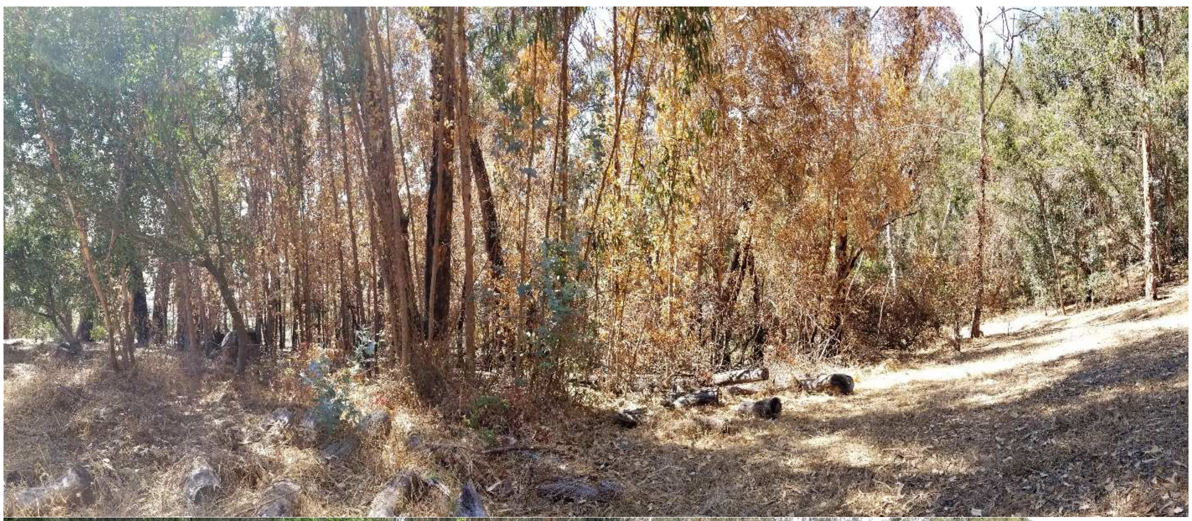
Characterization of Fuels, Fire Hazards, and Recommendations, Albany Hill, Albany, CA

December 13, 2022



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Summary

This report assesses and describes the types of fuels and their relative fire hazards on the Albany Hill and Creekside Park in the City of Albany in Alameda County, California as well as the privately held open spaces on Albany Hill and its surroundings. It builds upon a 2012 Vegetation Management Plan in the Albany Hill Creekside Master Plan[1] and extends the analysis to adjacent parcels. This addition sets the foundation for multi-owner grant proposals and management that would reduce hazard for the entire hill, rather than be limited to City-owned property. This report also integrates information from a consulting biologist, aimed at protecting monarch butterflies.

Fuels are generally based on vegetation type. Several changes in fuel conditions since the 2012 Vegetation Management Plan have occurred. Importantly, the City has performed several fire hazard reduction measures, both in the eucalyptus groves along the ridgeline and in the oak woodlands north of Jackson St. Property owners – especially those east of Pierce – have completed admirable work to reduce fire hazards. Along the southern boundary of City property, defensible space is limited by property boundaries, and therefore does not extend to 100-ft from structures.

Wildland fire behavior predictions indicate a high level of hazard, with more than a quarter of the area expected to burn with exceedingly long flame lengths, rapid rate of fire spread and widespread torching and production of embers. The highest hazard is in the eucalyptus stands on the top of Albany Hill. The area north and east of Jackson St is where the wildfire hazard is least.

The Fire Management Goals and Possible Actions from the 2012 Vegetation Management Plan are affirmed. Recommended actions correspond to vegetation type, distance from structures, as well as the health of eucalyptus trees and presence of monarch habitat. Specific recommended actions are to:

- Remove dead and dying eucalyptus throughout the area, and specifically on City property. Grants should be pursued to fund this costly operation that will benefit the wider community
- Continue thinning of understory shrubs in the oak woodlands, and remove small dead material created by those operations. Large dead material (larger than four inches) can and should be used to dissuade unauthorized trail development and use.
- Defensible space should be created and maintained within 100-ft of all structures. The City should work with landowners that have structures within 100-ft of City property to achieve this goal. This is another action that could be funded with grants.
- Where monarch butterfly habitat is present, the City and private landowners should consider alternative fuel management strategies whereby mid-story vegetation is not removed for fire hazard reduction, but kept for wind reduction. Specific and limited

[1] https://www.albanyca.org/home/showdocument?id=28577

tree planting is recommended on private property so that wind can be reduced over time. The wildfire of 2022 impacted the area where planting was to be targeted,

Introduction

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This report includes the following:

1. Results of fuel assessment, and description of the types of fuels (total fuel volume, fuel characteristics such as amount of woody material, dead and downed debris and height to live crown)
2. Relative fire hazards, based on fire behavior analysis and hazard mapping completed by other entities
3. Proposed treatments (projects) to reduce hazards, with priorities.

The following tasks were accomplished:

- Initial meeting with City staff
- Determine areal scope, collaborators, including adjacent properties
- Review existing plans, previous work
- Assess fuel management's effect on butterflies
- Site visit
- Data collection of existing fuel models, volumes characteristics
- Description of fire behavior
- Development of recommendations for projects
- Propose treatment methods, sequencing, prioritization
- Prepare grant justifications, cost estimates
- Prepare report

The area focused on in this report are the properties that make up the Albany Hill and Creekside Park boundary (shown in magenta in Figure 1). A buffer area of 1000 feet from this boundary is the study area analyzed. The total area with the boundary of the Albany Hills and Creekside park is 55.8 acres and the study area amounts to 292.1 acres.

FIGURE 1. STUDY AREA BOUNDARY MAP.

Methods

In order to assess the fuels on the property, we evaluated several different datasets and approaches. Fuels are classified into surface fuels, and canopy fuels. Surface fuels are those that will carry the fire near the surface of the ground, generally below 12 feet in height. Surface fuels can be comprised of grass (both live and dead), foliage of both herbaceous and woody plants, and various sizes of dead twigs, branches and logs. Canopy fuels are those in the tree canopy, comprised of living and dead foliage and branches, and bark, attached to the tree trunk.

Vegetation/Fuel Model/Canopy Fuel Datasets and Observations

1. We reviewed the mapped vegetation types from the 2012 Vegetation Management Plan, considering whether the vegetation types corresponded well to fuel types, as defined by Scott and Burgan, 2005.

2. We reviewed LandFire, 2016 version for its nation-wide set of standardized fuel types. We purchased readily available data from the California Forest Observatory (CFO, 2020)[2]. The data used in this analysis was: surface fuels, canopy height, canopy base height, canopy bulk density, and canopy density. Figures 2, and 11-13 portray the distribution of values in each of these fuel characteristics.
3. We met with City of Albany staff four times, on October 29, 2021, January 14, 2022, April 15, 2022, and August 8, 2022.
4. In addition, we met with City staff and Stuart Weiss, to discuss how monarch habitat and wildfire hazards interact. In addition, C. Rice visited the site after the March, 2022 wildfire east of Pierce Street. This was not to inform fuel types.

We also visited the site a third time to confirm fuel characteristics and compare the status with the previous mapping of vegetation and fuels.

The surface fuels layer was changed to reflect on-the-ground conditions. The canopy fuels data, and ladder fuel density were assumed to be representative of on-site conditions. A summary of each used in this modeling effort is presented below.

Data from the California Forest Observatory maps the drivers of wildfire behavior across the state of California including vegetation fuels. These data were derived from two data sources: airborne lidar and satellites.

The forest structure metrics were initially derived directly from airborne lidar data, hosted by the USGS 3D Elevation Program. However, these data are only available for a small fraction of California's 423,970 km^2 area. To overcome this, deep learning models – a form of pattern recognition – were used to identify these forest structure patterns (illuminated by the LiDAR data) in satellite imagery, then mapped each metric statewide.

The surface fuel models referenced in this document are classified in the system devised by Joe H. Scott and Robert E. Burgan in *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model*[4]. In their system, similar to previous surface fuel model sets, a series of numbers represent fuel models that are grouped by fire-carrying fuel type. Because of the nature of raster calculations, these are represented in the database as numbers. These fuel types and their corresponding numbers, as shown on Figure 2, are:

- Nonburnable (NB) – from 91 to 99
- Grass (GR) – 100s
- Grass-Shrub (GS) – 120s

[2] California Forest Observatory (2020). A Statewide Tree-Level Forest Monitoring System. Salo Sciences, Inc. San Francisco, CA. https://forestobservatory.com

[4] Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

- Shrub (SH) – 140s
- Timber-Understory (TU) – 160s
- Timber Litter (TL) – 180s
- Slash-Blowdown (SB) – 200s

Further details on each fuel model and their associated fuel loading by size class is provided in the Scott and Burgan's paper.

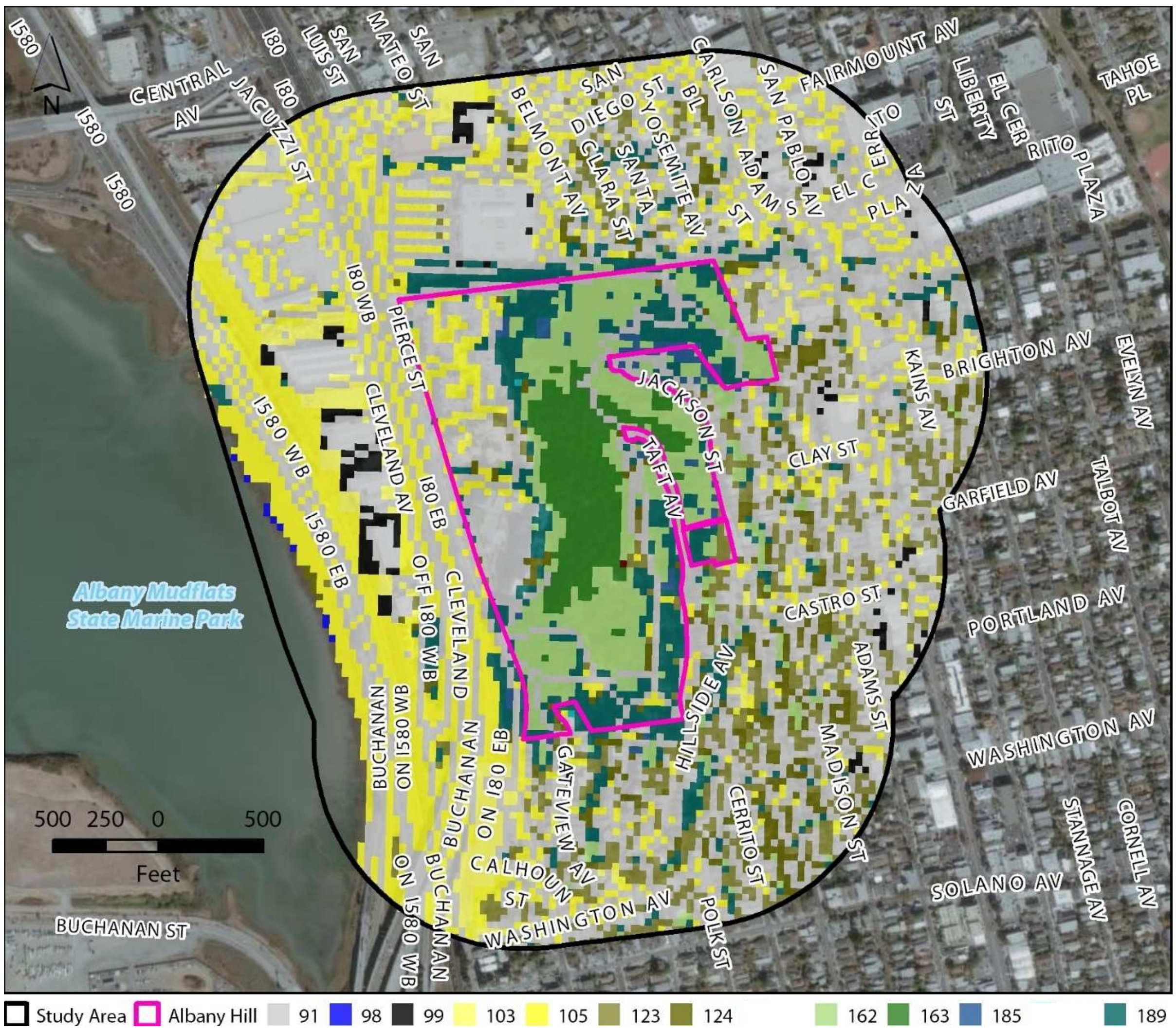


FIGURE 2. SURFACE FUEL MODEL MAP (CFO, 2020). ALBANY HILL PARK OUTLINED IN MAGENTA. STUDY AREA OUTLINED IN BLACK. SEE TABLE 1 FOR LEGEND DESCRIPTION.

After field visits by the consulting team, it was determined that some of the initial fuel assignments made by CFO did not accurately capture the fuels on the ground given the vegetation management work recently completed onsite. While some areas were over-representing fuel loading, other areas were not. Based on vegetation mapping completed for the property and observations from several site visits new fuel models were assigned for Albany Hill as mapped in Figure 3 below.

Fuels changed over time due to (1) management since the 2012 Vegetation Management Plan, (2) mortality of eucalyptus trees, (4) growth of the understory, sometimes from shrubby fuels into short trees, and (4) a recent fire, on June 26, 2022.

In many cases the description of vegetation in the 2012 Vegetation Management Plan is still valid, however, one whole vegetation type (Eucalyptus Forest Toyon Hill Top) is no longer appropriate. Because of the growth of young oaks, this area would best be classified in the mapping scheme of the 2012 Vegetation Management Plan as Eucalyptus Oak Woodland.

The 2022 fire burned, with varying intensity, influenced by topography and fuel volume available to burn. The fire burned eastward from Pierce, uphill to an informal trail and formed most of the eastern boundary of the fire. This further changed fuels however, the maps in this report have not been updated to reflect the new fuel models.

