To: Supplemental Sales Tax Oversight Commission (SSTOC), City of Orinda, CA
From: John Radke, Center for Catastrophic Risk Management, University of California, Berkeley

Answers to the Questions submitted by the Supplemental Sales Tax Oversight Commission (SSTOC) members (7/20/2022) regarding the UC Berkeley proposal, "A Strategic Wildfire Planning Process for Orinda: Transitioning from Basic, through Adaptive, to Transformative Wildfire Resilience in Orinda, CA."

I think it is important to point out that this proposal responds to the needs of the citizens of Orinda, the funders of Measure R, and those who we address here as the clients of this research. We see their needs as being significantly different than those of other entities. However, we do recognize that many other entities and organizations (such as MOFD, Calfire) will benefit from the findings of this research.

Paula Reinman's Questions:

• What is the final output? I understand it to be a program or application that people can use to get granular detail about the specific fire risk and vegetation management needs for their home, as long as they uploaded information about their vegetation. Is that correct? Do they get customized recommendations about vegetation management for their homes?

The final output will be a report with a series of maps that detail the current vegetation conditions, identifying the fuel models, and showing the wildfire intensity results of various wildfire scenarios based on common weather and extreme conditions. The geographic extent will be Orinda-wide, where users can zoom to their individual properties to assess their conditions and risk. The maps will be in digital format where one can zoom to individual neighborhoods and properties to see their classification. We will decide on the actual delivery platform after interacting with the TAC and other citizen groups like the Firewise community. It could be something like thematic shading on top of a Google Earth platform where the shading illustrates fire intensity of the current vegetation. It is our intent to delineate and work with fireshed neighborhoods and virtually mitigate by altering vegetation fuels and reburning in a fire model the fireshed to realize the impact. The more cooperation and crowdsourcing in a fireshed neighborhood, the more accurate and granular detailed the predictions and the more opportunity for custom mitigation scenarios and outcomes.

Our results will provide a very high spatial resolution map of where to begin the mitigation efforts to get the greatest result for the money spent to improve conditions and reduce the overall risk of a firestorm in Orinda. In a sense, recommendations about vegetation management on their individual properties.

• Who is the receiving organization for this work? I assume it's the City of Orinda. What is required from the City, from MOFD and from any other entities during the project? What is required from them after the project to maintain and promote the work?

The City of Orinda, and its citizens, are the receiving organization for this work. The City will examine the results, and once approved for public access, they will be made available to the citizens of Orinda. MOFD or any other entity, have no requirements, but may wish to participate in the discussions as the research is undertaken, and will receive the results at the same time as the community at large. The results of this research, at an enhanced spatial resolution and sophistication of vegetation classification, along with various burn scenarios, will likely benefit efforts to further strategize to keep Orinda safe. We recommend the City keep the interactive website active so that citizens can update any changes in vegetation growth and mitigation on their part. The database itself will track all updates which are then used to simulate any fire scenario. We would have to examine the current City computer operations to best answer the final question here. An outside contractor may be required to maintain the fire-safe-Orinda website if the system exceeds internal technical capacity.

• How is MOFD involved? Are they a receiving organization for the project? What if they do not want it or do not want to participate?

MOFD is a stakeholder, but not directly involved in the data acquisition and modeling process. Their mission is to protect Orinda and Moraga from a wildfire disaster. This research is to inform the individual citizen and their fireshed neighborhoods of their vegetation fuels risk, and to show them strategies on how they can reduce that risk on their own property and in their fireshed neighborhood. We assume the City will provide MOFD with a link to the report and database. We believe outputs from this research will be beneficial to MOFD in their efforts to reduce fuels in the City of Orinda, especially with high spatial accuracy of up-to-date vegetation inventory and modeled fuel burns under various weather conditions.

• What areas do the advisory committee influence? How?

The TAC is made up of a cross-section of the community to be informed, and inform the research effort so that we do not move forward without being aware of all known concerns and interests. We also hope the TAC can help strategize the engagement of citizens in the crowdsourcing effort to improve the accuracy of vegetation identification of each plant/bush/tree within each property.

• Has this or something like it been done anywhere else?

