Panel Review Report

of

Vegetation Treatment Program Environmental Impact Report Draft

by

California Board of Forestry and Fire Protection

In Association With

CAL FIRE Agency

Report coordinated by: California Fire Science Consortium

<u>VTPEIR Peer Review Panel</u>
Oversight and co-coordinators:
Scott Stephens, UC Berkeley Professor of Fire Science (CFSC co-chair)
Robin Wills, Regional Fire Scientist, National Park Service (CFSC co-chair)

Project coordinator
Stacey Sargent Frederick, California Fire Science Consortium Program Coordinator

Panel members:
Jay Perkins, Fire behavior specialist, US Forest Service (ret) and consultant
Ed Smith, Ecologist, The Nature Conservancy
Bill Stewart, UC Berkeley Forestry Specialist
Jan van Wagtendonk, National Park Service scientist, emeritus
Paul Zedler, Professor of Environmental Studies, University of Wisconsin

August 2014

Table of Contents

Table of Figures

Table of Tables

Chapter 1. Introduction

The draft Vegetation Treatment Program Environmental Impact Report (VTPEIR) was completed by CAL FIRE staff and their consultants in 2012. It was delivered to the California Board of Forestry and Fire Protection who have the legal responsibility to approve the EIR. Actions under this EIR were to be implemented primarily by the CAL FIRE agency. The draft details vegetation treatments that would be used to reduce fuels for fire prevention, safety, ecological restoration and other purposes. Projects using the CEQA of the VTPEIR could be undertaken on non-federal lands with some of the costs provided by funds awarded annually through the state legislature. The VTPEIR draft was opened for public review in 2013. Given the response from the public and other stakeholders, it was recommended by the state legislature that an outside review of the draft VTPEIR should be conducted. The results of that review are provided in this report.

The process of the review, information on the panel members, and an overview of the main findings are in Chapter 1. From this overview, each major issue and recommendations on how to address the issues are given in Chapters 2.1 through 2.6. Additional information (background, specific issues, and recommendations) can be found in the Appendix. Specific and global questions that were provided by the legislature and CAL FIRE staff are briefly addressed in Chapter 3. However, once it was clear that the Panel's consensus was to recommend a major revision to the VTPEIR, many of these questions became too specific or irrelevant, and thus were not addressed extensively in this report. Finally, additional information and a list of bibliographic references are provided to assist with the revision of this VTPEIR in the Appendix.

1.1 Review Process

The California Fire Science Consortium (CFSC) was commissioned by CAL FIRE and the Board of Forestry and Fire Protection to assemble and coordinate a team for a peer-review of the Draft VTPEIR.

VTPEIR Peer Review Panel

Oversight and co-coordinators:
Scott Stephens, UC Berkeley Professor of Fire Science (CFSC co-chair)
Robin Wills, Regional Fire Scientist, National Park Service (CFSC co-chair)

Project coordinator
Stacey Sargent Frederick, CFSC Program Coordinator

Panel members:
Jay Perkins, Fire behavior specialist, US Forest Service (ret) and consultant
Edward Smith, Forest Ecologist, The Nature Conservancy
Bill Stewart, UC Berkeley Forestry Specialist
Jan van Wagtendonk, National Park Service scientist, emeritus
Paul Zedler, Professor of Environmental Studies, University of Wisconsin

Summary of Panel Activities

During the course of this review process the panel was given the following documents and examples:

- The VTPEIR Draft
- Letters of public comment from the VTPEIR comment period
- Project level Vegetation Treatment Plans from within the CAL FIRE agency
- Global and specific questions regarding the VTPEIR that were negotiated between CAL FIRE, Board of Forestry, and the Legislature

Panel meetings

04/28-05/01 Pasadena, CA and San Diego, CA

During this meeting, personnel from CAL FIRE took the panel on a tour of example fuel reduction projects conducted by CAL FIRE and LA County Fire. CAL FIRE staff from many position levels participated in this field tour. Stakeholders of the area who sent in comment letters from the initial comment collection period were also invited to attend meetings and provide input to panel members during this week. *Stacey Frederick and Robin Wills were absent, all others present.*

05/29-05/30 Auburn, CA

This meeting began with field tours of three fuel reduction projects conducted by CAL FIRE. Associated VTP and project level documents were given to the panel. Again, various CAL FIRE staff, from the chief to the VTP planner attended this field tour and the following meeting. The following day consisted of a panel-only meeting to begin organizing thoughts for this draft. *Scott Stephens and Robin Wills were absent, all others present.*

1.2 Overall Evaluation

It is the panel's recommendation that the VTPEIR undergo major revision if it is to be a contemporary, science-based document. This will enable CAL FIRE's VMP foresters and fire staff to prioritize and design vegetation management projects framed around the different vegetation communities and their fire regimes throughout the state. VTPEIR projects should explicitly address project specific questions concerning the relative efficacy and appropriateness of different fuel treatments. Proposed treatments and re-treatment strategies tailored to historic fire regimes would theoretically minimize adverse ecological effects in situations where a goal is to maintain the current vegetation. In other situations, the goal may be to alter the current vegetation for ecological restoration or public safety goals. The complexity of California's vegetation as well as the many goals for vegetation management in fire prone areas means that there are no guaranteed 'best practices.' One avenue to move forward on defining and implementing best practices would be to utilize formal adaptive management: rigorous analysis of monitoring data collected in response to implementation of a representative sample of VTP projects. From monitoring efforts, the EIR could be used to implement projects and collect information on the relative efficacy and ecological effects of treatment and vegetation combinations.

The VTPEIR should explicitly describe how the treatments proposed for private lands fit into the state's overall fire plan, including protection of high value assets, state and local land use planning policies, and federal land use practices. Links between this EIR and the broader structure of fire management (including CAL FIRE's 2012 Strategic Plan, the Board of Forestry's 2010 Strategic Fire Plan and Community Wildfire Protection Plans (CWPPs)) should be described. There must also be a better explanation of how CAL FIRE will provide the Legislature and Governor's office with a logical and transparent plan of why and where increased expenditures on fuels management would be appropriate and effective. A revised VTPEIR should also include: a more realistic set of alternatives that would have lower acreages (10-15 year EIR) than those that are currently proposed; assumptions and plans that rely more strongly on scientific research results; results from internal and external monitoring of the different treatment and vegetation combinations; use of monitoring results to revise future plans and; adaptation suggestions to mitigate the potential for increased risk from treatments to public safety, public assets and environmental assets.

If the current EIR document is used as is, projects could be implemented without valuable planning and collaboration that would ensure both ecological and social goals are being met with minimal environmental impacts. Without deliberate oversight and revisions to the VTPEIR, unassessed environmental impacts and irreparable damage to public-agency relationships could result. This risk is what compels the panel to recommend the following revisions.

Chapter 2. Specific areas of Concern

Section 2.1 Conceptual Framework

2.1.A. Issue: Organization

The current VTPEIR attempts to collapse the state's varied fire and fuel regimes into a standardized matrix where all treatments are equally effective in all landscapes and fire regimes. California is the most diverse and endemic-rich state in the Union from a biodiversity standpoint (Stein *et al.* 2000, Stein 2002); thus management of its vegetation cannot be covered in a single document without different sections to reflect this diversity. Not only are there significant differences in the ecological role fire plays among trees, shrubs, and grasses, but these roles differ by ecoregion. Varying roles mean that vegetation treatments, fire behavior, and fire effects are also different.

While the panel recognizes that the VTPEIR included specific goals for different ecoregions, locating this information was very difficult. The information given also lacked the specificity to be of any real use given the various combinations of fuel types and project types within each ecoregion.

2.1.a. Recommendations

The diversity of vegetation across California and the statewide complexity should be recognized and explained throughout the document. These factors should also be explained in the introduction and executive summary. Furthermore, information related to any aspects of on-the-ground planning (i.e. specific goals, objectives, fire behavior, flora and fauna considerations), should be separated into three sections. These sections will be one for each of the major vegetation formations found in California: forests, grasslands, and shrublands. For further justification and descriptions of these three fuel types, see Appendix 1.1.

Within each of these three sections of the EIR, different project types should be delineated. These project types are Wildland-Urban Interface (WUI), fuel breaks, and ecological restoration. The result should be displayed in a matrix with specific goals and rationales under different project types given different vegetation types. Finally, for each of these projects, a sound scientific justification should be provided for both the fire and fuel management aspects as well as any ecological rationales. An example rational matrix under the new organization scheme is in Appendix 1.5 (Table 1.5.1). As will be noted in the following sections, projects in the WUI should become a stronger focus for this VTPEIR given their importance in other fire management documents (i.e., 2010 Strategic Plan) and their effectiveness (Calkin *et al*. 2014; Cohen 2010; Cohen 2008).

2.1.B. Issue: Executive summary needs more useful information

Given the complexity and length of the whole VTPEIR, the importance of having an easily accessible, clear, and useful executive summary is heightened. Currently, this section does not function as a standalone or useful document. This is primarily due to the lack of vital information. The executive summary also fails to lay out a clear, compelling justification for why these outlined projects need to be implemented.

2.1.b. Recommendations

The following pieces of information should be included in the executive summary:

- A clear statement about the problem the state is trying to solve, e.g., provide a compelling case for expending tax dollars on the hazard of wildland fuels reduction program
- A discussion on how this investment will affect the wildfire environment and how projects done under the EIR will benefit the state and its' occupants
- An introduction to the organizational structure of the document to assist in navigation
    - Specifically, this executive summary should guide a VMP planner to the sections most pertinent to their planned project.

Section 2.2. Fire Behavior

2.2.A. Issue: Fire behavior and suppression effectiveness need additional discussion

The wildfire analysis in Chapter 4 of the EIR is robust and quite complete. In particular, the "Fuel Rank Potential Fire Behavior" (FRAP 2010) product gets at the heart of what needs to be altered or modified in order to change fire behavior, fuel and vegetation. Of the three determinants that drive fire behavior—topography, weather and fuels— only fuels can be modified in order to change fire behavior. When fuels are altered, these two important fire behavior characteristics are altered: fire line intensity and rate of spread.

CAL FIRE already has tools to address these fire behavior aspects. Within the body of the data used for developing the Potential Fire Behavior product, it is stated that:

> *"CDF has developed a Fuel Rank assessment methodology for the California Fire Plan to identify and prioritize pre-fire projects that reduce the potential for large catastrophic fire. The fuel ranking methodology assigns ranks based on expected fire behavior for unique combinations of topography and vegetative fuels under a given severe weather condition (wind speed, humidity, and temperature). The procedure makes an initial assessment of rank based on an assigned fuel model (see surface fuels) and slope"* (FRAP 2010).

2.2.a. Recommendations

The EIR should use the Fuel Rank Potential Fire Behavior (FRAP 2010) metric as means for analyzing and setting goals and objectives for hazardous fuels reduction work. The use of this tool should be clearly outlined in the VTPEIR.

There are myriad citations (many in need of more recent references) within the EIR that support and explain the value in manipulating vegetation fuels to a point where fire behavior can be altered (reducing intensity, extent, and rate of spread). Below is one example (page 5.2-2)

> *"Fuel management practices clearly reduce fire behavior, particularly for area treatments such as broadcast prescribed fire (Biswell 1963, Truesdell 1969, Van Wagner 1968, Helms 1979, Rawson 1983). Fuel treatments removing ladder fuels on forested systems can significantly affect potential for crown fires, which are extremely difficult to control and often devastating (Dodge 1972, Rothermel 1991, Sapsis and Martin 1994). Fuels management also significantly reduces wildfire occurrence and acreage burned (Weaver 1955 & 1957, Davis and Cooper 1963, Wood 1978, 1979). In Southern California, fuelbreaks, areas previously burned by wildfires, and areas that had been prescribed burned, all contributed to limiting the final size of the 1985 Wheeler Fire (Salazar and Gonzalez-Caban 1987). Walker (1995) reports that the 1995 Warner Fire*

and the 1993 Geujito Fire similarly lost intensity when they ran into recent prescribed burn areas."

The VTPEIR should clearly show the suppression effectiveness of current vegetation condition and analyze how moderating the fuels will improve the state's effectiveness in keeping fires small and more controllable. This, in turn, should present fewer, costly large fires. A key point of the rationale for treatments that modify fire behavior is that escaped large fires generate much of the costs for fire suppression.

Specific recommendations

1. Define the probability of successful suppression (Initial Attack (IA) and Extended Attack (EA)) effectiveness for each of the Fuel Rank Potential Fire Behavior classes. This analysis will set the stage for the current situation and provide a benchmark against which each EIR Alternative can be evaluated. For a demonstration of this, see Appendix table 1.2.2.

2. Evaluate Probability of Success for each EIR Alternative: After quantifying the Probability of Success (step 1) the next step is to assign Probability of Success for each Alternative. By altering surface, ladder and/or crown fuels, the Fire Behavior ranking will change. The fuel profiles can then be targeted for priority treatment and to reduce the Fuel Ranking Fire Behavior Potential. Comparing the outcomes by EIR alternatives will give the decision makers a sense for whether there is an incentive for investing in a given set of fuels reduction projects. This will help to answer both EIR Goals 2 and 3.

3. Unit Fire Management Plans should specifically address a strategy within their Units for targeting areas of concern and how their treatment proposals will reduce the Fire Behavior Potential of each specific project.

2.2.B. Issue: Need a better rationale of how different fuel treatments meet different goals, especially that of fuel reduction near communities

The EIR has limited discussion or analysis on goals or objectives to be achieved in or proximate to communities. However, Cohen's research has shown many times over that the most effective treatments for home survival are those proximate to structures and infrastructure (Calkin *et al*. 2014; Cohen 2010; Cohen 2008).

Effective treatments are those that alter surface, ladder or crown fuels (Agee and Skinner 2005) to the extent that fire suppression can be done more safely and effectively. They are ecologically effective if a treatment alters fuels so that when the next wildfire does occur, the resulting fire severity is not deleterious to the immediate or surrounding ecosystems. For examples of these, see Appendix table 1.2.3. A discussion on how effective the hazardous fuels treatments will perform for both fire weather scenarios (levels) previously described should be included.

The EIR uses Finney's (2001) work and assumes that strategically treating 20-35% of a landscape is sufficient for changing fire behavior. The intent of Finney's work is to strategically place area treatments (a mosaic of treatments across a landscape) where fire behavior will be altered. By having strategically placed patches of fuel-reduced areas across the landscape, the fire behavior could be altered, perhaps at a landscape scale or perhaps more locally. Typical examples that have been effective are thinning or timber harvest projects that can visibly show a change in fire behavior (Skinner *et al.* 2004). Regardless of ownership or purpose, the reduction of fuels often greatly slows a fire and can allow the firefighters the needed chance to suppress or manage a fire.

2.2.b. Recommendations

The EIR needs to explain separately how treatments of fuels will be designed to function in the WUI (i.e. as a linear fuel break along one side of a community) and how they will be designed to function in larger landscapes where potentially complementary activities such as forest management, grazing, or irrigated pastures can also be part of the overall fuels modification. Given that CAL FIRE does not own the land and bases much of their work on having willing landowners step forward, achieving 35% of lands treated in a strategic manner may not be possible.

Irrespective of the manner by which a fuel profile is modified (grazing, prescribed fire, mechanical means, etc.) for fire suppression and community defense purposes, if the treatment does not reduce or change fire behavior, then the proposed project should be reconsidered. Additionally, if the fuel modification project is for reducing fire effects and fire severity, and the modeling indicates that it will not, then the project should be reconsidered. Project level fire planners should be using state of the art analytical tools for evaluating the effectiveness of reducing fire line intensity and spread rates. The same is required for analyzing fuels management treatment effectiveness on post-wildfire fire severity. Examples of these tools include FOFEM, Farsite, BehavePlus, FlamMap, and FireFamilyPlus.

The VTPEIR needs to include a more rigorous analysis on the interface problem and how projects should be utilized to enhance community protection objectives besides just treating landscapes. The EIR should be able to display the tradeoffs between performing fuels reduction work in support of community protection projects (i.e. Community Wildfire Protection Plans) and using fuel reduction on a landscape scale. CAL FIRE has participated in such an analysis and it could be carried forward in the VTPEIR. From the Sierra Nevada Forest Plan Amendment (FEIS Volume 2, Chapter 3, part 3.5 – page 273- Affected Environment and Environmental Consequences):

> *"Working collaboratively the SNFP Interdisciplinary Team and the California Department of Forestry and Fire Protection (Sapsis et al. 2000) tested the potential threat to Sierra Nevada communities located in urban wildland interface areas. For the purposes of their analysis, urban interface areas of settlement were defined as those with housing*

densities of 16 or more houses per square mile (1 structure per 40 acres). From these areas, two zones were buffered: (1) an inner "Fire Defense Zone" (0.25 miles wide) and (2) an outer "Fire Threat Zone" as a 1.25- mile area immediately adjacent to the inner fire defense zone. These zones are consistent with the California Department of Fire and Forestry's working definition of the Wildland Urban Interface (WUI) and the definition of urban wildland intermix zones used in this FEIS."

This level of analysis would help to evaluate how much investment in fuel modification in and around communities would be needed to continue working towards safer and better fire-adapted communities.