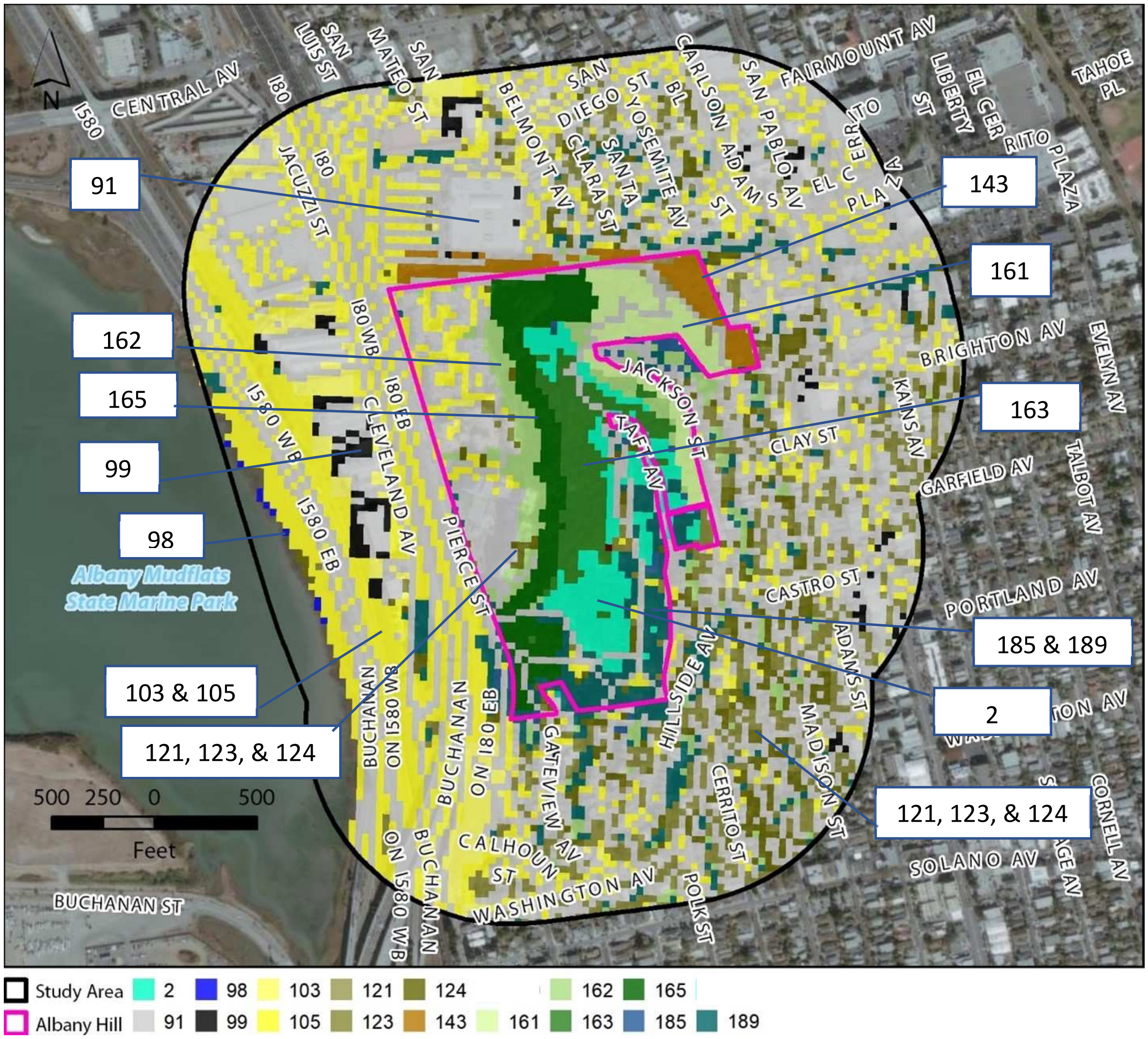


FIGURE 3. ALTERED BASED ON FIELD OBSERVATIONS SURFACE FUEL MODEL MAP (WRM, 2022). ALBANY HILL PARK OUTLINED IN MAGENTA. STUDY AREA OUTLINED IN BLACK. SEE TABLE 1 FOR LEGEND DESCRIPTION.

In the northeastern part of the property, Oak Woodland areas were changed to fuel model TU1 (161), grass areas had changed to a shrub/grass fuel model GS1 (121), and the riparian strip was changed to SH3 (143). In the norther section of the property, all treed areas were changed to TU5 (165). While immediately north of the property was changed to SH3 (143). In the southern tip, treed areas were also changed to TU5 (165). And immediately next to the building in the western part of the property, all treed areas were changed to TU5 (165). Additionally, in all other areas not already changed, the treed areas were assigned to an old Fuel Model 2 (from the original 13 fuel model set)[5]. While the 2012 Vegetation Management Plan did not assign

[5] Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rep. INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

fuel models to the vegetation types, these fuel models generally follow the vegetation types mapped in the 2012 Vegetation Management Plan, and modified based on in locations where the vegetation has changed since 2012, or where the vegetation type does not neatly correspond to fuel types.

One type of fire behavior analysis was conducted: a deterministic model to be used to compare before and after fuel treatments. The model used weather parameters which were derived from the 97th percentile data summarized for 10 years of data from the OAKLAND NORTH weather station located just south of the UC Berkeley Hill Campus.

Description of Surface Fuel Models

Discounting the non-burnable types (NB1, NB8, and NB9), which account for 47% of the area, as outlined in pink in Figure 3; four other fuel models account for the majority of the remainder of the area: GR5 (105), GS3 (123), TU2 (162), and TL9 (189).

FIGURE 4. GRASS MODEL GR5 (105).

The grass model (GR5) is located in the areas surrounding buildings and highways in the western part of the study area as well as interspersed throughout the surrounding residential and commercial center. These fuel types are generally associated with low to moderate flame lengths; however, fire spread can be rapid in the right conditions.

FIGURE 5. GRASS-SHRUB MODEL GS (121 TO 123), LOCATED ON THE WESTERN SIDE OF THE PARK WITH NATIVE UNDERSTORY SHRUBS.

FIGURE 6. GRASS-SHRUB MODEL GS (121 TO 123), IN LANDSCAPED YARDS SURROUNDING THE PARK

The grass-shrub model (GS3) is again found outside of the Albany Hills and Creekside Park boundary, but within the surrounding buildings. This likely represents landscape shrubs and native shrubs, and tangles of vines and dead debris. These fuel types can be source of embers.

FIGURE 7. TIMBER-UNDERSTORY FUEL MODEL (TU1, OR 161), WITH LOW HAZARD FUELS.

FIGURE 8. TIMBER-UNDERSTORY FUEL MODEL (TU2, OR 162), WITH LOW HAZARD FUELS. BECAUSE THE FUELS ARE COMPACT, THE PREDICTED FLAME LENGTHS ARE GENERALLY LOW IN THIS FUEL MODEL, EVEN THOUGH THE FUEL LOAD, OR VOLUME, IS MODERATE.

The timber-understory model (TU2) is the lighter green within the park boundary, surrounding the darker green (TU3). Together, these account for 10.3% of the study area. These fuel types represent treed areas with a significant amount of understory and ladder fuels (grass and/or toyon or short eucalyptus sprouts). Flame lengths can be moderate to high, with torching trees likely.

FIGURE 9. THE MOST HAZARDOUS TIMBER-UNDERSTORY FUEL MODEL (TU5, OR 165).

TL9 (189) accounts for 7.4% of the study area. This fuel model is shown in dark cyan on Figure 2 and Figure 3 and is located at the edges of developed area as well as between buildings. These likely represent older, larger eucalyptus with a well-developed layer of leaf litter and bark debris. This fuel model can produce relatively high flame lengths and rapid spread. When TL9 is assigned to other vegetation types, such as redwood stands, it is generally not a source of embers; however, eucalyptus stands categorized as TL9 can be expected to produce firebrands long distances.

FIGURE 10. THE MOST HAZARDOUS TIMBER-LITTER FUEL MODEL (TL9, OR 189).

TABLE 1. FUEL MODELS FOUND WITHIN THE STUDY BOUNDARY, AS SHOWN IN FIGURE 3.

Value	FBFM40	Title	Description	Acres	Percent
91	NB1	Urban/Developed	Urban/Developed	132.6	46.8%
98	NB8	Water	Water	0.2	0.1%
99	NB9	Bare Ground	Barren, Roads, Other	3.7	1.3%
2	FM2	Timber Grass and Understory	Fire spread is primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to litter and dead-down stemwood from the open shrub or timber overstory, contribute to the fire intensity. Moderate load.	7.2	2.5%
103	GR3	Low Load, Very Coarse, Humid Climate Grass	Low load, very coarse, humid climate grass continuous, coarse humid climate grass, any shrubs do not affect fire behavior	10.8	3.8%
105	GR5	Low Load, Humid Climate Grass	Low load, humid climate grass, fuelbed depth is about 1-2 feet	51.2	18.0%
121	GS1	Low Load, Dry Climate Grass-Shrub	Low load, dry climate grass-shrub shrub about 1 foot high, grass load low, spread rate moderate and flame length low	0.2	0.1%
123	GS3	Moderate Load, Humid Climate Grass-Shrub	Moderate load, humid climate grass-shrub, moderate grass/shrub load, grass/shrub depth is less than 2 feet, spread rate is high and flame length is moderate	21.6	7.6%
124	GS4	Moderate Load, Dry Climate Grass	Moderate load, dry climate grass, continuous, dry climate grass, fuelbed depth about 2 feet	11.1	3.9%
143	SH3	Moderate Load, Humid Climate Shrub	Moderate load, humid climate shrub, woody shrubs and shrub litter, possible pine overstory, fuelbed depth 2-3 feet, spread rate and flame low	3.8	1.3%
161	TU1	Low Load Dry Climate Timber-Grass-Shrub	Low load dry climate timber grass shrub, low load of grass and/or shrub with litter, spread rate and flame low	5.1	1.8%
162	TU2	Moderate Load, Humid Climate Timber-Shrub	Moderate load, humid climate timber-shrub, moderate litter load with some shrub, spread rate moderate and flame low	7.8	2.7%
163	TU3	Moderate Load, Humid Climate Timber-Grass-Shrub	Moderate load, humid climate timber grass shrub, moderate forest litter with some grass and shrub, spread rate high and flame moderate	5.6	2.0%
165	TU5	Very High Load, Dry Climate Timber-Shrub	Very high load, dry climate shrub, heavy forest litter with shrub or small tree understory, spread rate and flame moderate	7.8	2.7%
185	TL5	High Load Conifer Litter	High load conifer litter, light slash or dead fuel, spread rate and flame low	1.0	0.4%
189	TL9	Very High Load Broadleaf Litter	Very high load broadleaf litter, may be heavy needle drape, spread rate and flame moderate	13.9	4.9%

Canopy Fuels

Canopy fuels are not categorized into different models. Instead, they are measured in terms of canopy base height, canopy bulk density, and canopy cover. These characteristics are described below and portrayed in Figures 11-13.

Canopy base height is lowest portion of the tree canopy that could carry a fire upward into the tree. Usually, it is foliage, however, it could also be tree bark, or an accumulation of dead twigs in the tree canopy. It is an important value that influences the likelihood of torching.

Canopy cover is linked to canopy bulk density, and is the percentage of the area covered by tree crowns. This factors into the possibility of fire traveling from one tree crown to another without the support of a surface fire.

Canopy bulk density is the volume of foliage in the tree canopy in a given area. This is linked to canopy cover, but also considers the biomass in the tree canopy.