To answer this question it is necessary to first look at higher-resolution data itself. High resolution remotely-sensed images are filled with fine-grained detail that can be difficult to interpret by visual inspection, and require automated techniques, such as machine learning, to resolve. Machine learning techniques, such as support vector machines or random forest classifiers, are efficient algorithms that can be used to classify the high level of detail in the images into meaningful clusters of pixels. Both of these machine learning algorithms have been applied in many studies using mid-to-high resolution remotely-sensed images (Braun *et al.* 2010, - Zhao *et al.* 2020). One issue is that the high degree of detail in high resolution images inevitably leads to a greater amount of superfluous pixels. To address this problem, the pixels in high resolution images can be clustered into similar classes and segmented into meaningful regions called "objects." For vegetation classification, this object-based image analysis approach with machine learning algorithms can be used on high resolution images to help segment "objects" and delineate them into vegetation classes. Examples of vegetation objects are trees, groups of trees, shrubs, and grass.

Alternatively, more complex deep learning models, such as deep neural networks and convolutional neural networks, have also been widely used for vegetation classification and identification to a high level of accuracy (Li *et al.* 2012, Radke *et al.* 2020, Ayhan *et al.* 2020). The integration of deeper and wider networks, in addition to convolution operations have the capacity to interpret and learn the complex patterns in the input data features. While deep learning models pose a powerful option for automated vegetation classification, many high-quality training samples are required to effectively train the model. An important component of our proposal is to rely on crowdsourcing to generate these training samples via vegetation identification and labeling. Post-processing and filtering techniques will also improve the fidelity of the training samples.

This proposed research is part of a 30-year effort in modeling and identifying vegetation and wildfire risks in the wildland-urban regions of California. Radke (1995) introduced a vector polygon delineation method that mapped vegetation fuels to better define areas of fire intensity, spread and flame length from a BEHAVE fire model. This approach is advanced in our machine learning, support vector machine classification. Radke's PhD student, Wei Luo (2004), developed a cellular automata modeling approach to studying wildland urban interface fires in her dissertation. Radke's PhD student, Jianchun Xu (2006), developed a spatial data gathering technology for large scale fire modeling in the wildland urban interface, which included a form of crowdsourcing where ordinary citizens identified vegetation through crowdsourcing. Radke (2006) argued that the current scale of the data and models used in fuel identification and wildland urban interface modeling must move to a backyard scale to engage the individual homeowner in a fuels management strategy. Li and Radke (2012) propose a very high spatial resolution support vector machine approach to classify vegetation from a 3m^2 multispectral satellite imagery. Radke et. al. (2018) show that higher spatial resolution data sets have produced significantly better modeling results than more conventional data sets in similar circumstances. In 2018 they identified and modeled vegetation fuels at 5 m^2 resolution and calculated 91.25% accuracy of mapped fuel cover where for the same landscape the standard LandFire dataset at 30 m^2 resolution results in an accuracy of only 48.75%. We propose to better this 2018 advancement by modeling ground data at 1 m^2 resolution and 3 m^2 resolution for this proposed 2022 Orinda research.

To the best of our knowledge a community action plan using our proposed state-of-the-art research has not been done anywhere else.

Braun, A. C., Weidner, U., & Hinz, S. (2010). Support vector machines for vegetation classification A revision. Photogrammetrie-Fernerkundung-Geoinformation, 273-281.

Zhao, F., Wu, X., & Wang, S. (2020). Object-oriented vegetation classification method based on UAV and satellite image fusion. *Procedia Computer Science*, *174*, 609-615.

Li, W., Radke, J., Liu, D., & Gong, P. (2012). Measuring detailed urban vegetation with multisource high-resolution remote sensing imagery for environmental design and planning. *Environment and Planning B: Planning and Design*, *39*(3), 566-585.

Ayhan, B., Kwan, C., Budavari, B., Kwan, L., Lu, Y., Perez, D., ... & Vlachos, M. (2020). Vegetation detection using deep learning and conventional methods. *Remote Sensing*, *12*(15), 2502.

Weimin Li & John D. Radke (2012): Geospatial data integration and modeling for the investigation of urban neighborhood crime, Annals of GIS, 18:3, 185-205

• What is the minimum percentage of citizens / parcels that need to participate by providing crowdsourced data? Is the purpose of the crowdsourced data to validate the model, to provide individual property level insights or something else?

