Assessing fuel treatment effectiveness during wildfires under future climate conditions in southern California

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Authorization to Submit Thesis

This thesis of Carrie A. Minerich submitted for the degree of Master of Science with a Major in Natural Resources and titled “Assessing fuel treatment effectiveness during wildfires under future climate conditions in southern California," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

The wildland-urban interface (WUI) is one of the fastest growing land-use types in the United States resulting in increased populations directly vulnerable to wildfire hazards. One way to mitigate fire danger near the WUI is through adjacent fuel reduction treatments. While there is a national priority to reduce fire risk through fuel treatments, the efficacy of such treatments to mitigate fire behavior in a changed climate is unknown. We selected four fuel treatments in southern California intercepted by wildfires within the last decade to evaluate fuel treatment effectiveness under future conditions. We used FlamMap to conduct a change analysis of flame length, fire line intensity, max spot distance, and crown fire activity using 97th percentile weather and fuel moisture representative of historical and projected mid-21st century conditions. We found little change in flame length, fire line intensity, max spot distance, and crown fire activity within the fuel treatment under future conditions. However, increased fire behavior activity 1-2 kilometers from fuel treatments under future climatic conditions could impact the fuel treatment effectiveness. These results have important implications to increase cost-effectiveness of long-term fuel treatment programs by providing suggestions on where to focus on strategic areas that require further reduction of fuels to allow for safe fire management operations, protection of property, life, and egress.

Acknowledgements

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1. Introduction

With anthropogenic climate change driving increased wildland fire activity, area burned, and increased fire season length in the western United States (US), managing fire risk in the expanding wildland-urban interface (WUI) is an on-going challenge (Barbero *et al.* 2015; Abatzoglou and Williams 2016; Keyser and Westerling 2017; Radeloff *et al.* 2018). In the US, the WUI is the fastest-growing land type (Radeloff *et al.* 2018). While WUI fragments wildland vegetation, it leads to increased human ignitions and is difficult to fight a fire in (Theobald and Romme 2007; Alexandre *et al.* 2016; Hakes *et al.* 2017; Radeloff *et al.* 2018). WUI disasters, or enormous cost and loss of life and property, appear to be occurring with increased frequency (Calkin *et al.* 2014) and this trend will likely continue in the coming decades (Bowman *et al.* 2017).

In areas near the WUI zone, fuel treatments are commonly applied to manage wildland fire impacts. Fuel treatments change the vegetation structure to alter fire behavior, by decreasing flame length, rate of spread, and crown fire, allowing fire suppression to be conducted safely and effectively (van Wagtendonk 1996; Agee *et al.* 2000; Graham *et al.* 2004; Syphard *et al.* 2011a). Depending on topography, WUI proximity, and fuel loading, treatments take many forms, including mechanical thinning (such as masticating), prescribed burning, and hand removal to create gaps in the vegetation structure (Syphard *et al.* 2011b; Brown *et al.* 2012). Studies that have observed fuel treatment interactions with fire have concluded wildland fire size and severity can be mitigated by strategically placed fuel treatments (Finney *et al.* 2005; Kennedy and Johnson 2014). Fuel treatments are generally not a stand-alone defense for WUI against wildfire intrusion and require additional resources to be effective during a wildfire incident (Syphard *et al.* 2011b; Kennedy and Johnson 2014). Fuel treatment objectives vary depending on implementation in WUI or wildland areas (Syphard *et al.* 2011b). However, fuel treatments near the WUI are usually designed to prevent fire from spreading into communities by allowing firefighters to use treatments as safety zones, anchor points, for burn out operations, and to protect egress (Radeloff *et al.* 2005; Reinhardt *et al.* 2008). Fuel treatment efficacy has primarily been evaluated using fire severity metrics or ecological measurements after a fire has intercepted the treatment (Martinson and Omi 2003; Reinhardt *et al.* 2008; Kennedy and Johnson 2014). What remains unknown is evaluating fuel treatment effectiveness empirically using fire behavior modeling software with observed wildfire interception.

Climate-wildfire relationships are well-understood to be drivers of wildfire occurrence, fire behavior, and area burned (Abatzoglou and Kolden 2013; Abatzoglou and Williams 2016; Keyser and Westerling 2017; Syphard *et al.* 2017) by affecting fuel moisture directly (i.e. biomass ability to burn) and indirectly through fuel structure (amount and connectivity of combustible biomass) (Kolden and Brown 2010; Pausas and Paula 2012; Abatzoglou and Kolden 2013). Weather and climate can influence fuel treatment effectiveness through combinations of fuel moisture, temperature, relative humidity, and wind (Bradstock *et al.* 2012). Climate change has altered wildfire activity over much of the US, contributing to increased fire weather season length (Westerling *et al.* 2006; Jolly *et al.* 2015) and increased wildfire area burned (Abatzoglou and Williams 2016). Despite these observed increases and projections for continued changes in fire weather and fire activity in the coming decades (Barbero *et al.* 2015), there has been limited research to assess the impacts of future climatic conditions on fuel treatment effectiveness.

Some of the most disastrous WUI wildfires globally have occurred in southern California in the last two decades (Bowman *et al*. 2017). California leads the US in housing loss from wildfires each year and this has rippling social, economic, and ecological effects (Syphard *et al.* 2012). Fuel reduction treatments have been widely accepted and implemented to try to mitigate the wildfire hazard in southern California in the WUI (Syphard *et al.* 2011b; a). and fuel treatment placement has become a national priority and strategy to protect WUI communities (Mell *et al.* 2010).

Our primary goal was to evaluate four fuel treatments in southern California to determine whether they will meet effectiveness objectives in climatic conditions representative of both contemporary conditions and those projected for the mid-21st century. Understanding the potential fire behavior and the efficacy of current fuel treatments under current and future conditions has important implications to increase cost-effectiveness of fuel treatment programs. Such modeling efforts can be used to modify fuel treatments to better withstand predicted future fire behavior as well as identify current fuel treatments that will be robust to future conditions.

2. Methods

Study area

Southern California has a Mediterranean climate, with little precipitation between April and October (Brown *et al.* 2012; Kolden and Abatzoglou 2018). Southern California's meteorology creates two distinct fire regimes: fall fires typically driven by strong offshore winds, primarily Santa Ana winds, and summer fires driven by topography, fuel, hot dry weather, and weak winds in the absence of non-Santa Ana winds (Jin *et al.* 2014; Kolden and Abatzoglou 2018). Southern California's summer is influenced by maritime air, resulting in a strong coast-inland gradient in the summer months (Williams *et al.* 2018) that typically restricts large summer fires from occurring on the coastal range.

Southern California has a diverse geographic landscape that varies in elevation and includes steep mountainous terrain and semi-arid characteristics that include shrub chaparral, woodland, and forested vegetation. Historically in California, prior to European settlement, vegetation was fire-adapted with fires occurring at a regular fire return interval with infrequent summer wildfires that held over into fall and becoming active during autumn katabatic wind events, also known as Santa-Ana winds (Mensing *et al.* 1999; Kolden and Abatzoglou 2018). In today's Southern California landscape, humans have altered vegetation, increased population density, ignitions, and subsequently increased fire frequency, leading to increased WUI disasters, loss of property, and loss of life (Parks *et al.* 2015; Kolden and Abatzoglou 2018).

Three southern California National Forests (NF) (i.e., San Bernardino, Angeles, and Los Padres) cover approximately 1.2 million hectares over nine counties in central and southern California. Despite the relatively small size of these forests (the largest, Los Padres, is 680,000 hectares), they serve a huge population base (USFS 2018) that is encroaching into the wildland (Syphard *et al.* 2011b; Radeloff *et al.* 2018; USFS 2018).

Fuel Treatments

We selected four fuel treatments for this study (Figure 1): Camino Cielo, Ojai Community Defense Zone (herein referred to as Ojai CDZ), Charlton-Chilao (herein referred to as Chilao), and Lone Pine. The Chilao fuel treatment was implemented in higher-elevation forested area and the other three were implemented in lower-elevation sites dominated by chaparral shrublands. Fuel treatments included mastication, lop and scatter, pile burning, hand thinning, and prescribed burning. Evaluating fuel treatments intercepted by wildfire aids in determining weather forcing and date restrictions for modeling analysis.

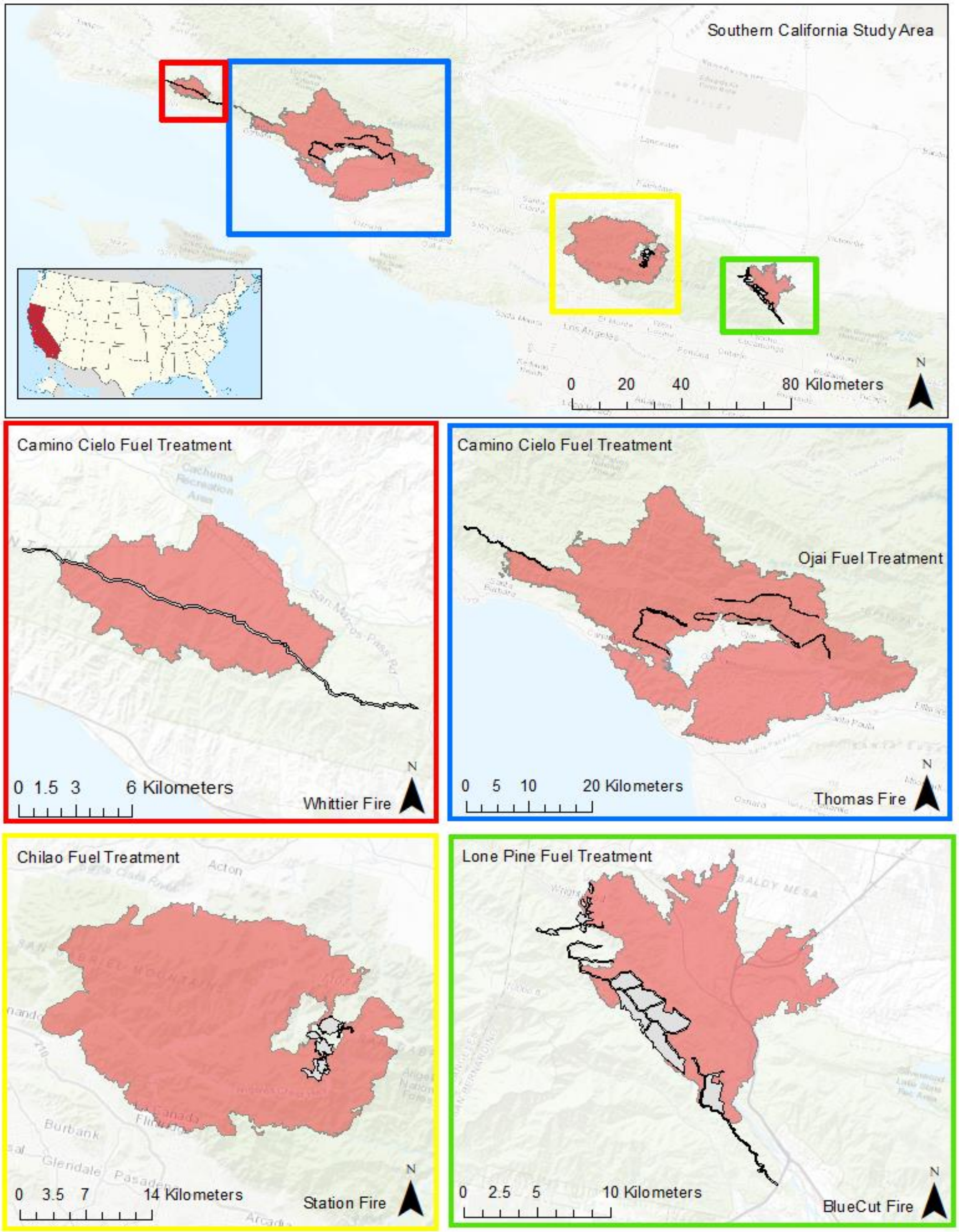

Figure 2.1: Southern California study area. Fuel treatments are grey polygons with black outline. Red polygon is wildfire that intercepted the fuel treatment.