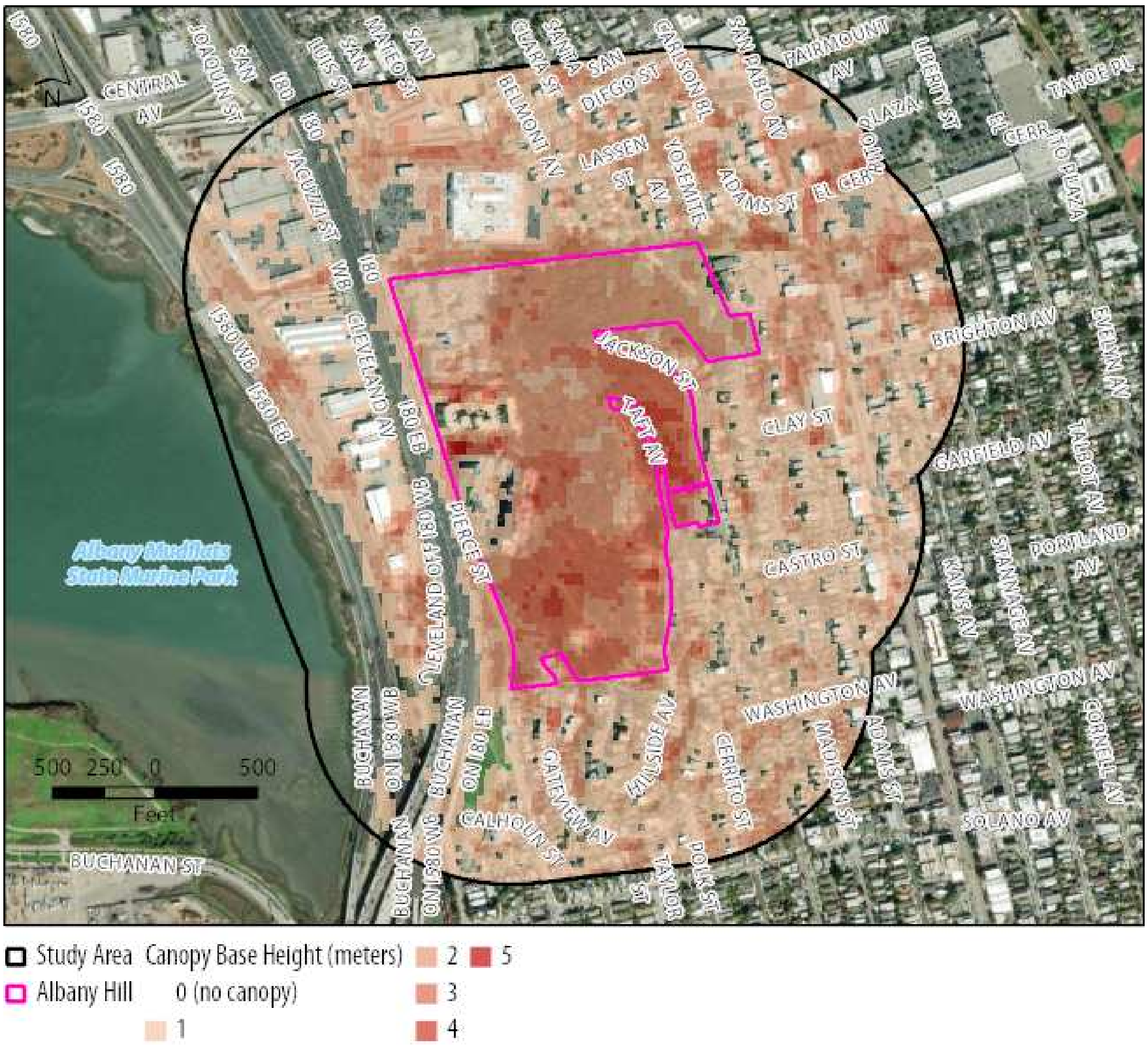


FIGURE 11. CANOPY BASE HEIGHT

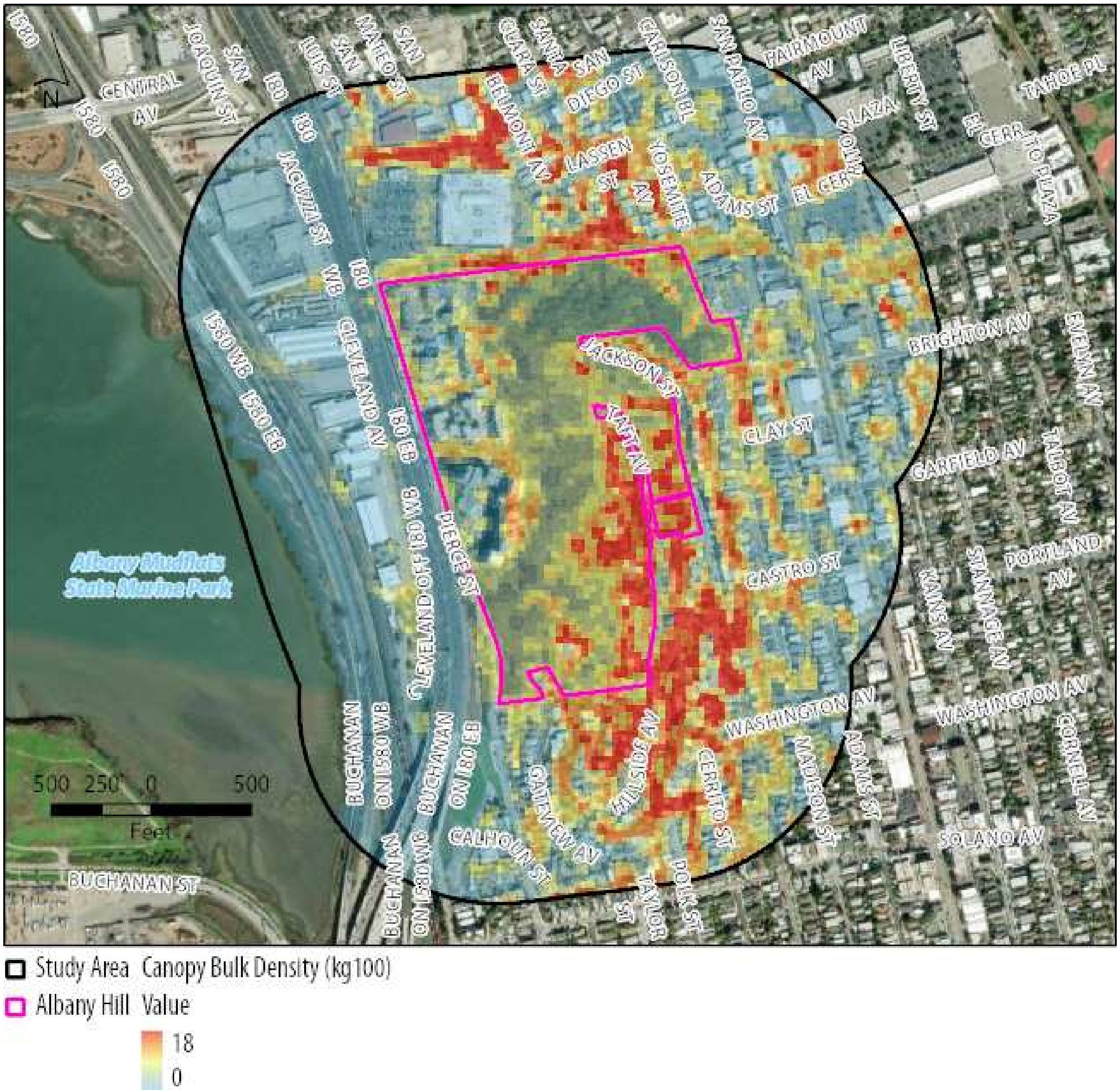


FIGURE 12. CANOPY BULK DENSITY.

FIGURE 13. CANOPY COVER.

Fire Behavior Modeling

Several fire behavior prediction software applications have been developed by the U.S. Forest Service. These include a wide variety of applications designed to specifically meet firefighting or fire prevention needs. For this analysis, we used one application FlamMap version 6.1.

FlamMap is a fire behavior mapping and analysis program that computes potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.). The FlamMap fire mapping and analysis system calculates fire behavior for each pixel within the landscape file *independently*, so FlamMap does not calculate fire spread across a landscape. It is designed for use by users familiar with fuels, weather, topography, wildfire situations and the associated terminology. Outputs are well-suited for landscape level comparisons of fuel treatment effectiveness because fuel is the only variable that changes. Outputs and comparisons can be used to identify combinations of hazardous fuel and topography, aiding in prioritizing fuel treatments[6].

Scenarios

We compiled weather data from a nearby RAWS station to reflect conditions that occur in 90th and 97th percentiles of a 10-year dataset (January 1995 to May 2021).

For all scenarios presented in this document, a fairly dry fuel moisture regime was used to model a "worst-case" scenario, though not necessarily the most extreme case. Due to climate change and other factors, a worst-case scenario that reflects the most extreme case has proven to be unpredictable.

Regardless, to predict fire behavior, three essential data categories are needed:

1. Fuel model characteristics
2. Weather conditions
3. Fuel moisture conditions

The inputs into the FlamMap scenarios, both the south/southwest and east/northeast (Diablo) scenarios, are summarized in Table 2.

The nearest Remote Automated Weather Station to the Albany Hill and Creekside Park is located just north of the City of Oakland off Grizzly Peak Boulevard near Marlborough Terrace. A summary of the 10-hr fuel moisture data for Oakland North shows that 10-hour fuel moistures are low throughout the year at this site. The Average hovers around 20% for much of the year, but minimum 10-hour fuel moistures fall below the 3rd percentile throughout the summer months. However, the longest sustained minimum 10-hr fuel moisture occurs during the months of September, October, and November. For this reason, further analysis focused on those months.

A review of the historic winds recorded during the months of September, October, and November reveal that **for all hours of the day**, the predominate wind direction in the area is from the south-southwest (11% of recordings). However, the strongest (fastest) winds recorded came from the north to northeast (over 40 mph) (see Figure 13).

The wind rose for the afternoon hours (from 1200 to 1500 hours), bears out these findings.

A quick summary of fuel moisture recorded for Oakland North show that a critical value of 2.6% was measured in 1999, with an average low of 4.3% for that year.

Though the Oakland North weather station recorded winds from the southwest, northeasterly winds (or Diablo winds[7]) can be especially conducive for transport of embers. The most extreme weather values

[6] Source: https://www.fs.usda.gov/rmrs/tools/flammap (accessed on 7/26/2021).

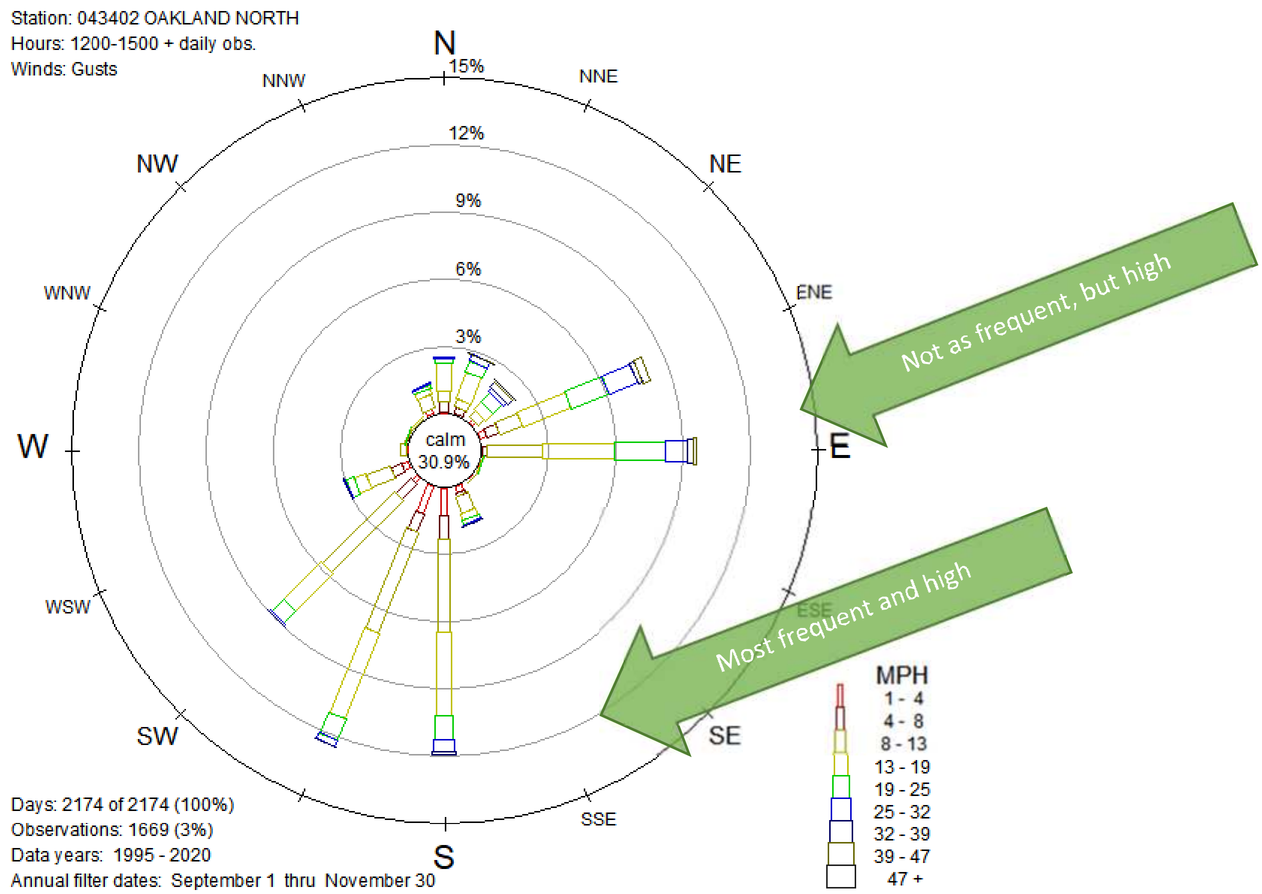
[7] Diablo winds are offshore wind events that flow northeasterly over Northern California's Coast Ranges, often creating extreme fire danger for the San Francisco Bay Area. Diablo winds are driven by a surface pressure gradient

typically are recorded during Diablo wind events in October, as was evident in the later part of October, 2019. Usually, days with recorded relative humidity below 20% are associated with Diablo wind events. Diablo events generally last from 15 to 35 hours. During a Diablo wind event, the wind direction is somewhat sporadic, sometimes even exhibiting a complete reversal for 2-4 hours. The wind speed ramps up slowly - from 1-2 mph up to its maximum speed, and then down again - similar to a bell-shaped curve.

Because Diablo wind events have been known to occur in the area (i.e. Tunnel fire of 1991), we used both southwesterly and northeast wind data for our fire behavior predictions. The former because it is the predominate wind direction at the site and the later to capture the worst-case scenario. Table 2 below shows the initial parameters used for two fire behavior prediction scenarios.

TABLE 2. WIND DIRECTION AND SPEED USED FOR FIRE BEHAVIOR PREDICTION SCENARIOS.

Scenario	Wind Direction	Wind Speed
South/Southwest	205 degrees	20 mph
East/Northeast	68 degrees	20 mph



that forms in response to an inverted pressure trough that develops over California. (Source: https://www.fireweather.org/diablo-winds)

Figure 14. Wind rose for Oakland North for the months of Sept/Oct/Nov from 1995-2020.

Table 3. Fuel moistures used for fire behavior predictions based on FireFamily Plus analysis.

Fuel Model	1hr time lag class	10hr time lag class	100 hr time lag class	Live herbaceous fuel moisture	Live woody fuel moisture
All models	4	5	10	40	60

For the inputs detailed in Table 2 and 3 above, the following fire behavior characteristics were predicted for the entire modeled area surrounding the Albany Hills and Creekside Park.