Specific Recommendations

STATE-WIDE

Develop a state-wide set of hazardous fuels management desired future conditions. Each Unit Fire Plan should address how their hazardous fuels reduction projects will achieve this desired condition. For example:

> Priority 1: Reduce very high and high ranked fuels (see the Fuel Rank Potential Fire Behavior) to 'moderate' or 'below moderate' (where ecologically appropriate) in and around WUI/communities threatened by wildfire. Ecological principles should be considered; i.e., not introducing high severity burns or serious ground disturbing activities in areas where invasive species threaten local native species. Proposed fuels treatment activities should examine alternatives or mitigations to the proposed actions so that hazardous fuels reduction goals can still be met while minimizing the chance of an invasion by the exotics.
>
> Priority 2: Focus hazardous fuels work on landscapes that are severely threatened and are in Condition Class 2 or 3 (VTPEIR Page 4.2-13). Alternatively, use the Fire and Resource Assessment Program analysis of threatened landscapes from the CAL FIRE 2010 Strategic Fire Plan.
>
> Priority 3: Maintain areas already rated 'moderate' in the Fuel Rank with a priority on areas adjacent to WUI and critical or threatened ecological objectives.

Ranger Unit/Project Level

Husari *et al*. in Chapter 19 from "Fire in California's Ecosystems" (Sugihara *et al*. 2006) set out clearly that the fuels management objectives should be for modifying fuels for fire behavior and/or for ecological benefits.

A set of fire behavior-driven hazardous fuels reduction objectives could be established that would aid the project implementers in setting project goals and objectives (see Section 2.1). For the set of fire modeling tools Unit-level fuels abatement plans should be using, refer to the Section 2.2.b Fire Behavior (Recommendations b (p. 10)).

2.2.D. Issue: Need to clarify terms and concepts in relation to the VTPEIR

A few terms and concepts in the VTPEIR are recommended below for review.

2.2.d. Recommendations

1. Use fire behavior analysis, where appropriate, instead of fire severity

   The terms fire severity and fire behavior are interchangeably used in VTPEIR Chapter 5. However, these terms are not synonymous and each portray a unique factor in the wildland fire world. The VTPEIR uses the fire severity analysis as the metric for evaluating Alternatives and achieving EIR goals. In many cases, a more accurate metric would be fire behavior analysis. For a more in-depth description of the differences between these two terms and their use, see Appendix 1.2.

2. Define 'severe weather'

   The fire related modeling in the VTPEIR is for 'severe fire weather conditions.' The term 'severe fire weather condition' is not defined in the VTPEIR nor is there a rationale as to why this level of fire weather was used for modeling purposes. Fire modeling should be tested against the severe fire weather event (i.e. 95th percentile and 97th percentile) as well as a fire weather event that is a more typical fire season event, i.e. 80th percentile. Fire weather breakpoints are points on the cumulative distribution of one fire weather/danger index computed from climatology without regard for associated fire occurrence/business. For example, the value of the 90th percentile energy release component (ERC) is the climatological breakpoint at which only 10 percent of the ERC values are greater in value (National Wildfire Coordinating Group 2014).

3. Fuel breaks

   Another hazardous fuels strategy that needs to be analyzed is the design, development, and maintenance of fuel breaks. Fuel breaks as defined in the CAL FIRE 2010 Strategic Fire plan are "*wide strips of land on which trees and vegetation has been permanently reduced or removed. These areas can slow, and even stop, the spread of a wildland fire because they provide less fuel to carry the flames. They also provide firefighters with safe zones to take a stand against a wildfire, or retreat from flames if the need arises."* There is much discussion over the effectiveness of fuel breaks as embers and crown fires may easily be able to cross this barrier, especially given certain weather conditions.

   Fuel breaks require up-front investment to establish and routine maintenance to retain their effectiveness. The VTPEIR should address how fuel breaks fit into the hazardous fuels reduction programs and expenditures of hazardous fuels reduction dollars. The Alternatives in the VTPEIR should evaluate different levels of investment and maintenance while considering their effectiveness (Reinhardt *et al*. 2008). The tradeoffs between fuel break effectiveness and the ecological damage done should be carefully considered.

The VTPEIR needs to make a case for the effectiveness of fuels breaks across various fuel types, i.e. grass, shrubs, and timber. There should be an inventory and evaluation of the fuel breaks within the state that includes the development costs associated with continuing to develop and maintain a system. In the absence of fuel break data, the Unit Fire Plans should justify their expenditures of hazardous fuels reduction dollars for the continuing investment in developing and/or maintain existing fuel break against doing projects on a landscape scale or projects proximate to communities. Across all of the Alternatives within the VTPEIR, different levels of investment (capital and maintenance) in fuels breaks should be clearly detailed (Agee *et al*. 2000).

Section 2.3. Southern California Chaparral and related systems

2.3.A. Issue: Acknowledgement of the diversity and complexity of shrub ecosystems

The VTPEIR as written does not appropriately represent the significant difference between the fire-vegetation relation for chaparral types and that of forests. Fire recurrence in forests is typically dependent on frequent ignitions resulting in moderate to low intensity fires burning in light fuels mostly beneath mature trees. These are not "stand replacing" fires (except perhaps for some understory herbs and shrubs and occasional small, patchy crown fires). In contrast, chaparral fire recurrences are much less frequent and typically kill most of the above ground biomass (Hanes 1971). Although in one sense these are "stand replacing fires," as most or all of the above ground portions of the plant are consumed or killed in another they are not, because the chaparral will have much the same species composition as it had before the fire after a transient period in which short lived herbs and some shrubs may be prevalent or even dominant. This will be the case as long as the species can reproduce from sprouts or viable seeds.

The diversity of California shrub ecosystems is confirmed by the fact that the Manual of California Vegetation (Sawyer *et al*. 2009) defines more than 100 shrub dominated "vegetation alliances." In addition, there are multiple tree alliances that include substantial shrub components. Over large parts of California, shrublands and forests intermingle in complex ways. There is a gradient from uniform shrublands (chaparral, coastal sage scrub, sagebrush steppe) to shrublands with scattered trees (e.g., "Foothill Pine Woodland" — shrublands with emergent trees) to mosaics of shrub patches within forest, to forests with varying densities of shrub understories. Shrublands and grasslands also intermingle in a similar way, though this has been much more confused by human activities, especially fire, land clearing, and grazing, than the forest-shrub relation.

This taxonomic and ecological richness of shrublands should be kept in mind when viewing shrubs and shrublands strictly as fuel. As fuel, shrubs are more often than not seen as needing to be modified. But from an ecological perspective, shrublands are an essential element of California landscapes, providing cover in places where forest and grassland cannot be stable.

2.3.a. Recommendations

The complexities of this ecological diversity require a much attuned ecological understanding to effectively manage this vegetation type and preserve the functions of this ecosystem. While many individuals within an agency like CAL FIRE are very knowledgeable about the natural history and ecology of the systems with which they work, no institution or group can be said to possess all the knowledge necessary to provide infallible guidance for the multiplicity of situations on the ground that potentially require management. What this situation suggests is that evolving a maximally efficient and minimally ecologically damaging regime of pre- and post-fire vegetation management is a task that must enlist the expertise of multiple agencies and many persons with expert knowledge. But "the current best science" is not sufficient. There are uncertainties that arise because we do not fully understand how ecosystems respond to our actions under known environmental conditions, and because the environmental conditions, which have never been wholly predictable, promise to become even less predictable in the near future.

To address these concerns, the first step is to weave a firm understanding of the complexities of the shrub ecosystem throughout the VTPEIR document. As suggested in Section 2.1.A, the diversity of California's vegetation must be a major component of this VTPEIR. As the vegetation types are different, the treatments and rationale for treatments must also differ. The second step is to redefine the goals of projects in shrublands to focus more on the main CAL FIRE responsibility — fire protection in ways that minimize damage to natural systems— and less on the conservation of natural systems. For further discussion and background on both these steps, see Appendix 1.3.

As there is not strong scientific agreement on how fire and fuel reduction should be used in these southern shrub areas for ecological restoration, the current recommendation is to focus on projects that protect WUI areas with minimal harm to the ecosystem rather than attempting to achieve ecological goals in these areas. Until the intricacies of shrub-dominated ecosystems are better understood, limited projects should be completed outside the WUI. If treatments are performed beyond the WUI, there should be a strong justification that demonstrates:

- That there are not more suitable WUI-project alternatives that could achieve goals more efficiently and with less environmental harm
- That there is a detailed plan designed by those with expert knowledge that shows a strong rationale based on literature
- How the goals will be achieved (e.g. that a fuel break is __% likely to be effective)
- That mitigation measures for adverse impacts and monitoring provisions are provided
- That, in addition to the normal public meeting required, comments are collected and formal responses (possibly showing changes to the plan in response to such comments) are given

Section 2.4. Monitoring

2.4.A. Issue: Lack of standardized and systematic monitoring programs

From both the VTPEIR document and the site visits by the Panel, there was a consensus that a monitoring program is needed to ensure that treatments are implemented as planned, and to check the effectiveness and impacts of any vegetation management program. The VTPEIR does not currently outline satisfactory requirements for monitoring to occur but rather relies on anecdotal methods of observation with limited to no pre/post observations. Specifically, the current 'checklist' does not accomplish either verification of implementation or effects of management on biota or fuels. Chapter 7-1 of the VTPEIR states four main monitoring programs. While the 'baseline' and' implementation' programs are well-defined, the 'effectiveness' and 'validation' monitoring programs are not. The latter two programs are very important and should be outlined in more detail in the VTPEIR or another program of monitoring should be included.

Furthermore, many assumptions within the VTPEIR are drawn from broad-based research and may not be inferable to specific VTPEIR projects. While vegetation management has been done for decades in California, there is still a dearth of systematic information relating to projects in different ecosystems. The VTPEIR provides the opportunity to learn much about California ecosystems and their response to fuel treatments. By outlining and creating a system that requires strong monitoring principles across the state, CAL FIRE will be able to employ the principles of adaptive management to determine project-specific information.

2.4.a. Recommendations

It is recommended that a monitoring system be created that is similar to CAL FIRE's post incident analysis program. This system will utilize mandatory reporting on selected treatments to improve future management. This would also require clearly stating the measurable objectives of projects up-front as well as require stakeholder support of these objectives. It is recommended that every three years, an independent review team will randomly select project sites and report on the effects of treatment. Budgetary requirements that enforce monitoring should be incorporated into the VTPEIR to ensure monitoring occurs. A dedicated budget for monitoring should also be set to ensure the work is achieved.

While the example recommendation is adaptive management, the key element is implementing a monitoring program that has a self-learning component and provides for collaborative decision-making. Requiring that all VTPEIR projects to be monitored would be far too daunting of a task. Instead, it is proposed that representative and randomly selected projects be subjected to closer monitoring (with both pre-project and post-project data collection). By using an established selection method throughout California, the application of the scientific method to a large representative data set can provide for better information on how to manage the landscape in a changing future. The use of sampling over monitoring-holistically will also relieve some of the expense and time of a monitoring program. Rather than having monitoring resources used for all projects poorly, the resources can be devoted to some projects effectively while still providing the needed information.

The monitoring program should include a mechanism for reporting that facilitates constant improvement in both business practices and ecological management. In other words, the results of the monitoring program should be used to plan future treatments based on the success or failures of previous ones. Changes that result in future plans could be related to anything from a lack of change in actual fire behavior characteristics to the protection of an ecological function or even a specific species. Programs, such as CAL MAPPER, that increase transparency within the organization will be a valuable tool in the monitoring process and are an admirable step forward (see Section 2.5 for more information on programs/tools that should be discussed in the VTPEIR).

Although the exact details of this program will be left up to the discretion of the CAL FIRE revision team, a few additional suggestions for the framework follow:

Design

- Each project should rely on reputable and contemporary science (fire ecology, fire behavior, climate amplification, etc.) when characterizing and setting explicit goals and SMART objectives (**S**pecific, **M**easurable, **A**chievable, **R**elevant, and **T**ime-bound) (Doran 1981).
- The design of these monitoring programs should follow that of a scientific experiment and include the testing of hypotheses, identification of uncertainties, and description of assumptions (Before-After-Control-Impact or BACI) embedded within management experiments.
- Any additional tools (i.e. fire behavior models) should be used to show how the proposed management actions will move ecosystems towards the objectives. This stage should use modeling to explicitly show how the proposed strategy is predicted to work during and after implementation.
- Using external, third party groups to implement and analyze these monitoring programs should be strongly considered or required. The benefits of using a third party over an internal reporting system include increased accountability and neutrality, as well as expert oversight throughout the process. Results obtained through a third party may also be perceived as less biased or with a more developed knowledge base (given the potential to include expert ecologist) than an internal monitoring team. Thus additional benefits for the publics' positive perceptions of these programs may result.

Data Collection

- Sample selection: it is recommended that a number of projects for each specific vegetation type and area be randomly selected for inclusion in the monitoring program, comprising 20% (for example) of total project areas in a given year. However, if a particular project or suite of projects is perceived by the public as controversial (i.e. in chaparral systems), then monitoring this project with heightened scientific rigor and transparency should be considered.

  - A sample could be drawn that represents a TBD percentage of planned projects per year per vegetation/project type.

- Rigorous data collection using standard scientific methods should be used to produce verifiable data.
  - All monitoring should include pre-and-post assessments.
  - Methods should include guidelines for sample size estimation, and statistical power assessment. Resources regarding this recommendation can be found here: http://www.statsoft.com/Textbook/Power-Analysis.

Analysis and Use of Information

- The analysis procedures and reporting of results should be outlined with a clear assessment of whether or not the proposed goals were met by the project, and specific procedures that will be followed when goals are not met.
- The knowledge derived from empirical results should be integrated into the next round of management.
- Common criticism and roadblocks for the use adaptive management include too much flexibility for managers to make decisions without a formal and transparent decision-making process. It has been criticized as a program that allows unclear goals and even more unclear future management plans to be implemented. To mitigate these criticisms, the monitoring and management program should provide a site-specific and scientific rationale for all projects (see Section 2.1).

For additional resources on adaptive management, see Appendix 1.4.

Section 2.5. Interaction of projects to be covered under VTPEIR with other projects that change fire behavior

2.5.A. Issue: The VTPEIR has limited congruity with previous projects and independent projects

As initially drafted, the nine goals for the VTPEIR go far beyond the desired accomplishments of fuels reduction projects (for example: Goal 2 is to modify wildfire behavior, Goal 3 is to reduce suppression costs). It currently includes goals that will be the result of a much larger range of projects than will be conducted on private and public lands outside of VTPEIR related projects. Larger environmental outcomes such as enhancing forest health, restoring the natural range of fire-adapted plant communities, maintaining air quality, maintaining water quality, reducing the area of noxious weeds and non-native invasive plants, improving wildlife habitat, and providing a multiple use CEQA compliant document for a wide range of vegetation management projects will be the result of projects covered by the VTPEIR as well as other projects that do not fall under the scope of this VTPEIR.

Reports and projects such as the 2010 Strategic Fire Plan and CAL FIRE's 2012 Strategic Plan provided valuable information that was not clearly integrated into the VTPEIR. While there was mention of some aspects of these reports, the overall linkage between the VTPEIR and these plans was lacking. The previous plans did not appear to be a clear, driving force for the writing of the current VTPEIR. For example, the focus of the Strategic Plans was predominantly based on using fuel reduction to minimize the risk of wildfire to high value assets such as communities. In the VTPEIR, this distinction was not made, but rather all goals were held at the same level of importance. Plans to incorporate programs that provide a proven public-involvement model, such as Community Widlfire Protection Plans, were also lacking.

2.5.a. Recommendations

The larger goals (those other than 2 and 3) cannot realistically be achieved through fuel treatments alone. Instead of promoting all these goals as equivalent, the EIR can hold these as supplementary and ensure that projects do not negatively affect the additional goals. A more tractable EIR would focus on Goals 2 and 3 and treat the other 7 goals as constraints for each project. A greater focus on Goals 2 and 3 would provide a more measurable overlap with the Board of Forestry's 2010 Strategic Fire Plan and CAL FIRE's 2012 Strategic Plan.

Our Panel proposes reorganizing the potential landscape around key vegetation related fire behavior variables (see Sections 2.1 and 2.2.). Specific projects would not be defined by how the fuels/vegetation is altered (e.g. prescribed burn, mechanical or manual treatment, grazing or herbicides) but by three dominant local landscape purposes: 1) wildland urban interface (WUI) around defined communities, 2) creation of fuel breaks, and 3) ecological restoration (where CAL FIRE or another lead agency has well defined and measurable outcomes). Each project should document fire management and/or ecological rationales and explain how it fits into the larger scheme of landscape management. For additional discussion on each of these, see Appendix 2.5.

Other programs, like the Community Wildfire Protection Plans (CWPP) done in conjunction with Fire Safe Councils, are also recommended to be included in a revised VTPEIR, especially given the positive collaboration that already exists between CAL FIRE and such entities. By using the provisions set-up in the CWPP's, the prioritization of goals and projects would be more likely to reflect a cohesive plan that better incorporates the needs of the private landowners and fosters cooperation. Other examples of programs that CAL Fire uses but should be thoroughly discussed in the VTPEIR include CAL MAPPER, fire hazard severity zones (PRC 4201-4204), SRA/DPA Review, and the database of historic fire perimeters.

2.5.B. Issue: Recalculate acreage estimates to be more accurate given constraints and conditions

Throughout the VTPEIR, the estimates of acres treated (especially for prescribed burn treatments) exceeds the realistic limits given the numerous constraints on implementing such projects. These overestimates are not conducive to envisioning the future of treatments in California and may cause both confusion and dissatisfaction among readers of the VTPEIR.

