Response to reviewers’ comments on the “Wind Tunnel Experiments to Study Chaparral Crown Fires”

We wish to thank the reviewers for thorough reading of our manuscript and comments that lead to the significant manuscript improvement. Each comment is addressed below and the appropriate changes are incorporated in the manuscript. We hope that the reviewers will find the revised manuscript suitable for publication in JoVE.

**Editors Comments**

Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammatical errors.

**Response:**

The manuscript is now thoroughly proofread and changes and corrections are implemented.

**Comment**

Please avoid use of the pronouns “you” and “your” throughout the manuscript.

**Response**

Instances of “you” and “your” have been removed

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**Comment**

The JoVE format style does not allow footnotes, please merged any footnotes into the text.

**Response**

Trademarks for products replaced by generic product name thus footnotes are no longer in text.

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**Comment**

Please re-word the Short Abstract to more clearly state the goal of the protocol. For example, “This protocol/manuscript describes…”. Please re-word the Long Abstract to more clearly state the goal of the protocol.

**Response**

Short and long abstracts have been modified to more clearly state the goal of the protocol.

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**Comment**

Please ensure that all text in the protocol section is written in the imperative tense as if you are telling someone how to do the technique (i.e. “Do this”, “Measure that” etc.) Any text that cannot be written in the imperative tense may be added as a “Note”, however, notes should be used sparingly and actions should be described in the imperative tense wherever possible.

**Response**

All protocol language has been updated to the imperative tense.

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**Comment:**

Protocol Detail: Please note that your protocol will be used to generate the script for the video, and must contain everything that you would like shown in the video. Please add more details to the following protocol steps. There should be enough detail in each step to supplement the actions seen in the video so that viewers can easily replicate the protocol.

1.11: How do you choose the values?

**Response:**

These values correspond to the signal outputs from the load cell. That is, when calibrating precision weights are added to the load cells, the signal produced by the load cell when measuring the mass can be obtained from the instrument interface. The Load Cell Calibration step in the protocol has been re-structured in order to improve clarity in the methodology. We hope the updated protocol section addresses the inquiry.

**Comment:**

2) 3.3,6.3: Please mention what button is clicked on in the software to do this, or which menu items need to be selected.

**Response:**

To clarify the software interface an additional figure (Figure 3) is now in the manuscript. Also, the text is modified for clarity.

**Comment**

Protocol Numbering: All steps should be lined up at the left margin with no indentations. There must also be a one-line space between each protocol step.

**Response**

Steps have been lined up at the left margin with no indentations and a one-line space between each step has been added.

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**Comment**

Protocol Highlight: After you have made all of the recommended changes to your protocol (listed above), please re-evaluate the length of your protocol section. There is a 10-page limit for the protocol text, and a 3- page limit for filmable content. If your protocol is longer than 3 pages, please highlight ~2.5 pages or less of text (which includes headings and spaces) in yellow, to identify which steps should be visualized to tell the most cohesive story of your protocol steps.

o The highlighting must include all relevant details that are required to perform the step. For example, if step 2.5 is highlighted for filming and the details of how to perform the step are given in steps 2.5.1 and 2.5.2, then the sub-steps where the details are provided must be included in the highlighting.

o The highlighted steps should form a cohesive narrative, that is, there must be a logical flow from one highlighted step to the next.

o Please highlight complete sentences (not parts of sentences). Include sub-headings and spaces when calculating the final highlighted length.

o Notes cannot be filmed and should be excluded from highlighting.

**Response**

We have highlighted ~2.5 pages of the protocol for the filmable content. Please see the updated manuscript.

**Comment**

Discussion: JoVE articles are focused on the methods and the protocol, thus the discussion should be similarly focused. Please ensure that the discussion covers the following in detail and in paragraph form: 1) modifications and troubleshooting, 2) limitations of the technique, 3) significance with respect to existing methods, 4) future applications and 5) critical steps within the protocol.

**Response**

Several updates have been made to the discussion section. Items 1) – 5) required for this section are included as requested. Please see the manuscript.

**Comment**

Figure/Table Legends:: Please expand the legends to adequately describe the figures/tables. Each figure or table must have an accompanying legend including a short title, followed by a short description of each panel and/or a general description.