Flame Length (SW)

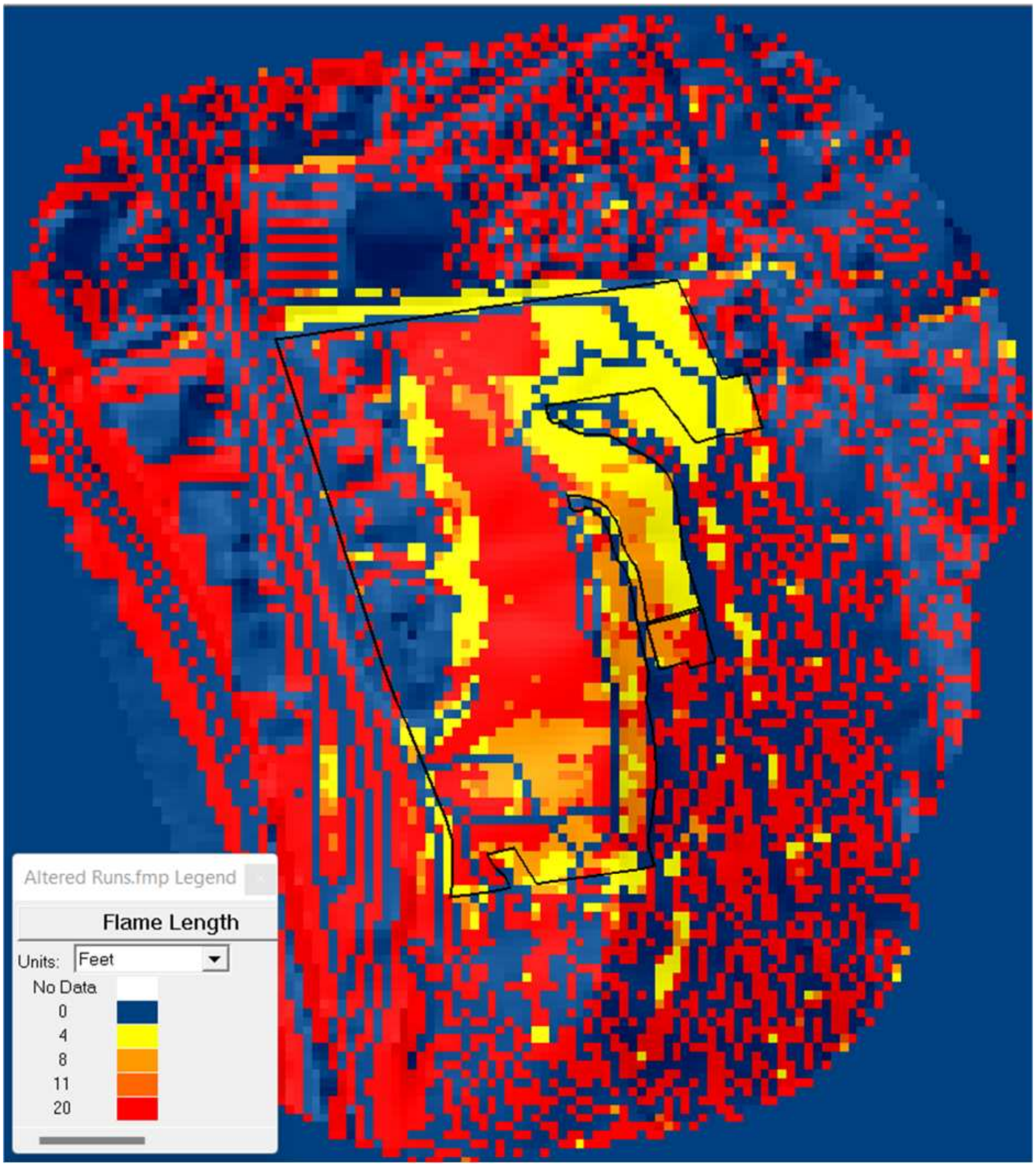


FIGURE 15. PREDICTED FLAME LENGTHS (IN FEET) FOR THE SOUTHWEST WIND SCENARIO.

TABLE 4. ACRES PER PREDICTED FLAME LENGTH CATEGORY FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

Flame Length Category	Acres	Percent
No predicted fire	136.5	48.2%
< 4 feet	18.7	6.6%
4 – 8 feet	10.3	3.6%
8 – 11 feet	2.8	1.0%
11-20 feet	49.2	17.4%
> 20 feet	66.0	23.3%

Under these conditions, just over 40% of the area is predicted to burn with flame lengths over 11 feet in length. The areas with lower flame lengths are due to lesser amounts of fuel and relatively sheltered positions on the hill. These areas of lower flame lengths (under 4 feet) are concentrated in the northeast and surrounding the western buildings.

Fireline Intensity (SW)

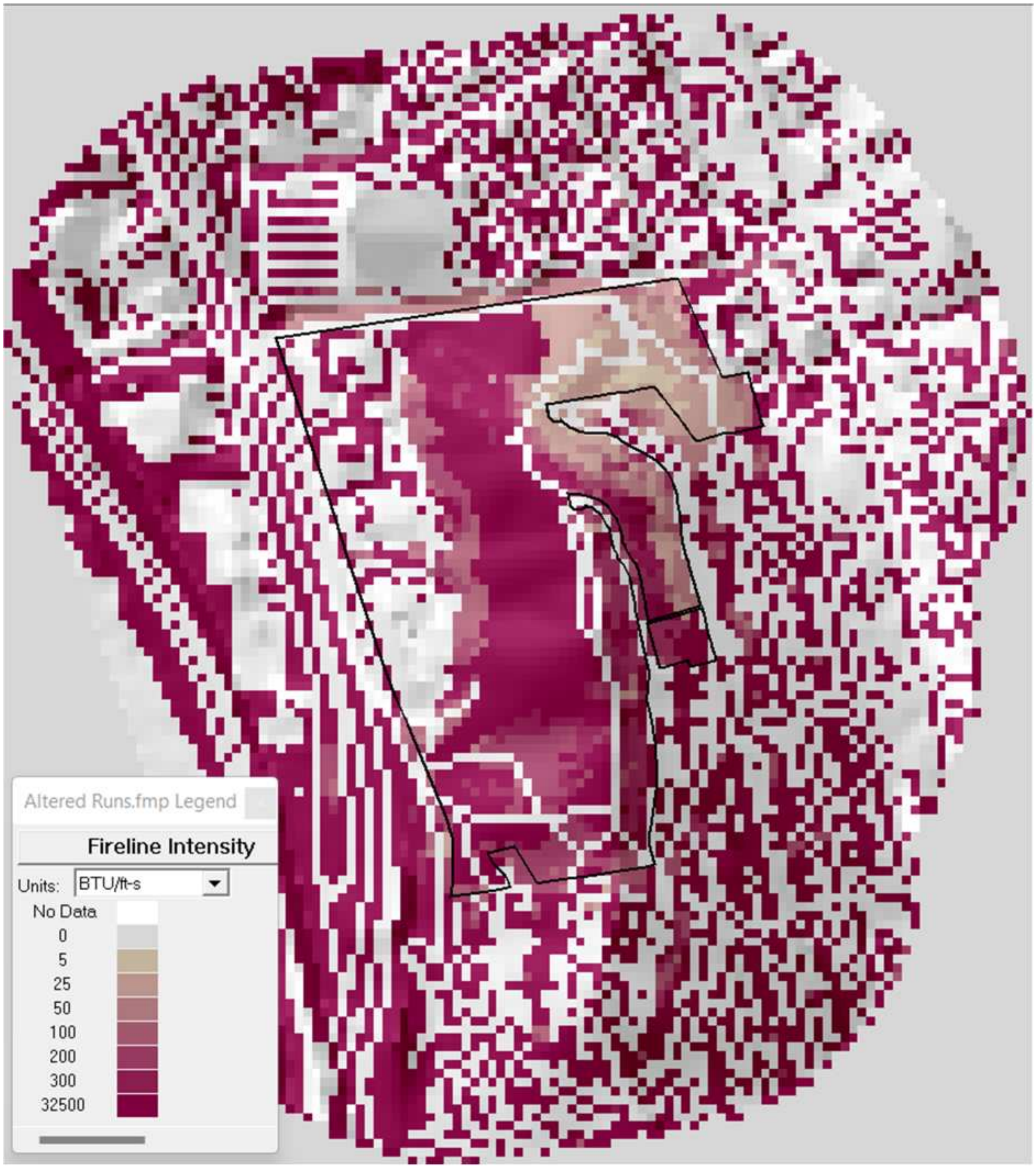


FIGURE 16. PREDICTED FIRELINE INTENSITY (BTU/FT-S) FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

TABLE 5. ACRES PER FIRELINE INTENSITY CATEGORY FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

Fireline Intensity Category	Acres	Percent
No predicted fire	136.5	48.2%
< 5 btu/s/ft	0.7	0.3%
5 - 25 btu/s/ft	5.9	2.1%
25 - 50 btu/s/ft	4.3	1.5%
50 - 100 btu/s/ft	5.4	1.9%
100 - 200 btu/s/ft	9.9	3.5%
200 - 300 btu/s/ft	3.3	1.2%
> 300 btu/s/ft	117.4	41.4%

More than 41% of the study area burns at a fireline intensity over 300 btu/ft-s. This indicates a fireline heat output that would exceed the amount a hand crew could sustain and would have to be fought using equipment such as dozers or aerial support. Though there are some areas to the northeast within the park that could be fought with a hand crew.

Rate of Spread (SW)

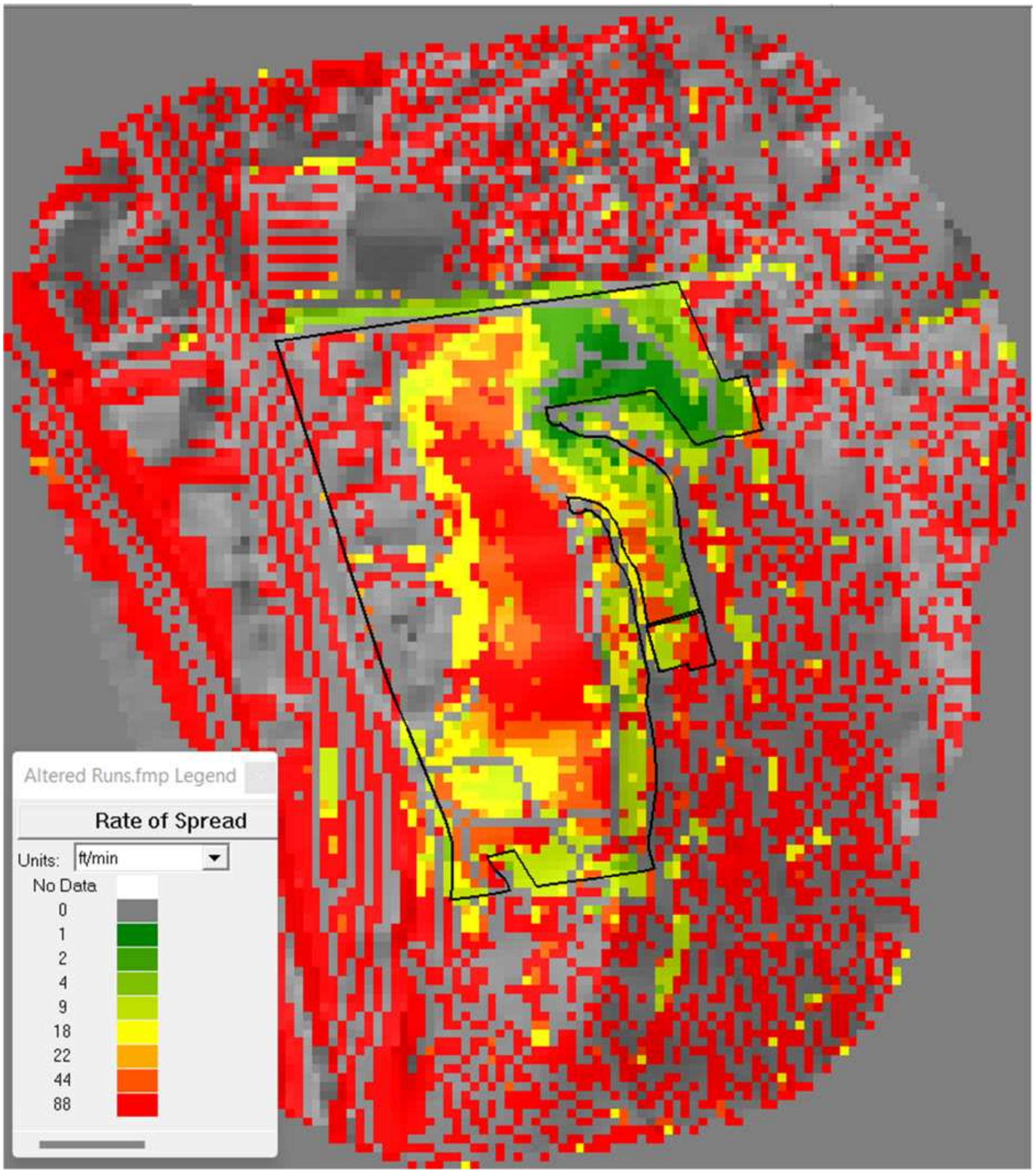


FIGURE 17. PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

TABLE 6. ACRES PER PREDICTED RATE OF SPREAD CATEGORY FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

Rate of Spread Category	Acres	Percent
No predicted fire	136.5	48.2%
< 1 foot/minute	1.9	0.7 %
1 – 5 ft/min	8.8	3.1%
5 – 10 ft/min	9.5	3.3%
10 – 15 ft/min	6.0	2.1%
15 – 20 ft/min	4.2	1.5%
20 – 40 ft/min	10.2	3.6%
> 40 ft/min	106.6	37.6%

A little more than third (37%) of the study area burns at a spread rate over 40 ft/minute. This elevated rate of spread is likely due to wind speed and the flashy nature of the grass fuels prevalent in the study area.

