STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE
RESEARCH SCREENING COMMITTEE

November 17, 2023
10:00 a.m.

Air Resources Board
Research Division
Cal/EPA Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

California Air Resources Board

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

November 17, 2023
10:00 A.M

Agenda

California Air Resources Board

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

September 6, 2023
10:00 A.M

Minutes

Research Screening Committee Members in Attendance
Sam Silva
Aly Tawfik
Francesca Hopkins
Bryan Hubbell
Tim Wallington

I. Approval of Minutes of Previous Meeting

April 26, 2023

II. Discussion of Requests for Proposal (RFP)

1. "Air Toxic Pollutants Associated Cancer Health Monetization Research," $500,000

One committee member provided comments as follows:
The current version of this Scope of Work (SOW) is very good and should result in proposals that provide sound estimates of cancer incidence and valuation. One remaining suggestion in Task 3 is that the solicitation asks for inclusion of low and high estimates "to address uncertainties". Methodologies exist to provide more complete characterizations of uncertainties in incidence and valuation estimates. The committee member recommends modifying the language to read "The monetization should where possible include characterization of the probability distribution of monetized values of incident cancer cases, reflecting uncertainties in exposure, risk, and valuation. In cases where probability distributions are not able to be characterized, low and high estimates should be provided that represent feasible combinations of key uncertain factors in the estimations. In both cases, the contractor should provide a complete listing of key sources of uncertainty with a judgement of the likely direction and magnitude of impact on the quantified estimates."

Staff agreed to incorporate these comments into the document. In addition, they will clarify language on the uncertainty of valuation methodologies by requesting the contractor(s) to include central estimates in addition to low and high estimates. They will also revise some wording in the document as suggested such as saying "draw on"

and “should be appropriate” rather than “build on” and “could be used” – also, “possible cancer cases” will be changed to “expected cancer cases” throughout the document as recommended by the reviewers.

Motion: Move to recommend that California Air Resources Board (CARB) accept the proposal, subject to the inclusion of revisions based on comments from staff and the committee.

The committee approved the motion.

2. “Characterization of Train Brake- and Wheel-Wear PM Emissions,” $900,000

The committee recognized that the SOW was well developed, organized, and comprehensive to address the latest policy issues such as understanding near-railroad emissions and exposure. The committee recommended creating an RFP with the SOW as is.

Motion: Move to recommend that CARB accept the proposal.

The committee approved the motion.

III. Discussion of Research Proposals

1. “Improvement of the Toxic-Metal Aerosol Real-Time Analysis (TARTA) Instrument for Field Deployment,” San Diego State University, $150,000, Proposal No. 2873-307

One committee member was highly supportive of the team and the work being proposed. The committee member mentioned that the software interface, which would allow both an advanced mode and an “easy” mode with colors to indicate the level of metals detected, would need to be better described and tested with the user test groups the SOW has already outlined. The contract manager and the manager for the CARB section both commented that this addition will be beneficial, and the instrument interface would be tested with scientific staff and members of the public through a community-based organization.

Motion: Move to recommend that CARB accept the proposal, subject to inclusion of revisions based on comments from staff and the committee.

The committee approved the motion.

IV. Discussion of a Proposed Contract Augmentation

1. “Quantifying and Identifying the Potential Causes of Nitrous Oxide Emissions in California Soils under Fumigation (Phase 2),” University of California, Davis, $400,000, Contract No. 22RD036

The committee expressed support of this augmentation, which is a Phase 2 project supplement to a pre-approved Phase 1 contract, and recognized the importance of the project. One member commented that the Phase 2 proposal did not provide results of the Phase 1 study and missed specific information on the field procedure such as crops selected and sampling frequency. Staff explained that the Phase 1 contract was recently approved and hence development of the field procedure has not been started. The Principal Investigator (PI) is recruiting a postdoctoral researcher to lead the field study of Phase 1, who is expected to join the team in November 2023. The Research Division (RD) Chief further clarified that the project was broken into two phases because of two separate funding sources in different fiscal years (FYs).

Motion: Move to recommend that CARB accept the contract augmentation, subject to the inclusion of revisions based on comments from staff and the committee.

The committee approved the motion.

V. Discussion of Draft Final Reports

1. "Post-COVID Transportation Scenarios: Evaluating the Impact of Policies," University of California, Davis, $199,936, Contract No. 20STC008

   Members noted that the report was well written and clear. They acknowledged that this would be a good reference moving forward when exploring the impacts of different transportation options. A member highlighted the finding that telework does not reduce vehicle miles traveled (VMT). The member also requested that the authors make a stronger statement of the findings in the abstract, thus bringing more of the findings to the fore.