The Camino Cielo fuel treatment is a several decades old fuel treatment that runs 588-hectares along the top of the crest of the Santa Ynez mountains on the Los Padres NF. This fuel treatment type-converted chaparral shrub to grass vegetation type. We assessed two sections of the Camino Cielo fuel treatment totaling 528-hectares intercepted by two fires in 2017: the Whittier Fire (non-Santa Ana wind fire) in July and the Thomas Fire in December (Santa Ana wind fire). We assessed 340-hectares intercepted by and surrounding the Whittier Fire and 188-hectares intercepted by and surrounding the Thomas Fire. Camino Cielo is important access to several ridge tops to provide an anchor point to make a stand against a wildfire and protect the coastal communities of Santa Barbara and Montecito.

The 1562-hectare Ojai CDZ on the Los Padres NF include Chismahoo, Echo Falls, Foothill, Horn, Kennedy, Laguna, Lower Shelf, Nordhoff Ridge, Rice Wills, Sisar, Superior, and Upper Shelf fuel treatments. Ojai CDZ was intercepted in December 2017 by the Thomas Fire (Santa Ana wind fire). The Ojai CDZ has been regularly maintained and transformed shrub/chaparral to grass vegetation type. Ojai CDZ provides firefighter access to several strategic areas surrounding the Ojai valley, to make a stand against a wildfire by either widening the fire line or as an anchor point for firing operations, that will contribute to protecting values-at-risk, Ojai, and surrounding communities.

The 3,400-hectare Chilao fuel treatment on the Angeles NF was completed in 2009 in a high elevation forested area and intercepted in August-September 2009 by the Station Fire (non-Santa Ana wind fire). A dry timber forest with Ponderosa pine (*Pinus ponderosa*) overstory and dense snowbrush (*Ceanothus velutinus*) and mountain mahogany (*Cercocarpus spp.*) was thinned to reduce the understory vegetation and increase overstory spacing in different fuel reduction amounts as determined in the environmental assessment (EA) across the fuel treatment. Chilao protects several values-at-risk off the Angeles Crest highway, including a US Forest Service campground, fire engine station, helicopter pad, a radio repeater, and historical landmarks, as well as ensuring a safe egress route.

The Lone Pine fuel treatment includes Lone Pine Canyon, Upper Lone Pine, Boa, Boundary Ridge, Bluecut, and Wrightwood fuels reduction and prescribed burning units (hereon referred to as Lone Pine) across 2,143-hectares on the San Bernardino National Forest (NF) (exception Wrightwood located on the Angeles NF). Lone pine was transformed from dense shrub to a sparse shrub and grass vegetation type. Lone Pine was intercepted in July 2016 by the Blue Cut fire (non-Santa Ana wind fire). Lone Pine protects several small towns, egress, and provides anchor point for firing operations.

Data

Fuel treatment design uses fire behavior modeling programs, historic weather data, and fire behavior modeling programs to create a treatment prescription that will reduce fire behavior observations (i.e.: flame length, fire line intensity, max spot distance, and crown fire activity) to desirable levels (van Wagtendonk 1996; Agee *et al.* 2000).

LANDFIRE is a geospatial database that primarily serves as the foundation data for fire behavior modeling in the US (Rollins 2009). We acquired Scott and Burgan 40 fire behavior fuel models (Scott and Burgan 2005), canopy cover, canopy height, canopy bulk density, and canopy base height landscape data from LANDFIRE using the 2008 database for the Chilao fuel treatment, due to Station Fire interception in 2009, and 2014 database for all other fuel treatments, due to LANDFIRE data availability. We used ArcFuels to modify raster values of each LANDFIRE layer to create a treated landscape file that best represented the available fuels at time of fire interception, restricting modifications to within the fuel treatment polygon (Appendix A). We reduced the raster value of each LANDFIRE landscape data file within the fuel treatment polygon 50% on Camino Cielo, Ojai, sections of Chilao, and the Lone Pine road treatments, 40% on the prescribed burns on Lone Pine, and 25% on sections of the Chilao, per NEPA documents, U.S. Forest Service Activity Tracking System (FACTS) database, and discussions with the three southern California National Forest fuels managers (Personal communication with N. Elmquist, L. Blake).

We used statistically downscaled data to RAWS stations closet to each fuel treatment from 13 global climate models (GCM) for historic (1950-2005) and future periods (2006-2100). We used the Los Prietos RAWS station for Camino Cielo west, located on the backside of the Santa Ynez mountains, sheltered from ocean influences and more accurately reflects the origin of the Whittier fire. We used the Montecito RAWS for Camino Cielo east, located on the southern, or ocean, side of the mountains and more accurately reflects the conditions present when the Thomas fire intercepted the treatment. We used Ojai RAWS for Ojai CDZ; Chilao RAWS for Chilao, and Mormon Rocks RAWS for Lone Pine.

Downscaling GCMs is needed to reflect changes in meteorology at spatial and temporal scales for applied purposes (Abatzoglou and Brown 2012). We used 13 GCMs from the Coupled Model Intercomparison Project Phase 5 (CMIP5) with Representative Concentration Pathway RCP8.5 forcing through the mid-21st century for future scenarios. It is important to use modeled historic weather data and not observed historic data so the analysis includes a comparison of modeled historic and modeled future weather conditions. We imported all GCMs from each fuel treatment analysis into FireFamily Plus (Bradshaw and McCormick 2000) and created two separate equally weighted special interest groups, one that that averaged the historic GCM models and one that averaged the future models. As noted previously, southern California has two distinct fire regimes with well-delineated spatial patterns (Kolden and Abatzoglou 2018). For fuel treatments intercepted by Santa-Ana wind events, we restricted the annual filter to September 15 – February 15 and non-Santa-Ana wind fires as May 15-

September 15, following Kolden and Abatzoglou (2018), to best model fuel treatment efficacy during a wildfire interception. The National Fire Danger Rating System (NFDRS) is a climate-based system to indicate current fire danger when compared to historic data (Andrews *et al.* 2003). The 90th and 97th percentile values for weather and fuel moisture has traditionally been used as the lower limits for the highest fire suppression staffing levels and for this analysis, we chose the 97th percentile to represent fires that are typically more disastrous in the WUI. We calculated the maximum and minimum temperature at the 97th percentile and. We calculated maximum relative humidity, minimum relative humidity wind speed, 1-hour, 10-hour, 100-hour (dead fuel moisture), live herbaceous, and live woody at the 3rd percentile to capture the lower extremes. We calculated the highest frequency wind direction, time for minimum temperatures, maximum temperatures, and wind speed for an 8-12-day period of the wildfire during the time the fuel treatment was intercepted to account for climatic variability. We excluded the effects of Santa-Ana and katabatic wind events and use fixed wind speed as determined from the 3% percentile. Wind speed remained constant throughout the analysis (Appendix B).

Analyses

We conducted a fire behavior change analysis to determine the change in fuel treatment effectiveness and the subsequent shift in fire management decisions from historic to future weather. To assess the effectiveness of the fuel treatments under future climate conditions, we used the fire behavior modeling program FlamMap to geospatially conduct a change analysis using the treated landscape file with modeled historical and future conditions at the 3rd or 97th percentile weather and fuels data for each fuel treatment. We modeled flame length, fire line intensity, maximum spot distance, and crown fire activity using 60% foliar moisture and 1300-hour conditioning time for all fuel treatments. We used Rothermel's (1982) charts for interpreting wildland fire behavior characteristics, commonly accepted in wildland fire management (National Wildfire Coordinating Group 2013), to interpret the effectiveness of the fuels treatment during fire interception.

Fire line intensity is the amount of heat released per second by a meter-wide slice of the flaming combustion zone (Andrews and Rothermel 1982). We reclassified fire line intensity into 5 classes. Class 0: 0 kw/m/s. Class 1: 1 – 1,100 kw/m/s. Class 2: 1,101 – 5,500 kw/m/s. Class 3: 5,501 – 11,000 kw/m/s. Class 4: ≥11,001 kw/m/s. We conducted an absolute change analysis within each class between modeled future and modeled historic climate conditions for each fuel treatment for fire line intensity.

Flame length is the length of the flame at the head of the fire measured from the middle of the combustion zone to the average position of the flame tip (Andrews and Rothermel 1982). We reclassified flame length into 5 classes: 0m, 1m, 2m, 3m, and ≥4m; to represent each category of fire suppression interpretation. We conducted an absolute change analysis within each class between modeled future and modeled historic climate conditions for each fuel treatment for flame length.

Table 2.2: Fire suppression interpretation using flame length and fire line intensity.

FLAME LENGTH	**FIRE LINE INTENSITY**	**FIRE SUPPRESSION INTREPRETATION*** *Andrews and Rothermel 1982
<1.2m (4 FT)	**<1,100 kw/m/s** (~100 BTU/ft/s)	Direct attack with hand tools; handline effective
2.4m (8 FT)	**5,500 kw/m/s** (~500 BTU/ft/s)	Heavy equipment effective as handline unreliable to hold fire
3.3m (11 FT)	**11,000 kw/m/s** (~1000 BTU/ft/s)	Indirect attack effective as fire presents control issues
>3.3m (> 11 FT)	**> 11,000 kw/m/s** (~>1000 BTU/ft/s)	Major fire runs with crowning and spotting probable

The home ignition zone consists of three distinct distances for structure protection from wildland fire (Reinhardt *et al.* 2008). We chose the outer most distance of the home ignition zone, 60m, to classify maximum spot distance and classified maximum spot distance into three classes: 0m, <60m, and ≥61m. We conducted an absolute change analysis within each class between modeled future and modeled historic climate conditions for each fuel treatment for max spot distance. Max spot direction was excluded since it is wind-dependent.

A crown fire occurs when a surface fire makes the transition into the canopy (vanWagner 1977; 1993). FlamMap classifies crown fire activity (CFA) into 3 categories: surface fire, passive crown fire (i.e. single tree torching), and active crown fire (i.e. group torching). FlamMap does not model independent running crown fire. We reclassified the future crown fire activity prior to conducting the change analysis to see the change between the starting CFA value and the ending CFA value (Appendix C). We conducted an absolute change analysis of each category to determine the change in crown fire activity between modeled future and modeled historic climate conditions for the Chilao fuel treatment only, since the other fuel treatments were shrub dominated and are often in a high-intensity crown fire regime (Keeley and Fotheringham 2001).

We extended the change analysis for each fuel treatment to include a buffered untreated landscape area outside the fuel treatment. We chose a 1km buffer for road treatments, Camino Cielo West and East, Ojai CDZ, and Lone Pine road, and 2km buffer for large vegetation areas encompassed within Chilao and Lone Pine prescribed burn (RX) fuel treatments.

3. Results

Over the four fuel treatments, little change occurred between historic and future fire behavior conditions (Appendix D).