Crown Fire Activity (SW)

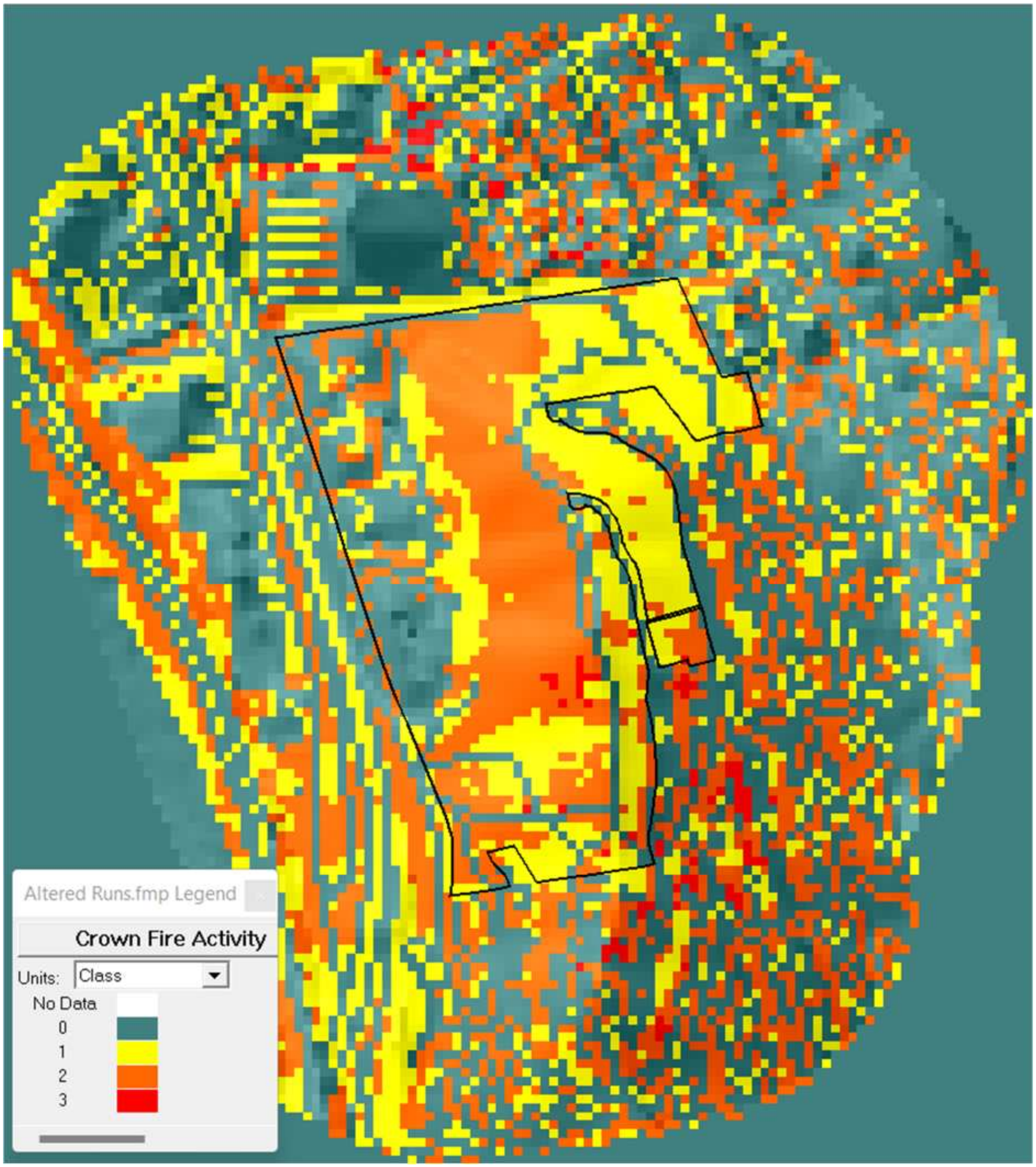


FIGURE 18. PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

TABLE 7. ACRES PER CROWN FIRE ACTIVITY CATEGORY FOR THE SOUTH/SOUTHWEST WIND SCENARIO

Crown Fire Activity Category	Acres	Percent
No predicted fire	136.5	48.2%
Surface fire (1)	67.3	23.7%
Torching fire (2)	76.9	27.1%
Active crown fire (3)	2.8	1.0%

Over 28% of the study area is predicted to exhibit torching or crown fire activity, potentially sending embers aloft into areas to the northeast. Most of this torching happens outside of the park boundaries, but within the park boundary the heavily treed area on the western slope of the hill harbors a potential ember source for the develop to the east.

Maximum Spot Distance (SW)

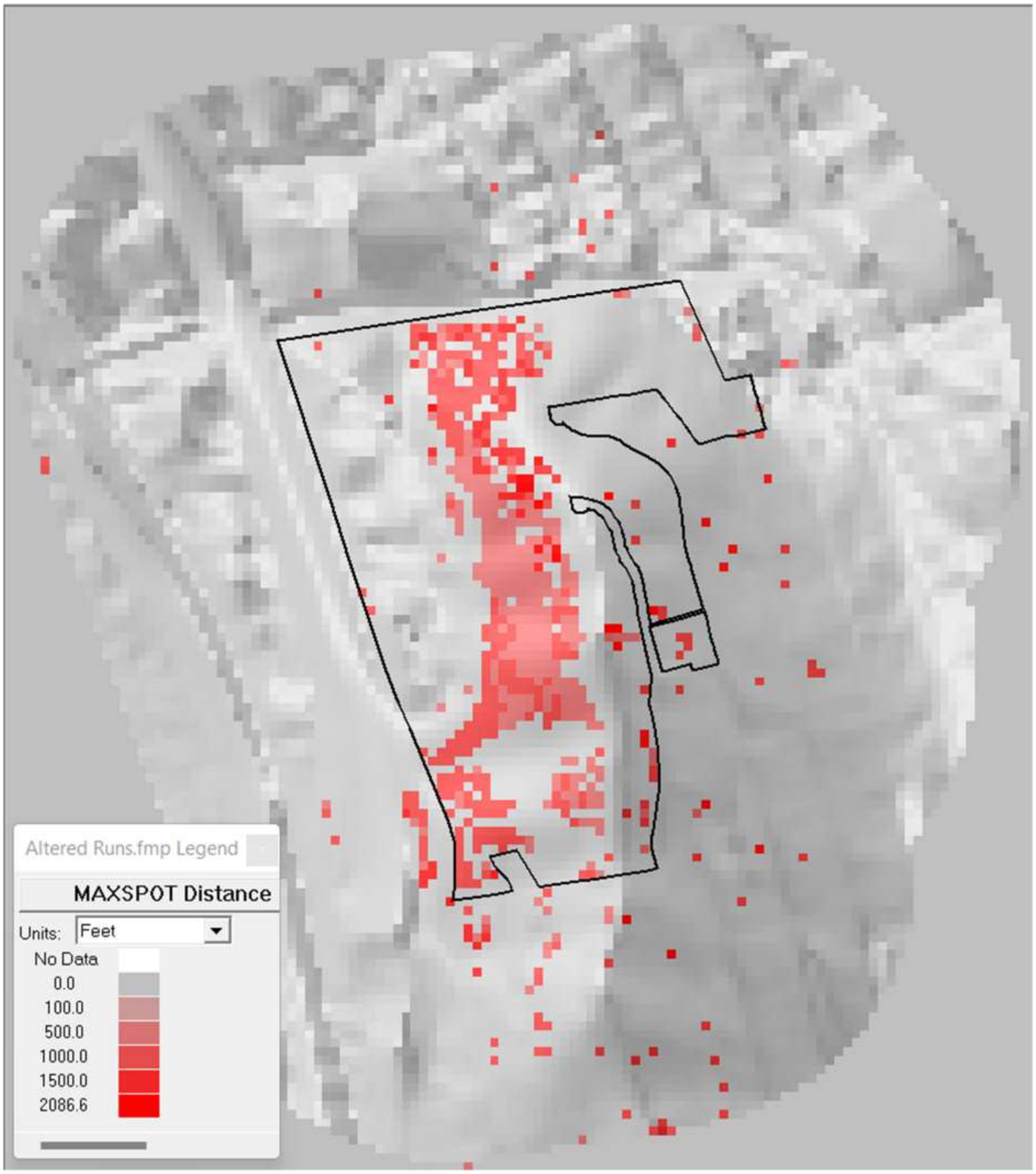


FIGURE 19. PREDICTED MAXIMUM SPOT DISTANCE (IN FEET) FOR THE SOUTH/SOUTHWEST WIND SCENARIO. FOR EXAMPLE A PIXEL ON THIS MAP OF THE MAXIMUM SPOT DISTANCE (2086.6) REPRESENTS EMBERS THAT COULD POTENTIALLY TRAVEL OUTWARDS 2086.6 FT FROM THIS LOCATION.

Spotting is simulated only from torching trees for passive and active crown fire. Maximum spot distances of embers are calculated for each pixel that is predicted to torch. This metric is not intended to simulate the numbers of embers, exact locations embers would land, or locations of resulting spot fires.

Fire behavior is calculated for each landscape node, nodes are a fixed grid equal to the landscape spatial resolution. If a node experiences passive or active crownfire, sixteen (16) incrementally-sized embers are lofted and followed to determine the maximum spotting distance and direction. Crown Fraction Burned and Canopy Cover are used to determine the number of torching trees used to determine firebrand lofting height. Maximum spotting distance & azimuth are calculated using canopy cover, crown fraction burned, elevation, and wind information, including gridded wind if available. The Maximum Spot Distance is created from this information[8].

For this study area, using the data from CFO and under the condition simulated, spot distance is relatively high, however, only a small portion of the area is predicted to actual produce spot fires. These areas are located in the central portion of the study area.

TABLE 8. ACRES PER MAXIMUM SPOT DISTANCE CATEGORY FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

Maximum Spot Distance Category	Acres	Percent
No predicted embers	266.4	94.0%
< 100 feet	None	n/a
100 – 500 feet	7.3	2.6%
500 – 1,000 feet	7.7	2.7%
1,000 – 1,500 feet	1.8	0.6%
> 1,500 feet	0.4	0.1%

[8] From the Spotting documentation for FlamMap (accessed on 8/25/2021 http://flammaphelp.s3-website-us-west-2.amazonaws.com/)

East/Northeast Scenario

For the inputs detailed in Table 5 above, the following fire potential was predicted for the entire modeled area surrounding the Albany Hills and Creekside Park.

Flame Length (NE)

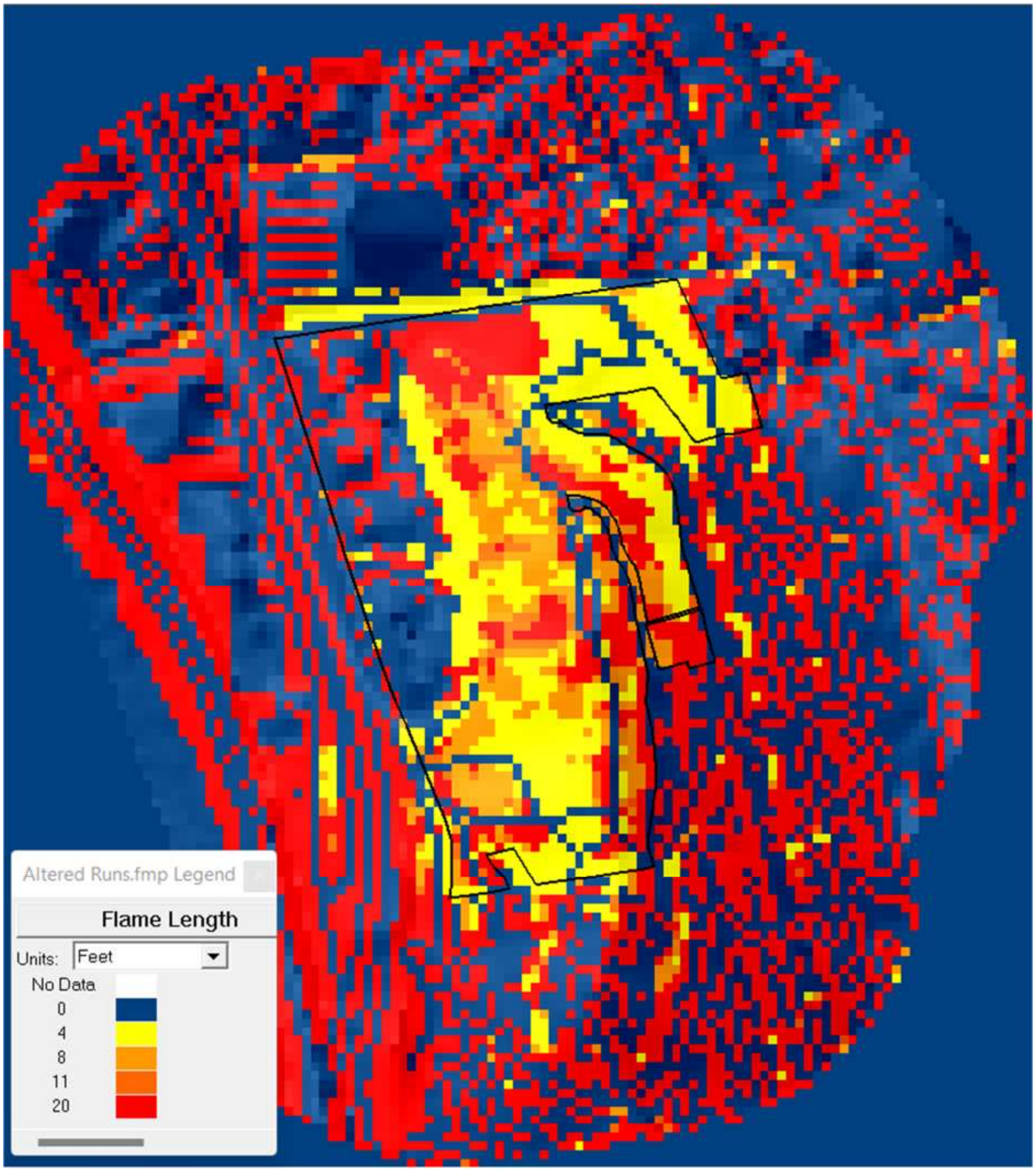


FIGURE 20. PREDICTED FLAME LENGTHS (IN FEET) FOR THE EAST/NORTHEAST WIND SCENARIO.