**Response**

All figures and tables now have expanded legends followed by short descriptions.

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**Comment**

References:Please make sure that your references comply with JoVE instructions for authors. Citation formatting should appear as follows: (For 6 authors or less list all authors. For more than 6 authors, list only the first author then *et al.*): [Lastname, F.I., LastName, F.I., LastName, F.I. Article Title. *Source*. Volume (Issue), FirstPage – LastPage, doi:DOI (YEAR).]

1) Please abbreviate all journal titles.

**Response**

References have been updated and journal titles have been abbreviated.

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**Comment**

Commercial Language:JoVE is unable to publish manuscripts containing commercial sounding language, including trademark or registered trademark symbols (TM/R) and the mention of company brand names before an instrument or reagent. Examples of commercial sounding language in your manuscript are S-Biner®, NI LabView, LabView, MATLAB®.

1) Please use MS Word’s find function (Ctrl+F), to locate and replace all commercial sounding language in your manuscript with generic names that are not company-specific. All commercial products should be sufficiently referenced in the table of materials/reagents. You may use the generic term followed by “(see table of materials)” to draw the readers’ attention to specific commercial names.

**Response**

Trademarks for products replaced by generic product name thus footnotes no longer in text.

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**Comment**

Please define all abbreviations at first use. Please use standard abbreviations and symbols for SI Units such as µL, mL, L, etc., and abbreviations for non-SI units such as h, min, s for time units. Please use a single space between the numerical value and unit.

**Response**

Abbreviations and symbols have been updated.

**Reviewer 1**

**Comment:**

1st half of paper very well written paper. Did not think the Protocol section was a good way to get the information across on the experimental set up and how the instrumentation worked. As written, I couldn't recreate the experiment, nor do I know how to interpret the results and apply it to the real world. Some significant experimental details missing (see below).

**Response:**

The protocol section is now modified to enable reader to recreate the experiment.

**Comment:**

No figure captions were attached to the article. Better images of experimental setup and flame video processing. Discussion of the figures needs to be improved.

**Response:**

We have added figure captions, better images of experimental setup, sample frames from experiment video and discussions of the figures. Please see the updated manuscript.

Additional Comments to Authors:

**Comment**

Table 1. Is the Crown Height, the distance between the bottom of the crown and the ground?

I would suspect it's not the top height of the crown relative to the ground surface, right?

**Response**

In Table 1, Crown Height represents the distance between the bottom of the crown fuel bed and the bottom of the surface fuel bed. The text introducing Table 1 has been updated to define all table parameters including the crown height.

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**Comment:**

-could you include starting fuel moisture content in the table for fuel bed and crown canopy?

**Response:**

The fuel moisture was measured for each experiment but it was not controlled. This is now clarified in the manuscript. Range of fuel moisture across the experiments is now included in the text.

**Comment:**

\*Protocol:

-This section is strange. Like a recipe for how to set things up? It reads like an undergrad lab class, listing to-do steps. I'd rather just learn how the instrumentation works and how the experiment was conducted.

**Response:**

It was our intention to enable the reader the reproduce the experiments in their labs as per the JoVE’s editorial instructions.

**Comment:**

-Fig. 2 is hard to see what is going on. I just see some C clamps.

**Response:**

The figure is enhanced and the additional legend added for clarity.

**Comment**

-lines 165 to 178 - could you provide the density of the fuel load too. 2 kg of chamise is placed on a hanging platform, but how deep is the material, over what area is the material spread, etc. same with excelsior. 500 g over what depth and what area? over what downwind distance does the fuel cover?

**Response:**

Density is now given in the manuscript and updated diagrams provide more insight on the fuel bed configurations.

**Comment**

What is the geometric relationship between the surface fuels and the crown fuel? is there crown fuel immediately above all surface fuel? Lines 179-184 - where were the thermocouples actually placed (with respect to the fuels)?

**Response**

The crown fuels are immediately above the surface fuel. The manuscript has been updated with a description on the geometric relationship between both fuel layers and Figure 1 has been updated to depict the fuel bed arrangements. Also, new figure, Figure 4, is included to present the thermocouple arrangement.