Crowdsourcing is an important effort used to validate, or ground truth, our modeling process for vegetation identification through remote sensing and image processing. Based on the crowdsourced validation data we propose combining a rule-based classifier and Support Vector Machine classifier to produce vector objects or polygons of like vegetation. These polygons might delineate individual plants or like clusters of plants. We randomly chose the training data sites and use them to train the classifier. We can calculate the initial classification accuracy of our process using this technique. We initially use our own technical staff to identify on the ground vegetation and classify these polygons in the training sites. We then train Orinda citizens to undertake the same validation process and through this crowdsourcing technology we add to and improve the accuracy of the dataset. The more citizens that participate, the more we reduce uncertainty and improve the accuracy predictions. It isn't possible to estimate the absolute minimum required percentage of citizens / parcels that need to participate to capture meaningful results. However, if even one citizen on one parcel participates, it is an improvement over the status quo. The more citizen participation, the higher the accuracy of our results, the better the model, the better the prediction, and the more accurate and better the strategy for mitigating a wildfire disaster.

Jud Hammon's Questions:

To be more specific, here are my questions about your proposal. Please be as complete as you can in responding to each question.

1. Do you have any data showing how higher-resolution data sets have actually produced significantly better modeling results than more-conventional data sets in similar circumstances?

Yes, Radke, *et al* (2018) show that higher-resolution data sets produced significantly better modeling results than more-conventional data sets in similar circumstances. Documented in their Appendix D, the accuracy of their mapped fuel cover at 5 m^2 resolution is 91.25%; the accuracy of mapped fuel cover from the standard LandFire dataset at 30 m^2 resolution is 48.75%. For the proposed 2022 Orinda research they propose an improvement in their efforts by modeling ground data at 1 m^2 resolution when public domain at that resolution data is available; and 3 m^2 resolution at other times using cost effective Planetscope satellite data which widely available for all sites.

2. You propose a crowdsourcing effort to help validate your initial identification of vegetation conditions. Approximately what fraction of Orinda households would need to be actively participating, in order to give high confidence that your sensors and AI system are correctly identifying the location, type, and size, of vegetation throughout Orinda?

This question is very similar to one proposed by Paula Reinman above. I include the same answer here. The crowdsourcing is an important effort used to validate or ground truth our modeling process for vegetation identification through remote sensing and image processing. Based on the crowdsources validation data we propose combining a rule-based classifier and Support Vector Machine classifier to produce vector objects or polygons of like vegetation. These polygons might delineate individual plants or like clusters of plants. We randomly chose the training data sites and use them to train the classifier. We can calculate the initial classification accuracy of our process using this technique. We initially use our own technical staff to identify on the ground vegetation and classify these polygons in the training sites. We then train Orinda citizens to undertake the same validation process and through this crowdsourcing technology we add to and improve the accuracy of the dataset. The more citizens that participate, the more we reduce uncertainty and improve the accuracy predictions. It isn't possible to estimate the absolute minimum required percentage of citizens / parcels that need to participate to capture meaningful results. However, if even one citizen on one parcel participates, it is an improvement over the status quo. The more citizen participation, the higher the accuracy of our results, the better the model, the better the prediction, and the more accurate and better the strategy for mitigating a wildfire disaster.

3. What data do you have that demonstrates that your remote-sensing system will give reasonably accurate measures of fuel moisture content in Orinda's vegetation?

We use standard Normalized Difference Vegetation Index (NDVI) to quantify vegetation greenness, useful in understanding vegetation density and assessing changes in plant health. We use Soil Adjusted Vegetation Index (SAVI) to correct the Normalized Difference Vegetation Index (NDVI) for the influence of soil brightness in areas where vegetative cover is low. The Normalized Difference Water Index (NDWI) is also known to be strongly related to the plant water content. It is therefore a very good proxy for plant water stress. Both NDVI and NDWI are positively correlated with live fuel moisture. Chuvieco et al. (2004) present an empirical method for deriving fuel moisture content (FMC) from NDVI and surface temperature. Their model shows high accuracy ($r^2 > 0.8$) for both grasslands and shrubs. It is used to derive a spatial estimator of FMC in Mediterranean conditions such as those found in Orinda. In addition, we plan on sampling some vegetation to validate our modeled estimates of FMC with actual ground truth measurements. We follow the fuel moisture sampling and lab processing procedures from Pollet and Brown (2007)

E. Chuvieco et al.. / Remote Sensing of Environment 92 (2004) 322–331

J. Pollet and A. Brown. 2007. Fuel moisture sampling guide. Salt Lake City, UT: U.S. Department of Interior, Bureau of Land Management, Utah State Office. 30 p. http://www.wfas.net/nfmd/references/fmg.pdf (May 14, 2015).