   Motion: Move to recommend that CARB accept the DFR, subject to the inclusion of revisions based on comments from staff and the committee.

   The committee approved the motion.

2. "Airborne Flux Measurement of Volatile Organic Compounds and Oxides of Nitrogen in California," University of California, Berkeley, $700,000, Contract No. 20RD003

   One committee member raised a query regarding the technical details in the DFR. In response, staff assured that the report indeed contains adequate technical information.

   Another question pertained to the Staff Evaluation, which originally stated, "In addition, the contractors have made significant contributions to the scientific community by submitting five manuscripts." The committee member pointed out that a manuscript would not have an impact until it is accepted for publication. Staff subsequently revised the Staff Evaluation to read, "The contractors have made significant contributions to the scientific community by publishing three manuscripts and submitting two manuscripts

to esteemed journals, such as Science, Environmental Science & Technology, and Atmospheric Chemistry and Physics."

Furthermore, there was feedback regarding the quality of several figures in the DFR. In response to this concern, the staff committed to requesting the contractor to improve the clarity of the figures in the final report. Overall, the committee members think it is a well-written report addressing an important scientific topic.

Motion: Move to recommend that CARB accept the DFR, subject to the inclusion of revisions based on comments from staff and the committee.

The committee approved the motion.

3. "Decision Drivers to Facilitate Lower-Polluting Product Choices by Consumers," University of California, Los Angeles, $200,000, Contract No. 20RD008

   A committee member provided a summary of the DFR and recommended the additional explanations requested by staff be included. The committee member noted that the report is relatively concise and would not be made too long by the additions. The requested additions include explanations of the inclusion/exclusion criteria, of effect size metrics, of differences between the DFR and a related systematic review, and of the chosen sample size in the DFR.

   Comment from the public: The PI for the project noted that discussion of a related systematic review was unwarranted because of quality concerns over that review.

   Motion: Move to recommend that CARB accept the DFR, subject to the inclusion of revisions based on comments from staff and the committee.

   The committee approved the motion.

4. "Strategies for Incentivizing High-Occupancy, Zero-Emission, New Mobility Options," University of California, Berkeley, $700,000, Contract No. 19RD009

   Committee members provided the following comments:
   - This was a big report, including numerous phases of research.
   - Its ultimate goal was how to use policies to drive changes in modes of transport and in-built environment, housing choices, etc. to reduce VMT and associated emissions.
   - A lot was packed into this report. Not all of it was of equal quality or utility. Needed more evenness in writing, and it was hard to extract good insights.
   - The findings were interesting.
     - The report noted that there are a lot of issues around e-bikes, and it tried to evaluate potential barriers to using these. Some included individual barriers, imposed by topography.

- The committee recommends careful thinking about how to include different research elements to inform meaningful policy scenarios. Some work needs to be done on relative balance of reporting methodology vs results. Survey results were overwhelming, lost meaning after a time. It is recommended that the researchers extract from survey the results that inform later parts of report.
- There were concerns about the data sets used. Information from bike share feed used data from only two months, cooler months. How representative is that of hot months? What does that mean with regards to broader interpretation?
- Concerned about focus groups. Good insights but did not include anyone with less than college education. Impacts choices of lower education populations. Large fractions of Northern and Southern CA population have lower than college education. Northern CA had no people with children, and that impacts mobility choices. What does it mean to have focus groups that do not represent the population?
- This section should have information on how focus group work informs rest of report. Direct mapping would be informative.
- Challenging when they were looking at e-bike analysis, why did they use specific correlation coefficients? Do regression analysis instead of individual correlation coefficient. Use dummy variables. Get overall impacts.
- Comments on survey analysis. This was challenging since the sampling period occurred during COVID lockdowns. The researchers characterized that well. But similar biases in representativeness occurred. Much higher educational attainment than general population. Underrepresented of younger populations in San Diego, and other areas. Underrepresented in Hispanic and other populations.
- A number of problems with grammatical errors. Text missing, text duplicated. Graphs should have scales match to compare relevant groups or should be combined into one plot.
- For some of the results, it would have been nice to break out by occupation. Who has the option of taking modes of transport like telework?
- For the scenario modeling, there was no information directly on peer review of the 3 models. What evaluations were done to look at performance of model? Much easier to put that information in summary form in appendix. Choices of where households can locate, important to look at availability of jobs where they want to relocate. Very little info in model about occupational choices. Description of modeling, think carefully about how elements of model fit together. Not clear how discreet choice model fits into activity sim, urban sim. Complete flow diagram of time steps would be helpful. See how choice A affects choice B affects choice C. That information would give a sense of how these models are working together and help interpret results.
- An interesting and valuable conclusion was that policy scenarios, integrated policies have a bigger impact than individual policy pieces.