**Comments**

Representative Results: (249-253) having a figure showing a frame from the video with notation showing flame height and angle would be nice.

**Response**

A new figure (Figure 5) showing a frame with flame geometry notation has been added.

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**Comments**

-Are there captions that go with figures???

**Response**

Now we have included the figure captions in the body of the ms.

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**Comment**

-some explanation of Fig. 3 is needed in text. this is not a pdf, correct? since it's frame number, it implies that the flames start small, get large, then decay with time? is that because the 500 g of surface fuel or the 2kg of crown fuel has been completely consumed? something else?

**Response**

For greater clarity the original time replaced the frame number in the x-axis of the flame height figure. Indeed, in a typical experiment the flames start small, the flame will get large close to the middle of the fuel bed then will decay with time as it gets closer to the end of the fuel bed. The experiment in the figure is Case F (wind at 1m/s and distance between crown and surface fuel at 70 cm). In this case, the wind helps the flame to tilt. Because of the flame tilt, radiative heat transfer of the flame to the fuel bed is enhanced, Albini (1985)31. As the flame travels through the fuel bed it will pre-heat the fuel ahead of it. The mid fuel bed seems to be an optimum location where sufficient preheating has occurred over a large amount of fuel to create a large flame. The end of the fuel bed is also pre-heated, however, the amount of fuel becomes limited so that less pyrolysis gases are released which results in decreased flame height. This is now clarified in the manuscript.

**Comment**

-Fig. 4. is this the average from many repeated experiments (if so how many)? or just one experiment? For what case (with or without wind, etc.)? Moisture content? What is the total burn time tf? it seems like this would be useful information, in addition to the normalized curve provided. just to be clear, this is for surface fuel only?

**Response**

The mass loss rate depicted in the figure represents data for the crown fuel bed. This was a Case F experiment (Wind at 1m/s, distance between surface and crown at 70cm). The fuel moisture content was 45%, relative humidity was 66% and the total burn time was 2.5 minutes. The manuscript has been updated with this information.

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**Comment**

Fig. 5. Moisture content of fuel (are you assuming that fuel equilibrates with RH, that's why you are listing RH) Is that appropriate for live fuel? Just to be clear, no surface fuel, so instead of soaking the excelsior surface fuel bed (as explained in the Protocol section), you instead soaked the crown fuel directly? And what is the actual value of tf?

**Response**

We are listing fuel relative humidity to show environmental conditions at the time of the experience. Not necessarily indicating that the fuel moisture will equilibrate within the short experimental period. Regarding the surface fuel, the reviewer is right that no surface fuel was present, which means that instead of soaking the excelsior surface fuel bed we soaked the crown fuel directly. The actual value of tf for the mass loss curves are now listed in the manuscript.

**Comment**

-Fig. 6 What should I learn from Fig. 6 (as compared to Fig. 4, the other surface fuel plot)? Wouldn't information on tf help the reader understand what is going on better?

**Response**

We agree that information on tf would help the reader understand what is happening in the experiment, therefore we have now included this information in the manuscript. Thank you for bringing this to our attention.

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**Comment**

Fig. 7: where are T10 through T15 located relative to the ignition location? why is T12 much hotter and T14 cooler? is the fuel inhomogeneous? For this no wind case, how does the fire move in this case. From the numbering of the T sensors, one could surmise that the fire is moving in a preferred direction. But should it, for a no wind case?

**Response**

Figure 4 with experimental setup has been added to clarify the thermocouple arrangement. Thermocouple T10 is placed in the leading edge of the crown fuel bed, T15 is near the back of the fuel bed. Thus, T12 is closer to the ignition location than T14. The temperatures in the crown are consequence of preheating from the surface fire from beneath and the crown fire development itself. Since in most of our experiments the surface fire would propagate faster than the crown fire, the superposition of the flames would occur only at the leading edge of the crown. This superposition would lead to higher temperature. However, this is not sufficient to explain the observed large variations in the crown temperature. Although, we would place the fuels as homogeneously as possible, the vicinity of individual thermocouples and their orientations relative to fuel branches was never the same. This radiative heating from the burning branches would introduce additional disparities in measured temperature at each thermocouple. This is now discussed briefly in the manuscript.