Camino Cielo, West

Flame length pixel count decreased in the 0m class and increased in the 2m and 3m classes from historic to future weather conditions (Figure 3.1). Fire line intensity pixels saw little change. Max spot distance pixels decreased in the 0m class and increased in the ≥61m class. Figure 3.1 shows each fire behavior class with either increases or decreases in pixels under future climate conditions on the x-axis with the percent area of the fuel treatment covered with each fire behavior class on the y-axis.

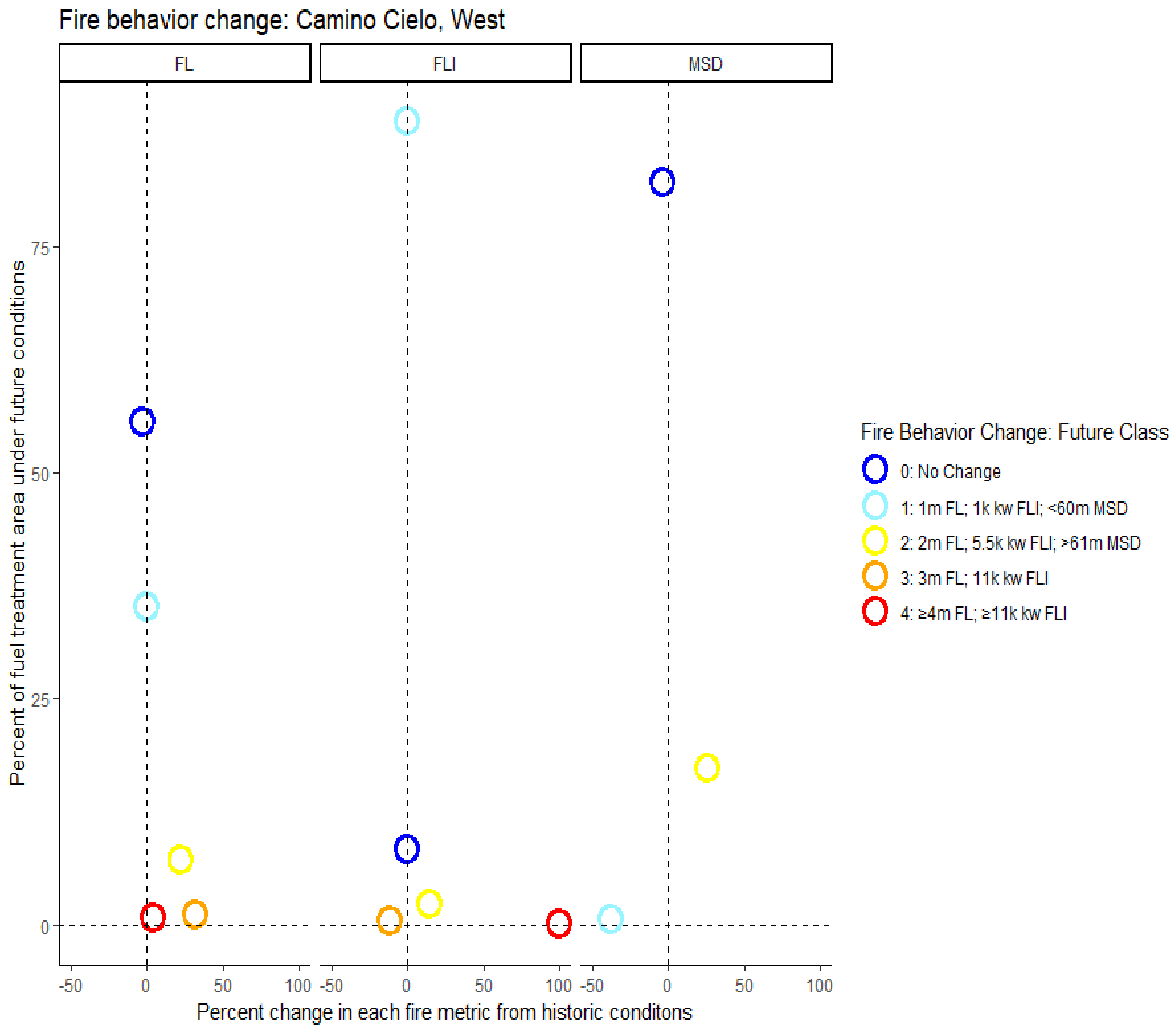

Figure 3.1: Fire behavior change metric per class where x-axis is relative percent change in fire behavior class from historic conditions and y-axis is relative percent change of future fuel treatment area where FL is flame length, FLI is fire line intensity, and MSD is max spot distance.

Camino Cielo, East

Flame length pixel count remained unchanged in each class (Figure 3.2) from historic to future climate conditions. Fire line intensity pixels remained unchanged in all classes except for class 3, which experienced a 107% increase, though only over a small area (1.4%) of the fuel treatment. Max spot distance pixel count remained unchanged. Figure 3.2 shows each fire behavior class remaining close to or on both 0 line of the x-axis, except for class 3 fire line intensity (FLI) which increased in the number of pixels under future climate conditions, though only over a small area of the fuel treatment.

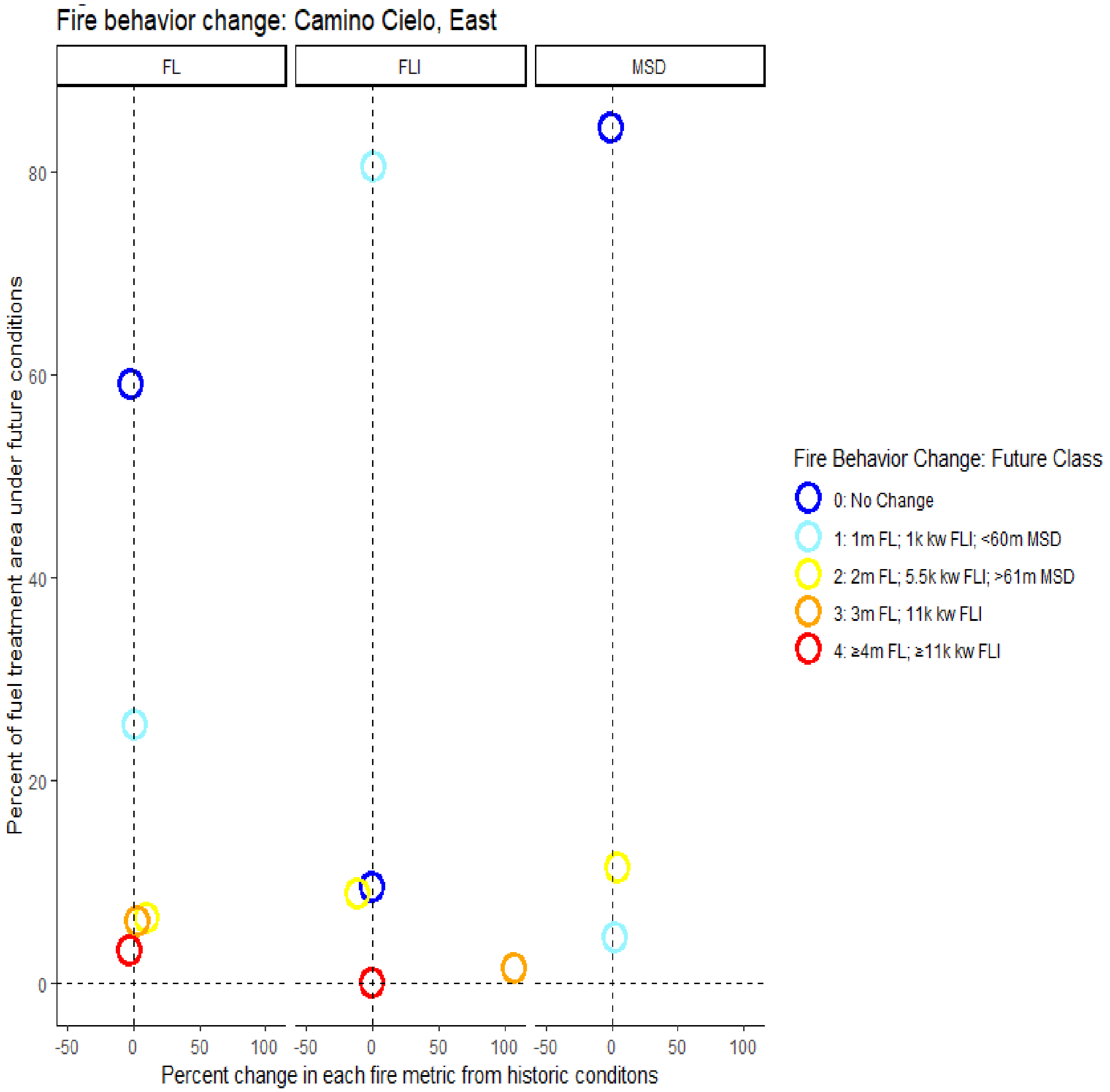

Figure 3.2: Fire behavior change metric per class where x-axis is relative percent change in fire behavior class from historic conditions and y-axis is relative percent change of future fuel treatment area where FL is flame length, FLI is fire line intensity, and MSD is max spot distance.

Ojai CDZ

Flame length pixel count remained unchanged in each class (Figure 3.3). Fire line intensity pixel count remained unchanged in each class and max spot distance pixel count remained unchanged. Figure 3.3 shows each fire behavior class remaining on or very close to the 0 line of the x-axis' with little change occurring between historic and future fire behavior class on the x-axis and the percent area of the fuel treatment covered with each fire behavior class on the y-axis.