2.5.b. Recommendations:

Treatment acres

The next version of this EIR should not dictate where CAL FIRE can do projects (within the SRA's 37 million acres), but should offer a realistic assessment of the number of treatment acres to undergo treatment per decade. According to the current VTPEIR, over 216,000 acres a year will be treated (if 47,000/year is the status quo, four times which total equals 216,000/year). This is poorly justified. An alternative approach would set an upper limit of acres treated. This limit should be in line with the Fire Plan goal of focusing on high value assets; mainly WUI acres and larger projects of lower cost fuel mosaic acres. Based on the Fire Plan logic, maximizing total acres is not the goal. The goal is to protect assets with effective fuels treatments *and* fire suppression. To better achieve this goal, a fire risk assessment could be used to determine the best areas to apply treatments (see Section 2.2). The revised VTPEIR needs more realistic numbers that better reflect the actual and likely projects that will be completed.

Prescribed burn acres

Much like the overall treatment acres proposed, the amount of projected annual prescribed burning acreage should to be calibrated to a more realistic number that takes into account the many additional restrictions and barriers that may relate to different tools. For example, the use of prescribed fire as a management tool or the burning of piles created by manual or mechanical harvests may be limited in some air basins. The VTPEIR would be more useful if it included current information on the recent experience with the number of burn days, appropriate weather, and public health limitations in different parts of the state. These same considerations and calibrations should be factored into the acreage number for manual treatment acres if these treatments will utilize pile burning to dispose of debris. A provision that encourages cooperation between CAL FIRE units and the local Prescribed Fire Councils could be useful in achieving these goals.

For examples of how the tables should be revised to more accurately reflect acreage, see Appendix 1.5 and Appendix Tables 1.5.2-1.5.4.

Section 2.6. Information availability and public transparency

2.6.A. Issue: Updated, relevant, and scientifically sound information needs to be included in the VTPEIR and in the future project plans

To improve the VTPEIR, a sound scientific foundation should be reflected with each vegetation management plan providing a clear rationale for the selected action. This should be done by providing additional references to support claims in the VTPEIR and including additional scientific concepts that are relevant to the planned actions.

2.6.a. Recommendations

a) Include additional scientific findings throughout VTPEIR. For specific recommendations on references and concepts see other sections of Chapter 2 and the Appendix in this review report.

b) Create a system to supply CAL FIRE personnel with easy-to-access and relevant information sources.

  i. With the wealth of information constantly being produced and added to fire science, keeping up-to-date can be overwhelming and time consuming. Additionally, many staff of natural land resource agencies do not have access to academic journals, which remain the main avenue for disseminating scientific findings. Given these stipulations, the California Fire Science Consortium can work with CAL FIRE to connect its personnel to needed information through a database of references.

  ii. A major role of CFSC is to translate the scientific research into accessible and understandable products. These include research briefs, summaries, webinars, workshops, and field visits. An overview of the current resources provided by the CFSC will be presented to CAL FIRE staff. If additional information needs are identified, the CFSC may be a source of future assistance.

  iii. An additional tool that may be of use to CAL FIRE staff are trainings that both relay new, applicable scientific findings as well as teach skills to access additional research in the future.

2.6.B. Issue: Public interaction and transparency regarding CAL FIRE VTP projects could be greatly improved

Proposed projects on private land require permission from the landowner to be completed. Lack of landowner cooperation may be a significant barrier to placing fuel treatments, particularly in residential communities. CAL FIRE should take steps to build a stronger, more trusting relationship with the public.

Completing projects with greater transparency is a vital element of creating and maintaining a trusting work relationship between the public and land management agencies (Shindler *et al*. 2014). As the Vegetation Management Program uses public funds from taxpayer dollars, CAL FIRE holds some responsibility to use a transparent process that allows stakeholder involvement beyond project commentary. Providing such information, being open to receiving feedback, and making fair decisions will help to build agency trust (Olsen and Sharp 2013, Shindler *et al*. 2011). Engaging other agencies involved in fire and natural resource management as well as fostering collaboration with the public are goals mentioned in the 2010 Strategic fire plan that would be applicable to VTPEIR projects.

2.6.b. Recommendations

a) The current VTPEIR could greatly benefit from a communication plan that informs the public and interested parties about upcoming vegetation management projects. This communication plan should go beyond merely informing the public of a project, but should also include the rationale and the general implementation plan.

   Sharing the extensive internal work done for the Vegetation Management Program (VMP) and promoting and showcasing upcoming projects would be a major step towards transparency. With a few exceptions to outside agencies, this work is not currently being shared outside of CALFIRE (with the new exception of efforts such as CAL MAPPER). To protect issues of privacy, specific details such as property addresses and names should be deleted from internal project documents before being made publicly available to avoid potential privacy concerns that are often raised with the sharing of such documents.

The suggested communication plan should include the following elements:

Projects should include a general description of what is expected to be done. This should be announced at least six weeks before the project takes place. A more detailed description of the project, including project goals and scientifically-grounded rationale as to why and how these goals will be met, should be released prior to the project implementation. The monitoring plan and its results should be made publically available when completed.

At minimum, the above information should be posted on a website database. Additional outreach via newsletters, TV, radio, or events may be included. Public meetings are likely to be required in the future under the 2015 Budget language and are somewhat effective at raising awareness of actions. However, they are often one of the lowest rated sources of information (McCaffrey and Olsen 2012) as they are focused on the agency transmitting information to the public rather than an interactive format. These meetings provide limited to no opportunities for the pubic to give input or to feel that their comments are being legitimized and heard. Other options that allow for more interaction are strongly encouraged as these are typically the most trusted and valuable sources of information (McCaffrey and Olsen 2012).

i. CAL FIRE should champion collaborative efforts that focus on preemptive conflict resolution with the public. For example, when a new project comes out, a public meeting with *at least 6 weeks' notice* of the date should be announced to discuss the proposed project. Public comments and suggestions should be addressed in the plan. An outline of how these comments and meetings will be addressed should be included in the VTPEIR or other internal documents to promote consistency throughout the Units.

ii. For these interactions (and others) it is highly recommended that CAL FIRE invest in trainings for staff and personnel that will provide the necessary skills for fostering positive relationships and conflict resolution.

iii. The VTPEIR should be made public once completed. While an additional formal process of public comment period may not be required, the VTPEIR technical revision team should remain available to answer questions and concerns about the EIR.

b) Another major goal of the 2010 Strategic Fire Plan was to increase the effective enforcement of laws like CA 70, Public Resources Code (PRC) §4290 and §4291, Code of Regulations (CCR) Title 14, with CCR Titles 19 and 24. These laws require vegetation buffers for fire safety and other fire safe principles. It is recommended that CAL FIRE use this tool to increase the effectiveness of fuel reduction projects under the VTPEIR by adding provisions to encourage landowners to comply with these laws before CAL FIRE works on their private property.

c) For inspiration and advice on how to better communicate with the public on both these suggestions, the County of Los Angeles Fire Department may provide relevant expertise. http://www.fire.lacounty.gov/forestry-division/fire-hazard-reduction-programs/

Chapter 3. Responses to legislative queries

After the consensuses from the Review Panel showed that major revisions to the VTPEIR were needed, a broader review that resulted in the six major points, Sections 2.1-2.6 become the focus. However, the questions raised by the legislative queries were still discussed by the Panel. In order to address all questions, the following bullet points (with references to the section(s) that best elaborate on the question) are provided.

Global Questions

1. *Are VTPEIR vegetation management activities and goals clearly stated? Are the goals and activities the appropriate ones?*

Panel Response: Needs improvement

- While clearly stated, the goals are very broad and do not appropriately reflect the complexity of various ecosystems and their management needs
- The supporting detail of how they will be achieved is difficult to find or absent (Sections 2.1 and 2.2)
- Being able to achieve all goals at one time, especially given additional restrictions like air quality management and shrub ecology, would be difficult at best (Sections 2.1 and 2.3)
- The treatments should be based on specific goals for specific project types (Section 2.1)
- The protection of human life and property should be a major goal for this VTPEIR, given the responsibilities of CAL FIRE and the Strategic Fire Plans (Sections 2.1 and 2.5)
- An additional goal of creating a transparent and trusted agency through VTPEIR should be included (Section 2.6)

2. Is the Program (the intended activities under the VTPEIR) stated in the VTPEIR sufficiently described so as to permit a reasoned determination whether it will achieve the proper goals and objectives? Is it based on the best available scientific information? If not, provide suggested changes to the Program that would meet the goals and objectives.

Panel Response: Needs improvement

- The complexity of the issues at hand are not well-reflected in the goals; the goals are simply too broad
- The goals need to be based on additional recent, sound science references (Appendix and Chapter 2)
- Amount (acres) of prescribed fire proposed is not possible given other restrictions on fire as a management tool (Section 2.5)
- Does not adequately address the different ecosystems and associated fire regimes (Sections 2.1 and 2.3)
- No plan for to strategic placement of treatments or the fire risk assessment (Sections 2.2 and 2.5)
- No monitoring and thus no ability to objectively see if goals are met (Section 2.4)

3. The Program goals, as laid out in the Executive Summary of the VTPEIR, include improving forest health, reducing the severity and intensity of wildfires, modifying wildland fire behavior to help reduce catastrophic losses to life and property, safeguarding watershed health, and improving wildlife habitat. Does the VTPEIR document adequately address whether alternative *means of achieving the Program goals exist that might reflect a better balance of achieving key project goals in an environmentally superior way and at less cost?*

Panel Response: Needs improvement

- Need to explore more alternatives, i.e.:
  - o treating only the wildland urban interface (Section 2.1 and 2.3)
  - o Community protection strategies to strengthen "zones" PRC 4291 (Section 2.6)
  - o emphasizing ecological restoration through adaptive management (Section 2.1 and 2.4)
  - o return to a more "natural state" of fire and return interval
- Improved justification for program instead of alternatives
- State the justification for using VTP, especially over suppression costs (possibly with monetary cost/benefit analysis)

4. Do potential impacts from vegetation management activities proposed in the VTPEIR exist that are not addressed? Impacts identified should be supported by current science.

Panel Response: Needs improvement

- Need to address more specific impacts on a more local basis (Sections 2.1, 2.2, and 2.3)
- Needs to include provisions that avoid over treatment of land and to ensure the treatments are successful (Section 2.4); a balance between action and caution
- The impacts of fuel breaks on vegetation, soil, etc. (esp. bulldozer-created and soil related impacts)
- Additional references needed (Appendix)

5. Are the identified benefits and evaluation of potential significant adverse impacts of the proposed vegetation treatment activities consistent with current science?

Panel Response: Needs improvement

- Improve the scientific discussion here; currently there is no/limited discussion of different ecosystems and how fire affects them (Appendix; Sections 2.1-2.4)
- This is especially true for treatments in shrub ecosystems (Section 2.3)

6*. Were fire behavior, fire ecology, and the role of fire in supporting resilient ecosystems in relation to fuel load and fuel treatments evaluated consistent with the current science?*

Panel Response: Needs improvement

- Needs additional detail and description, (Section 2.2)
- Need to clarify use of terms (Section 2.2)
- Needs additional references (Appendix)

- Limited current science on fire in south coast chaparral exists to justify treatments; change goal here to public safety in most cases (Section 2.3)

7. *The landscape constraints, minimum management requirements and mitigation measures in the VTPEIR are intended to mitigate the potential significant adverse impacts from projects and prevent substantial degradation of the environment from vegetation management activities. Does the current science support this conclusion, considering the landscape constraints, minimum management requirements and mitigation measures provided in the VTPEIR?*

Panel Response: Needs minimal improvement

- Mitigation measures may be satisfactory
  - But given the project scope, the impacts are unknown and thus the mitigation measure may be insufficient
- Document is too broad to cover all this effectively (Section 2.1)
- Measures often based on an "as needed" basis, leaving much decision to the project manager. Instead, incorporate an adaptive management plan (Section 2.4) that is carried out by an outside party to prevent bias.
- No overall size restrictions on projects themselves, resulting in huge estimates for treatments like prescribed fire (Section 2.5). If there was a self-decided maximum to project acres, this could alleviate some public concern.

8. *Are the objectives of fuel treatments for public safety clear in the VTPEIR? If not, what should be added or deleted to these objectives for clarification? How should prioritization of potential treatments occur? Under what conditions are such treatments effective?*

Panel Response: Needs improvement

- Need specific objectives for public safety and clear priorities were applicable (Section 2.1)
- Outline the priority of treatment placement to maximize public safety and economic efficiency
- Enforce defensible space regulations, encourage CWPP co-op; could include incentive/disincentive for private-land owners to do treatments on their land before receiving CAL FIRE assistance (Sections 2.5 and 2.6)
- Prioritize 100' buffer zone around houses for citizens to complete (Section 2.5)
- Public safety should be a major focus throughout the document

Specific Questions

1. Does the VTPEIR adequately explain the role of fuels treatments in maintaining a vegetative pattern over a chaparral landscape that would contribute to a resilient ecosystem? If not, what changes should be made to the VTPEIR to assist in achieving that outcome?

Panel Response: Needs substantial improvement

- Needs scientific references (Appendix)
- Given the lack of available scientific understanding, forgo goal of restoration and in these areas and instead focus on public/property protection with the least ecological impact (Section 2.3)
- Fuel reduction and fire is not always ecologically beneficial here or may only be beneficial if implemented a certain way (Section 2.3)

2*. The VTPEIR proposes treated acre targets for each of the bioregions (California Biodiversity Council classification) in the state. Are the targets for bioregions where chaparral ecosystems are predominant consistent with the maintenance and promotion of ecosystem resilience? If not, what is a range of treated acres that would support maintenance of a resilient chaparral ecosystem or what other substitute metric should be proposed that is based on the best available scientific information?*

Panel Response: Needs substantial improvement

- Needs details on size, placement, and frequency that are based on science (Section 2.5)
- Ecosystem resilience may not be compatible with public safety: reprioritize goals (Section 2.1)
- Resilient southern chaparral not caused by more fire, may be made worse: need to correct this assumption (Section 2.3)

3. *Does the process outlined in the document governing subsequent activities undertaken in reliance on the VTPEIR provide sufficient oversight and control to ensure that they will be adequately monitored, assessed, and mitigated? Does the proposed monitoring approach in Chapter 7 (Monitoring) provide information and direction consistent with current science to enable the program to evaluate ecological performance and fuel treatment effectiveness over time? Given current science, what is the appropriate scale of evaluation?*

Panel Response: Need substantial improvement

- Need specific requirements on both pre and post monitoring with a dedicated budget for this monitoring (Section 2.4)
- Needs monitoring for more than just mitigation impacts (Section 2.4)

- Incorporate adaptive management principles (Section 2.4)
- Currently, modeling could be easily manipulated to reflect a desired report without actual effectiveness assessment; use of an outside party to monitor projects would remove the ability of mangers to rely on self-rating checklists that may not always show sound evaluation
- Mitigation measures should be more similar to best practices rather than mitigation

4. *Are the mitigations within the VTPEIR to prevent the spread of invasive species that can be expected to result from vegetation treatment activities addressed in a manner consistent with current science?*

Panel Response: Needs improvement

- Need references to support mitigation measures (Appendix)
    - Distinguish between measures for invasives vs. exotics
- Need more specificity based on location/vegetation type (Section 2.1)

5. *Is there evidence to support the conclusion that fuel treatments can effectively assist fire suppression efforts on the head, flanks, or heel of the fire over a range of fire weather conditions in chaparral dominated landscapes?*

Panel Response: Needs improvement

- Needs references (Appendix)
- Need to clarify fire danger metric and state suppression effectiveness analysis, especially given different weather conditions (Section 2.2)
- Connect the fire behavior/intensity to suppression effectiveness (Section 2.2)

6. *Does the content of the environmental checklist reflect sufficient scientific rigor to identify and address environmental issues at a local project scale to ensure individual projects are within the scope of the VTPEIR?*

Panel Response: Needs substantial improvement

- No required public input/review (Section 2.6)
- Checklist not available as part of VTPEIR draft and there is no way to assess this question without this example
- The checklist should include sufficient rigor, specificity, and quantitative approach (Section 2.4)
- Few “triggers” that cause outside agency or public input, nor a change in management
- No clear definition for what constitutes “no significant adverse impacts”

Chapter 4. Comments on individual goals

The recommended restructuring of the VTPEIR discussed in the previous sections will lead to changes that make many of these comments null. While the previous sections should be the basis for revision, individual comments on the original goals are provided below for informational purposes.

1. *Maintain and enhance forest and range land resources including forest health to benefit present and future generations*

    - Too general
    - Assumes the treatments are *always* beneficial, does not admit to the negative impacts fuel treatments may have or justify their need
    - Does not include shrublands or watersheds
    - Limited justification on how this goal is met beyond showing the acres treated
    - Assumes landowner cooperation
    - Consider including collaboration with other agency partners in this goal as this is not the priority for CAL FIRE
        - Ex: "In collaboration with other state and federal agencies, NGOs, and private landowners, maintain and enhance …"

2. *Modify wildland fire behavior to help reduce catastrophic losses to life and property consistent with public expectation for fire protection*

    - Use more than 'acres treated' to justify meeting a goal
    - Need a direct tie between fire behavior and a safer/more successful firefighting environment
        - Analysis is present in the VTPEIR document but the justification should be in the executive summary with a clear link to how this will be achieved
    - The phrase "consistent with public expectations for fire protection" should be clarified or deleted
        - Or reword as "Modify wildland fire behavior to help reduce loss of life and catastrophic losses of property consistent with public expectation for fire protection."