**Comment**

Fig 8. Where are the T sensors, how are they arranged? Why does the max Temperature decrease for T04, T08, T09?

**Response**

Figure 4 with experimental setup has been added to clarify the thermocouple arrangement.

**Comment:**

-Fig. 7 & 8: is there any rhyme or reason for choosing U=0 for Fig. 7 and U = 1 m/s for Fig. 8? i.e., they have different fuel "geometries", so no real way to compare the two cases.

**Response:**

Data in the original manuscript was presented as representative data as can be obtained through the methodology described. For Fig. 7 and 8, two separate cases were included as typical trends that can be obtained through different configurations of the experiment. We now realize that it is advantageous to show results that can be cross referenced such as mass loss for both the surface and crown layers for the same experiments. Per your comment and with this in mind, we have re-structured the way mass loss data is presented. Four representative experiments were selected, crown mass loss and surface mass loss data is now included for these experiments. Please see the updated manuscript.

**Comment**

-Could you show an overlay of surface fire and crown fire fuel mass vs. time and for for the same case with T sensors located at the same (x, y) location, as well as temperature vs. time?

**Response**

As an example of temperature vs time and mass loss vs time please see Figure 1 below. The representative experiment in the figure is a Class B experiment, that is an experiment modeling independent crown spread where no surface fuel bed was present. The arrangement of the thermocouples is presented in Figure 2. For brevity we did not include both plots in the manuscript.



Figure 1 – Representative Class B experiment (a) crown mass loss trend (b) crown fuel bed temperature.

**Comment**

-Discussion section indicates that your results help us understand fire spread, but without some idea of where the T sensors are located, we can't figure that out from the information provided.

**Response**

Thank you for bringing this to our attention, to better navigate the reader through thermocouple location a CAD drawing of the fuel beds with thermocouple location labels has been added. For your reference that diagram is presented here as Figure 2 and in the manuscript as Figure 4.



Figure 2 – Fuel bed diagram with thermocouple arrangement.

**Comment:**

You also mention importance of packing density in discussion, but this information is not provided in the document.

**Response**

The value of packing density is now included as 9.2 kg/m3 per Omodan reference 30 (Omodan, Sunday. *Fire Behavior Modeling-Experiment on Surface Fire Transition to the Elevated Live Fuel*. University of California, Riverside, 2015)

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**Comment:**

-Good list of references.

**Response:**

Thank you!

**Reviewer 2**

**Comment:**

This is an interesting, laboratory-based technique to study transition and spread for surface and crown fuels. It's useful to have this information in the literature. I have several comments, mostly relating to benefits and drawbacks of the technique that should be included for its broadest applicability and future work.  
**Response:**

We are glad that the reviewer finds the manuscript informative.

**Comment:**

*Major Concerns:*

I would suggest stressing this is a laboratory technique. There are other techniques that focus on prescribed fires, etc. in the outdoors. There is a benefit for this being indoors that should be mentioned. I also suggest noting this in the title and the abstract, for instance "A laboratory technique to study chaparral fuels…". I would argue both laboratory and field measurements are worthwhile, but you will capture more measurements in the lab like this, they're just not necessarily 100% realistic.

Why isn't heat flux measured, particularly convective/radiative? Many papers have shown this to be important (e.g. Finney et al., PNAS). Should this be suggested as something that can be added in the future?

**Response:**

We agree with the reviewer that both laboratory and field measurements have advantages and shortcomings. This is now further stressed in the manuscript. Also, the abstract now clarifies that this is about laboratory techniques.

We also agree with the reviewer that having the heat flux measurements would definitely be advantageous. In the revised manuscript we added explanation of the relevance of directly measured heat fluxes (Finney, 2015) or indirectly inferring them (Tachajapong, 2009, 2014). At the initiation of the present study we did not have technical capability for heat flux measurements and had to proceed with the study by indirectly estimating heat release through fuel mass loss rate. Definitely, adding heat flux capabilities in the future is recommended. This is now added to the manuscript.