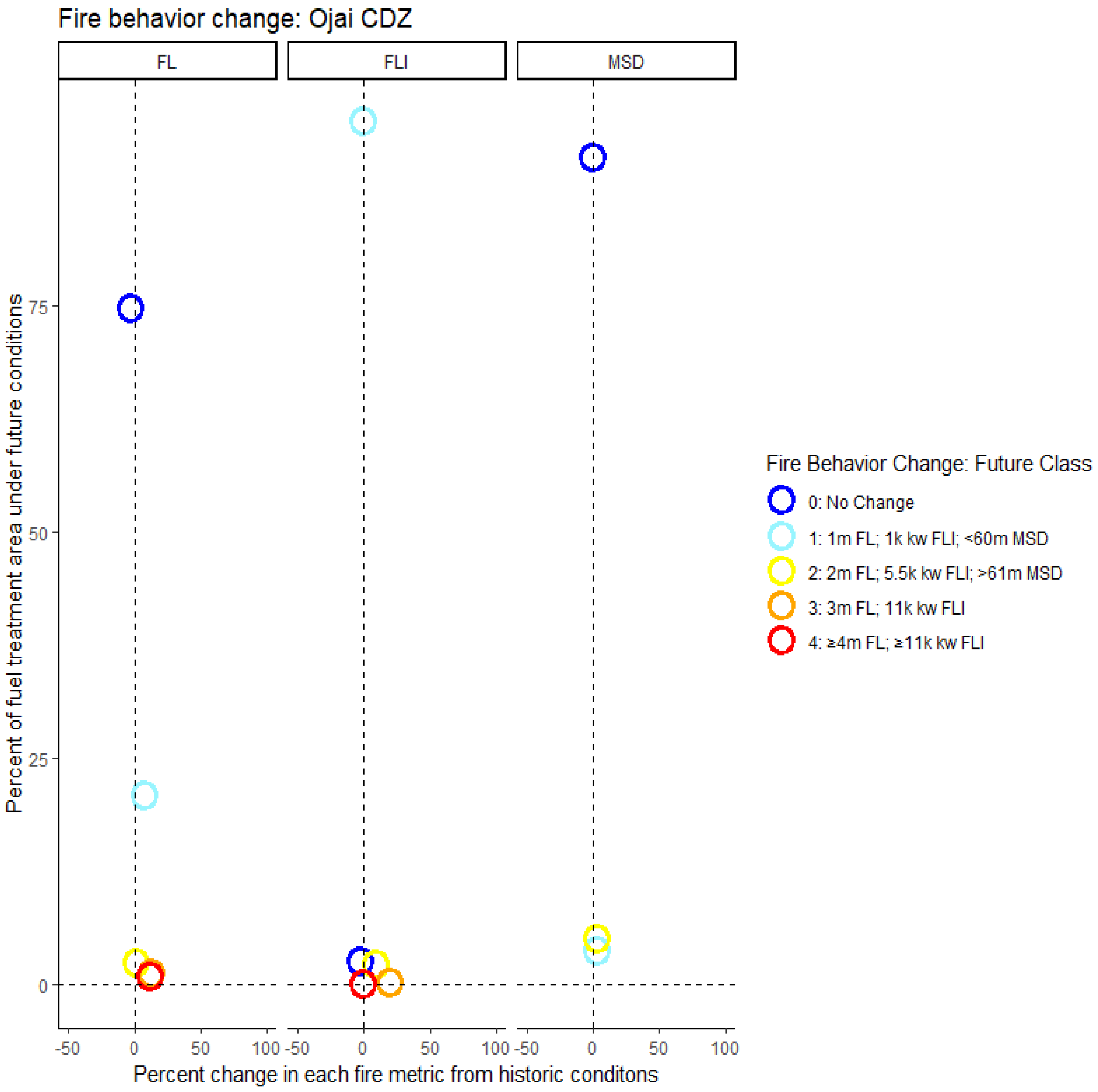

Figure 3.3: Fire behavior change metric per class where x-axis is relative percent change in fire behavior class from historic conditions and y-axis is relative percent change of future fuel treatment area where FL is flame length, FLI is fire line intensity, and MSD is max spot distance.

Chilao

Crown fire activity remained unchanged in each class (Figure 3.4). Flame length pixel count remained unchanged in each class. Fire line intensity pixel count saw a decrease in all classes except for class 1 which saw a small increase (2.61%) over 81.3% of the fuel treatment area. Max spot distance pixel count remained unchanged. Figure 3.4 shows each fire behavior class remaining on or very close to the 0 line of the x-axis (indicating no change) with little change occurring between historic and future fire behavior class on the x-axis and the percent area of the fuel treatment covered with each fire behavior class on the y-axis.

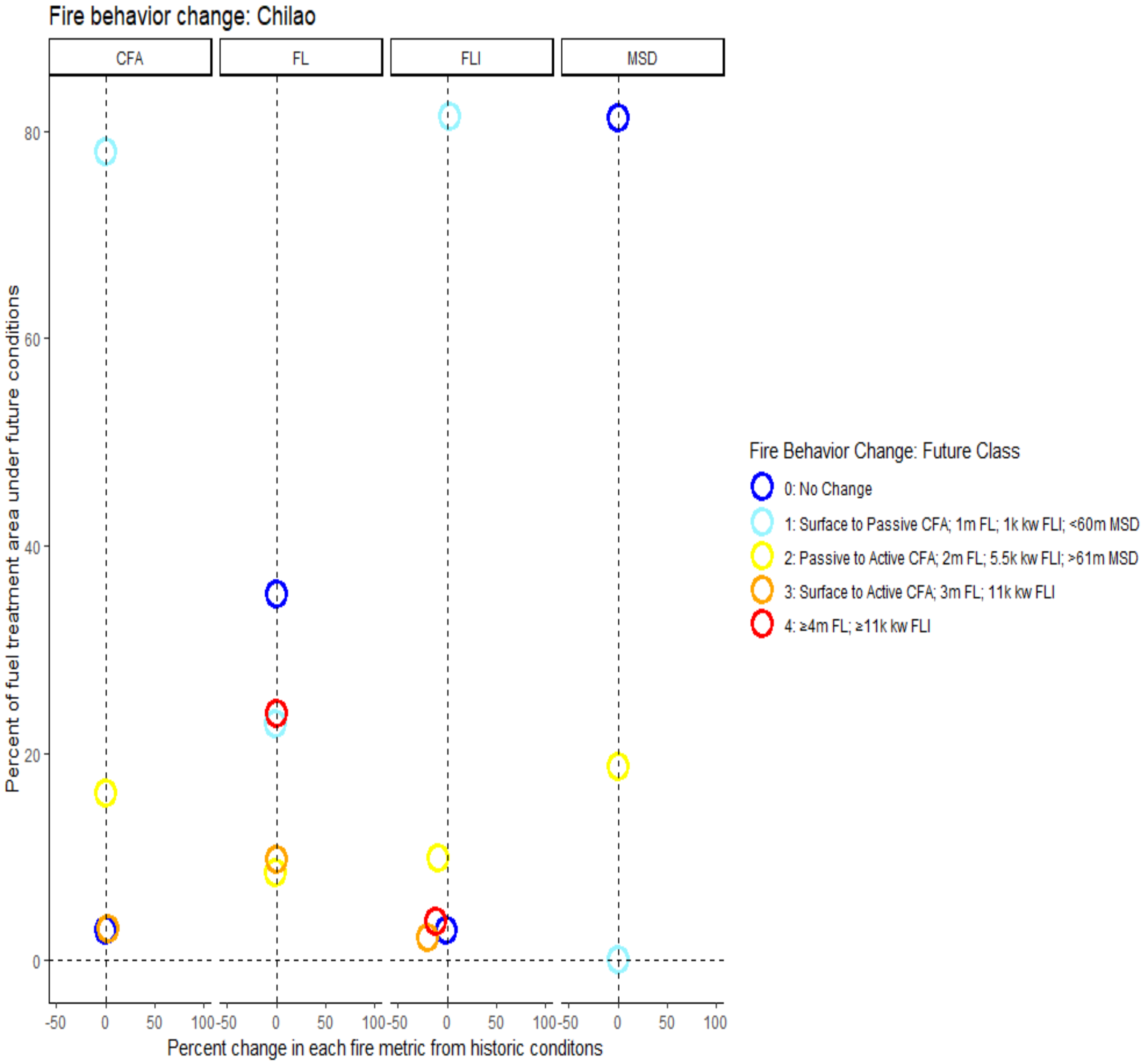

Figure 3.4: Fire behavior change metric per class where x-axis is relative percent change in fire behavior class from historic conditions and y-axis is relative percent change of future fuel treatment area where CFA is crown fire activity, FL is flame length, FLI is fire line intensity, and MSD is max spot distance.

Lone Pine

Flame length pixel count remained unchanged in each class (Figure 3.5). Fire line intensity pixel count had a 100% increase in class 4m, though only over a small portion of the fuel treatment area (0.02%). Other classes in fire line intensity pixel count remained unchanged. Max spot distance pixels remained unchanged. Figure 3.5 shows each fire behavior class remaining close to or on the 0 line of the x-axis (indicating no change), except for class 4 fire line intensity (FLI) which increased in the number of pixels under future climate conditions, though only over a small area of the fuel treatment.

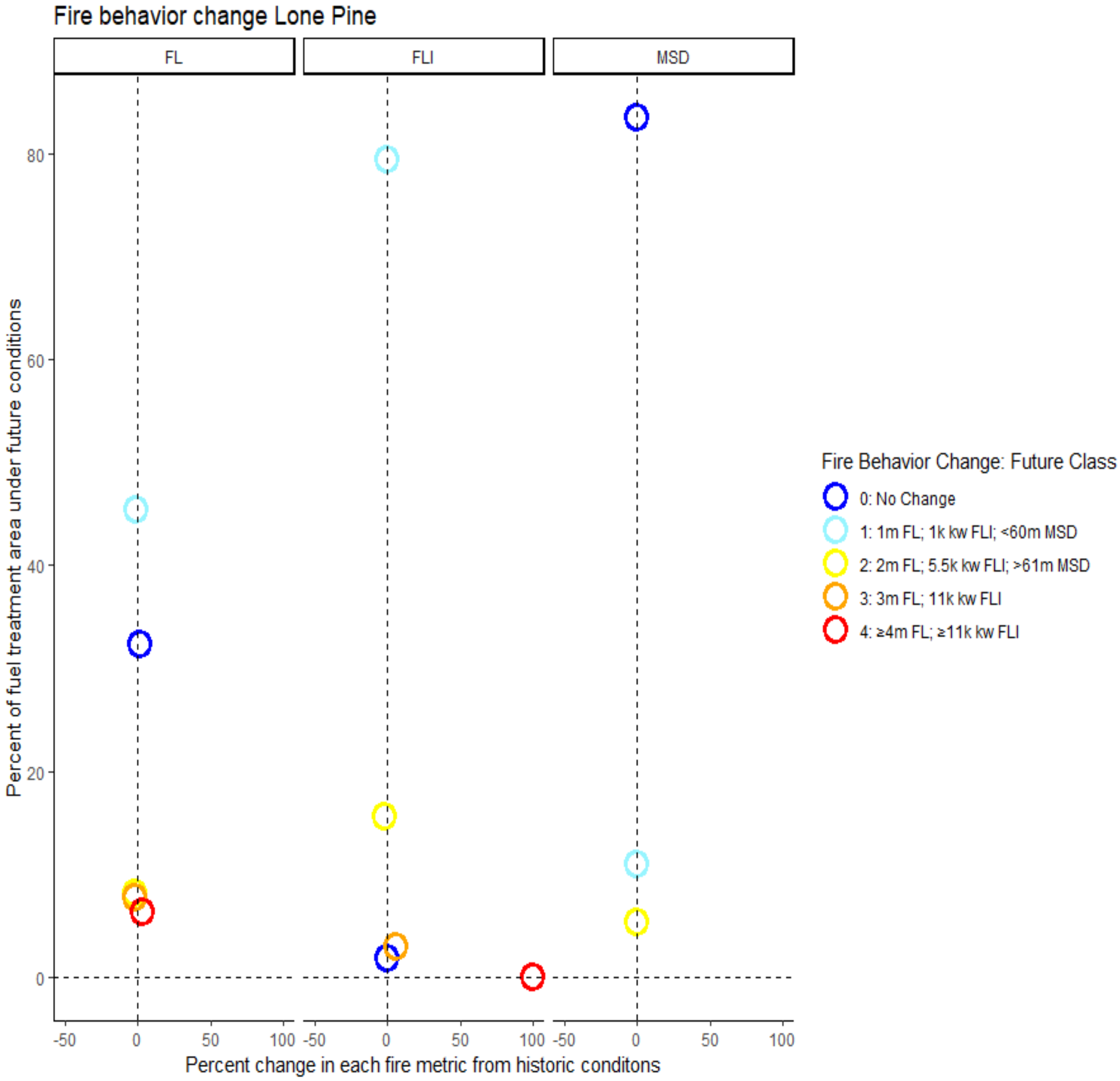

Figure 3.5: Fire behavior change metric per class where x-axis is relative percent change in fire behavior class from historic conditions and y-axis is relative percent change of future fuel treatment area where FL is flame length, FLI is fire line intensity, and MSD is max spot distance.

4. Discussion

The area within the fuel treatments will not see appreciable increases in fire behavior (i.e., more active fire) under future conditions, suggesting these fuel treatments will still be relatively effective by mid-21st century, if maintained. Since the fuel treatments themselves are meant to provide a safe working space for firefighters to conduct both direct and indirect attack operations, it is also important to look at how fire behavior around these treatments changes in the untreated fuels. Generally, fire behavior increased within the buffered areas outside of the treatment perimeters. We describe these changes below.