TABLE 9. ACRES PER PREDICTED FLAME LENGTH CATEGORY FOR THE EAST/NORTHEAST WIND SCENARIO

	East/Northeast		South/Southwest		
Flame Length Category	**Acres**	**Percent**	**Acres**	**Percent**	**Difference**
No predicted fire	136.5	48.2%	**136.5**	**48.2%**	None
< 4 feet	23.7	8.3%	**18.7**	**6.6%**	1.7% more
4 – 8 feet	11.6	4.1%	**10.3**	**3.6%**	0.5% more
8 – 11 feet	3.3	1.2%	**2.8**	**1.0%**	0.2% more
11-20 feet	46.2	16.3%	**49.2**	**17.4%**	0.9% less
> 20 feet	62.2	21.9%	**66.0**	**23.3%**	1.4% less

Less than the South/Southwest FlamMap predictions, just over 37% of the area is predicted to burn with a flame length over 11 feet. While the East/Northeast scenario is overall slightly less volatile than the South/Southwest scenario, it still predicts quite high flame lengths for much of the area outside the park. Within the park, flame lengths are much lower overall.

Fireline Intensity (NE)

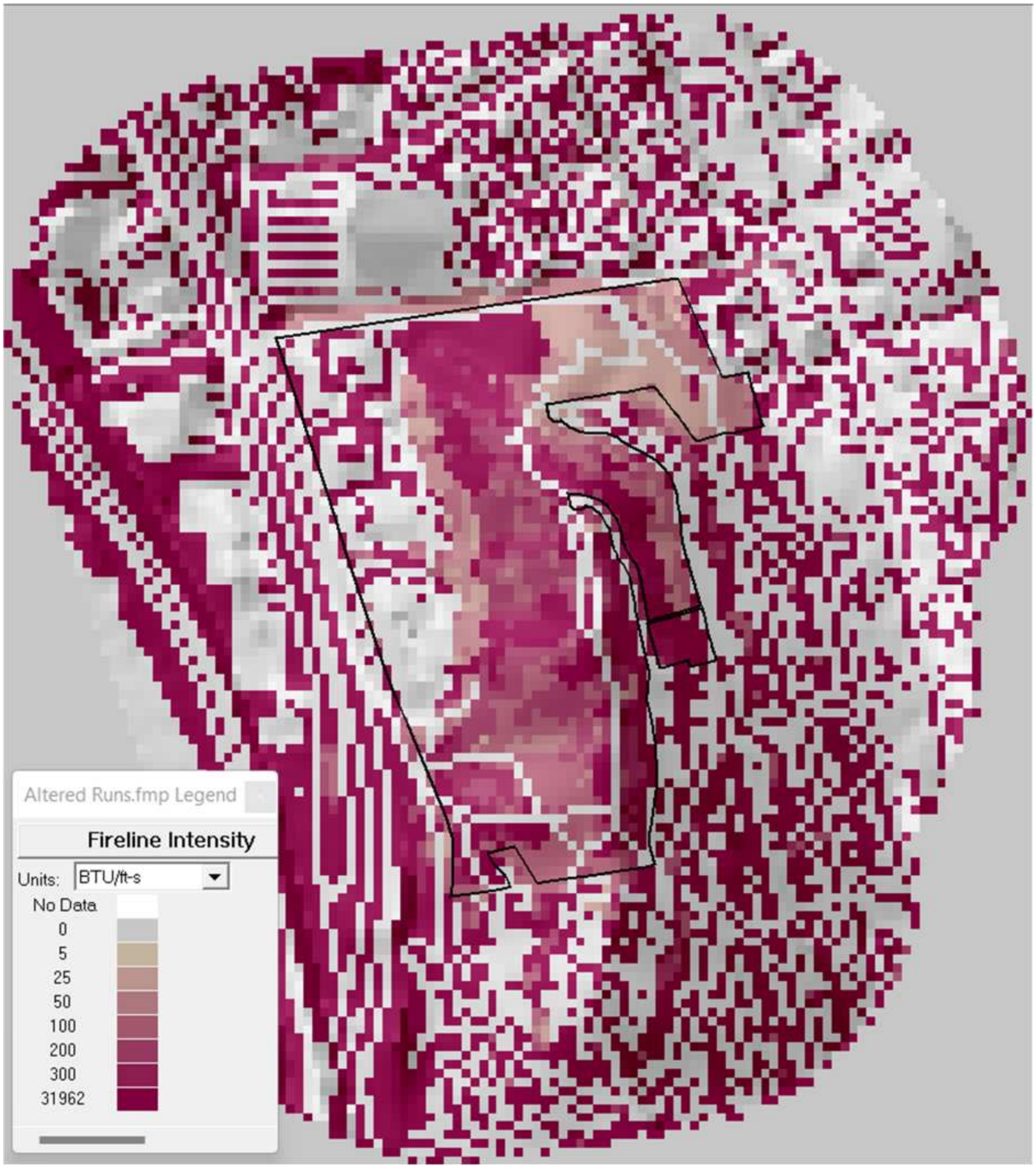


FIGURE 21. PREDICTED FIRELINE INTENSITY (BTU/FT-S) FOR THE EAST/NORTHEAST WIND SCENARIO.

TABLE 10. ACRES PER FIRELINE INTENSITY CATEGORY FOR THE EAST/NORTHEAST WIND SCENARIO.

	Northeast		Southwest		
Fireline Intensity Category	**Acres**	**Percent**	**Acres**	**Percent**	**Difference**
No predicted fire	136.5	48.2%	**136.5**	**48.2%**	None
< 5 btu/s/ft	None	n/a	**0.7**	**0.3%**	0.3% more
5 - 25 btu/s/ft	4.3	1.5%	**5.9**	**2.1%**	0.6% less
25 - 50 btu/s/ft	7.2	2.6%	**4.3**	**1.5%**	1.1% more
50 - 100 btu/s/ft	9.4	3.3%	**5.4**	**1.9%**	1.4% more
100 - 200 btu/s/ft	10.8	3.8%	**9.9**	**3.5%**	0.3% more
200 - 300 btu/s/ft	4.3	1.5%	**3.3**	**1.2%**	0.3 % more
> 300 btu/s/ft	110.9	39.1%	**117.4**	**41.4%**	2.3% less

Similarly, 39% of the study area burns at a fireline intensity over 300 btu/ft-s. This indicates a fireline heat output that would exceed the amount a hand crew could sustain and would have to be fought using equipment such as dozers or aerial support. Though there are some areas to the northeast within the park that could be fought with a hand crew.

The main different between the ENE versus the SSW scenario is that the entire park seems to be sheltered from the ENE winds, thus the overall fireline intensity within the park is much less than in the SSW scenario.

Rate of Spread (NE)

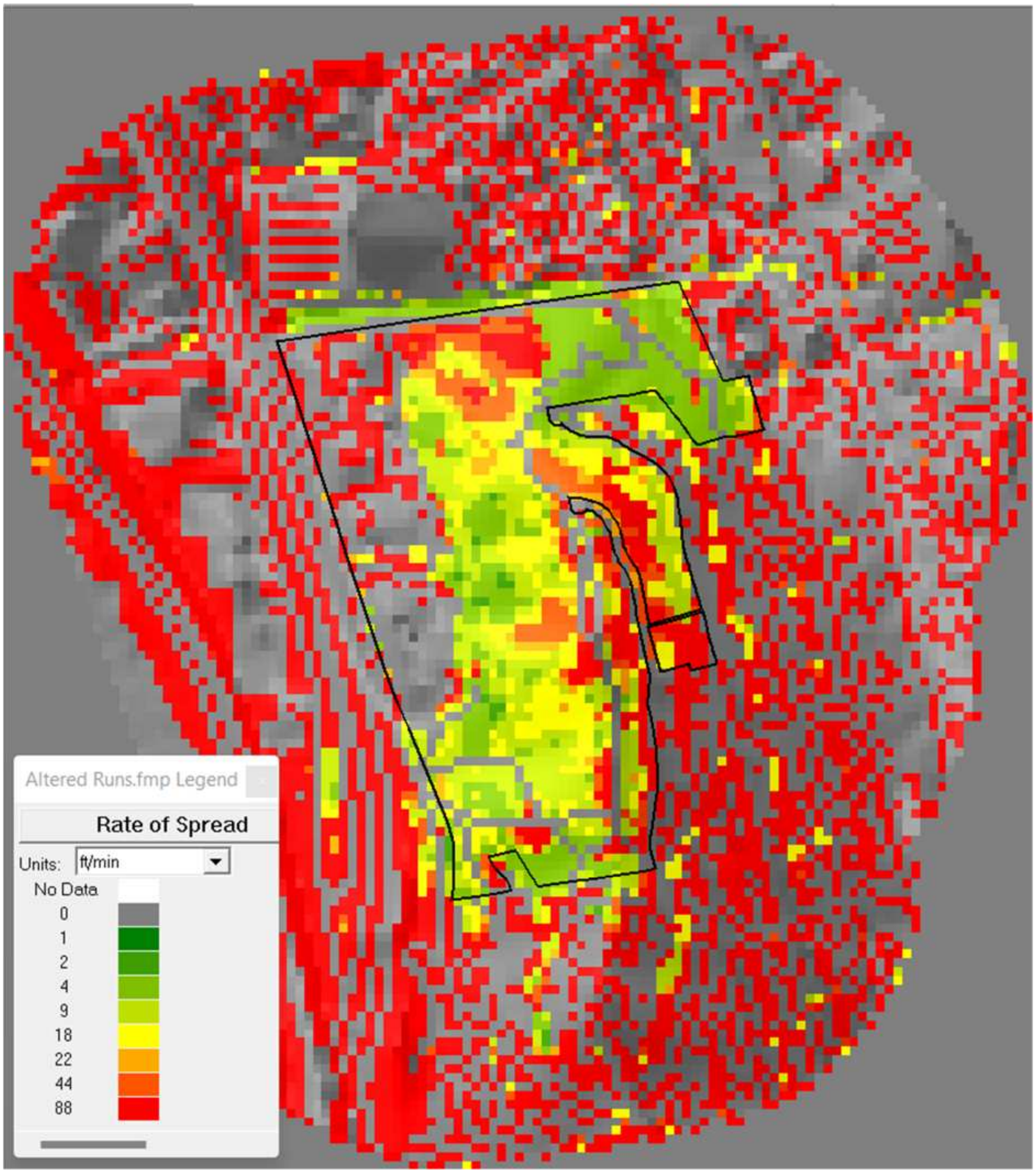


FIGURE 22. PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE EAST/NORTHEAST WIND SCENARIO.

TABLE 11. ACRES PER PREDICTED RATE OF SPREAD CATEGORY FOR THE EAST/NORTHEAST WIND SCENARIO.

	Northeast		Southwest		
Rate of Spread Category	**Acres**	**Percent**	**Acres**	**Percent**	**Difference**
No predicted fire	136.5	48.2%	**136.5**	**48.2%**	None
< 1 foot/minute	None	n/a	**1.9**	**0.7 %**	0.7% less
1 – 5 ft/min	15.3	5.4%	**8.8**	**3.1%**	2.3% more
5 – 10 ft/min	12.8	4.5%	**9.5**	**3.3%**	1.2% more
10 – 15 ft/min	6.3	2.2%	**6.0**	**2.1%**	0.1% more
15 – 20 ft/min	3.2	1.1%	**4.2**	**1.5%**	0.4% less
20 – 40 ft/min	6.5	2.3%	**10.2**	**3.6%**	1.3% less
> 40 ft/min	103.0	36.3%	**106.6**	**37.6%**	1.3% less

Again, the rate of spread for the East/Northeast scenario is predicted to be somewhat less than the South/Southwest scenario – within the park boundary. However, 36% (mostly outside the park) of the area is still predicted to burn with a rate of spread over 40 ft/minute, which would quickly out-pace any fire suppression efforts.

Crown Fire Activity (NE)

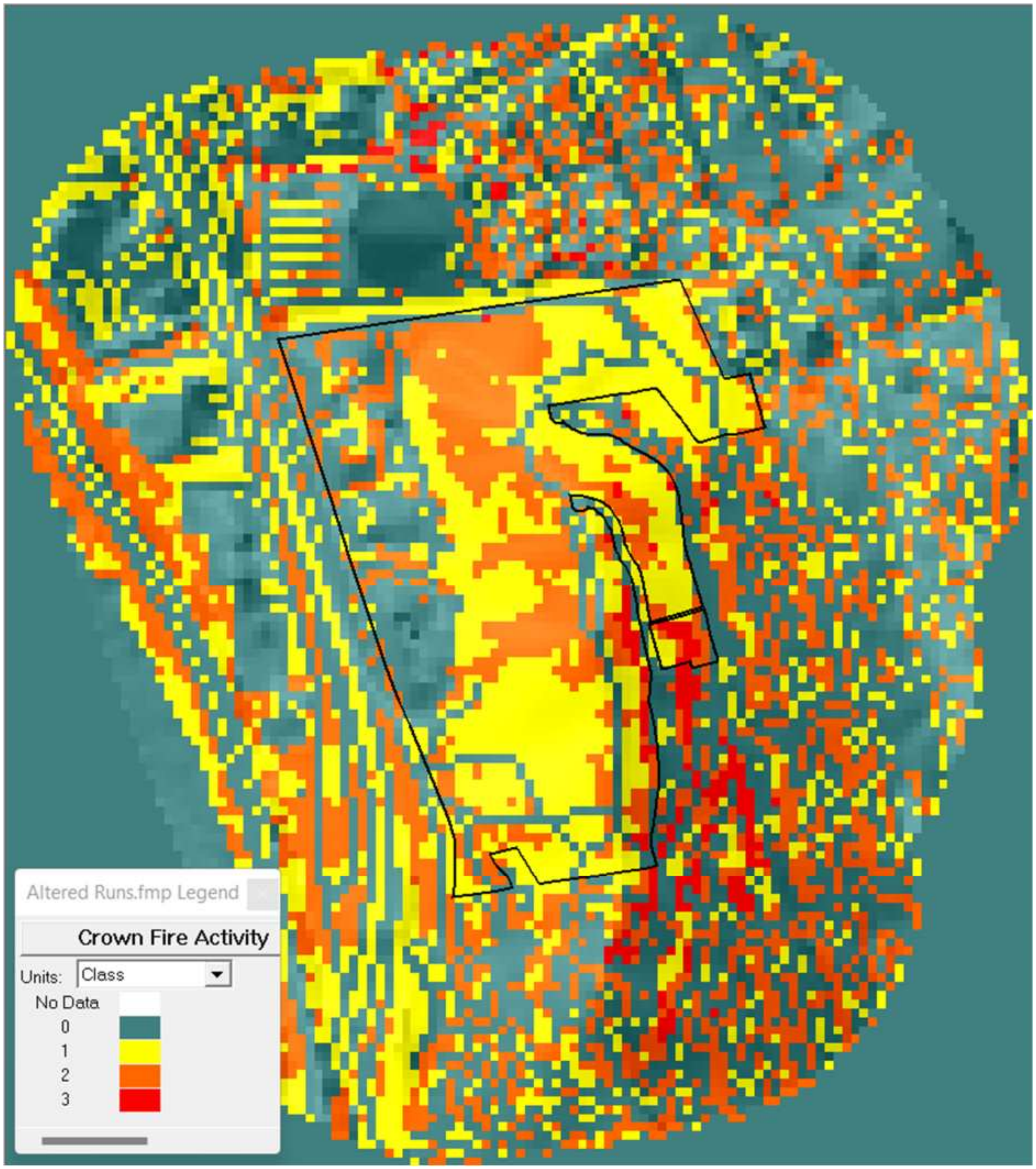


FIGURE 23. PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE EAST/NORTHEAST WIND SCENARIO.