**Comment**

Regarding thermocouple measurements, details appear missing. What is the size, response rate, specific location, type, etc. Were radiation corrections applied? Can you include error estimates in the figure caption or figure itself? This is important if convective heating is important, which I assume is at this small scale with these fine fuels.

**Response**

Thank you for your comment. We agree that our manuscript benefits from a better description of the thermocouple array system we used in order to obtain temperatures. Thus, we have updated the manuscript with thermocouple specification including size, response rate, thermocouple location and type. We have also added a diagram with the thermocouple placement within the fuel bed configurations (Figure 2 here, Figure 4 in the manuscript).

**Comment**

*Minor Concerns:*

1. How do Mediterranean fuels differ from traditional canopy fuels? You cite Van Wagner, which has a theory for transition, but little mention is made. As far as I'm aware, there is no direct theory for spread in crown fuels, only rough correlations by M. Alexander that extend Rothermel's equations by a constant factor with a low R^2. So this additional data is very useful. This could help further motivate your paper and distinguish it from other crown fires.

**Response**

We agree that crown fire theory as the one presented by Van Wagner is quite relevant to our work. Following Van Wagner’s crown fire categories, we observed that our experiments displayed some active and passive crown fire behavior but rarely did we see independent crown fire. For this manuscript we have added a brief discussion on Van Wagner’s fire categories and we wish to continue our data analysis in the future in order to provide a bit more insight into how and why we observed these categories of fire and what is the significance of this. We hope this contribution will increase the body of knowledge on chaparral crown fire.

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**Comment**

Other crown fires in tree stands also are ~100 feet + while yours are smaller. What is a typical height for chaparral fuels and how do your experiments compare with that?

**Response**

Typical chaparral crown height is anywhere between 3 and 6 ft (Countryman and Philpot, 1970). In our experiments distance from the surface fuel to the bottom of the crown was 2 ft to 2.3 ft. We selected crown-surface distance to address two different flame regions of interest: continuous flame and intermittent flame.

**Comment**

There are a number of outdoor measurements in the literature in similar types of fuel beds I think are worth citing. Some discussion of differences and advantages would be worthwhile.  
a. <https://doi.org/10.1016/j.firesaf.2006.01.006>  
b. <https://doi.org/10.1016/j.firesaf.2008.06.004>

**Response**

Thank you for bringing to our attention the works by Silvani *et al.* (2008) and Morandi *et al.* (2006). Indeed, such studies involved fuel beds similar to the ones in our study with the difference that their experiments were performed in the field whereas ours are laboratory scale. There are many advantages to both field and laboratory scale fire experiments including the ability to control wind speeds in laboratory studies and the ability to more precisely replicate the natural environment for field experiments. It is beneficial that the reader is aware of these differences and we have thus updated the manuscript with a brief discussion on laboratory versus field chaparral fire experiments.

**Comment**

Can other fuels than the ones you mention be used and tested in the same way?

**Response**

Yes, aside from chamise chaparral other types of chaparral fuels can be used and tested in the same way. In addition to chamise (*Adenostoma fasciculatum*), other chaparral fuels include manzanita (*Arctostaphylos glandulosa*) and hoaryleaf ceanothus (*Ceanothus crassifolius*). In the protocol chamise was the fuel chosen because as per Sun *et al.* it is the most flammable of these species. The protocol can be modified to include other species as long as the branch size is maintained below ¼ inch for uniformity. The manuscript has been updated to include this information.

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**Comment**

How was moisture content of the fuels determined?

**Response**

Fuel moisture content was obtained by oven drying. Samples of fuel are collected prior to experiments and taken to an oven to be dried, fuel moisture is calculated from the initial sample weight and the final weight after drying. The manuscript has been updated to include fuel moisture calculation procedures.

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**Comment**

Is the MATLAB script for flame height mentioned available with this document or based on previous work, e.g. Audoin et al?

**Response**

It is in house developed matlab script. We will be working with the editor to make the script available with the manuscript and the video.

**Comment**

Reference 24 appears to be incomplete.

**Response**

The reference is now completed.

**Comment**

Page 3, line 68-69 - what do the basket results have to do with spreading results, how do they compare? It was not clear by the tests.