Camino Cielo, West

Flame length increased around several fuel treatment road corners to levels requiring hand crews and heavy equipment under future conditions (Figure 4.1). Fire line intensity increased outside the fuel treatment to levels where indirect attack may not be effective, indirectly impacting the fuel treatment effectiveness. Max spot distance increased in the ≥61m class on several areas of the fuel treatment, requiring heavy equipment, indirect attack, or a full retreat of fire personnel. This fuel treatment will effectively modify fire behavior under future conditions, though widening and intensifying fuels reduction in key areas outside the fuel treatment that modeled increased fire behavior will improve the effectiveness.

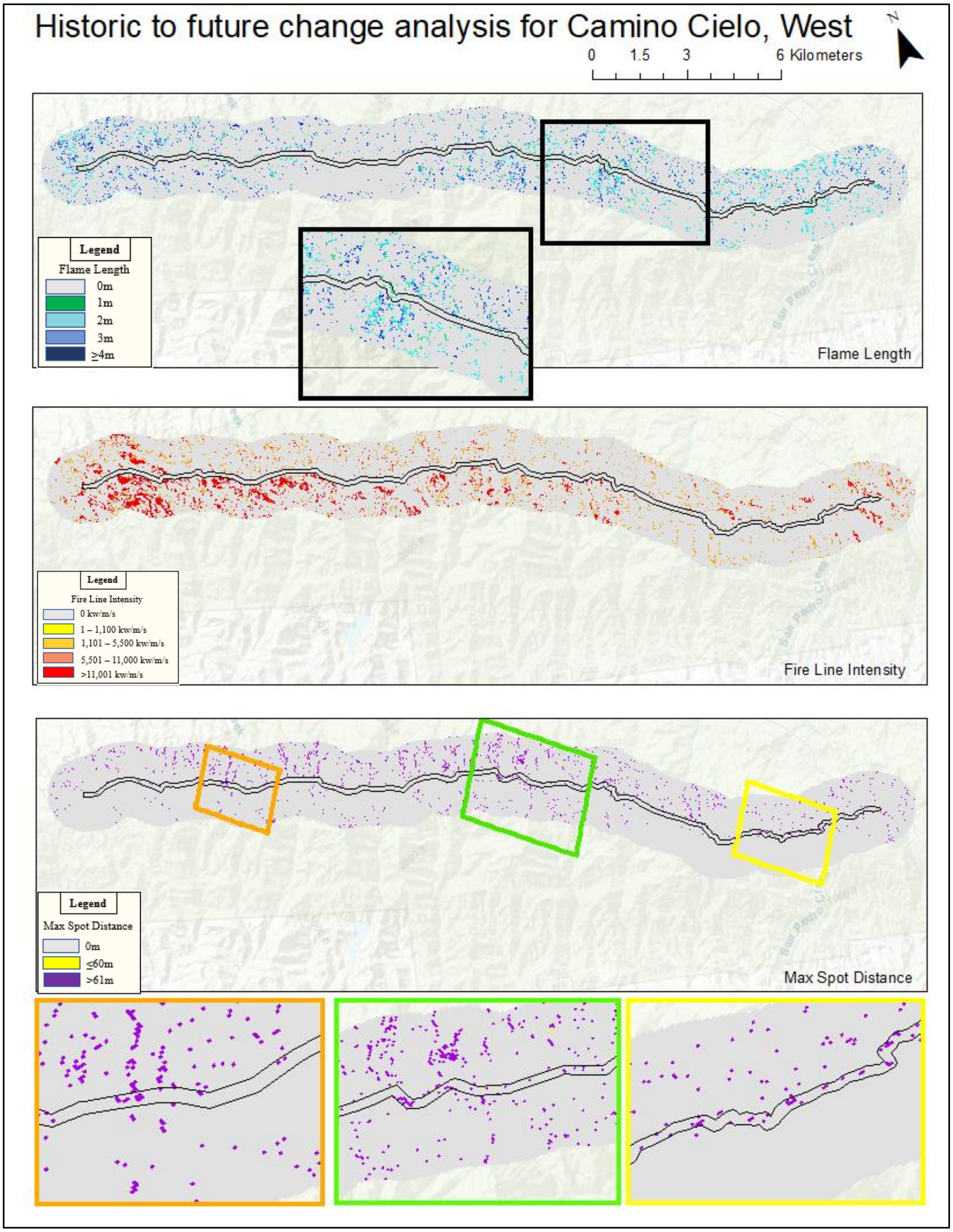

Figure 4.1: ArcGIS raster change analysis from historic to future climate conditions for Camino Cielo, West. Fuel treatment is black outline with the buffer area in gray.

Camino Cielo, East

Little change occurred on the east side of the Camino Cielo fuel treatment (Figure 4.2). This could be attributed to the Montecito RAWS station used for this analysis, located on the ocean side of the mountains. This area of the Camino Cielo fuel treatment will continue to effectively modify future fire behavior to levels experienced under historic conditions and fire management will need to do little to change suppression tactics.

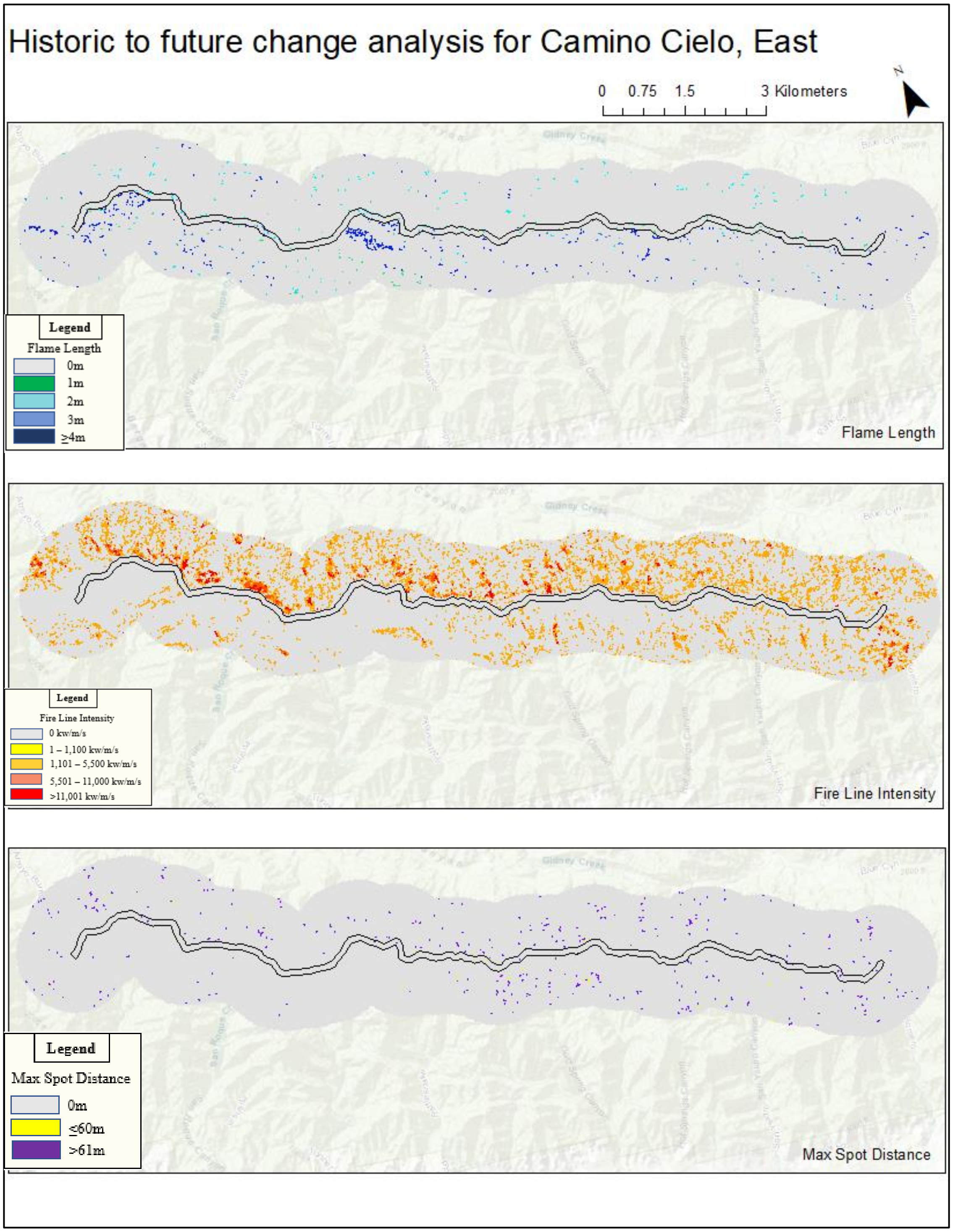

Figure 4.2: ArcGIS raster change analysis from historic to future climate conditions for Camino Cielo, East with each fire behavior class. Fuel treatment is black outline with the buffer area in gray.

Ojai CDZ

Little fire behavior change occurred inside the Ojai CDZ under future conditions (Figure 4.3). The buffered area outside the Ojai CDZ saw scattered increases however no concentrated area of pixels was observed. The Ojai CDZ will continue to effectively modify future fire behavior to levels experienced under historic conditions and fire management will need to do little to change suppression tactics.