4. What data do you have showing that your proposed more-sophisticated set of sensors and resulting higher-resolution data set will give more accurate predictions on fire-weather patterns in the event of an actual wildfire?

The proposed analysis does not predict fire-weather patterns. Rather, it is designed to model the fire impact of various weather patterns.

5. Why do you believe that your remote sensor system will result in a landscape model that is significantly more accurate than existing landscape data?

Our evidence is in our peer reviewed Radke et al (2018) research report to the California Energy Commission that showed that our $5m^2$ spatial resolution remotely sensed approach improved contemporary landscape data from 48.75% accuracy to 91.25% accuracy of mapped fuels. We plan to improve this using new remote sensors with of $3m^2$ spatial resolution, and at times we can take advantage of even higher spatial resolution sensors of $1m^2$.

6. How could your model be used in real time, to more accurately guide first responders (including both fire fighters and evacuation teams) in the event of an actual fire?

The proposed analysis is designed for strategic planning in advance of a fire event to mitigate and reduce the risk of future catastrophic wildfires. It is not intended for operational real-time emergency fire response, which is the domain of first responders.

7. What staffing would Orinda need to have, to maintain and use the model in the future? Please include the number of full-time-equivalent persons and qualifications of each, as well as a brief description of the tasks each person would perform.

I could only answer this after assessing the current Orinda staff, their computer equipment and skill set. A quick guess is that once built, this system could easily be maintained with a qualified and skilled part time contract position of ~ 25% time. As far as, "a brief description of the tasks each person would perform", it is too premature to address this request. During the research project, interaction with the community will help determine the needs, dependency and future use of this system.

Chris Decareau's Questions:

• Objective 1.B: If MOFD (CalFire) uses Hauling Scale for fire response, will the BIP be able to correlate to the Hauling scale so residents can gauge whether their property MAY be protected under vegetation mitigation strategies (understanding that some Plan scenarios may change the BIP based on underlying dynamics).

Although the Hauling Chart is used as a nomograph to show when an incident commander is likely to deploy firefighters and types of apparatus to a location to engage the fire, the Burn Intensity Potential (BIP) is a good metric to use to gauge what type of fire response engagement might likely occur. If a fireshed can collectively reduce the BIP to where the incident commander is likely to deploy firefighters, then a neighborhood has a fighting chance of being saved. If the BTUs and Rate of Spread can be shown to drop into the green zone on Figure 2 in the proposal, an incident commander will be quite confident that it is a safe neighborhood for their fire fighters to defend.

• Objective 2: One risk of crowdsource data is obsolescence or industry capture, such as happened to WeatherUnderground. This is a risk to the Plan that should be addressed during design.

Significant vegetation change happens on an approximate 5-10 year scale, rather than annually. So, we would envision that the citizenry could be asked perhaps once or twice a decade to update their vegetation classes. While this would be ideal, one of the advantages of the rapid return of the remotely sensed data is the ability to detect change at a very high spatial resolution ($3m^2$) on an almost daily basis. These sensors function independent of crowdsourcing. We will always have accurate remotely sensed change data. If crowdsourced data is no longer available to validate, we at least continue to have accurate data from the satellite sensors.

• Objective 3.A: Is the classification map based on the BIP or Hauling Scale or some other metric. Won't the metric vary by scenario: weather and intensity.

The BIP metric comes from the burn scenarios in the wildfire modeling. The Hauling Chart is used as a nomograph to show when the incident commander is likely to deploy firefighters and appropriate apparatus to a location to engage the fire. The metric varies, based on weather conditions and fuel moisture. A good gauge for this is time of year, whether drought conditions are present, temperature, wind speed and direction, relative humidity, and trends in the Vapor Pressure Deficit (VPD). So yes, it will vary by scenario. Therefore, we will run the wildfire models on various scenarios to try to encompass a range of all possible events.

• Objective 3.B: How does suppression difficulty index vary from Hauling Scale or BIP? Is there a relationship?