**Response**

The basket experiments dealt with the burning characteristics of chamise as a chaparral fuel which we thought it would be useful for the reader since we also use chamise fuel. We indeed agree that these studies did not address spread but we hope that the spread studies we included by Tachajapong et al., Lozano et al., and Li et al., help illustrate works focusing on fire spread for chaparral fuel.

**Reviewer #3:**

*Manuscript Summary:*

The ms details a method for studying the behaviour and spread of fires burning through model fuels representing chaparral shrubs over litter in a small combustion wind tunnel

**Comment**

*Major Concerns:*

While the ms provides many details about the methodology used, it is rather poor in its presentation of results. Those presented do not allow direct comparison of the different components, seemingly selected at random instead of attempting to illustrate any particularly interesting point. Deficiencies in the methodology in regard to providing a consistent and uniform experimental design (i.e. fuel moisture content and fuel bulk density variations do not appear to have been identified by the authors but have been found to be quite important in fire behaviour studies elsewhere.

**Response**

Thank you for reviewing our manuscript and for the comments provided. In order to address the major concerns, we have re-formatted part of the representative results section as to allow comparison between datasets. The protocol section has also been updated. Please see the updated version of the manuscript. Detailed answers to comments in the PDF are provided below.

**Comment**

*Minor Concerns:*

Numerous comments and suggestions have been entered into the PDF of the ms for the consideration of the authors.

**Response**

The authors would like to express their gratitude for the comments on the PDF of this manuscript. Many improvements were made and references added based on these comments. Below are responses to those comments.

**Comments**

“Because of the regional Mediterranean climate…” Causality? Does chaparral occur in the Mediterranean region?

**Response**

This part is now rephrased.

**Comment**

“…which cover 5% of the land in the state…” Is this a large component of the vegetation? If not, why is it important here? Provide some bounds for your studies.

**Response**

Thank you for your question. Indeed, this information is not relevant from the methodology presented and it has been thus removed. Please see the updated manuscript.

**Comment**

All shrubs fit this criteria--is that enough to consider fires in this fuel a 'crown fire'? This statement needs a supporting reference.

**Response**

Thank you for your question. Chaparral fires are typically characterized as crown fires in the literature, a reference indicating this information has been added to the manuscript.

**Comment**

On “dynamics3-11”: What is the purpose of this non-exhaustive list?

**Response**

We agree with the reviewer that the body of work on laboratory scale modeling of wildfires is vast. We believe these references are a good starting point for the reader interested in learning about laboratory

**Comment**

On “Lozano5”This work was carried out before reference 6, thus the narrative linking the two is incorrect. Lazy writing.

**Response**

Thank you for bringing this to our attention. We reworded this sentence in the manuscript.

**Comment**

On “…fire conditions..” Do you mean behaviour?

**Response**

Yes, we have updated the manuscript.

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**Comment**

On “…topography, weather and fuel..” Provide a reference. See

**Response**

Reference has been added.

**Comment**

On “It has been shown that wind affects energy release rate in the fuels” Do you mean combustion rate?

**Response**

Yes, in this context energy release rate refers to the energy released through combustion.

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**Comment**

This repeats lines 66-67 from the previous paragraph.

**Response**

Thank you for bringing this to our attention, we have corrected this in the manuscript.

**Comment**

On “Energetically, a fuel particle ignited if the amount of heat that it receives results in a mixture of gases that successfully react with oxygen”. There needs to be initiation of thermal degradation reactions first that produce these gases--see Sullivan and Ball (2012).

**Response**

Thank you for providing this information on the thermal reactions producing the reaction gases described here. We have now included the Sullivan and Ball (2012) in the manuscript in order to direct readers to literature on chemical scale processes involved in cellulose burning.

**Comment**

On “Since 2001, we..”

**Response**

Thank you for your comment, this has been re-phrased in the updated manuscript.

**Comment**

On “Parameters measured include mass loss rate, fuel temperature, flame height, fuel moisture content and relative humidity of the ambient air.” What about air speed if, as per L77, wind is critical?

**Response**

Correct, we controlled for air speed. The manuscript has been updated in order to better clarify this.

**Comment**

On “..induced” applied? Induced would be that created by the fire.