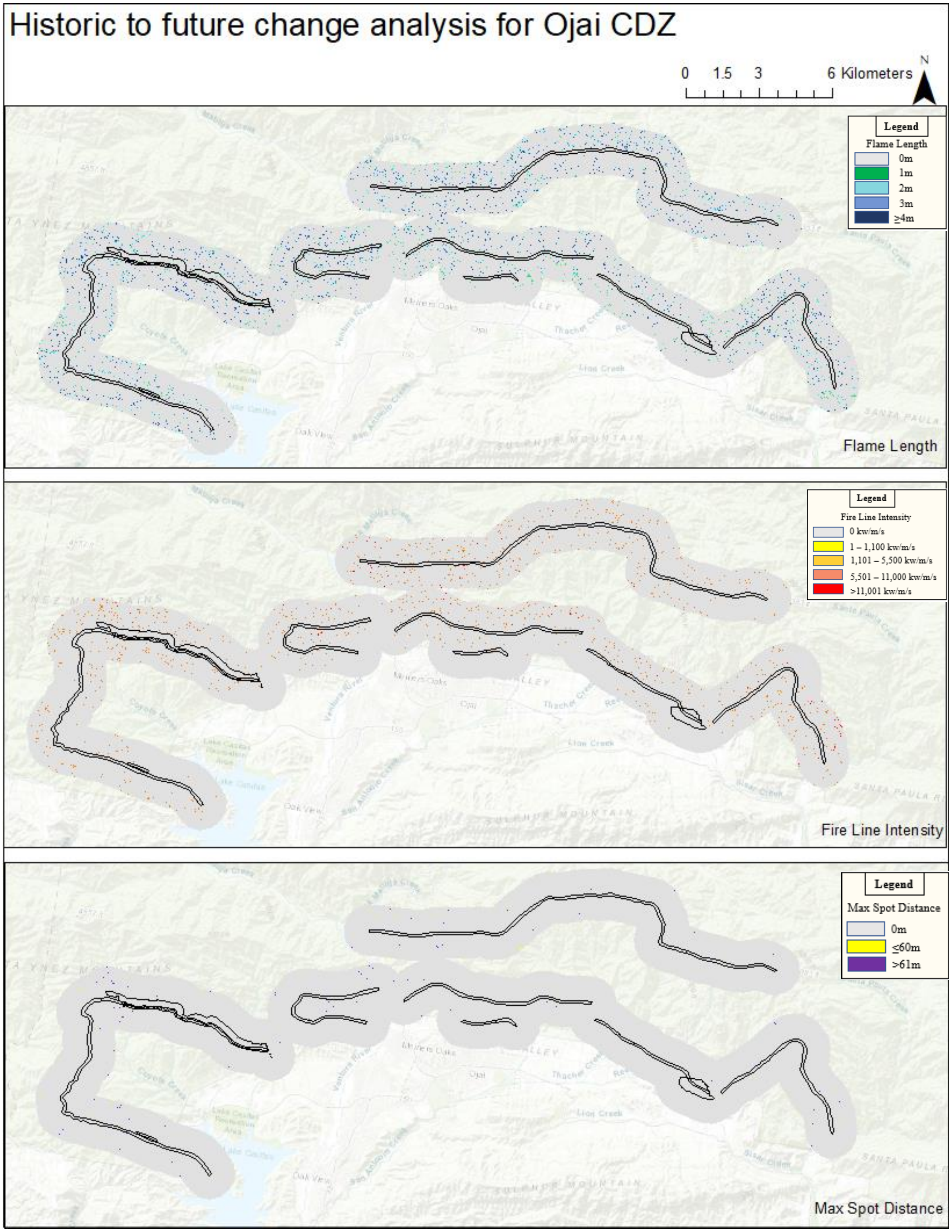

Figure 4.3: ArcGIS raster change analysis from historic to future climate conditions for Ojai CDZ with each fire behavior class. Fuel treatment is black outline with the buffer area in gray.

Chilao

No fire behavior change occurred under future conditions (Figure 4.4) for crown fire activity, flame length, and max spot distance within and the buffered area surrounding the fuel treatment. The fire line intensity buffered area outside the fuel treatment experienced an increase in class 4, ≥11,001 kw/m/s, though this increase is likely due to modeling error. If this increase is accurate and not a modeling error, this will inhibit fire management from accessing the fuel treatment and relying on safe egress unless additional fuels reduction is applied to areas abutting the highway.

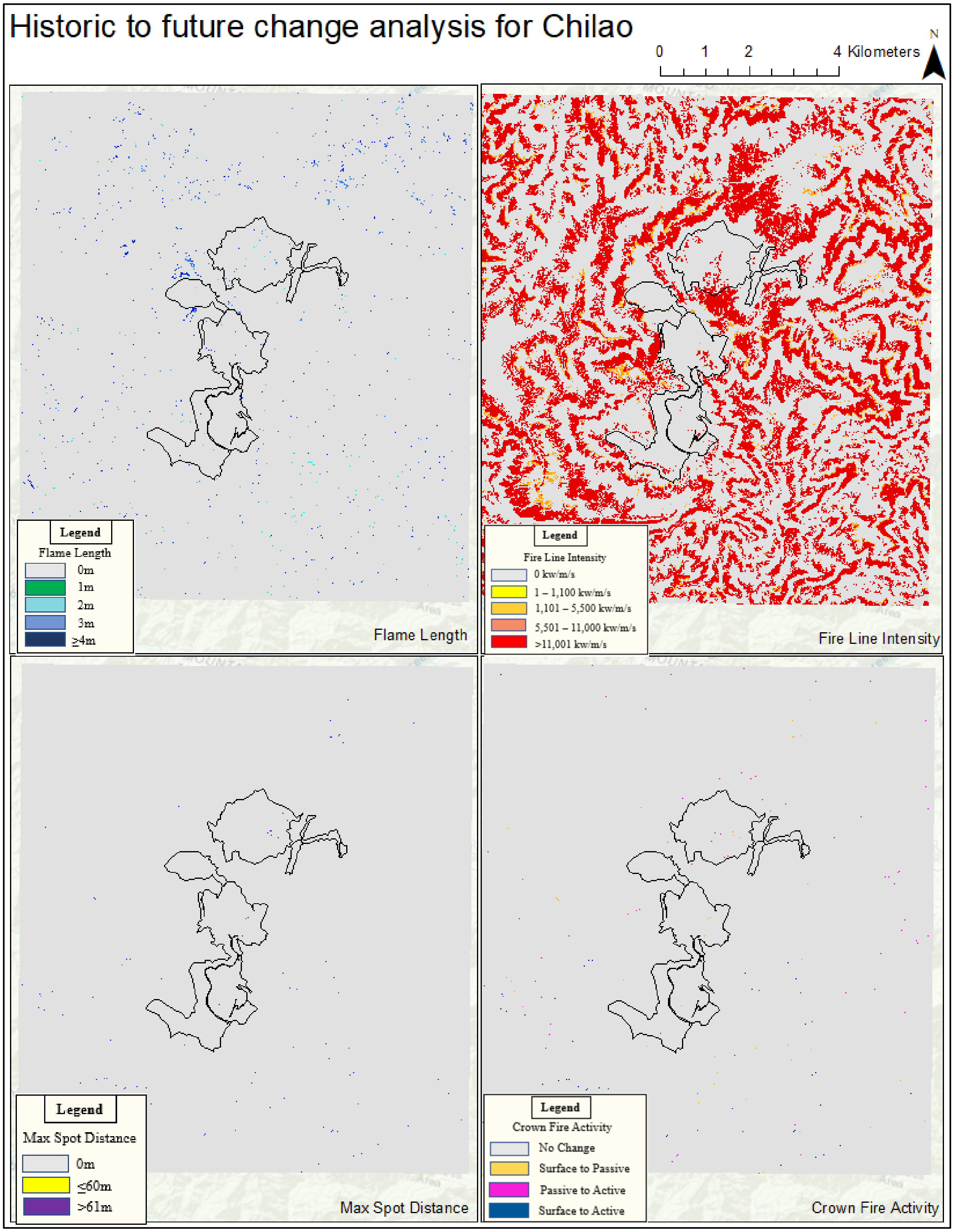

Figure 4.4: ArcGIS raster change analysis from historic to future climate conditions for Chilao with each fire behavior class. Fuel treatment is black outline with the buffer area in gray.

Lone Pine

Overall, little change occurred with each fire behavior metric in each class under future conditions. The Lone Pine fuel treatment will continue to meet effectiveness under future conditions. The road fuel treatment around Lytle Creek should receive some additional fuels reduction due to the slight scattered increase of flame length pixels to class 4 levels, above where even indirect attack can take place.

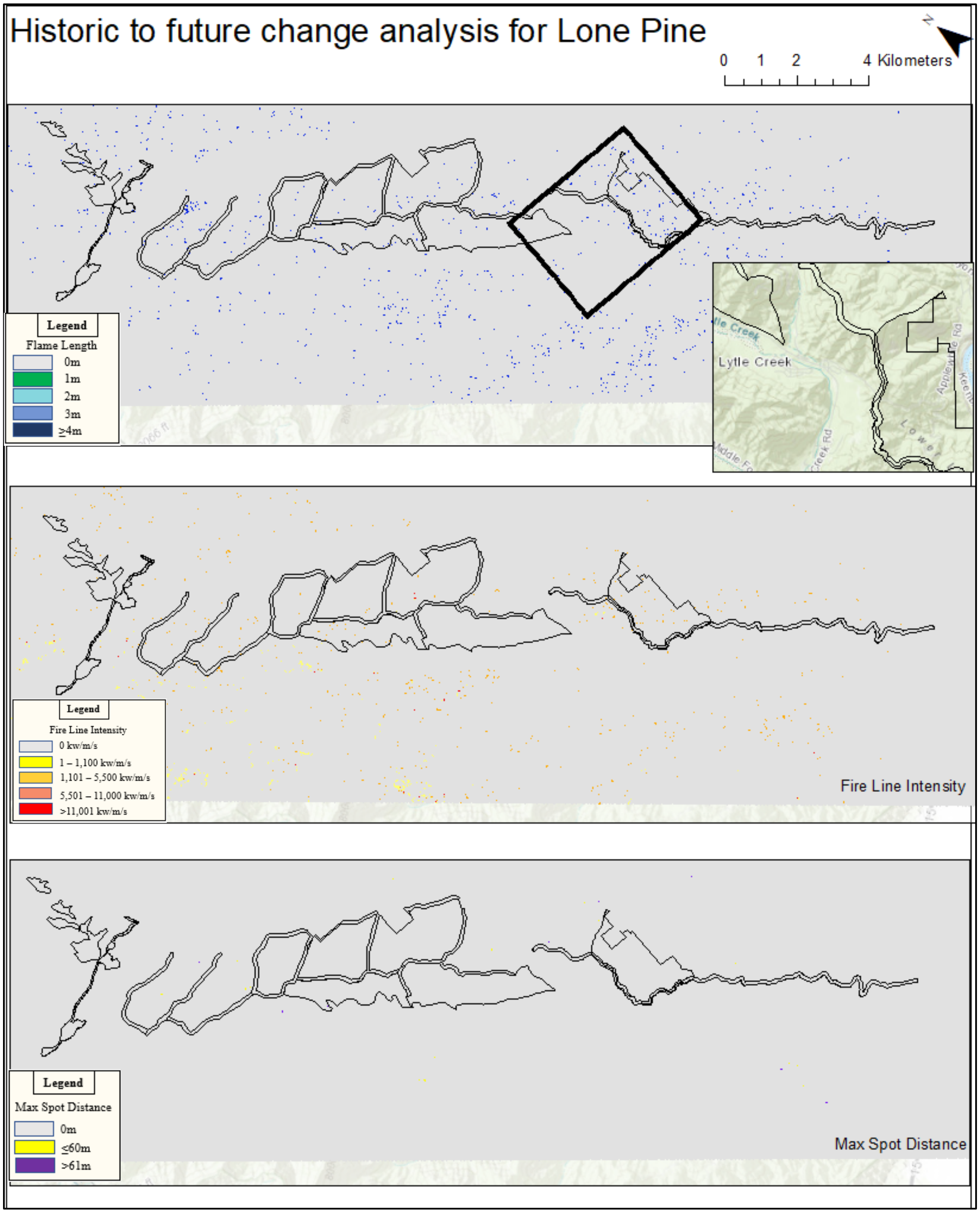

Figure 4.5: ArcGIS raster change analysis from historic to future climate conditions for Lone Pine with each fire behavior class. Fuel treatment is black outline with the buffer area in gray

5. Conclusion

We found little change in flame length, fire line intensity, max spot distance, and crown fire activity under modeled future conditions within the four fuel treatments. Outside the fuel treatments, in the buffered areas, some fuel treatments saw increased activity, such as the increased fire line intensity on Camino Cielo west that could impact Camino Cielo effectiveness. It is important to understand how a changing climate will impact current fuel treatment effectiveness for retreatment planning. The projected small change in fire behavior will increase the cost-effectiveness of fuel treatment programs by allowing land managers to focus on strategic areas that require further reduction of fuels or widen treatments to allow for safe fire management operations, protection of property, life, and egress.

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Appendix A: Crosswalks to determine treated landscape changes within the fuel treatment polygon. LANDFIRE raster file inputs for fuel model, canopy cover, crown height, canopy bulk density, and crown base height.