A suppression difficulty index is a combination of where first ignition occurs, and what the accessibility is for deploying apparatus and egressing residents. It has more to do with the movement of resources in, and residents out, of the fire region. It does look for bottle necks or choke points that are identified from BIP predictions. The Hauling Chart is again a nomograph to show when the incident commander is likely to deploy firefighters and types of apparatus to a location to engage the fire.

• Objective 3.C.1: Define relationships between different spatial unit/metric and BIP, SDI and/or Hauling Scale.

The BIP spatial unit at the very smallest resolution is $3m^{2,}$ but more likely defined by a larger polygon that is the result of the SVM classifier of fuels. The SDI is generated using a networked based location-allocation algorithm, and delivers apparatus to the fire and moves residents from the fire along transportation corridors. Choke points are identified using the BIP, and weights can be added to represent evacuation delays. These weights can be calculated from historic data where normal and congested traffic occurs. The Hauling Chart is again a nomograph to show when the incident commander is likely to deploy firefighters and types of apparatus to a location to engage the fire. Incident commanders can show unique interpretations of the Hauling Chart, but for the most part, from Radke (1995) they are consistent in their interpretation of fire risk.

• Objective 3.C.2: Is "collective" a unit/metric for a neighborhood/fireshed?

In this context, "collective" refers to the neighbors in the fireshed. For example, your neighbor's property, although it is not your responsibility, might actually endanger your property, and therefore it is of concern to you, and vice versa. They collectively share the risk.

• Objective 3.C3: Does "proprietary" mean to UC or Orinda? Is this a licensing issue for future budgets?

In this context, "proprietary" refers to the collective homeowners that together own the risk of wildfire, or manage their neighborhood and collectively own a much safer and fire-resistant neighborhood. I believe the citizens of Orinda would own the database since it is paid for using Orinda tax revenues. The University of California will not impose any ownership requirements on the data, which will remain in the public domain.

• Task 1: Clarify monthly method of "briefing" the TAC. Meetings with CC, SSTOC, MOFD, & OFC are problematic to schedule and require Brown Act provisions.

In past projects we have kept the TAC informed through an email thread that was updated monthly. We had online meetings once a quarter to report progress and we met in person once a year. These updates helped the research team as much as it helped the TAC be engaged with the progress. On several occasions members of the TAC were able to help the research group more effectively accomplish tasks. It would be helpful if at least one representative from CC, SSTOC, MOFD, and OFC would be on the TAC. These briefings are not intended to be formal enough to require Brown Act provisions, they are more to keep everyone informed and to communicate where problems might be surfacing.

• Task 2: Notify/list proprietary or licensed data that the Orinda Wildfire Plan will depend on for future updates. (see Obj. 3.C.3 above)

The only proprietary or licensed data that will be used in this research is remotely sensed imagery from private satellite companies. This is the only data that would need to be licensed if Orinda wished to use it for future updates. However, we believe Orinda would not need the original data used in this research but would rather license future data for future updates. All public domain data used in this research is accessible to Orinda with no licensing necessary. Until the final report is submitted to Orinda, the UC group will keep the crowdsourced data on a secure server, only accessible to those that contribute data from their own individual property. Orinda will have to determine the access and security protocols for this crowdsourced data after the project is complete. All public domain remotely sensed data and their resultant classified products will be accessible to Orinda with no licensing necessary. All the classified products from the machine learning efforts will be available to Orinda with no licensing necessary.

• Task 11: relates to Obj 3.C.2 that individual lots with one metric have a different risk metric when aggregated with neighbors. There could be significant social "dependence" developed if residents get two metrics: lot vs neighborhood.

A good observation and true. This is why we promote a Wildfire Plan for Transformative Resilience, a fundamentally new system where a profound shift in the human relationship with wildfire that embraces the dynamic and rapidly changing role of fire in social–ecological systems. You cannot survive wildfire without engaging and working with your neighbors. The landscape is not a blank canvas and each property has its own unique landscape. The fireshed is where we engage together in a common cause to reduce the fuel loads and give ourselves a fighting chance to suppress fire should it occur. If one property is perfect amongst others that are not, that perfect property is still not going to see fire fighters risk their lives to save their structure(s).

• Task 14: Orinda Police and MOFD are working with ZoneHaven already to design evacuation options and procedures. How can the UC/Radke fire modeling provide supplemental or complementary information for Orinda?