3. *Reduce the severity and associated suppression costs of wildland fires by altering the volume and continuity of wildland fuels*

        - Clarify that severity can only be reduced by affecting fire intensity (not to be used interchangeably, perhaps fire behavior was meant here (see Section 2.2))

- State that indirect attack can save resources and reduce risk to life and property
- Reducing fuel volume on a landscape scale may not be appropriate for all areas (i.e. South Coast)
- Limited or hard to find the support for this conclusion
    - A cost/benefit analysis may be of use
- Explicitly state the wildfire metric that is being measured, mitigated, or affected
    - Are the fuels being treated to reduce wildfires for 75th percentile fire season/fire danger wildfires? 85th percentile fires? 90th percentile fires?
    - How will these treatments affect the resulting fire ecology and future pattern (size, frequency, extent)? Are they trying to change public perspective?

4. *Reduce the risk of large, high intensity fires by restoring a natural range of fire-adapted plant communities through periodic low intensity vegetation treatments*
    - This is not appropriate for shrub-dominated ecosystems. Burning in southern chaparral is not low intensity and the science does not support "frequent" historic fires (this goal is applicable to Northern Shrub ecosystems and other forest types)
    - No compelling case made for reducing the risk of large, high intensity wildfires through fuel management

5. *Maintain or improve long term air quality through vegetation treatments that reduce the severity of large, uncontrolled fires that release air pollutants and greenhouse gases*
    - This goal may be unachievable under the current Clear Air Act restrictions; exemption may need to happen before it can be met
    - Inappropriate use of the word "severity"
    - Need to show the tradeoffs between fuel treatment smoke and wildfire smoke
    - The statement is aspirational – it is not inevitable that vegetation management will result in greater carbon storage over long periods of time
    - If this a major goal, a strong case could be made to not use prescribed burning but rather an alternative; even with the mitigation measures described in Chapters 5.6.1 and 5.6.2 of the VTPEIR, smoke emissions will occur

6. *Vary the spatial and temporal distribution of vegetation treatments within and across watersheds to reduce the detrimental effects of wildland fire on watershed health*

- The spatial pattern is predominantly determined by private-owner agreement; ability to strategically place treatments may be limited
- In southern chaparral, creating a mosaic of ages is likely to mean that some patches will burn at younger ages than they would have if the landscape had not been subjected to management
- Fuel mosaics will not necessarily constrain fire size given different weather conditions but will reduce fire intensity

7. *Reduce noxious weeds and non-native invasive plants to increase desirable plant species and improve browse for wildlife and domestic stock*

- The goal should be modified by adding maintenance of native ecosystems as a desired outcome; focusing on "desirable" species is very narrow goal
- Need more support as to why this goal will be achieved through the plan
- Need to address that soil disturbance and open canopies can favor invasive species

8. *Improve wildlife habitat by spatially and temporally altering vegetation structure and composition, creating a mosaic of successional stages within various vegetation types*

- It would be difficult to accomplish this even with unlimited resources and a high degree of cooperation among agencies and private landowners
- Planning "spatial and temporal" alteration of vegetation in a way that is sustainable and that avoids negative consequences such as weedy invasion seems daunting and would surely require an adaptive management approach. That is, the state of knowledge is not such as to permit a plan to be drafted (probably by limited staff) that can then be implemented in perpetuity

9. *Provide a CEQA-compliant programmatic review document process/mechanism for other state or local agencies, which have a vegetation management program/project consistent with the VTP, to utilize this guiding document to implement their vegetation treatment programs/project*

- Delete this goal: other agencies should be required to write their own CEQA document due to dissimilar goals and requirements

Chapter 5. Corrections and additions

These are specific, minor issues that the Panel wished to address. While not expansive, these are included to provide example of issues that should be considered when revising the VTPEIR.

- Include additional glossary terms used within the VTPEIR to not only inform the reader of necessary background information but to also clarify terms that may have other meanings elsewhere.
    - Ex: fuel breaks, severe fire weather, etc.
- Broken/missing links: Many website links within the document are no longer valid
    - Ex: 4.2-21
        - http://cdfdata.fire.ca.gov/ fire_er/fpp_planning_plans
        - http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan
- *Overall Table ES.3*: the +,-,0 system is inadequate
    - Too broad of a measurement metric to show the weighing of alternatives; should instead have a specific measurement of achieving each goal
    - Limited connection between chart analysis and conclusion

Appendix

Appendix 1.1

Support for the division of VTPEIR sections into three fuel-type sections and project types (Chapter 2.1)

Fuel type distinctions (Chapter 2.1.a)

Rather than using the ecoregions to provide details on planning projects, it is recommended that a combination of fuel types and project types be used to provide a matrix that allows for more specificity.

Bishop (2007) used the primary drivers of large, short-term changes in rate of fire spread to distinguish among the three fuel types associated with trees, grasses, and shrubs. He found that effective wind speed and the fuel layer carrying the fire were the most important drivers. For forests, fires spread primarily in surface fuel, for shrubs fires spread through the crowns, and for grasses the grass was the primary carrier. Within each formation, subtypes can further be distinguished by fire behavior, fire regimes, and the ecological role of fire can be identified. Important fire behavior characteristics include rate of spread and fire line intensity. Fire regime attributes include seasonality, return interval, size, spatial complexity, and severity. Based on these distinctions, the formations can be further divided into the following subtypes:

Appendix Table 1.1.1. Vegetation subtypes by dominant vegetation formation

Tree dominated	Grass dominated	Shrub dominated
Hardwood forests Long-needled conifers Short-needled conifers	Annual Perennial	Vigorous post-fire sprouters Weak post-fire sprouters Obligate seeders

Within subtypes are Wildlife Habitat Relations (WHR) types that have specific fuel models associated with them that can be used for fire behavior predictions using either the 13 Northern Forest Fire Laboratory models (Anderson 1982) or the 40 Standard Fire Behavior Fuel Models (Scott and Burgan 2005). In addition, fire return interval (FRI)s and return interval departures can be assigned to each WHR type (Van de Water and Safford 2011, Safford *et al.* 2011). This information should be used in the EIR descriptions of the vegetation to be treated to develop the ecological and fire managerial rationales.

Based on the FRAP vegetation map (fvegwhr13b_map) and the State Responsibility Area map (SRA13_2), the following tables show the number of SRA acres, fuel models, and median FRIs for each Wildlife Habitat Relationships type for the subtypes. Additional fire regime attributes can be associated with each subtype. Information on the fire regime attributes of vegetation alliances found in the Manual of California (Sawyer *et al*. 2009) can be found in Appendix 2 of the manual and associated with the WHR types.

Appendix Table 1.1.2. Hardwood forest WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Montane Riparian	98,556	8	TL2	13
Aspen	3,827	8	TL2	20
Montane Hardwood	2,513,090	9	TL6	13
Hardwood	130	9	TL6	13
Eucalyptus	15,300	9	TL9	5
Valley foothill riparian	15,131	9	TL6	12
Total	2,646,034			

Appendix Table 1.1.3. Long-needled conifer WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Sierran Mixed Conifer	1,713,946	9	TL8	9
Montane Hardwood-Conifer	885,450	9	TL8	13
Ponderosa Pine	446,265	9	TL8	7
Eastside Pine	442,993	9	TL8	7
Klamath Mixed Conifer	291,315	9	TL8	12
Jeffrey Pine	27,716	9	TL8	7
Undetermined Conifer	2,447	9	TL8	12
Total	3,810,132			

Appendix Table 1.1.4. Short-needled conifer WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Douglas Fir	1,472,636	8	TL3	12
Redwood	1,216,416	8	TL2	15
Red Fir	103,168	8	TL3	33
Closed-Cone Pine-Cypress	69,894	9	TL2	59
Lodgepole Pine	31,216	8	TL3	36
Subalpine Conifer	9,890	8	TL1	132
Juniper	304,340	8	TL4	77
Pinyon-Juniper	58,626	8	TL4	94
White Fir	167,223	10	TL5	12
Total	3,433,308			

Appendix Table 1.1.5. Grassland WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Annual Grassland	6,504,573	1	GR4	3
Blue Oak-Foothill Pine	527,950	2	GR4	12
Valley Oak Woodland	67,860	2	GR4	12
Blue Oak Woodland	2,561,158	2	GR4	12
Coastal Oak Woodland	675,444	2	GR4	12
Perennial Grassland	5,740	3	GR6	3
	10,342,725			

Appendix Table 1.1.6. Shrubland WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Mixed Chaparral	1,214,087	4	SH7	59
Montane Chaparral	278,187	4	SH5	24
Sagebrush	837,521	5	SH7	41
Bitterbrush	99,010	5	SH2	53
Low Sage	21,734	5	SH2	53
Chamise-Redshank Chaparral	528,025	6	SH6	59
Coastal Scrub	575,917	5	SH2	100
Total	3,554,481			

Appendix Table 1.1.7. Desert shrub WHR types in State Responsibility Areas (SRA)

WHR Type	Acres	Anderson	Scott and Burgan	Median FRI
Desert scrub	223,502	5	SH2	610
Alkali Desert Scrub	196,390	5	SH2	610
Desert Succulent Scrub	13,494	5	SH1	610
Joshua Tree	6,609	5	TU5	610
Desert Riparian	1,736	9	TL6	610
Palm Oasis	3	9	TL6	610
Total	441,734			

Appendix 1.2 Support for the use of Fire Behavior concepts (Chapter 2.2)

Additional information on how to utilize know fire behavior to manage for fire (Chapter 2.2.b)

Flame length is the firefighter's gauge to fire line intensity, which, in turn, aids in deciding how to attack a wildfire. All firefighters are taught from the beginning of their careers the thresholds for successful and safe firefighting as shown in Table 1.2.1 (National Wildfire Coordinating Group 2014). Rate of spread is an indicator of the number of resources needed to build fire containment lines quickly enough to arrest or stop an advancing wildfire. The VTPEIR's goal is to change the fuel characteristics so that wildfires may exhibit a less intense flaming front and/or slow the spread rate. This will provide firefighters an improved probability of success at suppressing a wildfire thus resulting in fewer acres burned. Fire intensity (radiant heat and flame impingement) is also the key for defensible space in and around homes and communities (Cohen and Butler 1996; Cohen 2000).

Appendix Table 1.2.1 Firefighting guidelines from the Incidental Response Pocket Guide (National Wildfire Coordinating Group 2014)

Fire Behavior Hauling Chart

Tactical Interpretations from Flame Length

Flame Length	Interpretations
Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handline should hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractor-plows, engines and retardant drops can be effective.
8 to 11 feet	Fire may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

The probability of successful suppression (Initial Attack (IA) and Extended Attack (EA)) effectiveness should be evaluated for each of the Fuel Rank Potential Fire Behavior classes and vegetation types. An example of this analysis is in Appendix Table 1.2.2. This analysis will set the stage for the current situation and provide a benchmark against which each EIR Alternative can be evaluated.

Appendix Table 1.2.2 Example of quantification of suppression effectiveness in different vegetation types

Life Form	Grass Dominated	Shrub Dominated		Tree Dominated	
		Young	Old	Litter	Crown
Subtype	Annual Perennial	Vigorous post-fire sprouters Weak post-fire sprouters Obligate seeders Other		Hardwood forests Long-needled conifers Short-needled conifers	
Expected Fire Behavior	Surface Fire: expected rate of spread is moderate to high, with low to high fire line intensity (flame length).*	Surface/crown fire: expected rates of spread and fire line intensities (flame length) are moderate to high.*	Crown fire: control efforts at the head of the fire are Ineffective.**	Surface (litter): spread rates are low to moderate, fire line intensity (flame length) may be low to high.*	Crown fire: control efforts at the head of the fire are Ineffective.**
Fuel Rank	**Probability of Initial Attack/EA Success****				
Very High	Less Likely	Not Likely	Not Likely	Highly Likely	Not Likely
High	Likely	Likely	Not Likely	Highly Likely	Not Likely
Moderate	Highly Likely	Very Likely	Likely	Highly Likely	Not Likely

This table is for demonstration purposes only and to generate a discussion on how to quantify suppression effectiveness that could, in turn, be used to further assess at-risk "landscapes" or human "communities.

*Probability of Success will be driven by flame length and rate of spread (National Wildfire Coordinating Group 2014)

** NWCG Fireline Handbook Appendix B (2006).

Example table for effective treatment goals (Chapter 2.2.C).

Appendix Table 1.2.3 An example of the types of intensity of treatment that would alter fire behavior or enhance ecological function

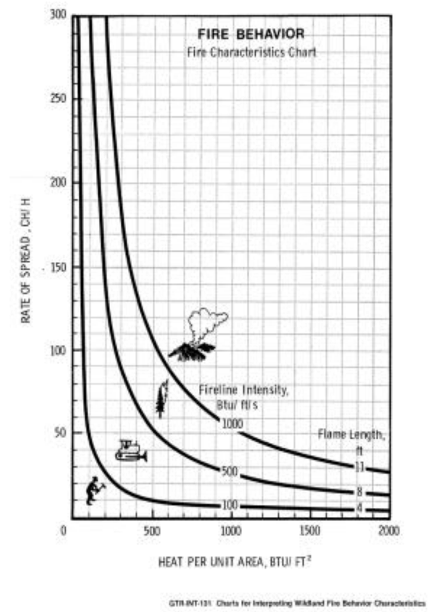
Purpose for Treatment	**Effective Fuels Treatment**	**Grass Dominated Systems**	**Shrub Dominated**	**Tree Dominated**
Community Protection- Private landowner responsibility	30' to 100' buffer' from structure.	Treat Annually Follow CAL FIRE Defensible space Guidelines	Treat as needed. Follow CAL FIRE Defensible space Guidelines	Treat as needed. Follow CAL FIRE Defensible space Guidelines
Community Protection- outside landowner responsibility	100 to 1320' Defense zone	Treat Annually	Eliminate continuity in brush, leaving occasional single or small group acceptable. Understory should be treated annually.	Prune trees to at least 8', thin trees so that no crowns are touching, preferably below 40% crown closure, eliminate all ladder fuels, (Agee and Skinner 2005)
Ecological Purposes	Landscape Level (watershed) treatments for community protection or ecological purposes.	Proposed activities should follow Fire Return Intervals displayed in Table I.5 "Conceptual Framework and Organization"	Proposed activities should follow Fire Return Intervals displayed in Tables I.6 & I.7 "Conceptual Framework and Organization"	Proposed activities should follow Fire Return Intervals displayed in Tables I.2, I.3 & I.4 "Conceptual Framework and Organization"

Fire Severity vs. Fire behavior (Chapter 2.2.d)

The two goals that are addressed using fire severity analysis are:

> EIR Goal 2: Modify wildland fire behavior to help reduce catastrophic losses to life and property consistent with public expectation for fire protection.
>
> EIR Goal 3: Reduce the severity and associated suppression costs of wildland fires by altering the volume and continuity of wildland fuels.

The basis for much of the analysis in Chapter 5 is fire severity. The EIR on page 5.2-1 states that "wildfire severity is usually measured by the percent mortality of the resulting burned vegetation." Fire severity is a post-fire metric for evaluating how intense a fire burned and the resulting effects. Keeley (2009) and Sugihara *et al*. (2006; Chapter 3) both describe fire severity as the effect on ecosystem components. There is a part of EIS Goal 3 for which a severity assessment is appropriate. However, a robust fire behavior based assessment for addressing the fire suppression related EIR Goals and issues is lacking. Using fire severity as a proxy for fire behavior is inappropriate. Sugihara *et al*. (2006; Chapter 3) further states that "***a high-intensity fire of short duration could result in the same level of severity as a low-intensity fire of long duration***." By using fire severity we miss the opportunity to evaluate the components that are most important from a fire suppression viewpoint: flame length (fire intensity) and rate of spread (forward, lateral or backwards). Fire intensity and rate of spread get right at whether firefighters will be effective and successful in their mission (Anderson 1982; Rothermel 1983). More importantly, these two fire behavior characteristics are key for assessing firefighter and public safety.



Appendix Fig. 1.2.1 Fire Behavior Characteristics from GTR-INT-131

Appendix 1.3

Additional information on fire in shrub ecosystems (Chapter 2.3)

The issues of fire and fire protection in shrubland ecosystems of California is not currently well-represented in the VTPEIR. To address this, two steps were advised. These two steps are discussed in more detail here. The shrub ecosystems discussed in this section refer predominantly to those in the southern parts of California.