TABLE 12. ACRES PER PREDICTED CROWN FIRE ACTIVITY CATEGORY FOR THE EAST/NORTHEAST WIND SCENARIO.

	Northeast		Southwest		
Crown Fire Activity Category	**Acres**	**Percent**	**Acres**	**Percent**	**Difference**
No predicted fire	135.5	48.2%	**136.5**	**48.2%**	None
Surface fire (1)	71.8	25.3%	**67.3**	**23.7%**	1.6% more
Torching fire (2)	70.4	24.8%	**76.9**	**27.1%**	2.3% less
Active crown fire (3)	4.9	4.9%	**2.8**	**1.0%**	3.9% more

While the area predicted in the Torching fire category diminished somewhat with a NE wind, the Active crown fire category increased by almost 4% with a NE wind. However, within the park, torching is lower, particularly along the western facing flanks of the hill.

Maximum Spot Distance (NE)

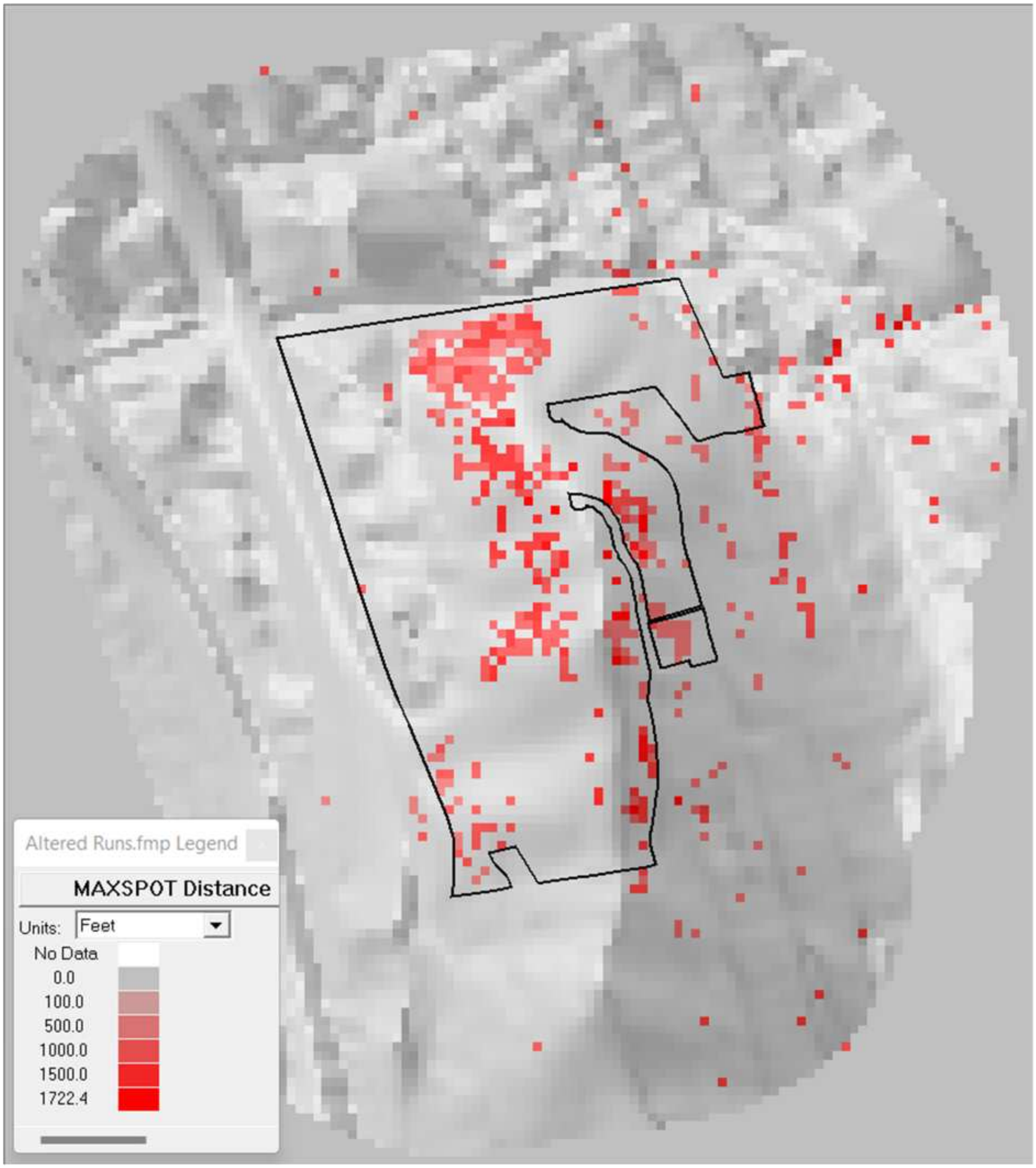


FIGURE 24. PREDICTED MAXIMUM SPOT DISTANCE (IN FEET) FOR THE SOUTH/SOUTHWEST WIND SCENARIO.

Spotting is simulated only from torching trees for passive and active crown fire. Maximum spot distances of embers are calculated for each pixel that is predicted to torch. This metric is not intended to simulate the numbers of embers, exact locations embers would land, or locations of resulting spot fires. Fire behavior is calculated for each landscape node, nodes are a fixed grid equal to the landscape spatial resolution. If a node experiences passive or active crown fire, sixteen (16) incrementally-sized embers are lofted and followed to determine the maximum spotting distance and direction. Crown Fraction Burned and Canopy Cover are used to determine the number of torching trees used to determine firebrand lofting height. Maximum spotting distance and azimuth are calculated using canopy cover, crown fraction burned, elevation, and wind information, including gridded wind if available. The Maximum Spot Distance is created from this information[9].

For this study area, using the data from CFO and under the condition simulated, spot distance is relatively high, however, only a small portion of the area is predicted to actual produce spot fires (similar to the southwest scenario). This is again centered within the park where understory fuels are present, however less areas are predicted to produce embers.

TABLE 13. ACRES PER MAXIMUM SPOT DISTANCE CATEGORY FOR THE EAST/NORTHEAST WIND SCENARIO.

	Northeast		Southwest		
Maximum Spot Distance Category	**Acres**	**Percent**	**Acres**	**Percent**	**Difference**
No predicted embers	271.1	95.6%	**266.4**	**94.0%**	1.6% more
< 100 feet	None	n/a	**None**	**n/a**	None
100 – 500 feet	3.9	1.4%	**7.3**	**2.6%**	1.2% less
500 – 1,000 feet	5.5	1.9%	**7.7**	**2.7%**	0.8% less
1,000 – 1,500 feet	2.7	1.0%	**1.8**	**0.6%**	0.4% more
> 1,500 feet	0.3	0.1%	**0.4**	**0.1%**	None

Recommendations

We reaffirm the Vegetation Management Strategy and Action Plan[10]. We did not reproduce this plan, but rather added comments and modified it.

The predicted fire behavior characteristics indicate that management action is justified. Long flame lengths (as appears on Figures 14 and 19), fast rates of fire spread (as shown in Figures 16 and 219 and potential for torching (as shown on Figures 17 and 22), especially at the top of the hill, would challenge fire suppression efforts. The distance the new fire starts from ember cast (predicted via the Maximum Spotting Distance results, as shown in Figures 18 and 23) presents the possibility of ignitions outside the park due to a fire on City property.

Actions by residents and landowners of adjacent property are also warranted, as shown by similar fire behavior characteristics outside the park possibly due to abundant landscaping and flammable structures.

The areas of highest priority for treatment are those areas highest on the hill and those nearest residences. The areas on the top of the hill can provide the greatest opportunity for long-range spotting, both due to the position on the slope and the long flame lengths and possibility of torching. Treatment in the areas nearest structures with long flame lengths and predicted

[9] From the Spotting documentation for FlamMap (accessed on 8/25/2021 http://flammaphelp.s3-website-us-west-2.amazonaws.com/)

[10]https://www.albanyca.org/home/showdocument?id=28577

torching is also high priority because of the higher likelihood of structure loss due to direct heat transfer form a fire on City lands.

This set of recommendations acknowledges the work done to reduce hazard, both through thinning eucalyptus trees, and carefully managing oak woodlands. There are a few modifications to Figure 4 of Appendix B of the 2012 Vegetation Management Plan "Potential Fire Management Goals and Possible Actions" that we recommend.

For the Fire Management Goal "Reduce the chance of damage to life and property by keeping fire from crossing boundaries – Participate in cooperative projects with adjacent landowners, we would add to the Possible Actions, to remove dying trees.

For the Fire Management Goal Reduce damage to structures and developed areas from wildfire near structures, we would add to the Possible Actions, to extend the management of fuels to private property, and to all properties to 100-ft from structures, regardless of land ownership. Also, to emphasize the action "Reduce potential for ember production, especially from trees on hilltop, to include especially dying trees.

Last To add an additional Fire Management Goal to state, "Modify fuels to consider monarch habitat". Possible Action would be to "Retain wind sheltering vegetation at mid-story level around significant/viable habitat locations, and manage for low flame lengths elsewhere, assuming embers will emanate from the locations of monarch habitat and land throughout the properties.

In the section "Prioritizing Fuel Management Treatments, topic #6, Window of Opportunity, we would note that there is unprecedented funding as a result of unprecedented wildfires in northern California. This highlights the increased benefits of collaborative actions, because funding now prioritizes multi-ownership projects. This includes an opportunity to support structure retrofitting so that the homes become more ignition-resistant.

Multiple Objectives – In many cases, the objectives can be achieved simultaneously, but in some cases, they conflict/ are not compatible. While the City cannot dictate management on private property, it can influence both management and outcomes, through funding/cost-share of actions, and inspections for compliance with City fire codes. Management (in all properties) ~~between private and public lands~~ differ in timing, strata, locations, and methods. Timing: The timing of vegetation management varies both within different seasons of the year, and varies in length of time between treatments, spanning several years. Treatments also can address different strata of the forest; the vegetation nearest the ground, mid-story or overstory can be treated separate, with resulting differences in aesthetics, fire behavior, species diversity and recreational opportunities. Where treatments occur matter, and are tied to values at risk, access, and position on the slope or other terrain-based factors. Finally, treatment methods influence the outcome. Treatment methods include mechanical equipment spanning mowers for grass, masticators for woody shrubs or small diameter trees, or use of feller-bunchers for whole tree removal. Hand labor is often used on steep terrain and on smaller project sites where control is desired. Prescribed use of grazing animals is useful for management of the lower strata, with the type of animal matching the type vegetation present.

Recreation – Management for fuels with recreation in mind. Treatments to remove eucalyptus can be consistent with recreational use. Recreational use increases the need for hazard tree removal in order to increase public safety. Thinning the stand offers increases in views; however, removal of all trees would increase wind speeds, and reduce shade, both effects would reduce the quality of the recreational experience.

Landownership – The most critical sites for monarch habitat are not in City property; the City has no control over the management of this site, except that the City Fire Department inspects the property for compliance with codes.

Monarchs – A conundrum exists with the monarch habitat. The need for wind shelter is in conflict with fire hazard reduction measures. In order to accommodate the habitat requirements, sheltered locations will need to be protected from other locations. The ideal habitat turns out to be one that ensures torching of trees.

Horizontal separation of the monarch habitat may limit the amount of torching in the actual habitat area.

Because the area of monarch habitat is expected to torch, all areas would need to be managed assuming embers will land in the area. In other words, in order to preserve the monarch habitat, all other parts of Albany Hill will need to be kept in a low fire hazard state. This places an increased burden on City property and on other landowners.

On City property, management is divided into four management zones:

1. Lands on City property within 100-ft of structures
2. City property outside of 100-ft of structures
3. Private owned and developed lands within 100-ft of structures
4. Privately owned and developed lands outside of 100-ft from structures. For these properties, it is possible easements on these lands may restrict what can be done Investigating easements on these privately-held lands is beyond the scope of this project.