- Additional suggestion – include an executive summary at beginning would be helpful. Missing parts in literature review. Encourage adding discussing barriers related to the public's knowledge. For example, there are publications on barriers to Electric Vehicle (EV) adoption that show the public has little knowledge of EVs. This particularly impacts low-income Californians, and there are also limitations in charging infrastructure. Primary mode for charging. Adding these points to literature review would be helpful.

Staff agreed to address these concerns in a revised version of the report.

Motion: Move to recommend that CARB accept the DFR, subject to the inclusion of revisions based on comments from staff and the committee.

The committee approved the motion.

VI. Other Business

1. Update on Research Planning

Staff updated the committee on current research planning efforts. FY 2023-24 planning is currently being closed out. For FY 2024-25, the planning process kicked off with a public call for comments and concepts. CARB received 117 comments and concepts on all the research areas CARB funds including health, environmental justice, messaging, air quality, mobile sources, climate and sustainable communities and transportation. Currently RD is completing its internal review and will be sharing the comments and concepts with program staff in other divisions. This internal input will aid the Research Program in narrowing down the list to approximately 30 high priority project concepts that will be presented to the public in early November. The public meeting provides the public a chance to provide input critical for helping CARB decide which projects will ultimately be funded. The public input, plus that of external stakeholders, environmental justice advocates and Board Members will aid in narrowing down the list to the top 10-12 projects that will fit the projected budget for FY 2024-2025. The CARB Research Program also publishes a large document every few years outlining future research priorities. CARB is closing out the Triennial Strategic Research Plan covering FYs 2021-2024 and is gearing up to write the 5-year plan covering FYs 2025-2030. A large public engagement effort will occur next year to inform that plan.

The committee had no major comments on this item.

Item No.: II.1
Date: November 17, 2023
Proposal No.: 2875-309

Staff Evaluation of a New Research Project

Title:	Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality impacts of Wildfires and Prescribed Burns
Prime Contractor:	University of California, Davis (UCD)
Subcontractor:	National Center for Atmospheric Research (NCAR)
Principal Investigators:	Michael Kleeman, Ph.D. Keith Bein, Ph.D. Sean Raffuse, Ph.D. Kelley Barsanti Ph.D.
Contract Type:	Interagency Agreement
Budget:	$805,000
Contract Term:	36 Months

For further information, please contact Dr. Dongmin Luo at (916) 277-0834.

I. Summary

The most severe air pollution events in recent California history have all been associated with extreme wildfires, exposing millions of residents to unhealthy levels of combustion gases, primary particulate matter (PM), and secondary reaction products. Prescribed fires have been promoted as a tool for the management of fire-resilient ecosystems and mitigation of risk for catastrophic wildfires. However, prescribed fires could also have potentially significant consequences for air quality and public health. Therefore, conducting a research project would help to better understand the relative emissions, chemistry, and transport of smoke from wildfires versus prescribed burns. These scientific studies will support policies that are likely to influence the pace and scale of prescribed burns in the State of California, including through the Action Plan of the Wildfire and Forest Resilience Task Force. In support of this effort, this research project will quantify the relative magnitude and timing of pollutant emissions, extent of chemical transformation, transport and

dispersion, and resultant toxicity of smoke from wildfires and prescribed burns. The investigators will analyze the measurement data and the modeling results to draw conclusions about the potential air quality benefits and trade-offs of prescribed burning activities. They will compare the results to the unplanned wildfires and wildfires modified by pre-fire fuels treatment, that occur upwind of the population centers.

II. Technical Summary

Objective

The objective of this project is to evaluate the air quality impacts of wildfires and prescribed burns on urban population centers downwind of fires by analyzing the measurement data and the modeling results to draw conclusions about the potential air quality benefits (and disbenefits) of prescribed burning activities compared to unplanned wildfires, and wildfires modified by pre-fire fuels treatment.

Background

California's most destructive wildfires in recent history have occurred in the last 20 years. The severity and frequency of wildfires in the western U.S. have been increasing over the past decade and are becoming more difficult to contain. Public health concerns are also increasing over wildfires that reach the wildland-urban-interface (WUI; zone of transition between unoccupied/undeveloped land and human development) where human-made objects are engulfed and burned, releasing diverse and mostly uncharacterized levels of air toxics and reactive chemicals into the atmosphere. Wildfire smoke is often transported to local and regional population centers, affecting the surface-level air quality while worsening air pollution exposures to air pollutants and complicating the atmospheric formation of health-affecting air pollutants like ozone and secondary organic aerosols (SOA). The scale of these effects is still not fully understood.