**Response**

Thank you for bringing this to our attention, we have re-worded in the manuscript.

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**Comment**

On “…the suspended fuel bed…” This aspect of the experiment needs to be introduced and discussed prior to this. It seems to relate to the previous work utilising 'baskets' which also were not properly explained for the uninitiated.

**Response**

The manuscript has been updated with an expanded description of the experimental setup.

**Comment**

Protocol comments

**Response**

There were several comments on the protocol, in order to address them and for greater clarity, we reformatted this section, added new figures and included new supplemental information.

**Comment**

On Representative Results “A custom MATLAB script…” This is all methods, not results.

**Response**

Thank you for bringing this to our attention, we agree that this should not be part of the results section. We have moved information about our processing script to the introduction section.

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**Comment**

On “Fuel consumption rates were obtained for both fuel beds.” Where are these measurements in relation to the ignition line?

**Response**

Fuel consumption rates were calculated for the entirety of both fuel beds. The manuscript has been updated to clarify this.

**Comment**

On “…experimental time t and the total burn time tf …” How are these determined? t\_f needs to be defined.

**Response**

The total burn time is defined as the time when flaming combustion has stopped. We have updated the manuscript to clarify this.

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**Comment**

On “…conducted on August 14th, 2015…” Why is this important?

**Response**

Based on your question, we re-evaluated the need for this information and realized that it is not relevant in the context presented. We have thus removed it and all similar calendar date information for experiments throughout the manuscript.

**Comment**

On “Figure 6 – Surface fuel mass loss for U = 1, surface-crown separation d = 60 cm (Class E)” How are these two figures meant to comparable if they are totally different conditions. What is the point of these two graphs if they are not meant to be compared? Can Figure 4, 5 and 6 be combined?

**Response**

The purpose of the data in the original manuscript was to show typical trends in the data obtained through the methodology described. We now realize it is advantageous to provide data that will allow for comparison between data sets. To address this issue we have presented the data in a new form on the updated manuscript. Mass loss for both the surface layer and crown layer for the same experiments are now presented, this allows for cross examination of the mass loss for both layers.

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**Comment**

Comments on “Discussion”

**Response**

The authors would like to thank the reviewer for comments throughout the Discussion section. The new version of the discussion addresses comments.

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**Comment**

There are a number of aspects of this methodology for which experimental uniformity does not appear to have been controlled and which would have significant effect on ability to replicate experiments. These include controlling or limiting effect of fuel moisture content (both of surface and crown fuels), and bulk density of fuel beds. These two factors have been found to be the most important after air speed in determining the behaviour of fire in a large range of fuels. Considering the variables that you have controlled, have you investigated the residual error in fire spread to identify whether these are capturing the bulk of the factors influencing the behaviour of your fires? See Mulvaney et al (2016).

**Response**

We agree that fuel moisture content and bulk density are important parameters for fire spread for both the crown fuel bed and surface fuel bed. In the protocol described by the ms, fuel moisture content (FMC) is measured for each experimental set but FMC was not one of the controlled parameters. Instead, we focused on the influence of wind, fuel bed separation and surface fuel bed presence on chaparral crown fire behavior. Indeed in the future, the methodology should be expanded to include fuel moisture content and fuel bulk density variations. We believe this is an important next step in the methodology described by the manuscript. In addition, experimental design of a study that includes fuel moisture and bulk density as controlled parameters would benefit from the analysis presented by Mulvaney *et al.* as this approach quantifies the variation of experiments which include fuel moisture, fuel particle diameter and fuel load as varied parameters.

References:

Countryman CM (1966) The concept of the fire environment. Fire Control Notes 27, 8-10.

Mulvaney JJ, Sullivan AL, Cary GJ, Bishop GR (2016) Repeatability of free-burning fire experiments using heterogeneous forest fuel beds in a combustion wind tunnel. International Journal of Wildland Fire 25, 445-455. doi:10.1071/WF15068.

Sullivan AL, Ball R (2012) Thermal decomposition and combustion chemistry of cellulosic biomass. Atmospheric Environment 47, 133-141. doi:10.1016/j.atmosenv.2011.11.022.