The Fire management goals and Possible Actions from the 2012 Vegetation Management Plan are affirmed. Recommended actions correspond to vegetation type, distance from structures, as well as the health of eucalyptus trees and presence of monarch habitat. Specific recommended actions for wildland fire hazard reduction are to:

- Remove dead and dying eucalyptus throughout the area, and specifically on City property. Grants should be pursued to fund this costly operation that will benefit the wider community

- Continue thinning of understory shrubs in the oak woodlands, and remove small dead material created by those operations. Large dead material (larger than four inches) can and should be used to dissuade unauthorized trail development and use.
- Defensible space should be created and maintained within 100-ft of all structures. The City should work with landowners that have structures within 100-ft of City property to achieve this goal. This is another action that could be funded with grants.
- Where monarch butterfly habitat is present, the City and private landowners should consider alternative fuel management strategies whereby mid-story vegetation is not removed for fire hazard reduction, but kept for wind reduction. Specific and limited tree planting is recommended on private property so that wind can be reduced over time. The wildfire of 2022 impacted the area where planting was to be targeted.

For structures themselves, retrofitting the exterior materials is advised. The most obvious retrofitting actions are to replace vents to be ember-resistant, and to create and maintain a noncombustible zone within five feet of structures, and to separate wooden fences and decks from the house by at least 5 feet of non-combustible'[' materials.

The recommendations for the parks are valid for private lands, too. These are areas not addressed previously.

Appendix A: Terms Used in This Report

1h Fuel Class – Group of fuels possessing common characteristics. Dead fuels are grouped according to 1-, 10-, 100-, and 1000-hour timelag, and living fuels are grouped as herbaceous (annual or perennial) or woody.

10h Fuel Class – Group of fuels possessing common characteristics. Dead fuels are grouped according to 1-, 10-, 100-, and 1000-hour timelag, and living fuels are grouped as herbaceous (annual or perennial) or woody.

100h Fuel Class – Group of fuels possessing common characteristics. Dead fuels are grouped according to 1-, 10-, 100-, and 1000-hour timelag, and living fuels are grouped as herbaceous (annual or perennial) or woody.

Active Crown Fire - A fire in which a solid flame develops in the crowns of trees.

Canopy Base Height – A property of a plot, stand, or group of trees, not of an individual tree. For fire modeling, canopy base height is an effective value that incorporates ladder fuel, such as tall shrubs and small trees.

Canopy Bulk Density – a bulk property of a plot, stand, or group of trees, not of an individual tree. The most basic methods for estimating canopy bulk density use a tree list in conjunction with allometric equations to predict individual-tree biomass. The biomass data are then summarized by any of several methods to provide an estimate of bulk density or to create a vertical profile of bulk density in horizontally thin layers.

Canopy Cover – The percent of a fixed area covered by the crown of an individual plant species or delimited by the vertical projection of its outermost perimeter; small openings in the crown are included.

Canopy Height – The height of the foliage above ground for any point of the canopy. For example, tree height is the height of the tree apex (topmost point) above ground.

Crosswalk – A crosswalk is any system or table designed to assist a user in cross- referencing one vegetation classification to another; in this case, a fuel model classification.

Crown Fire – A fire that advances from top to top of trees or shrubs more or less independent of a surface fire. Crown fires are sometimes classed as running or dependent to distinguish the degree of independence from the surface fire.

Crown Fire Activity – See Crowning Potential. The presence of a crown fire or torching in any one area.

Crown Fire Activity (or Potential) – Results from a fire prediction software. Predictions are either Non-burnable, Surface Fire, Passive Crown Fire, and Active Crown Fire.

Crowning Potential – A probability that a crown fire may start, calculated from inputs of foliage moisture content and height of the lowest part of the tree crowns above the surface. See also "spotting potential."

Fire Behavior – The manner in which a fire reacts to the influences of fuel, weather, and topography.

Fire Hazard Severity – Fire hazard severity zones are based on the combination of vegetation, topography, weather, crown fire potential, ember production and movement, and the likelihood of an area burning. Buildings constructed in Very High Fire Hazard Severity Zones are required to be built using fire-resistive features.

Fire Hazard Severity – Fire hazard severity zones are based on the combination of vegetation, topography, weather, crown fire potential, ember production and movement, and the likelihood of an area burning. Buildings constructed in Very High Fire Hazard Severity Zones are required to be built using fire-resistive features.

Fire Hazard Severity – Fire hazard severity zones are based on the combination of vegetation, topography, weather, crown fire potential, ember production and movement, and the likelihood of an area burning. Buildings constructed in Very High Fire Hazard Severity Zones are required to be built using fire-resistive features.

Fireline Intensity – The product of the available heat of combustion per unit of ground and the rate of spread of the fire, interpreted as the heat released per unit of time for each unit length of fire edge. The primary unit is Btu per second per foot (Btu/sec/ft) of fire front; (b) The rate of heat release per unit time per unit length of fire front. Numerically, it is the product of the heat yield, the quantity of fuel consumed in the fire front, and the rate of spread.

Flame Length – The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface), an indicator of fire intensity.

FlamMap – A software program that simulates potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.), fire growth and spread and conditional burn probabilities under constant environmental conditions (weather and fuel moisture).

Flaming Front – That zone of a moving fire where the combustion is primarily flaming. Behind this flaming zone combustion is primarily glowing or involves the burning out of larger fuels (greater than about 3 inches in diameter). Light fuels typically have a shallow flaming front, whereas heavy fuels have a deeper front.

Foliar Moisture Content – The weight of water compared with the weight of cellulose, expressed as a percentage. A 100 percent moisture content is found when that portion of a plant has equal weights of water and cellulose.

Fuel – Any combustible material, especially petroleum-based products and wildland fuels

Fuel Bed – An array of fuels usually constructed with specific loading, depth, and particle size to meet experimental requirements; also, commonly used to describe the fuel composition.

Fuel continuity – A description of the spacing between individual fuel elements, for example, are tree crowns touching the crowns of all its neighbors or are they moderately, or even widely, spaced.

Fuel Characteristics – Factors that make up fuels such as compactness, loading, horizontal continuity, vertical arrangement, chemical content, size and shape, and moisture content.

Fuel Model – Simulated fuel complex for which all fuel descriptors required for the solution of a mathematical rate of spread model have been specified.

Fuel Moisture – The quantity of moisture in fuel expressed as a percentage of the weight when thoroughly dried at 212 degrees F.

Fuel Type – An identifiable association of fuel elements of distinctive species, form, size, arrangement, or other characteristics that will cause a predictable rate of spread or resistance to control under specified weather conditions.

Ladder fuels – Vegetative fuels that provide a pathway for fire to move from the surface to the tree canopy.

LANDFIRE – The LANDFIRE Program produces geo-spatial products and databases covering the United States of America. LANDFIRE is a partnership between the wildland fire management programs of the United States Department of Interior, the USDA Forest Service and the Nature Conservancy.

Live Herbaceous Fuel Class – Group of fuels possessing common characteristics. Dead fuels are grouped according to 1-, 10-, 100-, and 1000-hour timelag, and living fuels are grouped as herbaceous (annual or perennial) or woody.

Live Herbaceous Fuel Moisture (LiveH) – Fuel moisture for the Live Herbaceous Fuel Class.

Live Woody Fuel Class – Group of fuels possessing common characteristics. Dead fuels are grouped according to 1-, 10-, 100-, and 1000-hour timelag, and living fuels are grouped as herbaceous (annual or perennial) or woody.

Live Woody Fuel Moisture (LiveW) – Fuel moisture for the Live Woody Fuel Class.

Moisture of Extinction (X Moist) – The fuel moisture content, weighed over all the fuel classes, at which a fire will not spread.

Passive Crown Fire – A fire in the crowns of trees in which trees or groups of trees torch, ignited by the passing front of the fire.

Pixel – A picture element that, reflects the same characteristics over a specified size of the surface.

Rate of Spread – The relative activity of a fire in extending its horizontal dimensions. It is expressed as rate of increase of the total perimeter of the fire, as rate of forward spread of the fire front, or as rate of increase in area, depending on the intended use of the information. Usually it is expressed in chains (66 feet) or acres per hour for a specific period in the fire's history.

Relative Humidity – The ratio of the amount of moisture in the air, to the maximum amount of moisture that air would contain if it were saturated.

Residence time – The length of time a wildfire burns at a single location. This behavior characteristic is typically defined by the fuel size categories that are present and dominant**.**

Surface Fire – A fire that burns on the surface of the ground and are primarily fueled by short vegetation and twigs or dried leaves. Surface fires range from low to high intensity depending on the conditions. While they may scorch a tree canopy, surface fires will not consume its foliage. Surface fires often spread slowly, but can begin to spread rapidly when they occur in an area that has a steeply sloped landscape or are pushed by wind. That said, most surface fires ultimately die out before they are able to develop into the next level of classification: crown fires.

Spotting – Behavior of a fire producing sparks or embers that are carried by the wind and which start new fires beyond the zone of direct ignition by the main fire. Large glowing firebrands are carried high into the convection column and then fall out downwind beyond the main fire, starting new fires. Such spotting can easily occur 1/4 mile or more from the firebrand's source.

Timelag - Time needed under specified conditions for a fuel particle to lose about 63 percent of the difference between its initial moisture content and its equilibrium moisture content. If conditions remain unchanged, a fuel will reach 95 percent of its equilibrium moisture content after 4 timelag periods.

Torching – The burning of the foliage of a single tree or a small group of trees, from the bottom up.

Appendix B: Fuel Model Parameters for All Standard Fuel Models

This table describes the fuel characteristics used as inputs to the FlamMap fire behavior prediction software, and includes fuel loads (volumes) by time lag/size class.

Fuel model code	Fuel load (t/ac)					Fuel model type[a]	SAV ratio (1/ft)[b]			Fuel bed depth (ft)	Dead fuel extinction moisture (percent)	Heat content BTU/lb)[c]
	1-hr	10-hr	100-hr	Live herb	Live woody		Dead 1-hr	Live herb	Live woody			
GR1	0.10	0.00	0.00	0.30	0.00	dynamic	2200	2000	9999	0.4	15	8000
GR2	0.10	0.00	0.00	1.00	0.00	dynamic	2000	1800	9999	1.0	15	8000
GR3	0.10	0.40	0.00	1.50	0.00	dynamic	1500	1300	9999	2.0	30	8000
GR4	0.25	0.00	0.00	1.90	0.00	dynamic	2000	1800	9999	2.0	15	8000
GR5	0.40	0.00	0.00	2.50	0.00	dynamic	1800	1600	9999	1.5	40	8000
GR6	0.10	0.00	0.00	3.40	0.00	dynamic	2200	2000	9999	1.5	40	9000
GR7	1.00	0.00	0.00	5.40	0.00	dynamic	2000	1800	9999	3.0	15	8000
GR8	0.50	1.00	0.00	7.30	0.00	dynamic	1500	1300	9999	4.0	30	8000
GR9	1.00	1.00	0.00	9.00	0.00	dynamic	1800	1600	9999	5.0	40	8000
GS1	0.20	0.00	0.00	0.50	0.65	dynamic	2000	1800	1800	0.9	15	8000
GS2	0.50	0.50	0.00	0.60	1.00	dynamic	2000	1800	1800	1.5	15	8000
GS3	0.30	0.25	0.00	1.45	1.25	dynamic	1800	1600	1600	1.8	40	8000
GS4	1.90	0.30	0.10	3.40	7.10	dynamic	1800	1600	1600	2.1	40	8000
SH1	0.25	0.25	0.00	0.15	1.30	dynamic	2000	1800	1600	1.0	15	8000
SH2	1.35	2.40	0.75	0.00	3.85	N/A	2000	9999	1600	1.0	15	8000
SH3	0.45	3.00	0.00	0.00	6.20	N/A	1600	9999	1400	2.4	40	8000
SH4	0.85	1.15	0.20	0.00	2.55	N/A	2000	1800	1600	3.0	30	8000
SH5	3.60	2.10	0.00	0.00	2.90	N/A	750	9999	1600	6.0	15	8000
SH6	2.90	1.45	0.00	0.00	1.40	N/A	750	9999	1600	2.0	30	8000
SH7	3.50	5.30	2.20	0.00	3.40	N/A	750	9999	1600	6.0	15	8000
SH8	2.05	3.40	0.85	0.00	4.35	N/A	750	9999	1600	3.0	40	8000
SH9	4.50	2.45	0.00	1.55	7.00	dynamic	750	1800	1500	4.4	40	8000
TU1	0.20	0.90	1.50	0.20	0.90	dynamic	2000	1800	1600	0.6	20	8000
TU2	0.95	1.80	1.25	0.00	0.20	N/A	2000	9999	1600	1.0	30	8000
TU3	1.10	0.15	0.25	0.65	1.10	dynamic	1800	1600	1400	1.3	30	8000
TU4	4.50	0.00	0.00	0.00	2.00	N/A	2300	9999	2000	0.5	12	8000
TU5	4.00	4.00	3.00	0.00	3.00	N/A	1500	9999	750	1.0	25	8000
TL1	1.00	2.20	3.60	0.00	0.00	N/A	2000	9999	9999	0.2	30	8000
TL2	1.40	2.30	2.20	0.00	0.00	N/A	2000	9999	9999	0.2	25	8000
TL3	0.50	2.20	2.80	0.00	0.00	N/A	2000	9999	9999	0.3	20	8000
TL4	0.50	1.50	4.20	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL5	1.15	2.50	4.40	0.00	0.00	N/A	2000	9999	1600	0.6	25	8000
TL6	2.40	1.20	1.20	0.00	0.00	N/A	2000	9999	9999	0.3	25	8000
TL7	0.30	1.40	8.10	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL8	5.80	1.40	1.10	0.00	0.00	N/A	1800	9999	9999	0.3	35	8000
TL9	6.65	3.30	4.15	0.00	0.00	N/A	1800	9999	1600	0.6	35	8000
SB1	1.50	3.00	11.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB2	4.50	4.25	4.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB3	5.50	2.75	3.00	0.00	0.00	N/A	2000	9999	9999	1.2	25	8000
SB4	5.25	3.50	5.25	0.00	0.00	N/A	2000	9999	9999	2.7	25	8000