Climate change will amplify cycles of extreme precipitation followed by drought, worsening wildfire risk. Since there is no practical way to prevent the most dangerous ignition events, managing fuel loads and forest structure through prescribed burning has received renewed attention as an approach to mitigate future wildfire risk. Historically, frequent controlled fires were used by

indigenous populations to assist hunting, promote desired vegetation growth, and prevent catastrophic wildfires. Prescribed burning also served a cultural role and is called cultural burning by some indigenous leaders. There have been significant efforts in California in recent years to expand cultural and prescribed burning. In that regard, the State has recognized the wildfire crisis and developed policies in response. In August 2020, Governor Newsom signed the Agreement for the Shared Stewardship of California's Forests and Rangelands that called for improved coordination and a commitment to scale up proactive vegetation treatments to 1 million acres per year by 2025. The State of California also created the Wildfire and Forest Resilience Task Force and released its Action Plan, a comprehensive framework for increasing both community and ecological resilience to wildfire in California.

The Action Plan calls on the California Air Resources Board (CARB) to lead the interagency analysis of prescribed fire smoke data to document public health impacts compared with wildfire smoke exposures. However, data that should be used for such analyses are not readily available. Multiple limitations impede the characterization of fire due to the lack of chemical speciation in the emissions database and the difficulties in accurately accounting for the type of objects (both natural and human-made) that were burned, especially when wildfires reach WUI. This research aims to improve our understanding of the effects of planned and unplanned fires on communities. It will be accomplished by gathering more information about smoke from wildfires and controlled burns and using computer models to predict the outcomes of controlled burns. This will help us have more accurate and reliable data on the benefits and drawbacks of controlled burning compared to unplanned wildfires near populated areas.

Proposal Summary

In this research proposal, a comprehensive measurement-modeling approach will be used to assess the air quality and public health implications of prescribed burning that relies on (i) a mobile measurement platform specifically designed for rapid deployment during fires; and (ii) chemical transport models (CTMs) that include fire-specific refinements. For measurements, the Rapid Response Mobile Research Unit developed at UCD is a fully contained, self-powered mobile research

laboratory designed for in situ measurement and sampling of smoke during active wildfires. For models, the CTM developed at UCD has been used to evaluate source contributions to primary and secondary PM in California for more than 20 years. The Multi-Scale Infrastructure for Chemistry and Aerosols version 0 (MUSICAv0) model developed at NCAR is a multi-scale version of the Community Atmosphere Model with Chemistry (CAM-Chem) global model with regional refinement down to ~6 km resolution. These measurement and modeling tools will be used to carry out the following three major research tasks.

Task 1: Design a Research Plan / Field Deployment Plan for Characterizing Wildfire Smoke

- Fire Selection and Sampling Strategies*:* Measurements will be made in at least two wildfires and two prescribed burns over the first two years of the project as conditions permit, and locations will be prioritized based on the prevalence of recent catastrophic wildfires, wildfire hazard index, and proposed efficacy of prescribed burns. Northern California (North Coast, Klamath, Modoc, Sierra Nevada), with greater than 87% of the area burned in the largest wildfires over the past 6 years, is one region of priority. However, opportunities to sample in Southern California (South Coast, Transverse) will also be pursued. WUI wildfires will be prioritized over all other fires given current knowledge gaps, limited opportunities, and inherent challenges in sampling these events.

- An advisory committee will be formed with individuals from these stakeholder agencies, as well as CARB, and local District Staff to consult on the selection, location, and duration of sampling events. For wildfires, UCD anticipates a minimum of two days per sampling event but will be equipped for a maximum of ten consecutive sampling days. Prescribed burns will be sampled for the duration of the event. Ambient background conditions will be measured immediately prior to ignition for prescribed burns and upwind of wildfires using the same sampling and analysis techniques.

Task 2: Design Multiple Scenario-Based Modeling Frameworks for Prescribed Burning Activities

- Model Wildfires in Northern California and Southern California: Principal Investigator (PI) Dr. Michael Kleeman has support under National Institutes of Health/ National Institute of

Environmental Health Science, U.S. Department of Agriculture, and U.S. Environmental Protection Agency (US EPA) to simulate smoke exposure during all major wildfires in California over the past 10 years using a combination of advanced emissions models, CTMs (source-oriented UCD/Caltech model for this project), and machine learning models. For these retrospective simulations, wildfire area burned will be derived from historically mapped perimeters from the California Department of Forestry and Fire Protection (CALFIRE) Fire and Resource Assessment Programs GIS database. Investigators will then use satellite-based active fire products (MODIS, VIIRS, GOES-ABI) to apportion the area burned within specific days.