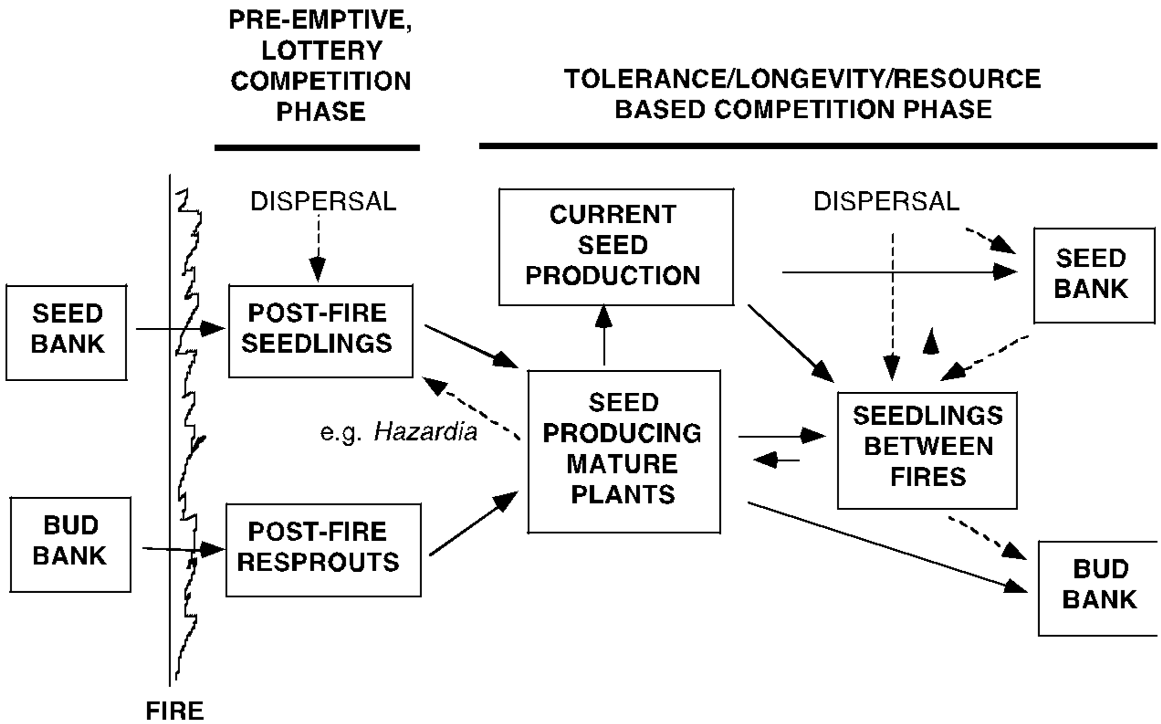
Step 1: Weave ecological background of shrub ecosystems throughout VTPEIR

The following is included to provide a brief summary of some key understandings that should be alluded to throughout the revised VTPEIR.

SIMPLIFIED DESCRIPTION OF LIFE HISTORY FEATURES OF SHRUBS WITH RESPECT TO FIRE

The capacity of species to recover from fire is assumed to be based on two types of regeneration – from buried seeds (the "seed bank") and from the sprouting from roots or lower stems that have survived the fire (the "bud bank") (Appendix Fig. 1.3.1). The "lottery competition phase" is assumed to be relatively short, 1-2 years during which the regeneration potential of seeds and resprouting is largely expended. One feature not included in this scheme is the distinction between species that continue to produce new sprouts—though not as vigorously as after fire, but sufficient to rejuvenate their canopies—and species with a much reduced capacity for continual recruitment of new stems from sprouts. This is not a dichotomous condition but a continuum. At one extreme are species of *Cercocarpus* which develop into individuals with a whole range of stem ages and, in old stands, an accumulation of large dead stems. At the other are some obligate seeding *Arctostaphylos* species which rarely produce new sprouts.

Another continuum that approaches a dichotomy is the capacity to establish seedlings that can eventually recruit to the canopy in unburned vegetation after the initial post-fire phase is past. A few chaparral species do this readily (*Prunus ilicifolia, Rhamnus* spp.) but most do not. Many drought deciduous species of the coastal sage scrub have this ability. Species that are able to expand their populations from seed dispersal post-fire can sustain plant cover without the intervention of fire.



Appendix Fig 1.3.1 Simplified scheme of fire response and post fire population dynamics of shrubs

HOW THE FIRE ECOLOGY OF SOUTHERN SHRUB ECOSYSTEMS DIFFERS FROM THAT OF FOREST IN REGARDS TO FIRE

Shrublands, like nearly all other California ecosystems, have a history of more or less frequent fire. Accordingly, the species that make up the shrublands are fire resilient. The means by which resilience is achieved differs among shrub species and can be simplistically divided into vigorous post-fire sprouters, weak post-fire sprouters, obligate seeders, and other. The vigorous sprouting species are of two types, those that also establish seedlings in abundance post fire (e.g., *Adnenostoma fasciculatum*) and the much more numerous group of species that do not (e.g. *Heteromeles arbutifolia*). The weak resprouters include many coastal sage scrub drought deciduous species such as *Salvia* spp. and *Artemisia californica*. These species also reestablish by seed and many can recruit new individuals to the canopy in the periods between fire if suitable gaps appear or are present. The 'other' category is included because there are possibilities not covered in the simple scheme as laid out here. Finally, it needs to be emphasized that there is geographic variation in fire response. Some species will sprout readily in some areas and not in others.

Taking all of this together, it can be said that virtually all shrub ecosystems will recover well from wildfire. To clarify the management-relevant risks Zedler (1995) proposed the concepts of "senescence risk" and "immaturity risk," defined as follows: **Senescence risk** is the risk that species populations may be greatly reduced or go locally extinct because of death or a loss of vigor of individual plants resulting from extreme age. Stands facing senescence risk will change significantly when burned because of the inability of formerly dominant species to regenerate.

It should be stressed that this is a largely hypothetical risk, as will be explained below. **Immaturity risk** is the risk that species will be burned before they have accumulated enough reserves of seeds or stored energy for resprouting at the time of fire. This risk is real, as has been demonstrated not only in California (e.g., Sampson 1944), but also in other Mediterranean climate regions. Though in theory species that resprout may face immaturity risk, in fact all demonstrated instances are for species that do not resprout or resprout only weakly and rely on seed banks for their recovery after fire.

In the past, some managers have felt strongly that because of the obvious capacity of some shrub systems to recover from fire, such systems needed frequent fire to remain “healthy.” Since this belief aligned with the objective of reducing fuel loads and “flammability” the idea that chaparral in particular needed to have management burning imposed was widely accepted. As this belief was being held, however, instances of the loss or significant reduction of species that were victims of immaturity risk began to accumulate. In addition, study of chaparral, some of which was conducted in mid-century and so should have been part of general knowledge, began to reveal that chaparral in addition to being resilient to fire at shorter intervals was also resilient to fire at long intervals (e.g. Sampson 1944, Horton and Kraebel 1955). Contrary to ideas that chaparral was subject to significant senescence, it was observed that the accumulation of dead and dying plants was part of a normal cycle of post fire stand development. Though in theory it might be possible for chaparral to become “senescent” in the sense defined above, it was evident that this would not occur for many decades and at ages far in excess of those that were the target for fuel reduction strategies.

Chaparral and Fire

In some forested types, actions that reduce the probability of severe fires can be more or less aligned with the restoration of a more natural fire regime. That is, the asymmetry between human needs and ecological needs can be acceptably small. The desired management regime of the ponderosa/Jeffrey/mixed conifer forest types can fall into this category. There is good reason to believe that past management actions and non-action has resulted in fuel structures that are significantly different from those that existed historically, with the result that fires are larger and especially more severe and damaging to the system than those that occurred historically. This may justify actions to modify fuel structure to permit management burning to be used to simulate the historical pattern.

But this “fuel reduction model” which aims at the restoration of a more natural fuel structure and a more natural fire regime through fuel manipulations and the imposition of management burns does not apply to southern chaparral and coastal sage scrub. These are vegetation types that might be characterized as being “obligate crown fire systems.” That is, if they burn, they burn in an intense crown fire that kills most or all of the above-ground plant tissue. Because of this, unmanaged chaparral is seen as a serious hazard to humans and their property. Given past and (regrettably) current development policy, chaparral wildfires have indeed wreaked serious damage to human life and property. Thus from a strict "human hazard reduction" viewpoint, management to reduce the amount of burnable biomass is said to be justified.

But in chaparral landscapes the discrepancy between what is best for the ecological integrity of the chaparral and what is best to minimize hazards to humans is very large. The best available information strongly suggests that fire return intervals for chaparral are much longer than many have believed. The Van de Water and Safford (2011) review of fire frequency estimates for California vegetation types supports the idea that chaparral is an infrequent fire system. The mean and median fire return intervals for the composite type "chaparral and serotinal conifers" are 55 and 59 years respectively. The mean minimum is 30 years. These numbers are significantly greater than those that have traditionally been cited. A widely help misconception is that the typical fire return interval is between 25-30 years (e.g., Dodge 1970), when in fact it is on the low end of the Van de Water and Safford (2011) estimates. This leads to the conclusion that in its present state, and in consideration of the substantial pressure from human-caused or human-related fire, chaparral does not need more fire, it needs less (Safford and Van de Water 2014). However, new scientific information could modify that conclusion in the future as it become available. For example tree-ring data collected by Lombardo *et al*. (2009) in bigcone Douglas-fir stands surrounded by chaparral indicate that both extensive and smaller fires were present in historical time.

Summarizing the important features of chaparral with respect to fire: 1) Mature chaparral has a more or less continuous canopy. If chaparral has not evolved to burn, it seems as though it has. 2) Chaparral rarely experiences surface fire. If fire is burning beneath the shrubs, ignition of the canopy is almost certain to result. Thus there is no possibility of instituting frequent "light" management burns to reduce the fuel in a manner analogous to what is done in certain forest types 3) It is of course true that after a fire the fuel loads of chaparral drops precipitously. Thus very young stands (meaning stands in the early stages of recovery after fire) are significantly less likely to propagate fires. But this period of significantly reduced propensity to burn is brief (less than 10 years) relative to the 50 year median time to the next fire. 4) If very young stands do burn, the obligate seeding species face significant risk of dramatic population decline because of a lack of seeds 5) Immaturity risk aside, burning chaparral at high frequency opens up stands, and if continued over long periods will degrade chaparral and foster the invasion of undesirable aliens, specifically the annual grasses 6) In some cases the increase in light fuels following fire-induced degradation can result in shorter intervals between fires, furthering the rate of degradation.

Considering these facts leads to this conclusion: Though it may theoretically be the case that completely removing fire from the landscape would cause significant and perhaps undesirable shifts in southern chaparral communities (that is, that senescence risk is real), it would be many decades before this became a practical worry. Therefore, at present there is very little to no <u>ecological</u> basis for imposing management burns on chaparral. Even if complete fire exclusion would be deleterious lighting, human accident, and arson will ensure that there are ignition events to forestall serious ecological problems related to the lack of fire in these ecological types.

These remarks do not consider the question of how much burning to impose on shrublands from a ranching perspective. On private lands there is no obligation to preserve native systems and burning at high rates to convert shrubs to systems with a higher proportion of grass can perhaps be economically justified. There are cases where aggressive burning that reduces shrub cover can have adverse ecological consequences. The most likely negative effect will be on steep erodable slopes where shrub removal can destabilize slopes. Another example of fuel reduction in shrubs are projects that might contribute to a landscape level plan for improving access and control in the event of a wildfire.

OTHER SHRUB SPECIES AND FIRE

NORTHERN CHAPARRAL

The management of shrublands in the northern areas of the state do not necessarily hold the same concerns as those in the southern portion of the state. Vegetation type-conversion here is of far lower concern given the observed recovery of these ecosystems post-fire. Northern shrublands also do not necessarily require a reduction in fire on the landscape as the southern ecosystems do (Safford and Van de Water 2014) and do not have the high number of anthropogenically caused fires. For these reasons, an ecological rationale for fuel treatments in shrub dominated and co-dominated ecosystems in northern California can be used.

COASTAL SAGE SCRUB TYPES

Coastal sage scrub (CSS) is a general term to describe shrub vegetation that is generally of lower stature (but with exceptions – such as *Malosma laurina*) and with a much higher occurrence of facultatively drought deciduous species, for example *Salvia* spp., *Eriogonum fasciculatum*, and *Artemisia californica*. Further north, *Baccharis pilularis* is a common species that fits with CSS in the broad sense. In general, the response of coastal sage scrub is similar to that of chaparral in that burned CSS will quickly recover after fire undergoing the same kind of so-called "autosuccesional" process (Hanes 1971) in which species present before a fire are predominately the species present after the fire. This species composition is because of resprouting and germination from a seedbank. Unlike most evergreen chaparral species, however, many of the non-evergreens are capable of expanding and rejuvenating their populations without fire. Seedlings will germinate and, when vegetation openings are present, can survive to maturity. This same ability makes CSS species more invasive than most chaparral species. This process has blurred the patterns of distribution of CSS from its historical range. For example, disturbed roadsides through chaparral landscapes will often be dominated by, e.g. *Eriogonum fasciculatum* and other opportunistic species.

The prescription and cautions applying to chaparral mostly also apply to CSS. Like chaparral, CSS does not "require" frequent fire to remain "healthy." In fact, in the Van de Water and Safford

(2011) paper CSS is assigned a median fire return of 100 years, about double the fire return interval of chaparral. Thus the cautions about prescribed burning apply equally to CSS.

Sagebrush steppe and related types

Sagebrush dominated vegetation occurs in mountain valleys and in the northeast portion of California that belongs to the Great Basin biotic province. Van de Water and Safford (2011) report median return intervals in the 30 and 40 year cycles. Despite the relatively short return intervals, sagebrush vegetation is not as clearly fire adapted as the vigorously resprouting and reseeding chaparral species. It is not clear if fire exclusion would seriously disrupt sagebrush systems. This leads to a general recommendation to avoid imposing burning treatments unless there are compelling reasons. One of these reasons may exist where sagebrush forms an understory in some forest types.

Step 2: Refocusing the goals for treatments

There are two fundamental motivations for any fire-related management action: 1) to reduce risks to human life and property, and 2) to take actions, such as restoration, that counteract trends or correct situations that are harmful to biodiversity and a healthy natural ecosystem. It may happen that any one action will fully serve both purposes, but in general, it is usually not the case. Therefore the proper approach to assessing impacts of hazard reduction actions that have as their objective reducing the risks to human life and property should assume a probability of undesirable ecological impacts. It is the purpose of an environmental impact statement to recognize these impacts. A common formula is to a) avoid the resource to be damaged, if not that, then b) minimize the impact, then c) repair or restore the site impacted, and finally d) if there is no alternative to damaging a site compensation in some manner financially or by actions that preserve or improve habitat elsewhere.

For reasons given above, in general (some exceptions in the next section) there is currently no ecological justification for fuel manipulations in the southern chaparral. Whether fuel manipulations are designed to slow or stop the spread of wildfires, or to serve as the control lines to facilitate management burning, justification for these types of actions must be focused on the benefits that they yield for protection of life and property. It is generally acknowledged that these justifications are compelling in the immediate Wildland Urban Interface—where human development abuts burnable wildlands. The question is, however, if there are significant benefits to offset the ecological costs for actions that take place in more remote locations. This question should be answered by fire behavior and fire management experts in conjunction with ecologists. It is argued that having, for example, a fuel break on a ridgeline will “break up the fuels” and permit crews access for setting backfires or doing additional clearing (something that can cause significant ecological damage if done recklessly). But such clearings will only be of utility for a specific set of circumstances – crews must be available, the fire must be moving in a direction to make action on the fuel break useful, and conditions must be such that there is a high probability that the fire will not just blow past the fuel break and continue to spread.

The use of fuel reduction zones or breaks as control lines for prescribed fire in southern chaparral is rarely justified because, as stated above, there is in general no reason to impose more fire on chaparral than it experiences at present.

POSSIBLE EXCEPTION TO FIRE AS AN ECOLOGICAL TOOL:
Because in many places there is too much fire, there can be cases in which fuel reduction by clearing or burning may have value in protecting valuable natural resources from too much burning. For example, in San Diego and Orange Counties the Tecate cypress is considered to be facing possible extirpation over large parts of its historical range because of too frequent fire. Carefully planned fuel breaks might have utility in helping to protect cypress stands from urban fires spreading.

If there are high value areas because of threatened or endangered species or other special natural attributes that would be harmed by untimely wildfire, carefully planned and judiciously targeted fuel reduction zones may be justified. In essence, this is the reverse of the fuel reduction along a WUI. In this case, it is to protect the natural vegetation against fires spreading from developed areas. The Tecate cypress example from above is one situation where this may be applicable. A county road runs along the southern boundary of Otay Mountain and the vegetation adjacent to this road is mostly of low quality because of a past history of intensive grazing. It may be worthwhile to restore perennial grassland along the highway as a low fuel zone. The "judicious" structure may apply here, because of the possibility that such an action might make things worse rather than better (fire might ignite more easily and propagate more rapidly in grassland and thus increase and not decrease the fire danger). But it is an option that merits consideration. If fuel reduction was to occur here, the plan should be designed and implemented by experts as well as presented to the public to an open comment period.

Appendix 1.4

Additional information on Adaptive management (Chapter 2.4)

Adaptive management is a formal process of "learning while doing" practiced by many agencies and organizations especially in "high stakes" natural resource management situations. Adaptive management typically includes the following steps: implement, evaluate, and integrate (or respond to) the lessons as they are learned.

High stakes means that there are either:

- values at risk
- uncertainties like climate change impacts
- a need for transparency and accountability
- controversial activities planned (disagreements about science and/ or policy)
- and/or controversial desired outcomes (e.g., fuel breaks in chaparral)

Adaptive management monitoring methods are often more complicated, expensive, and time consuming than others. However, the results gained can be far more valuable. If this process is done in a transparent manner, it can also improve the credibility of projects with stakeholders. This is by no means a perfect system; while many agencies are using this method of monitoring, struggles to effectively use and fund adaptive management programs still exist. This is why so many resources from collaborative workshops to online databases are being developed to further improve the design and use of adaptive management There are a couple of collaborative groups using adaptive fire management in California. Three examples are:

- California Klamath-Siskiyou Fire Learning Network (http://www.thewatershedcenter.com/?page_id=347)
- FireScape Monterey (http://firescape.ning.com/)
- FireScape Mendocino (http://mendocinofirescape.blogspot.com/2014_06_01_archive.html).