The results of our research will help inform any organization with more information. Professor González came to UC Berkeley from the MIT's engineering group and is one of the world leaders in mobility. She employs mobile phone records to understand the appearance of traffic jams and uses AI to better understand access and egress in transportation networks. Knowledge gained from modeling the Orinda project will likely be of great value to the Orinda Police and MOFD.

• Budget: "Year 1/Year 2" - Clarify calendar or fiscal year for budgeting purposes.

The Year 1 was expected to begin by the Fall semester 2022 (August 1st 2022). UC Berkeley requires Graduate Student Researchers (GSRs) to be hired for entire semesters. I attempted to align the budget with the GSRs expert in the areas needed for this research and their graduate programs. Year 2 would begin August 1st 2023. I include two months at the end to tie up loose ends and transfer everything to the City of Orinda, including the live database.

• Budget: I did not catch, but heard from the proposal presentation, that faculty will provide guidance and supervision, though the University is foregoing charges for that time after Year 1.

Yes, the professors will be providing guidance and supervision, as it is expected that this project will generate problems and solutions that will become part of each student's thesis.

There may be overlap in the emergency egress (network) modeling, but there are indications that the Radke proposal offers a more dynamic/situational model than may be currently implemented (Task 14). However, I am not an expert on the differences between the proposed modeling and Zonehaven or the methodology that the Police and Fire have adopted.

Again, we see our clients as the property owners/citizens of Orinda, and our efforts/models will be geared to their needs. They may appear similar in some way to the efforts of the Police and Fire, or they may not. We seek to push the envelope in every way, as this is the purpose of faculty and students at a top research university. This is how we all collectively advance theory and technology. We are never in competition with the world of consulting, rather we hope to advance solutions that are then adopted by the consulting world. We see the Orinda project as a prototype for the rest of the Californians who live in threatened wildland urban regions where both interface and intermix exist and have created ecologies that are extremely dangerous for both the residents and the fire fighters. We seek to change the paradigm and guide Californians to a state of Transformative Resilience.

To support this modeling effort, there will need to be Orinda staff, and SSTOC time, to review reports, as well as facilitate arrangement, notification and hosting of periodic meetings and a workshop or two.

In past projects our research team has taken on the facilitation, notification, and hosting of workshops. The final report will come at the end. We will release some preliminary findings if members of the TAC feel it can help other entities in Orinda.

Alex Weinstein's Questions:

- How will we measure success?
  - Key metrics?
  - Deliverables?
  - Next steps?

We will be quantifying what can be mitigated, and how much it will reduce wildfire risk using metrics that are common in wildfire and fuels modeling. All of this will be mapped at very high spatial resolution so that the individual property owner can see what on their property is causing the greatest risk. This will help them better see what needs to be immediately addressed. How many members of the community engage in the crowdsourcing will be another way of measuring success. High risk neighborhoods will be identified, and neighborhood groups can be targeted to make changes ad Orinda a safer community.

The deliverables will be digital maps available online indicating individual risk under various weather scenarios. These maps will illustrate what can be done by mitigating fuels on individual properties, what the results of such mitigation efforts would be, and how to access and egress from each property during an event. Routes that are in danger of failure during various event scenarios will be mapped for everyone to evaluate.

The results will provide a very high spatial resolution map of where to begin the mitigation efforts to get the greatest result for the money spent to improve conditions and reduce the overall risk of a firestorm in Orinda. In a sense, a road map to an Orinda safer from wildfire.

- What are the biggest risks to both timing and budget?

Delaying will cause staffing issues on the UC side (the three graduate students recruited for this type of research) where the GSRs will be allocated to other funded projects. These are the only three wildfire oriented environmental modeling and remote sensing planning students in the program. Losing them to another project would significantly change the timing of this project or even cause it to be cancelled.

- What does an ideal scenario look like in 26 months?
    - ie what are we doing with this treasure trove of data then.
    - How are we making it actionable?

As stated in other answers to questions above, the dataset will be a part of Orinda's infrastructure that will live on for the rest of time. It will be updated each year and its use will be seen in almost every other Orinda project. Over twenty years ago, through a joint Oakland/UC Berkeley initiative, my research lab designed the digital infrastructure (GIS) for the City of Oakland. Over the years it has integrated itself into every department and organization and now serves as the base for most projects in the City of Oakland. This Orinda initiative will take Orinda's digital infrastructure to a new spatial resolution which will likely impact many other Orinda community functions.

