an example, in the 2015 water year the total rainfall was 32 inches. The plant water needed was 33 inches. Plant water needed was only 100% supplied for 8 months. June only supplied 52%, July supplied no water, August supplied 2%, and September supplied 11%. If a reduction in stand density from the currently high stand density to that of a moderate stand density occurred it could result in an additional month of 100% supply of water

Table 15. Water Supply and Use for Fir/Pine/Oak Vegetation Type

Fir, Pine, Oak Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	2.11	0.81	0.56	0.79	1.33	2.44	3.25	3.89	4.97	4.96	4.41	3.34	32.86
Soil water	0.44	3.92	7.60	6.93	7.60	5.75	5.43	1.80	0.00	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	52%	0%	2%	11%	

Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	2.41	1.17	0.60	0.80	1.27	2.01	3.11	4.22	5.05	5.83	5.02	3.69	35.19
Soil water	1.33	7.60	7.60	7.60	7.60	7.60	7.60	6.29	2.15	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	38%	3%	31%	

Fir, Pine, Oak Vegetation Type (if treated to a moderate stand density)													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.76	0.68	0.46	0.66	1.11	2.04	2.71	3.24	4.14	4.14	3.67	2.78	27.38
Soil water	0.80	4.41	7.60	7.06	7.60	6.15	6.38	3.39	0.02	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	1%	2%	14%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	2.01	0.97	0.50	0.67	1.06	1.67	2.59	3.52	4.21	4.85	4.19	3.08	29.32
Soil water	1.73	7.60	7.60	7.60	7.60	7.60	7.60	6.99	3.69	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	77%	4%	37%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for Fir/Pine/Oak vegetation type during an average rain year and the 2015 calendar year.

Ceanothus, Scrub, Opening and Serpentine

Average total plant water needed for this vegetation type is 18 inches per year. In an average water year, plant water needs are 100% supplied for 10 months of the year. August is only supplied 7%, and September is supplied 61%. As an example, in the 2015 water year the total rainfall was 32 inches. The plant water needed was 17 inches. Plant water needed was only 100% supplied for 9 months. July supplied 44%, August supplied 4%, and September supplied 22%. A reduction in stand density does not change the water available in the Ceanothus, Scrub, Opening, Serpentine type.

Table 16. Water Supply and Use for Ceanothus/Scrub/Opening and Serpentine Vegetation Types

Ceanothus, Scrub, Opening Vegetation Type, Serpentine Vegetation Type													
Drought year (2015)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	2.55	4.29	15.28	0.12	4.82	0.59	2.94	0.25	0.77	0.00	0.08	0.38	32.07
Vegetation Water needed (Evapotranspiration)	1.07	0.41	0.28	0.40	0.68	1.24	1.66	1.98	2.53	2.53	2.24	1.70	16.73
Soil water	1.48	4.60	4.60	4.32	4.60	3.95	4.60	2.87	1.11	0.00	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	44%	4%	22%	
Average Rainfall year													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Rainfall	3.74	7.87	12.68	11.89	11.61	9.61	5.12	2.91	0.91	0.04	0.16	1.14	67.68
Vegetation Water needed (Evapotranspiration)	1.23	.59	.31	.41	.65	1.02	1.58	2.15	2.57	2.97	2.56	1.88	17.92
Soil water	2.51	4.60	4.60	4.60	4.60	4.60	4.60	4.60	2.94	.01	0.00	0.00	
Percent of Needed Water Supplied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	7%	61%	

Table showing water supplied by rainfall and water loss by evapotranspiration, by month, for Ceanothus/Scrub/Opening and Serpentine vegetation types during an average rain year and the 2015 calendar year.

Methods

Measurements

A variable radius plot cruise was used to determine the number, size, density, and health of the trees in the area. Using a grid pattern, 60 cruise plots (sample points) were placed throughout Paradise Pine Property Owners Association, Paradise Irrigation District and Paradise Unified School District land ownership. The species, diameter, and any signs of disease were recorded for all trees within each plot. Down and dead fuel was measured using Brown's transects, shrub density and average height to the tree crowns were measured on each plot. Tree health was assessed for each of the sampled trees using Keen's Tree Classification System based on each trees age and vigor. From this data, total trees per acre, diseased trees per acre and standing dead trees (snags) per acre were calculated.

A fixed-radius plot cruise was also used to measure the shrub height and density for the previously treated fire breaks. One hundred and twelve plots were placed in as many different vegetation types as possible. This data determined the retreatment intervals that will be required to maintain effective fire breaks.

Vegetation typing

Vegetation was delineated by analyzing aerial photos, slope and aspect, in conjunction with extensive field surveys and photos taken at each of the 60 cruise plots. The classification of plant cover types allowed for a better understanding of the plant species located throughout the project area and was used to divide the data and determine accurate plant water use and retreatment intervals. Seven cover types were identified throughout the project area and labeled as: Ponderosa Pine, Ceanothus/Shrub/Opening, Grey Pine/Live Oak, Fir/Live Oak/Cedar, Fir/Cedar, Riparian and Serpentine.

Appendix

Contains:

Past Projects

Operations Map

Special Status Plants Map

Soil Map

Cruise Plot Photos

Special Status Plant Photos

Migratory Bird I.D. Photos

Available at: http://www.buttefiresafe.net/appendix-to-the-mfhp