These three groups work with a limited set of stakeholders to manage a defined landscape with fire and other management activities for socio-cultural and ecological goals. We strongly recommend that CAL FIRE staff attend meetings and utilize available resources from these groups to help formulate plans for implementing successful vegetation management projects. CAL FIRE is already an integral participant in the FireScape Monterey.

ADDITIONAL RESOURCES FOR ADAPTIVE MANAGEMENT

EXAMPLES OF THE USE OF ADAPTIVE MANAGEMENT IN PROBLEM SOLVING, GROUP LEARNING, AND COLLABORATION

- http://www.ecologyandsociety.org/issues/view.php?sf=77
- DOI: http://www.doi.gov/archive/initiatives/AdaptiveManagement/
- NPS: http://www.usgs.gov/ecosystems/wildlife/adaptive_management.html

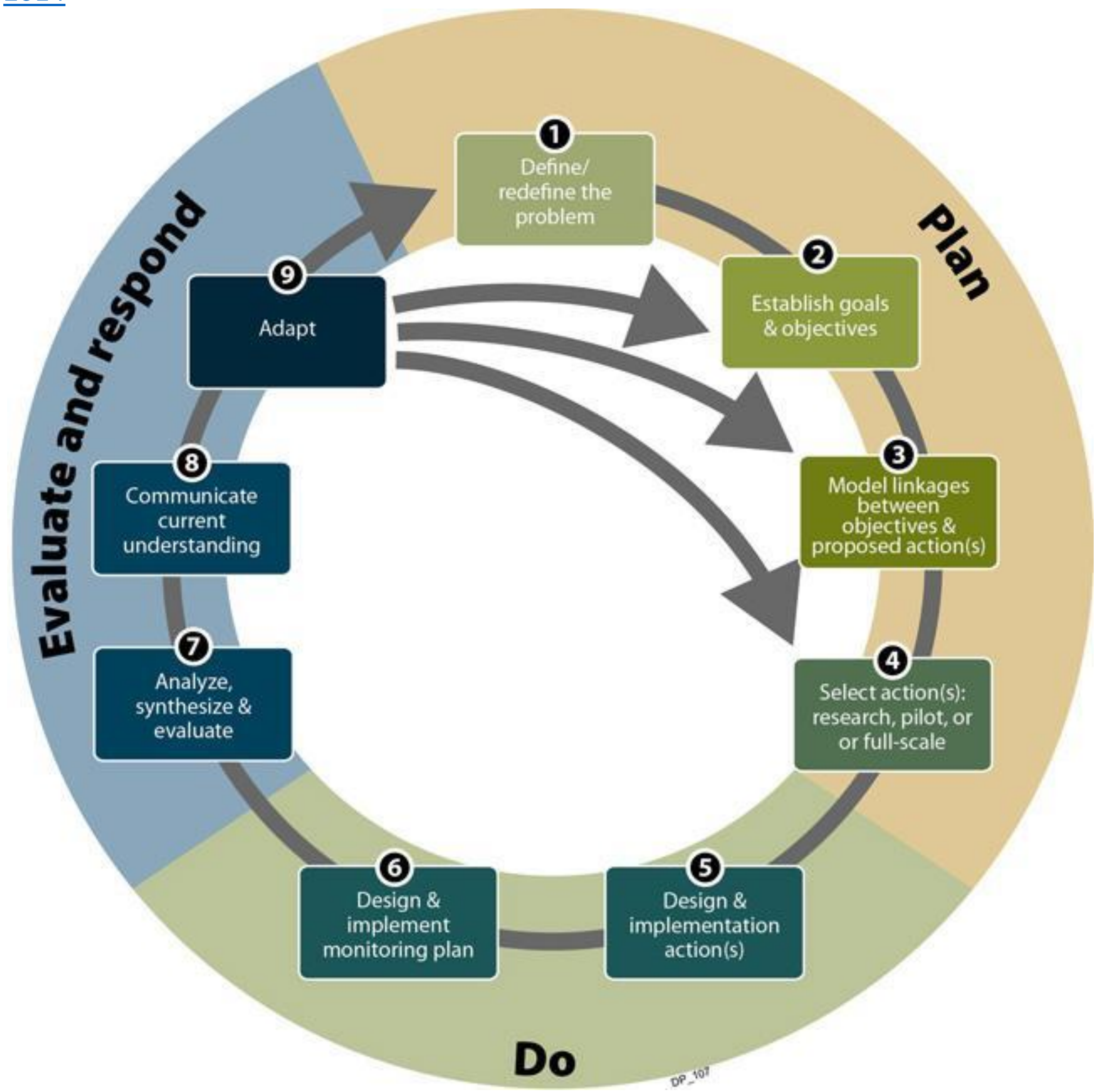
RESOURCES FOR DESIGNING THE MANAGEMENT PLAN

- Landscape Ecology, Modeling, Mapping & Analysis Project http://lemma.forestry.oregonstate.edu/projects/cmonster
- Collaborative resource management group resource: http://library.eri.nau.edu/gsdl/collect/erilibra/archives/D2013003.dir/doc.pdf
- Monitoring of vegetation composition and structure as habitat attributes (see Chapter 4): http://www.fs.fed.us/research/publications/gtr/gtr_wo89/gtr_wo89.pdf
- Conceptual model for resource management in the Sierra Nevada area: http://www.fs.fed.us/psw/publications/zielinski/psw_2000_zielinski002_manley.pdf

TRAINING

The CAMnet rendezvous this fall (The Sixth Collaborative Adaptive Management Rendezvous in Weaverville, California on October 6-8, 2014) may provide a valuable training opportunity for CAL FIRE staff. This event includes the local host of the Trinity River Restoration Program

(TRRP), sponsors U.S. Bureau of Reclamation, ESSA Technologies and the Platte River Recovery Implementation Program. http://www.adaptivemanagement.net/content/camnet-rendezvous-2014



Appendix Fig.1.4.1 Adaptive management conceptual diagram from California Department of Fish and Wildlife (https://www.dfg.ca.gov/erp/adaptive_management.asp)

Appendix 1.5

Additional information on project types (Chapter 2.1.a and 2.5.a)

Wildland-Urban Interface (WUI)

Projects in the WUI should arguably be a major focus for treatments under this VTPEIR and will be most effective when applied in conjunction with other projects. For example, residents would remain responsible for maintaining the 100’ buffer zone of defensible space (PRC 4291) but CAL FIRE projects could be done in conjunction to further fire-safe these private properties.

As many commenters have noted, the WUI is anchored by a concentration of homes that each have a variety of building specific fire risk factors. The Homeowner Wildfire Assessment is one tool (http://firecenter.berkeley.edu/homeassessment/home_assess_intro.html) that guides a homeowner through major risk factors. CAL FIRE is responsible to enforce the PRC 4291 defensible space treatments within 100' of private homes. The treatable WUI is the area outside of the PRC 4291 defensible 'circles' out to the edge of the defined WUI. Around some communities, there may also be high risk areas such as wind swept canyons that may be outside of a defined WUI but also part of the high risk landscape. Historical experience and the concentration of assets at risk suggest that the WUI areas will be the focus on most projects. Furthermore, treatments (i.e., prescribed burn, mechanical, manual, grazing, and herbicides) with limited chance of environmental spillover effects from fire, air, and water quality impacts will be favored. The expected higher than average costs per acres may well be justified by the concentration of public and private assets at risk.

Fuel breaks and complementary resource management actions (i.e., forest management, grazing, recent post-fire areas) that create significant areas where fire spread metrics are reduced

Fuel breaks area defined as *"... wide strips of land on which trees and vegetation has been permanently reduced or removed. These areas can slow, and even stop, the spread of a wildland fire because they provide fewer fuels to carry the flames. They also provide firefighters with safe zones to take a stand against a wildfire, or retreat from flames if the need arises" (*Strategic Fire Plan 2010). Fuel breaks should be established using science-based guidelines. For example, researching fuel break characteristics that are projected to increase the chance of fuel break success for each of the three different vegetation types should be tested. This would include defining proper fuel break widths and then collecting high quality post-fire data on effectiveness. If a project is designed to mitigate fire behavior and subsequent effects, the discussion must show how the treatment will affect fire behavior and how it will tie in with other treatments.

Placing fuel treatments inside of or adjacent to areas where complementary resource management actions and non-VTPEIR treatments take place will increase the effectiveness of treatments. The largest potential area of projects will be in the vegetation types where projects under this VTPEIR may only be a minor percentage of overall manipulation of vegetation to mitigate fire behavior. On both public lands adjacent to potential VTPEIR projects as well as on private lands, wildfires are the largest signal cause of fuels reduction. Forest management activities can significantly reduce fuels (especially if added expenses are incurred to treat or remove low value logging slash) and provide road access for fire suppression vehicles in the case of a future wildfire. Grazing can also reduce fuels if they are palatable to the grazing animals and the grazers are kept on site long enough to consume significant amounts of fuel. Areas that have experienced wildfire or prescribed burning have significantly reduced fuel loads, providing additional opportunities for projects that will strategically reduce fuel continuity and the landscape scale. The overall landscape level effectiveness of VTPEIR treatments that create fuel breaks and fuel mosaics will be a function of VTPEIR projects, non-

VTPEIR land-use treatments, and the amount of fuels that have regrown since treatments. The probable change in fire behavior within each project should be estimated with one of the proven modeling tools (see Section 2.2), but the larger landscape impacts require that each project also map the surrounding fuel mosaics and consider them when estimating the overall effectiveness.

Ecological restoration

If a project is proposed to restore the ecological integrity of an area, a thorough discussion of the ecological role of fire in the area must be included. This should be especially true for projects in shrubland ecosystems.

Some agencies such as the National Park Service have an overarching institutional goal of ecological restoration, detailed methodologies for designing projects, monitoring pre- and post-conditions, and use experience to develop improvements to the program. However, the lack of an explicit ecological restoration mandate as a major priority at CAL FIRE combined with the limited number of private parties or state agencies that have such a mandate, suggest that it will be difficult for CAL FIRE to use measurable fire severity metrics that can be successfully applied to WUI and fuel mosaic projects to ecological restoration projects.

Appendix Table 1.5.1 Example of potential project rationales for different projects in tree dominated fire systems

Project type	Fire/fuels managerial rationale	Ecological rationale
Wildland urban interface	Reduce fuels for hazard mitigation	Maintain some shrubs for wildlife habitats, minimize soil erosion over time
Fuel breaks and fuel mosaics	To be successful a large scale, long time frame strategy is needed with private forest/range managers and federal agency coordination as well as local community participation	Limit areal extent of large wildfires burning across ecologically modern continuous fuels
Ecological restoration	Create fire resilient forests and grasslands/meadows and reduce landscape scale high severity fire	Reduce meadow encroachment

Table revision recommendations (Chapter 2.5.b)

Given the above comments, the VTPEIR revision needs to fill in tables (see below Table 1.5.2-1.5.3) with realistic numbers or ranges of numbers. These numbers should be based on the real data obtained by CAL FIRE over the past decade that shows the realistic project size. Based on this data, CAL FIRE can provide an estimate of the median and range of project areas. If CAL FIRE desires larger projects to be completed in the future, the justification and rationale as to why this may be an option should be included.

Appendix Table 1.5.2 Proposed VTPEIR treatment acreage maximum per decade

Long term land cover type	WUI beyond defensible space circles	Fuel breaks, other fuel reduction units	Ecological restoration
Tree dominated			
Grass dominated			
Shrub dominated			

Appendix Table 1.5.3 Range of acres per project for Proposed VTPEIR treatments

	WUI beyond defensible space circles – (20- 100 ac?)	Fuel breaks, other fuel reduction units	Ecological restoration (200 – 2000 ac?)
Tree dominated	(30-85 ac in Prop 40)		
Grass dominated		(100-1000 ac in Prop 40)	
Shrub dominated			

Appendix Table 1.5.4 Proposed number of projects for VTPEIR treatments

	WUI beyond defensible space circles	Fuel breaks, other fuel reduction units	Ecological restoration
Tree dominated			
Grass dominated			
Shrub dominated			

References

Literature cited in this report

Note: references from quoted portions of the VTPEIR may not be listed here

2000. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, New York, 416 pp.

2006. Fire in California's Ecosystems. University of California, Berkeley, CA, 596 pp.

2012. FRAP. California Department of Forestry and Fire Protection.

Anderson, H.E., 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT, pp. 22.

Agee, J.K., Bahro, B., Finney, M.A., Omi, P.N., Sapsis, D.B., Skinner, C.N., Van Wagtendonk, J.W. and Phillip Weatherspoon, C., 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management, 127(1–3): 55-66.

Agee, J.K. and Skinner, C.N., 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management, 211(1–2): 83-96.

Bishop, J., 2007. Technical background of the Fire Line Assessment Method (FLAME). In: B.W. Butler and W. Cook (Editors), The fire environment—innovations, management, and policy. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO, pp. 27-74.

Calkin, D.E., Cohen, J.D., Finney, M.A. and Thompson, M.P., 2014. How risk management can prevent future wildfire disasters in the wildland-urban interface. Proceedings of the National Academy of Sciences, 111(2): 746-751.

Cohen, J., 2008. The wildland-urban interface fire problem: a consequence of the fire exclusion paradigm. Forest History Today(Fall): 20-26.

Cohen, J., 2010. The wildland-urban interface fire problem. Fremontia.

Cohen, J.D., 2000. Preventing disaster: home ignitability in the wildland-urban interface. Journal of Forestry, 98(3): 15-21.

Cohen, J.D. and Butler, B.W., 1996. Modeling potential structure ignitions from flame radiation exposure with implications for wildland/urban interface fire management, Thirteenth Fire and Forest Meteorology Conference. IAWF, Lorne, Australia.

Dodge, M., 1970. Fire control in chaparral. Science, 168(3920).

Doran, G.T., 1981. There's a S.M.A.R.T. way to write management's goals and objectives. Management Review (AMA FORUM), 70(11): 35-36.

Finney, M.A., 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science(47): 219-228.

Hanes, T.L., 1971. Succession after fire in the chaparral of southern California. Ecological monographs: 27-52.

Horton, J.S. and Kraebel, C.J., 1955. Development of vegetation after fire in the chamise chaparral of southern California. Ecology: 244-262.

Keeley, J.E., 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire, 18(1): 116-126.

Lombardo, K.J., Swetnam, T.W., Baisan, C.H. and Borchert, M.I., 2009. Using Bigcone Douglas-Fir Fire Scars and Tree Rings to Reconstruct Interior Chaparral Fire History. Fire ecology, 5(3): 35-56.

McCaffrey, S.M. and Olsen, C.S., 2012. Research perspectives on the public and fire management: a synthesis of current social science on eight essential questions. GTR-NRS-104. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. NRS-104. Newton Square, PA, pp. 1-40.

National Interagency Fire Center, 2006. NWCG fireline handbook: Appendix B, fire behavior, Boise, ID.

National Wildfire Coordinating, G., 2014. Incident Response Pocket Guide. PMS 461 NFES 001077.

Olsen, C.S. and Sharp, E., 2013. Building community-agency trust in fire-affected communities in Australia and the United States. International Journal of Wildland Fire, 22(6): 822-831.

Reinhardt, E.D., Keane, R.E., Calkin, D.E. and Cohen, J.D., 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management, 256(12): 1997-2006.

Rothermel, R.C., 1983. How to Predict the Spread and Intensity of Forest and Range Fires. GTR-INT-143, USDA Forest Service, Rocky Mountain Research Station.

Safford, H.D., Van de Water, K. and Schmidt, D., 2011. California Fire Return Interval Departure (FRID) map, 2010 version. USDA Forest Service, Pacific Southwest Region and The Nature Conservancy-California.

Safford, H. and Van de Water, K., 2014. Using fire return interval departure (FRID) analysis to map spatial and temporal changes in fire frequency on national forest lands in California, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, PSW-RP-266. Albany, CA.

Sampson, A.W., 1944. Plant succession on burned chaparral lands in Northern California, Universtiy of California, College of Agriculture, Agricultural Experiment Station, Berkeley, CA.

Sawyer, T.O., Keller-Wolf, T. and Evans, J., 2009. A manual of California vegetation. California Native Plants Society, Sacramento, CA.

Scott, J.H. and Burgan, R.E., 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's Surface Fire Spread model. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO, pp. 72.

Shindler, B., Gordon, R., Brunson, M.W. and Olsen, C.S., 2011. Public perceptions of Sagebrush ecosystem management in the Great Basin. Rangeland Ecology and Management, 64(4): 335-347.

Shindler, B., Olsen, C.S., McCaffrey, S.M., McFarlane, B., Christianson, A., McGee, T., Curtis, A. and Sharp, E., 2014. Tust: a planning guide for wildfire agencies and practitioners—an international collaboration drawing on research and management experience in Australia, Canada, and the United States, Oregon State University, Corvallis, OR.