- Why wouldn't we want to pursue this option for the City of Orinda?

This is a difficult question to answer. We believe our proposed solution to a wildfire plan for Orinda is a critical and necessary step in building a resilient landscape to protect against catastrophic wildfires.

Rachelle Latimer's Questions:

MOFD used ELMFIRE and FLAMMAP for modeling to build their risk maps as part of the current Community Wildfire Protection Plan. (approx. 1:17 in on the video from May 2022 SSTOC meeting begins discussion of the maps; 1:25 more detailed description of modeling) Recognizing MOFD decided to focus on 5 acre x 5 acre units rather going to the parcel level, how else will your modeling be different?

MOFD's mission is to protect all of Orinda from a wildfire. It has a very different focus on the problem. I have been trying to explain this throughout our engagement (with SSTOC and the UC). Measure R is about the citizens, the property owners, the homeowners and vegetation managers on those individual properties searching for a solution that will keep them from following the path of those less fortunate, in cities around California, that lost everything in a wildfire. These citizens are the clients of the Transformative Resilience wildfire plan that I am proposing here. My strategy is geared to the individual and builds outwards. MOFD does not have the luxury to take this approach. MOFD has to plan to defend Orinda today against an aggressive, fast-moving wildfire. My approach looks at a collective approach to removing fuel from the fireplace so to speak. MOFD has to work with consultants and stay within normative boundaries. At the university we invent solutions to important problems facing our communities, and although it may appear risky to an outsider because we do things that have no precedent, we are very comfortable in this environment. It is what we have been doing all our professional lives. In your position you likely already know this as it is literally the definition of what constitutes a PhD. It is not only how one earns a PhD, but also how we guide others to successfully complete their PhD. After mentioning risk and no precedent, I want to assure you that the solution I have scripted for Orinda is not high risk. After all, I live here with the rest of you so I am invested in this endeavor being successful.

One of my answers above focuses on what we have been doing at UC Berkeley over the past 25+ years with regards to wildfire. You can see that from our list of accomplishments, our discoveries have been headed in the direction of what I am proposing here, one small exploration and invention after another. We are confident that when we complete this project, the citizens of Orinda will know more about their risk, and how to reduce it, than anyone else in California. In addition, we feel that if Orinda citizens follow our recommendations and mitigate the fuels we individually point to, and reduce the fire intensity and

BTUs so that their neighborhood moves into the green zone on the Hauling Chart, any incident commander will deploy their fire fighters and apparatus to defend and save that neighborhood.

ELMFIRE is based on a cellular automata modeling approach. As noted earlier, my PhD student, Wei Luo (2004), developed such a modeling approach in her dissertation, but our approach to assessing risk in the fireshed is more dependent on the actual physiographic landscape plus fuels and FLAMMAP (which I see they also use) and FARSITE are more useful for predicting fire intensity. Their 5-acre spatial units, although they may serve their more generalized purposes, do not make sense for our parcel leveland our plant level approach to modeling and mitigation.

How does your model account for structures (homes) as pad of the flammable area of a lot?

Adding information about structures (homes) is not the focus of this proposal. I am addressing how to best use Measure R funding to get the best outcome for money spent in the short term. This is to reduce the rate of spread and vegetation fuels have been shown to be the greatest catalyst to this. The effort of this research is to keep the fire cool and easy to control and extinguish so that fire fighters will be able to go onsite and defend the structures (homes). If one was to address the structures (homes) issue, the modeling effort would quickly move to a Deep Learning model, like Radke, *et al.* (2020) where data gathering, and assembling would take on a very different protocol. The cost of data gathering alone would likely push such a study well over the million-dollar mark. We are more than willing to include building if the funding levels are sufficient for us to do so.

If ember cast is a major concern for fire spreading into Orinda, roofs and decking material may be as significant as vegetation in protecting the city

In Radke 1995, we looked at roofs and decking materials, and covered over 550 miles of travel on streets with human observers. The effort was funded by FEMA and NASA, and in today's dollars it would easily exceed the million-dollar mark. Still, through our proposed crowdsourcing online app we might be able to add in some observations that would allow us to add a map on high risk to roof or deck ignitions from ember casts.