Fuel Model:

Fuel Model: Chilao			
SB40	**25%**	**50%**	**75%**
91-99	No Change	No Change	No Change
101	101	101	101
102	101	101	101
121	102	101	101
122	121	121	102
142	122	121	121
147	141	121	121
161	161	181	161
162	161	181	181
165	162	161	182
182	181	181	181
183	181	181	181
184	182	182	181
185	183	182	181
186	182	182	181
187	184	181	181
188	181	181	181
189	186	182	181

Fuel Model : Ojai CDZ	
SB40	**50%**
91-99	102
101	101
102	101
121	101
122	102
142	121
147	121
161	161
162	181
165	182
182	181
183	181
184	181
185	181
186	181
187	181
188	181
189	181

Fuel Model: Camino Cielo West and East, Lone Pine Road	
SB40	**50%**
102	101
121	101
122	102
142	121
147	121
162	181
165	182
182	181
183	181
184	181
185	181
186	181
187	181
188	181
189	181

Fuel Model: Lone Pine RX	
SB40	**40%**
102	101
121	101
122	102
142	121
147	121
162	181
165	161
182	181
183	181
184	182
185	182
186	182
187	181
188	181
189	181

Canopy Cover:

Canopy Cover: Chilao			
Value	**0%**	**25%**	**50%**
0	0	0	0
15	15	11	8
25	25	19	13
35	35	26	18
45	45	34	23
55	55	41	28
65	65	49	33
75	75	56	38
85	85	64	43
95	95	71	48

Camino Cielo West and East, Ojai, Lone Pine Road	
Value	**50%**
0	0
15	8
25	13
35	18
45	23
55	28
65	33
75	38
85	43
95	48

Canopy Cover: Lone Pine RX	
Value	**40%**
0	0
15	9
25	15
35	21
45	27
55	33
65	39
75	45
85	51
95	57

Canopy Height:

Canopy Height: Chilao			
Untreated	0%	25%	50%
0	0	0	0
25	25	19	13
75	75	56	38
175	175	131	88
375	375	281	188
500	500	375	250

Canopy Height: Camino Cielo West and East, Ojai, Lone Pine Road	
Untreated	50%
0	0
25	13
75	38
175	88
375	188
500	250

Canopy Height: Lone Pine RX	
Untreated	40%
0	0
25	15
75	45
175	105
375	225
500	300

Canopy Bulk Density:

Canopy Bulk Density: Chilao			
Untreated	0%	25%	50%
1	1	1	1
2	2	2	1
3	3	2	2
4	4	3	2
5	5	4	3
6	6	5	3
7	7	5	4
8	8	6	4
9	9	7	5
11	11	8	6
12	12	9	6
16	16	12	8
17	17	13	9
18	18	14	9
22	22	17	11
24	24	18	12
25	25	19	13
27	27	20	14
30	30	23	15
34	34	26	17
35	35	26	18
38	38	29	19
45	45	34	23

Canopy Bulk Density: Camino Ceilo West and East, Ojai, Lone Pine Road	
Untreated	50%
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5
11	6
12	6
16	8
17	9
18	9
22	11
24	12
25	13
27	14
30	15
34	17
35	18
38	19
45	23

Canopy Bulk Density: Lone Pine RX	
Untreated	40%
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5
11	7
12	7
16	10
17	10
18	11
22	13
24	14
25	15
27	16
30	18
34	20
35	21
38	23
45	27

Canopy Base Height:

Canopy Base Height: Chilao			
Untreated	**0%**	**25%**	**50%**
0	5	10	20
1	6	11	21
2	7	12	22
3	8	13	23
4	9	14	24
5	10	15	25
6	11	16	26
7	12	17	27
8	13	18	28
9	14	19	29
10	15	20	30
11	16	21	31
12	17	22	32
13	18	23	33
14	19	24	34
15	20	25	35
16	21	26	36
17	22	27	37
18	23	28	38
19	24	29	39
20	25	30	40
21	26	31	41
22	27	32	42
23	28	33	43
24	29	34	44
25	30	35	45
26	31	36	46
27	32	37	47
28	33	38	48

Canopy Base Height: Camino Cielo West and East, Ojai, Lone Pine Road	
Untreated	**50%**
0	20
1	21
2	22
3	23
4	24
5	25
6	26
7	27
8	28
9	29
10	30
11	31
12	32
13	33
14	34
15	35
16	36
17	37
18	38
19	39
20	40
21	41
22	42
23	43
24	44
25	45
26	46
27	47
28	48

Canopy Bulk Height: Lone Pine RX	
Untreated	**40%**
0	15
1	16
2	17
3	18
4	19
5	20
6	21
7	22
8	23
9	24
10	25
11	26
12	27
13	28
14	29
15	30
16	31
17	32
18	33
19	34
20	35
21	36
22	37
23	38
24	39
25	40
26	41
27	42
28	43

Appendix B: Modeled historic and future temperature, relative humidity (RH), and fuel moistures of the 3rd and 97th percentiles along with FlamMap and FireFamily+ input details.

Camino Cielo, West

Camino Cielo, West										
FUTURE										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
76	104	7	28	8	270	2	2	4	2	60

HISTORIC										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
68	97	8	29	8	270	2	2	4	2	60

*wind direction average during fire interception dates used for FlamMap

Camino Cielo, West	
Dates for FireFamily+:	May 15 - September 15
Dates for FlamMap analysis:	July 8 - 19
FlamMap time for min temp:	200
FlamMap time for max temp:	1400
Los Prietos RAWS station elevation:	311m

Camino Cielo, East

Camino Cielo, East										
FUTURE										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
64	98	12	45	7	22	2	3	5	2	60

HISTORIC										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
57	91	14	47	7	22	3	4	7	3	60

*wind direction average during fire interception dates used for FlamMap

Camino Cielo, East	
Dates for FireFamily+:	September 15 - February 15
Dates for FlamMap analysis:	December 8 - 19
FlamMap time for min temp:	200
FlamMap time for max temp:	1400
Montecito RAWS station elevation:	457m

Ojai:

Ojai										
FUTURE										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
62	100	12	49	5	255	3	4	7	3	64

HISTORIC										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
55	93	14	52	5	255	3	4	8	3	64

*wind direction average during fire interception dates used for FlamMap

Ojai	
Dates for FireFamily+:	September 15 - February 15
Dates for FlamMap analysis:	December 4 - 12
FlamMap time for min temp:	200
FlamMap time for max temp:	1400
Ojai RAWS station elevation:	233m

Chilao:

Chilao										
FUTURE										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
75	103	19	63	10	270	3	5	9	4	72

HISTORIC										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
67	97	19	64	10	270	3	5	10	4	72

*wind direction average during fire interception dates used for FlamMap

Chilao	
Dates for FireFamily+:	May 15 - September 15
Dates for FlamMap analysis:	August 25 – September 1
FlamMap time for min temp:	300
FlamMap time for max temp:	1200
Chilao RAWS station elevation:	1661m

Lone Pine:

Lone Pine										
FUTURE										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
62	95	10	51	4	225	2	3	7	3	63

HISTORIC										
97%		3%		97%	*	3%				
Min Temp	**Max Temp**	**Min RH**	**Max RH**	**Wind Speed**	**Wind dir**	**1 hr**	**10 hr**	**100 hr**	**Herb**	**Woody**
55	88	11	51	4	225	2	3	7	3	64

*wind direction average during fire interception dates used for FlamMap

Lone Pine	
Dates for FireFamily+:	May 15 - September 15
Dates for FlamMap analysis:	August 16 - 23
FlamMap time for min temp:	300
FlamMap time for max temp:	1300
Mormon Rocks RAWS station elevation:	1005m

Appendix C: Crown fire activity (CFA) reclassification matrix. Future CFA was reclassified from 1 to 10, 2 to 20, and 3 to 30 so the change analysis captures the change in each class.

		FUTURE		
		1 (10)	**2 (20)**	**3 (30)**
HISTORIC	**1**	🟩 9	🟧 19	🟪 29
	2	X	🟩 18	🟦 28
	3	X	X	🟩 27

🟩 0 CFA	🟧 Surface to Passive	🟦 Passive to Active	🟪 Surface to Active

Appendix D: Total pixels per fire behavior category inside the fuel treatment polygon for modeled historic and future climate conditions, where percent relative delta is a relative percent change between each fire behavior class, percent relative area is percentage of each category inside the fuel treatment polygon, and percent area absolute change is the absolute change between historic and future fuel treatment area of each fire behavior category.

Camino Cielo: West				
HISTORIC		**FUTURE**		
Total pixels in fuel treatment area for FL	3456.00	**Total pixels in fuel treatment area for FL**	3456.00	
Total pixels FL 0m	1978.00	**Total pixels FL 0m**	1921.00	
Total pixels for FL 1m	1218.00	**Total pixels for FL 1m**	1218.00	
Total pixels for FL 2m	203.00	**Total pixels for FL 2m**	249.00	
Total pixels for FL 3m	31.00	**Total pixels for FL 3m**	41.00	
Total pixels for FL >=4m	26.00	**Total pixels for FL >=4m**	27.00	
Total pixels in fuel treatment area for FLI	3456.00	**Total pixels in fuel treatment area for FLI**	3456.00	
Total pixels with 0 FLI	291.00	**Total pixels with 0 FLI**	291.00	
Total Pixels for FLI <1,100 kw	3078.00	**Total Pixels for FLI <1,100 kw**	3068.00	
Total pixels for FLI 1,101-5,500 kw	68.00	**Total pixels for FLI 1,101-5,500 kw**	78.00	
Total pixels for 5,501 - 11,000 kw	17.00	**Total pixels for 5,501 - 11,000 kw**	15.00	
Total pixels for >11,001 kw	2.00	**Total pixels for >11,001 kw**	4.00	
Total pixels in fuel treatment area for MSD	3456.00	**Total pixels in fuel treatment area for MSD**	3456.00	
Total pixels with MSD 0m	2946.00	**Total pixels with MSD 0m**	2836.00	
Total pixels for MSD <60m	37.00	**Total pixels for MSD <60m**	23.00	
Total pixels for MSD >61m	473.00	**Total pixels for MSD >61m**	597.00	
From Historic to Future	**% Relative Delta**	**% Relative Area (Historic)**	**% Relative Area (Future)**	**%Area (Absolute Change)**
Percent change: FL 0m	-2.88	57.23	55.58	-1.65
Percent change: FL 1m	0.00	35.24	35.24	0.00
Percent change: FL 2m	22.66	5.87	7.20	1.33
Percent change: FL 3m	32.26	0.90	1.19	0.29
Percent change: FL >=4m	3.85	0.75	0.78	0.03
Percent change: FLI 0 kw/m/s	0.00	8.42	8.42	0.00
Percent change: FLI <1,100 kw	-0.32	89.06	88.77	-0.29
Percent change: FLI 1,101 - 5,500 kw	14.71	1.97	2.26	0.29
Percent change: FLI 5,501 - 11,000 kw	-11.76	0.49	0.43	-0.06
Percent change: FLI > 11,001 kw	100.00	0.06	0.12	0.06
Percent change: MSD 0m	-3.73	85.24	82.06	-3.18
Percent change: MSD <60m	-37.84	1.07	0.67	-0.41
Percent change: MSD >61m	26.22	13.69	17.27	3.59