Skinner, C., Ritchie, M., Hamilton, T. and Symons, J., 2004. Effects of prescribed fire and thinning on wildfire severity: the Cone Fire, Blacks Mountain Experimental Forest, Proceedings of the 25th Vegetation Management Conference, Redding, CA, pp. 12-12.

Stein, B.A., 2002. States of the union: ranking America's biodiversity, Arlington, Virginia.

Van de Water, K.M. and Safford, H.D., 2011. A summary of fire frequency estimates for California vegetation before Euro-American settlement. Fire Ecology, 7(3): 26-58.

Zedler, P.H., 1995. Fire frequency in southern California shrublands: biological effects and management options. In: J. Keeley and T. Scott (Editors), Brushfires in California

Wildlands: Ecology and Resource Management. International Association of Wildland Fire, Fairfield, Washington, USA, pp. 101-112.

Recent and additional references not cited in the draft VTMPEIR and literature cited in this report

Note: The draft VTPEIR lacked many important references as well as new references published after the VTPEIR was written. This list includes those that the panel felt would help provide a sound scientific basis for the revised VTEIR including those in this report.

2000. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, New York, 416 pp.

2001. American Association of State Highway and Transportation Officials, Washington D.C.

2006. Fire in California's Ecosystems. University of California, Berkeley, CA, 596 pp.

2013. LANDFIRE, Homepage of the LANDFIRE Project U.S. Department of Agriculture, Forest Service; U.S. Department of Interior.

Agee, J.K., Bahro, B., Finney, M.A., Omi, P.N., Sapsis, D.B., Skinner, C.N., Van Wagtendonk, J.W. and Phillip Weatherspoon, C., 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management, 127(1–3): 55-66.

Agee, J.K. and Skinner, C.N., 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management, 211(1–2): 83-96.

Anderson, H.E., 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT, pp. 22.

Atwood, J.L., Pairis, A.D., Fugagli, M.R. and Reynolds, C.A., 2002. Effects of fire on California gnatcatcher populations on Camp Pendleton Marine Corps Base, Antioch New England Institute, Kenne, New Hampshire.

Bansal, P., 2005. Evolving sustainably: a longitudinal study of corporate sustainable development. Strategic Management Journal, 26(3): 197-218.

Bellamy, J.A. and Mcdonald, G.T., 1999. Policy review evaluating integrated resource management. Society & Natural Resources, 12(4): 337-353.

Bellamy, J.A., Walker, D.H., McDonald, G.T. and Syme, G.J., 2001. A systems approach to the evaluation of natural resource management initiatives. Journal of Environmental Management, 63(4): 407-423.

Beltrán, B.J., Franklin, J., Syphard, A.D., Regan, H.M., Flint, L.E. and Flint, A.L., 2013. Effects of climate change and urban development on the distribution and conservation of vegetation in a Mediterranean type ecosystem. International Journal of Geographical Information Science, 28(8): 1561-1589.

Beyers, J.L. and Wakeman, C.D., 2000. Season of burn effects in southern California chaparral. In: J.E. Keeley, M. Baer-Keeley and C.J. Fotheringham (Editors), 2nd interface between ecology and land development in California. U.S. Geological Survey Open-File Report 00-62. Sacramento, CA., pp. 45-55.

Bishop, J., 2007. Technical background of the Fire Line Assessment Method (FLAME). In: B.W. Butler and W. Cook (Editors), The fire environment—innovations, management, and policy. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO, pp. 27-74.

Biswell, H.H., 1989. Prescribed burning in California wildlands vegetation management. University of California Press, Berkeley, CA.

Bowman, D.M.J.S., Balch, J., Artaxo, P., Bond, W.J., Cochrane, M.A., D’Antonio, C.M., DeFries, R., Johnston, F.H., Keeley, J.E. and Krawchuk, M.A., 2011. The human dimension of fire regimes on Earth. Journal of biogeography, 38(12): 2223-2236.

Bowman, D.M.J.S., Balch, J.K., Artaxo, P., Bond, W.J., Carlson, J.M., Cochrane, M.A., D’Antonio, C.M., DeFries, R.S., Doyle, J.C. and Harrison, S.P., 2009. Fire in the earth system. Science, 324(5926): 481-484.

Brooks, M.L., D'Antonio, C.M., Richardson, D.M., Grace, J.B., Keeley, J.E., DiTomaso, J.M., Hobbs, R.J., Pellant, M. and Pyke, D., 2004. Effects of invasive alien plants on fire regimes. BioScience, 54(7): 677-688.

Brown, G. and Harris, C.C., 2000. The US Forest Service: whither the new resource management paradigm? Journal of Environmental Management, 58(1): 1-19.

Brown, R.T., Agee, J.K. and Franklin, J.F., 2004. Forest restoration and fire: principles in the context of place. Conservation Biology, 18(4): 903-912.

California Department of Forestry and Fire Protection, 2012. FRAP.

Calkin, D.E., Cohen, J.D., Finney, M.A. and Thompson, M.P., 2014. How risk management can prevent future wildfire disasters in the wildland-urban interface. Proceedings of the National Academy of Sciences, 111(2): 746-751.

Cary, G.J., Flannigan, M.D., Keane, R.E., Bradstock, R.A., Davies, I.D., Lenihan, J.M., Li, C., Logan, K.A. and Parsons, R.A., 2009. Relative importance of fuel management, ignition management and weather for area burned: evidence from five landscape–fire–succession models. International Journal of Wildland Fire, 18(2): 147-156.

Cochrane, M.A., Moran, C.J., Wimberly, M.C., Baer, A.D., Finney, M.A., Beckendorf, K.L., Eidenshink, J. and Zhu, Z., 2012. Estimation of wildfire size and risk changes due to fuels treatments. International Journal of Wildland Fire, 21(4): 357-367.

Cohen, J., 2008. The wildland-urban interface fire problem: a consequence of the fire exclusion paradigm. Forest History Today (Fall): 20-26.

Cohen, J., 2010. The wildland-urban interface fire problem. Fremontia.

Cohen, J.D., 2000. Preventing disaster: home ignitability in the wildland-urban interface. Journal of Forestry, 98(3): 15-21.

Cohen, J.D. and Butler, B.W., 1996. Modeling potential structure ignitions from flame radiation exposure with implications for wildland/urban interface fire management, Thirteenth Fire and Forest Meteorology Conference. IAWF, Lorne, Australia.

Collins, B.M., Kelly, M., Wagtendonk, J.W.v. and Stephens, S.L., 2007. Spatial patterns of large natural fires in Sierra Nevada wilderness areas. Landscape Ecology, 22(4): 545-557.

Collins, B.M., Miller, J.D., Thode, A.E., Kelly, M., Wagtendonk, J.W.v. and Stephens, S.L., 2009. Interactions among wildland fires in a long-established Sierra Nevada natural fire area. Ecosystems, 12(1): 114-128.

Conard, S.G. and Weise, D.R., 1998. Management of fire regime, fuels, and fire effects in southern California chaparral: Lessons from the past and thoughts for the future, Tall Timbers Ecology Conference Proceedings, pp. 342-350.

Conrad, C.E., Roby, G.A. and Hunter, S.C., 1986. Chaparral and associated ecosystems management: a 5-year research and development program. GTR-PSW-091. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Berkeley, CA, pp. 15.

Dellasala, D.A., Williams, J.E., Williams, C.D. and Franklin, J.F., 2004. Beyond smoke and mirrors: a synthesis of fire policy and science. Conservation Biology, 18(4): 976-986.

Diffendorfer, J., Fleming, G.M., Tremor, S., Spencer, W. and Beyers, J.L., 2012. The role of fire severity, distance from fire perimeter and vegetation on post-fire recovery of small-mammal communities in chaparral. International Journal of Wildland Fire, 21: 436-448.

Dodge, M., 1970. Fire control in chaparral. Science, 168(3920).

Doran, G.T., 1981. There's a S.M.A.R.T. way to write management's goals and objectives. Management Review (AMA FORUM), 70(11): 35-36.

Emily E. Y. Moghaddas, S.L.S., 2008. Mechanized fuel treatment effects on soil compaction in Sierra Nevada mixed-conifer stands. Forest Ecology and Management: 3098-3106.

Fernandes, P.M. and Botelho, H.S., 2003. A review of prescribed burning effectiveness in fire hazard reduction. International Journal of Wildland Fire, 12(2): 117-128.

Ferrenberg, S.M., Schwilk, D.W., Knapp, E.E., Groth, E. and Keeley, J.E., 2014. Fire decreases arthropod abundance but increases diversity: early and late season prescribed fire effects in a Sierra Nevada mixed-conifer forest. 2(2): 79-101.

Fettig, C.J., Klepzig, K.D., Billings, R.F., Munson, A.S., Nebeker, T.E., Negrón, J.F. and Nowak, J.T., 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. Forest Ecology and Management, 238(1–3): 24-53.

Fettig, C.J. and McKelvey, S.R., 2014. Bark beetles responses to stand structure and prescribed fire at Black Mountain Experimental Forest, California, USA: 5-year data. Fire Ecology, 6(2): 26-42.

Finney, M.A., 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science(47): 219-228.

Giessow, J. and Zedler, P., 1996. The effects of fire frequency and firebreaks on the abundance and species richness of exotic plant species in coastal sage scrub, Proceedings of the California Exotic Pest Plant Council Symposium. California Exotic Pest Plant Council, San Diego, California, USA, pp. 86-94.

Goforth, B.R. and Minnich, R.A., 2007. Evidence, exaggeration, and error in historical accounts of chaparral wildfires in California. Ecological Applications, 17(3): 779-90.

Gould, J. and Golob, T.F., 1998. Clean air forever? A longitudinal analysis of opinions about air pollution and electric vehicles. Transportation Research Part D: Transport and Environment, 3(3): 157-169.

Halsey, R.W., Keeley, J.E. and Wilson, K., 2009. Fuel age and fire spread: natural conditions versus opportunities for fire suppression. Fire Management Today, 69(2).

Hanes, T.L., 1971. Succession after fire in the chaparral of southern California. Ecological monographs: 27-52.

Horton, J.S. and Kraebel, C.J., 1955. Development of vegetation after fire in the chamise chaparral of southern California. Ecology: 244-262.

Hurteau, M.D., Bradford, J.B., Fulé, P.Z., Taylor, A.H. and Martin, K.L., 2014. Climate change, fire management, and ecological services in the southwestern US. Forest Ecology and Management, 327(0): 280-289.

Kaczynski, K.M., Beatty, S.W., Van Wagtendonk, J.W. and Marshall, K.N., 2011. Effects of burn severity on non-native plants: a case study in Yosemite National Park, California. Fire Ecology, 7(2): 145-149.

Keeley, J., 2003. Fire and invasive plants in California ecosystems. Fire Management Today, 63(2): 18-19.

Keeley, J., 2010. Fire on California landscapes. Fremontia: Journal of the California native plant society, 38(2/3).

Keeley, J.E., 2002. Fire management of California shrubland landscapes. Environmental Management, 29(3): 395-408.

Keeley, J.E., 2005. Chaparral fuel modification: what do we know--and need to know? Fire management today, 65(4): 2.

Keeley, J.E., 2005. Fire Management of California Shrublands.

Keeley, J.E., 2005. Lessons from the 2003 fire siege in California. Fire Management Today, 65(4): 2.

Keeley, J.E., 2006. Fire management impacts on invasive plants in the western United States. Conservation Biology, 20(2): 375-384.

Keeley, J.E., 2006. Fire severity and plant age in postfire resprouting of woody plants in sage scrub and chaparral. Madrono, 53(4): 373-379.

Keeley, J.E., 2007. Chaparral and fire. Fremontia, 35(4): 16-21.

Keeley, J.E., 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire, 18(1): 116-126.

Keeley, J.E., Allen, C.D., Betancourt, J., Chong, G.W., Fotheringham, C.J. and Safford, H.D., 2006. A 21st century perspective on postfire seeding. Journal of Forestry, 104(2): 103-104.

Keeley, J.E., Baer-Keeley, M. and Fotheringham, C.J., 2005. Alien plant dynamics following fire in Mediterranean-climate California shrublands. Ecological Applications, 15(6): 2109-2125.

Keeley, J.E., Brennan, T. and Pfaff, A.H., 2008. Fire severity and ecosystem responses following crown fires in California shrublands. Ecological Applications, 18(6): 1530-1546.

Keeley, J.E. and Brennan, T.J., 2012. Fire-driven alien invasion in a fire-adapted ecosystem. Oecologia, 169(4): 1043-1052.

Keeley, J.E. and Fotheringham, C.J., 2003. Historical fire regime in southern California. Fire Management Today, 63(1).

Keeley, J.E., Fotheringham, C.J. and Morais, M., 1999. Reexamining fire suppression impacts on brushland fire regimes. Science, 284(5421): 1829-1832.

Keeley, J.E., Fotheringham, C.J. and Moritz, M.A., 2004. Lessons from the October 2003. Wildfires in Southern California. Journal of Forestry, 102(7): 26-31.

Keeley, J.E., Fotheringham, C.J. and Wuerthner, G., 2006. Wildfire management on a human-dominated landscape: California chaparral wildfires. In: G. Wuerthner (Editor), Widlfire–A century of failed forest policy. Island Press, Covelo, CA. Island Press, Covelo, CA, pp. 69-75.

Keeley, J.E. and McGinnis, T.W., 2007. Impact of prescribed fire and other factors on cheatgrass persistence in a Sierra Nevada ponderosa pine forest. International Journal of Wildland Fire, 16(1): 96-106.

Keeley, J.E., Ne’eman, G. and Fotheringham, C.J., 1999. Immaturity risk in a fire-dependent pine. Journal of Mediterranean Ecology, 1: 41-48.

Keeley, J.E., Pfaff, A.H. and Safford, H.D., 2005. Fire suppression impacts on postfire recovery of Sierra Nevada chaparral shrublands. International Journal of Wildland Fire, 14(3): 255-265.

Keeley, J.E., Safford, H., Fotheringham, C.J., Franklin, J. and Moritz, M., 2009. The 2007 southern California wildfires: lessons in complexity. Journal of Forestry, 107(6): 287-296.

Keeley, J.E. and Zedler, P.H., 2009. Large, high-intensity fire events in southern California shrublands: debunking the fine-grain age patch model. Ecological Applications, 19(1): 69-94.

Knapp, E.E. and Keeley, J.E., 2006. Heterogeneity in fire severity within early season and late season prescribed burns in a mixed-conifer forest*. International Journal of Wildland Fire, 15(1): 37-45.

Knapp, E.E., Schwilk, D.W., Kane, J.M. and Keeley, J.E., 2014. Role of burning season on initial understory vegetation response to prescribed fire in a mixed conifer forest. Canadian Journal of Forest Research, 37(1): 11-22.

Knapp, E.E., Skinner, C.N., North, M.P. and Estes, B.L., 2014. Long-term overstory and understory change following logging and fire exclusion in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management, 310: 903-914.

Knapp, E.E., Weatherspoon, P.C. and Skinner, C.N., 2012. Shrub seed banks in mixed conifer forests of northern California and the role of fire in regulating abundance. Fire Ecology, 8(1): 32-48.

Kobziar, L., Moghaddas, J. and Stephens, S.L., 2006. Tree mortality patterns following prescribed fires in a mixed conifer forest. Canadian Journal of Forest Research, 36(12): 3222-3238.

Lawson, D.M., Regan, H.M., Zedler, P.H. and Franklin, J., 2010. Cumulative effects of land use, altered fire regime and climate change on persistence of Ceanothus verrucosus, a rare, fire-dependent plant species. Global Change Biology, 16(9): 2518-2529.

Lombardo, K.J., Swetnam, T.W., Baisan, C.H. and Borchert, M.I., 2009. Using Bigcone Douglas-Fir Fire Scars and Tree Rings to Reconstruct Interior Chaparral Fire History. Fire ecology, 5(3): 35-56.

Manzello, S.L., Cleary, T.G., Shields, J.R. and Yang, J.C., 2006. Ignition of mulch and grasses by firebrands in wildland–urban interface fires. International Journal of Wildland Fire, 15(3): 427-431.

Maranghides, A., 2007. Fire behavior at the Wildland Urban Interface: modifying building codes to reduce building loses. National Institute of Standards and Technology.

Maranghides, A. and Mell, W., 2011. A case study of a community affected by the Witch and Guejito wildland fires. Fire Technology, 47(2): 379-420.

Matthew S. Carroll, K.A.B., 2000. Adaptation strategies of displaced Idaho woods workers: results of a longitudinal panel study. Society & Natural Resources, 13(2): 95-113.

McCaffrey, S.M. and Olsen, C.S., 2012. Research perspectives on the public and fire management: a synthesis of current social science on eight essential questions. GTR-NRS-104. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. NRS-104. Newton Square, PA, pp. 1-40.

McIver, J., Erickson, K. and Youngblood, A., 2012. Principal short-term findings of the National Fire and Fire Surrogate study. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-860. Portland, OR, pp. 210.

McKenzie, D., Miller, C. and Falk, D.A., 2011. The Landscape Ecology of Fire, 213. Springer.

Merriam, K.E., Keeley, J.E. and Beyers, J.L., 2006. Fuel breaks affect nonnative species abundance in Californian plant communities. Ecological Applications, 16(2): 515-527.

Merriam, K.E., McGinnis, T.W. and Keeley, J.E., 2004. The role of fire and fire management in the invasion of nonnative plants in California. Park Science, 22(2): 32-36.

Meyer, M., North, M. and Roberts, S., 2014. Truffle abundance in recently prescribed burned and unburned forests in Yosemite National Park: Implications for mycophagous mammals. 4: 24-33.

Meyer, M.D., Kelt, D.A., North, M.P. and Betts, B.J., 2007. Effects of burning and thinning on lodgepole chipmunks (neotamias speciousus) in the Sierra Nevada, California. Northwestern Naturalist, 88(2): 61-72.

Meyer, M.D. and Safford, H.D., 2011. Giant Sequoia Regeneration in Groves Exposed to Wildfire and Retention Harvest. Fire Ecology, 7(2): 2-16.

Minnich, R.A., 1983. Fire mosaics in southern California and northern Baja California. Science, 219: 1287-1294.

Minnich, R.A., 2002. An integrated model of two fire regimes. Conservation Biology, 15: 1549-1553.

Minnich, R.A. and Chou, Y.H., 1997. Wildland fire patch dynamics in the chaparral of southern California and northern Baja California. International Journal of Wildland Fire, 7(3): 221-248.

Minnich, R.A. and Franco-Vizcaíno, E., 2008. Chapter 16 A Probabilistic View of Chaparral and Forest Fire Regimes in Southern California and Northern Baja California. In: M.J.A.A.R.R. Andrzej Bytnerowicz and A. Christian (Editors), Developments in Environmental Science. Elsevier, pp. 339-364.

Moghaddas, E.E.Y. and Stephens, S.L., 2007. Thinning, burning, and thin-burn fuel treatment effects on soil properties in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management, 250(3): 156-166.

Moghaddas, J.J., York, R.A. and Stephens, S.L., 2008. Initial response of conifer and California black oak seedlings following fuel reduction activities in a Sierra Nevada mixed conifer forest. Forest Ecology and Management, 255(8-9): 3141-3150.

Moody, T.J., Fites-Kaufman, J. and Stephens, S.L., Fire history and climate influences from forests in the northern Sierra Nevada, USA. Fire Ecology, 2(2): 20-52.

Mooney, C., 2007. Fuelbreak effectiveness: state of the knowledge. Wildland Fire Operations Research Group.

Moritz, M.A., 2003. Spatiotemporal analysis of controls on shrubland fire regimes: age dependency and fire hazard. Ecology, 84(2): 351-361.

Moritz, M.A., Keeley, J.E., Johnson, E.A. and Schaffner, A.A., 2004. Testing a basic assumption of shrubland fire management: how important is fuel age? Frontiers in Ecology and the Environment, 2(2): 67-72.

National Interagency Fire Center, 2006. NWCG fireline handbook: Appendix B, fire behavior, Boise, ID. National Wildfire Coordinating Group. 2014. Incident Response Pocket Guide. PMS 461 NFES 001077.

Nesmith, J.C.B., Caprio, A.C., Pfaff, A.H., McGinnis, T.W. and Keeley, J.E., 2011. A comparison of effects from prescribed fires and wildfires managed for resource objectives in Sequoia and Kings Canyon National Parks. Forest Ecology and Management, 261(7): 1275-1282.

Newell, L.A., 1982. Planning for a large-scale chaparral management program in California, Symposium on Dynamics and Management of Mediterranean-type Ecosystems. USDA Forest Service general technical report PSW United States, Pacific Southwest Forest and Range Experiment Station, San Diego, CA, pp. 533-538.

North, M.P., Collins, B.M. and Stephens, S.L., 2014. Using fire to increase the scale, benefits and future maintenance of fuels treatments. Fire Ecology, 110(7): 392-401.

North, M.P. and Hurteau, M.D., 2011. High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. Forest Ecology and Management, 261(6): 1115-1120.

North, M.P., Van de Water, K.M., Stephens, S.L. and Callins, B.M., 2009. Climate, rain shadow, and human-use influence on fire regimes in the eastern Sierra Nevada, California, USA. Fire Ecology, 5(3): 20-34.

Noss, R.F., Franklin, J.F., Baker, W.I., Schoennagel, T. and Moyle, P.B., 2006. Managing fire-prone forests in the western United States. Frontiers in Ecology and the Environment, 4(9): 481-487.

Nowicki, B., 2002. The community protection zone: defending houses and communities from the threat of forest fire, Center for Biological Diversity.

Odion, D.C. and Davis, F.W., 2000. Fire, soil heating, and the formation of vegetation patterns in chaparral. Ecological Monographs, 70(1): 149-169.

Odion, D.C., Frost, E.J., Strittholt, J.R., Jiang, H., Dellasala, D.A. and Moritz, M.A., 2004. Patterns of fire severity and forest conditions in the western Klamath Mountains, California. Conservation Biology, 18(4): 927-936.

Odion, D.C. and Sarr, D.A., 2007. Managing disturbance regimes to maintain biological diversity in forested ecosystems of the Pacific Northwest. Forest Ecology and Management, 246(1): 57-65.

Olsen, C.S. and Sharp, E., 2013. Building community-agency trust in fire-affected communities in Australia and the United States. International Journal of Wildland Fire, 22(6): 822-831.

Pabst, K., Johnson, V. and Howard, S.M., 2009. Southern California wildfires 1984–2007: burn severity trends and ecological implications, Fourth International Fire Ecology & Management Congress: Fire as a Global Process. Association for Fire Ecology.

Pincetl, S., Rundel, P.W., De Blasio, J.C., Silver, D., Scott, T., Keeley, J.E. and Halsey, R., 2008. It's the land use, not the fuels: fires and land development in southern California. Real Estate Review, 37(1).

Price, O.F., Bradstock, R.A., Keeley, J.E. and Syphard, A.D., 2012. The impact of antecedent fire area on burned area in southern California coastal ecosystems. Journal of environmental management, 113: 301-307.

Rantala, M.H.T. and Kurttila, M., Measuring and monitoring socio-cultural sustainability in the action of forest biodiversity cooperation networks. Silva Fennica 46(3): 441–459.

Rehm, R.G. and Mell, W.R., 2009. A simple model for wind effects of burning structures and topography on wildland–urban interface surface-fire propagation. International Journal of Wildland Fire, 18(3): 290-301.

Reinhardt, E.D., Keane, R.E., Calkin, D.E. and Cohen, J.D., 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management, 256(12): 1997-2006.

Roberts, S.L., Kelt, D.A., Wagtendonk, J.W.v., Miles, A.K. and Meyer, M.D., Effects of fire on small mammal communities in montane forests. Journal of Mammalogy.

Roberts, S.L., van Wagtendonk, J.W., Miles, A.K. and Kelt, D.A., 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation, 144(1): 610-619.

Roberts, S.L., Van Wagtendonk, J.W., Miles, A.K., Kelt, D.A. and Lutz, J.A., 2008. Modeling the Effects of Fire Severity and Spatial Complexity on Small Mammals in Yosemite National Park, California. Fire ecology, 4(2): 83-104.

Rodriguez-Piñeros, S. and Lewis, D.K., 2013. Analysis and deliberation as a mechanism to assess changes in preferences for indicators of sustainable forest management: A case study in Puebla, Mexico. Journal of Environmental Management, 128(0): 52-61.

Rothermel, R.C., 1983. How to Predict the Spread and Intensity of Forest and Range Fires. GTR-INT-143, USDA Forest Service, Rocky Mountain Research Station.

Safford, H.D., Van de Water, K. and Schmidt, D., 2011. California Fire Return Interval Departure (FRID) map, 2010 version. USDA Forest Service, Pacific Southwest Region and The Nature Conservancy-California.

Safford, H. and Van de Water, K., 2014. Using fire return interval departure (FRID) analysis to map spatial and temporal changes in fire frequency on national forest lands in California, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, PSW-RP-266. Albany, CA.

Sampson, A.W., 1944. Plant succession on burned chaparral lands in Northern California, Universtiy of California, College of Agriculture, Agricultural Experiment Station, Berkeley, CA.

Sawyer, T.O., Keller-Wolf, T. and Evans, J., 2009. A manual of California vegetation. California Native Plants Society, Sacramento, CA.

Schmidt, L., Hille, M.G. and Stephens, S.L., 2006. Restoring northern Sierra Nevada mixed conifer forest composition and structure with prescribed fires of varying intensities. Fire Ecology, 2(2): 20-33.

Scholl, A.E. and Taylor, A.H., 2010. Fire regimes, forest change, and self-organization in an old-growth mixed-conifer forest, Yosemite National Park, USA. Ecological Applications, 20(2): 362-380.

Schuett, M.A., Selin, S.W. and Carr, D.S., 2001. Making it work: keys to successful collaboration in natural resource management. Environmental Management, 27(4): 587-593.

Schwilk, D.W., Keeley, J.E., Knapp, E.E., McIver, J., Bailey, J.D., Fettig, C.J., Fiedler, C.E., Harrod, R.J., Moghaddas, J.J., Outcalt, K.W., Skinner, C.N., Stephens, S.L., Waldrop, T.A., Yaussy, D.A. and Youngblood, A., 2009. The national fire and fire surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. Ecological Applications, 19(2): 285-304.

Schwilk, D.W., Knapp, E.E., Ferrenberg, S.M., Keeley, J.E. and Caprio, A.C., 2006. Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management, 232(1–3): 36-45.

Scott, J.H. and Burgan, R.E., 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's Surface Fire Spread model. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO, pp. 72.

Shindler, B., Gordon, R., Brunson, M.W. and Olsen, C.S., 2011. Public perceptions of Sagebrush ecosystem management in the Great Basin. Rangeland Ecology and Management, 64(4): 335-347.

Shindler, B., Olsen, C.S., McCaffrey, S.M., McFarlane, B., Christianson, A., McGee, T., Curtis, A. and Sharp, E., 2014. Tust: a planning guide for wildfire agencies and practitioners—an international collaboration drawing on research and management experience in Australia, Canada, and the United States, Oregon State University, Corvallis, OR.

Skinner, C., Ritchie, M., Hamilton, T. and Symons, J., 2004. Effects of prescribed fire and thinning on wildfire severity: the Cone Fire, Blacks Mountain Experimental Forest, Proceedings of the 25th Vegetation Management Conference, Redding, CA, pp. 12-12.

Skinner, C.N., Abbott, C.S., Fry, D.L., Stephens, S.L., Taylor, A.H. and Trouet, V., 2009. Human and climatic influences on fire occurrence in California's North Coast Range, USA. Special Issue: Fire history in California, 5(3): 76-99.

Skinner, C.N., ritchie, M.W., Hamilton, T. and Symons, J., 2004. Effects of thinning and prescribed fire on wildfire severity. University of California, Shasta County Cooperative Forestry Extension, pp. 80-91.

Stein, B.A., 2002. States of the union: ranking America's biodiversity, Arlington, Virginia.

Stephens, S.L. and Finney, M.A., 2002. Prescribed fire mortality of Sierra Nevada mixed conifer tree species: effects of crown damage and forest floor combustion. Forest Ecology and Management, 162(2–3): 261-271.

Stephens, S.L. and Fry, D.L., 2007. Fire history in Coast Redwood stands in the northeastern Santa Cruz Mountains, California. In: R.B. Standiford, G.A. Giusti, Y. Valachovic, W.J. Zielinski and M.J. Furniss (Editors), Proceedings of the redwood region forest science symposium: what does the future hold? Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Gen. Tech. Rep. PSW-GTR-194. Albany, CA, pp. 219-222.

Stephens, S.L., Martin, R.E. and Clinton, N.E., 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management, 251(3): 205-216.

Stephens, S.L. and Moghaddas, J.J., 2005. Fuel treatment effects on snags and coarse woody debris in a Sierra Nevada mixed conifer forest. Forest Ecology and Management, 214(1–3): 53-64.

Stephens, S.L., Moghaddas, J.J., Hartsough, B.R., Moghaddas, E.E.Y. and Clinton, N.E., 2009. Fuel treatment effects on stand-level carbon pools, treatment-related emissions, and fire risk in a Sierra Nevada mixed-conifer forest. Publication No. 143 of the National Fire and Fire Surrogate Project. Canadian Journal of Forest Research, 39(8): 1538-1547.

Syphard, A., Brennan, T. and Keeley, J., In Press. The role of defensible space for residential structure protection during wildfires. International Journal of Wildland Fire.

Syphard, A.D., Clarke, K.C. and Franklin, J., 2007. Simulating fire frequency and urban growth in southern California coastal shrublands, USA. Landscape ecology, 22(3): 431-445.

Syphard, A.D., Franklin, J. and Keeley, J.E., 2006. Simulating the effects of frequent fire on southern California coastal shrublands. Ecological Applications, 16(5): 1744-1756.

Syphard, A.D., Keeley, J.E. and Brennan, T.J., 2011. Comparing the role of fuel breaks across southern California national forests. Forest Ecology and Management, 261(11): 2038-2048.

Syphard, A.D., Keeley, J.E. and Brennan, T.J., 2011. Factors affecting fuel break effectiveness in the control of large fires on the Los Padres National Forest, California. International Journal of Wildland Fire, 20(6): 764-775.

Syphard, A.D., Keeley, J.E., Massada, A.B., Brennan, T.J. and Radeloff, V.C., 2012. Housing Arrangement and Location Determine the Likelihood of Housing Loss Due to Wildfire. PLoS ONE, 7(3): e33954.

Syphard, A.D., Massada, A.B., Butsic, V. and Keeley, J.E., 2013. Land use planning and wildfire: development policies influence future probability of housing loss. PLoS one, 8(8): 12.

Syphard, A.D., Radeloff, V.C., Hawbaker, T.J. and Stewart, S.I., 2009. Conservation threats due to human-caused increases in fire frequency in Mediterranean-climate ecosystems. Conservation Biology, 23(3): 758-769.

Syphard, A.D., Radeloff, V.C., Keeley, J.E., Hawbaker, T.J., Clayton, M.K., Stewart, S.I. and Hammer, R.B., 2007. Human influence on California fire regimes. Ecological applications, 17(5): 1388-1402.

Syphard, A.D., Radeloff, V.C., Keuler, N.S., Taylor, R.S., Hawbaker, T.J., Stewart, S.I. and Clayton, M.K., 2008. Predicting spatial patterns of fire on a southern California landscape. International Journal of Wildland Fire, 17(5): 602-613.

Syphard, A.D., Regan, H.M., Franklin, J., Swab, R.M. and Bonebrake, T.C., 2013. Does functional type vulnerability to multiple threats depend on spatial context in Mediterranean-climate regions? Diversity and Distributions, 19(10): 1263-1274.

Uzoh, F.C.C. and Skinner, C.N., 2009. Effects of creating two forest structures and using prescribed fire on coarse woody debris in northeastern California, USA. Fire Ecology, 5(2): 1-13.

Vaillant, N.M. and Stephens, S.L., 2009. Fire history of a lower elevation Jeffrey Pine-mixed conifer forest in the eastern Sierra Nevada, California, USA. Fire Ecology, 5(3): 4-19.

Van de Water, K. and North, M., 2011. Stand structure, fuel loads, and fire behavior in riparian and upland forests, Sierra Nevada Mountains, USA; a comparison of current and reconstructed conditions. Forest Ecology and Management, 262(2): 215-228.

Van de Water, K.M. and Safford, H.D., 2011. A summary of fire frequency estimates for California vegetation before Euro-American settlement. Fire Ecology, 7(3): 26-58.

van Mantgem, P.J., Stephenson, N.L., Keifer, M. and Keeley, J., 2004. Effects of an introduced pathogen and fire exclusion on the demography of sugar pine. Ecological Applications, 14(5): 1590-1602.

Van Wagtendonk, J.W. and Cayan, D.R., 2008. Temporal and spatial distribution of lightning strikes in California in relation to large-scale weather patterns. Fire ecology, 4(1): 34-57.

Van Wagtendonk, J.W. and Lutz, J.A., 2007. Fire regime attributes of wildland fires in Yosemite National Park, USA. Fire Ecology, 3(2): 34-56.

van Wagtendonk, J.W. and Moore, P.E., 2010. Fuel deposition rates of montane and subalpine conifers in the central Sierra Nevada, California, USA. Forest Ecology and Management, 259(10): 2122-2132.

Van Wagtendonk, J.W., Van Wagtendonk, K.A. and Thode, A.E., 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. Fire Ecology, 8(1): 11-31.

Weatherspoon, C.P., Husari, S.J. and Wagtendonk, J.W.V., 1992. Fire and fuels management in relation to owl habitat in forests of the Sierra Nevada and southern California. Chapter 12 In: J. Verner, K.S. McKelvey, B.R. Noon, R.J. Gutierrez, G.I.J. Gould and T.W. Beck (Editors), The California spotted owl: a technical assessment of its current status. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, en. Tech. Rep. PSW-GTR-133. Albany, CA, pp. 247-260.

Zedler, P.H., 1982. Plant demography and chaparral management in southern California. Dynamics and management of Mediterranean-type ecosystems, General Technical Report PSW-58. Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Berkeley, CA: 123-127.

Zedler, P.H., 1995. Fire frequency in southern California shrublands: biological effects and management options. In: J. Keeley and T. Scott (Editors), Brushfires in California Wildlands: Ecology and Resource Management. International Association of Wildland Fire, Fairfield, Washington, USA, pp. 101-112.

Zedler, P.H. and Seiger, L.A., 2000. Age mosaics and fire size in chaparral: a simulation study. Second Interface between ecology and land development in California. US Geological Survey Open-File Report 00-62, Sacramento, CA: 9-18.