Camino Cielo: East				
HISTORIC		FUTURE		
Total pixels in fuel treatment area for FL	2081.00	Total pixels in fuel treatment area for FL	2081.00	
Total pixels FL 0m	1247.00	Total pixels FL 0m	1227.00	
Total pixels for FL 1m	523.00	Total pixels for FL 1m	529.00	
Total pixels for FL 2m	121.00	Total pixels for FL 2m	133.00	
Total pixels for FL 3m	122.00	Total pixels for FL 3m	126.00	
Total pixels for FL >=4m	68.00	Total pixels for FL >=4m	66.00	
Total pixels in fuel treatment area for FLI	2081.00	Total pixels in fuel treatment area for FLI	2081.00	
Total pixels with FLI 0	194.00	Total pixels with FLI 0	194.00	
Total Pixels for FLI <1,100 kw	1667.00	Total Pixels for FLI <1,100 kw	1676.00	
Total pixels for FLI 1,100-5,500 kw	205.00	Total pixels for FLI 1,101-5,500 kw	182.00	
Total pixels for 5,501 - 11,000 kw	14.00	Total pixels for 5,501 - 11,000 kw	29.00	
Total pixels for >11,001 kw	1.00	Total pixels for >11,001 kw	0.00	
Total pixels in fuel treatment area for MSD	2081.00	Total pixels in fuel treatment area for MSD	2081.00	
Total pixels with MSD 0m	1767.00	Total pixels with MSD 0m	1754.00	
Total pixels for MSD <60m	90.00	Total pixels for MSD <60m	92.00	
Total pixels for MSD >61m	224.00	Total pixels for MSD >61m	235.00	
From Historic to Future	% Relative Delta	% Relative Area (historic)	% Relative Area (future)	%Area (absolute change)
Percent change: FL 0m	-1.60	59.92	58.96	-0.96
Percent change: FL 1m	1.15	25.13	25.42	0.29
Percent change: FL 2m	9.92	5.81	6.39	0.58
Percent change: FL 3m	3.28	5.86	6.05	0.19
Percent change: FL >=4m	-2.94	3.27	3.17	-0.10
Percent change: FLI 0 kw/m/s	0.00	9.32	9.32	0.00
Percent change: FLI <1,100 kw	0.54	80.11	80.54	0.43
Percent change: FLI 1,101 - 5,500 kw	-11.22	9.85	8.75	-1.11
Percent change: FLI 5,501 - 11,000 kw	107.14	0.67	1.39	0.72
Percent change: FLI > 11,001 kw	0.00	0.05	0.00	-0.05
Percent change: MSD 0m	-0.74	84.91	84.29	-0.62
Percent change: MSD <60m	2.22	4.32	4.42	0.10
Percent change: MSD >61m	4.91	10.76	11.29	0.53

Ojai				
HISTORIC		FUTURE		
Total pixels in fuel treatment area for FL	11402.00	Total pixels in fuel treatment area for FL	11402.00	
Total pixels FL 0m	8720.00	Total pixels FL 0m	8515.00	
Total pixels for FL 1m	2200.00	Total pixels for FL 1m	2376.00	
Total pixels for FL 2m	270.00	Total pixels for FL 2m	273.00	
Total pixels for FL 3m	117.00	Total pixels for FL 3m	132.00	
Total pixels for FL >=4m	95.00	Total pixels for FL >=4m	106.00	
Total pixels in fuel treatment area for FLI	11402.00	Total pixels in fuel treatment area for FLI	11402.00	
Total pixels with FLI 0	289.00	Total pixels with FLI 0	283.00	
Total Pixels for FLI <1,100 kw	10868.00	Total Pixels for FLI <1,100 kw	10851.00	
Total pixels for FLI 1,101-5,500 kw	230.00	Total pixels for FLI 1,101-5,500 kw	250.00	
Total pixels for 5,501 - 11,000 kw	15.00	Total pixels for 5,501 - 11,000 kw	18.00	
Total pixels for >11,001 kw	0.00	Total pixels for >11,001 kw	0.00	
Total pixels in fuel treatment area for MSD	11402.00	Total pixels in fuel treatment area for MSD	11402.00	
Total pixels with MSD 0m	10429.00	Total pixels with MSD 0m	10402.00	
Total pixels for MSD <60m	421.00	Total pixels for MSD <60m	432.00	
Total pixels for MSD >61m	552.00	Total pixels for MSD >61m	568.00	
From Historic to Future	% Relative Delta	% Relative Area (historic)	% Relative Area (future)	%Area (absolute change)
Percent change: FL 0m	-2.35	76.48	74.68	-1.80
Percent change: FL 1m	8.00	19.29	20.84	1.54
Percent change: FL 2m	1.11	2.37	2.39	0.03
Percent change: FL 3m	12.82	1.03	1.16	0.13
Percent change: FL >=4m	11.58	0.83	0.93	0.10
Percent change: FLI 0 kw/m/s	-2.08	2.53	2.48	-0.05
Percent change: FLI <1,100 kw	-0.16	95.32	95.17	-0.15
Percent change: FLI 1,101 - 5,500 kw	8.70	2.02	2.19	0.18
Percent change: FLI 5,501 - 11,000 kw	20.00	0.13	0.16	0.03
Percent change: FLI > 11,001 kw	0.00	0.00	0.00	0.00
Percent change: MSD 0m	-0.26	91.47	91.23	-0.24
Percent change: MSD <60m	2.61	3.69	3.79	0.10
Percent change: MSD >61m	2.90	4.84	4.98	0.14

Chilao				
HISTORIC		**FUTURE**		
Total pixels in fuel treatment area for FL	11658.00	**Total pixels in fuel treatment area for FL**	11658.00	
Total pixels FL 0m	4116.00	**Total pixels FL 0m**	4117.00	
Total pixels for FL 1m	2672.00	**Total pixels for FL 1m**	2661.00	
Total pixels for FL 2m	989.00	**Total pixels for FL 2m**	976.00	
Total pixels for FL 3m	1131.00	**Total pixels for FL 3m**	1131.00	
Total pixels for FL >=4m	2750.00	**Total pixels for FL >=4m**	2773.00	
Total pixels in fuel treatment area for FLI	11658.00	**Total pixels in fuel treatment area for FLI**	11658.00	
Total pixels with 0 FLI	335.00	**Total pixels with 0 FLI**	334.00	
Total Pixels for FLI <1,100 kw	9239.00	**Total Pixels for FLI <1,100 kw**	9480.00	
Total pixels for FLI 1,100-5,500 kw	1270.00	**Total pixels for FLI 1,101-5,500 kw**	1151.00	
Total pixels for 5,501 - 11,000 kw	319.00	**Total pixels for 5,501 - 11,000 kw**	256.00	
Total pixels for >11,001 kw	495.00	**Total pixels for >11,001 kw**	437.00	
Total pixels in fuel treatment area for MSD	11658.00	**Total pixels in fuel treatment area for MSD**	11658.00	
Total pixels with 0m MSD	9482.00	**Total pixels with 0m MSD**	9470.00	
Total pixels for MSD <60m	9.00	**Total pixels for MSD <60m**	9.00	
Total pixels for MSD >61m	2167.00	**Total pixels for MSD >61m**	2179.00	
Total pixels in fuel treatment area for CFA	11658.00	**Total pixels in fuel treatment area for CFA**	11658.00	
Total pixels with no data CFA	334.00	**Total pixels with no data CFA**	334.00	
Total pixels CFA Surface	9107.00	**Total pixels CFA Surface**	9095.00	
Total pixels CFA Passive	1873.00	**Total pixels CFA Passive**	1877.00	
Total pixels CFA Active	344.00	**Total pixels CFA Active**	352.00	
From Historic to Future	**% Relative Delta**	**% Relative Area (historic)**	**% Relative Area (future)**	**%Area (absolute change)**
Percent change: FL 0m	0.02	35.31	35.31	0.01
Percent change: FL 1m	-0.41	22.92	22.83	-0.09
Percent change: FL 2m	-1.31	8.48	8.37	-0.11
Percent change: FL 3m	0.00	9.70	9.70	0.00
Percent change: FL >=4m	0.84	23.59	23.79	0.20
Percent change: FLI 0 kw/m/s	-0.30	2.87	2.86	-0.01
Percent change: FLI <1,100 kw	2.61	79.25	81.32	2.07
Percent change: FLI 1,101 - 5,500 kw	-9.37	10.89	9.87	-1.02
Percent change: FLI 5,501 - 11,000 kw	-19.75	2.74	2.20	-0.54
Percent change: FLI > 11,001 kw	-11.72	4.25	3.75	-0.50
Percent change: MSD 0m	-0.13	81.33	81.23	-0.10
Percent change: MSD <60m	0.00	0.08	0.08	0.00
Percent change: MSD >61m	0.55	18.59	18.69	0.10
Percent change: CFA no data	0.00	2.86	2.86	0.00
Percent change: CFA surface to passive	-0.13	78.12	78.02	-0.10
Percent change: CFA passive to active	0.21	16.07	16.10	0.03
Percent change: CFA surface to active	2.33	2.95	3.02	0.07

Lone Pine				
HISTORIC		**FUTURE**		
Total pixels in fuel treatment area for FL	23220.00	**Total pixels in fuel treatment area for FL**	23220.00	
Total pixels FL 0m	7401.00	**Total pixels FL 0m**	7523.00	
Total pixels for FL 1m	10623.00	**Total pixels for FL 1m**	10531.00	
Total pixels for FL 2m	1938.00	**Total pixels for FL 2m**	1903.00	
Total pixels for FL 3m	1839.00	**Total pixels for FL 3m**	1802.00	
Total pixels for FL >=4m	1419.00	**Total pixels for FL >=4m**	1461.00	
Total pixels in fuel treatment area for FLI	23220.00	**Total pixels in fuel treatment area for FLI**	23220.00	
Total pixels with 0 FLI	438.00	**Total pixels with 0 FLI**	438.00	
Total Pixels for FLI <1,100 kw	18403.00	**Total Pixels for FLI <1,100 kw**	18429.00	
Total pixels for FLI 1,100-5,500 kw	3713.00	**Total pixels for FLI 1,101-5,500 kw**	3644.00	
Total pixels for 5,501 - 11,000 kw	664.00	**Total pixels for 5,501 - 11,000 kw**	705.00	
Total pixels for >11,001 kw	2.00	**Total pixels for >11,001 kw**	4.00	
Total pixels in fuel treatment area for MSD	23220.00	**Total pixels in fuel treatment area for MSD**	23220.00	
Total pixels with MSD 0m	19379.00	**Total pixels with MSD 0m**	19395.00	
Total pixels for MSD <60m	2581.00	**Total pixels for MSD <60m**	2565.00	
Total pixels for MSD >61m	1260.00	**Total pixels for MSD >61m**	1260.00	
From Historic to Future	**% Relative Delta**	**%Area (historic)**	**% Relative Area (future)**	**%Area (absolute change)**
Percent change: FL 0m	1.65	31.87	32.40	0.53
Percent change: FL 1m	-0.87	45.75	45.35	-0.40
Percent change: FL 2m	-1.81	8.35	8.20	-0.15
Percent change: FL 3m	-2.01	7.92	7.76	-0.16
Percent change: FL >=4m	2.96	6.11	6.29	0.18
Percent change: FLI 0 kw/m/s	0.00	1.89	1.89	0.00
Percent change: FLI <1,100 kw	0.14	79.25	79.37	0.11
Percent change: FLI 1,101 - 5,500 kw	-1.86	15.99	15.69	-0.30
Percent change: FLI 5,501 - 11,000 kw	6.17	2.86	3.04	0.18
Percent change: FLI > 11,001 kw	100.00	0.01	0.02	0.01
Percent change: MSD 0m	0.08	83.46	83.53	0.07
Percent change: MSD <60m	-0.62	11.12	11.05	-0.07
Percent change: MSD >61m	0.00	5.43	5.43	0.00