- Design Prescribed Burn scenarios to Mitigate Wildfire Risk: Prescribed burn scenarios will be modeled using MUSICAv0 (uses the updated Fire INventory from NCAR version 2.5 (FINNv2.5) for emissions from wildfires and prescribed burns) and the UCD/Caltech model uses the Bluesky Pouliot-Godowitch plume rise algorithm. The UCD/Caltech model typically obtains wildfire and prescribed burn emissions using the open source BlueSky smoke modeling framework which is supported by CALFIRE funding for this project. BlueSky will be modified to reflect the most recent updates for fuel loads, fuel consumption, emission factors, and fuel moisture.

Task 3: Data Analysis of Ambient Observations and Corroboration with Scenario-Based Modeling

- Compare Predicted and Measured Concentrations in Plumes Downwind of Wildfires and Prescribed Burn: Investigators will conduct simulations of the wildfires and prescribed burns measured during Task 1, using both the UCD/Caltech and MUSICAv0 models and then evaluate model predictive accuracy for those events. The evaluation will focus on PM2.5 mass, PM chemical composition, and relevant gas-phase US EPA-listed hazardous air pollutants. They will also evaluate model results using PurpleAir, US EPA Air Quality System, and satellite retrievals of aerosol optical depth. Measurements from multiple samples will be averaged in time and/or location to create a comparison point for model evaluation. The accuracy of model predictions during historical fires will be used as an estimate of the accuracy of model predictions under prescribed burn scenarios.

- The CTMs chosen for this project represent gas-phase chemistry and SOA formation with sufficient complexity to investigate differences in chemical aging of smoke between wildfires and prescribed burns. The models will be modified as needed to incorporate recent updates in emissions, chemical mechanisms, and SOA parameterizations that may impact predictions of plume chemistry and chemical aging of smoke. Models also will be modified as needed to better represent the differences between prescribed burns and wildfires that aren't routinely captured by the existing CTMs. Investigators will develop specific metrics to evaluate if the models accurately predict changes in smoke concentration and composition that are relevant for exposure and health outcomes. This will allow us to systematically evaluate the public health burden of wildfires and prescribed burns in the modeling scenarios.

Additional project tasks include regularly communicating with CALFIRE/ CARB staff as relevant to optimizing prescribed burns and wildfires targeted for measurements and model analysis, and compiling project results as a final report and peer-reviewed articles in scientific journals.

III. Staff Comments

Staff from CARB's Air Quality Planning and Science, Industrial Strategies, Sustainable Transportation and Communities, and Research Divisions reviewed 5 pre-proposals received in response to the CARB's solicitation from the University of California and California State University in May 2023. The review committee selected the UCD's pre-proposal for a full technical proposal since it most closely addressed all of the topics as expressed in the solicitation. An earlier version of the UCD full proposal was reviewed by the same review team as well as staff from US EPA, and CALFIRE (provided $50,000 funding support). The current version has incorporated staff comments to improve its clarity. The investigators also prepared a detailed "Response to Comments" file that addresses comments made by the review team. The response document was inserted in the UCD proposal as "attachment A."

The reviewers generally recognized the quality of the proposed research effort and the practical importance of the results. The reviewers stated that the assembled team has extensive experience and resources to apply to the project and the results will be well worth the resources. Dr. Kleeman (UCD) will serve as the PI coordinating and synthesizing the efforts of other task leaders. Dr. Kleeman

has assembled a uniquely qualified team to address the most critical knowledge gaps in the areas of emissions, chemical transformation, and exposure to smoke generated from prescribed burns and wildfires. Dr. Bein (UCD) will coordinate with all project stakeholders to select measurement locations/time periods, collect samples, and send samples to the laboratory for analysis. Dr. Raffuse (UCD) will lead the development of prescribed burn and wildfire emissions using the BlueSky modeling framework. Dr. Barsanti (NCAR) will lead the development of prescribed burn scenarios and interpreting comparisons of air quality under prescribed burn vs. wildfire scenarios. She will work with the team to interpret the public health implications of exposure predictions and write reports and peer reviewed papers documenting project results.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this proposal for $805,000.

Item No.: II.2
Date: November 17, 2023
Proposal No.: 2876-309

Staff Evaluation of a New Research Project

Title:	Impacts of Multiple Climate Change Stressors on Health in California
Prime Contractor:	University of California, Los Angeles (UCLA)
Subcontractor:	University of California, San Diego (UCSD)
Principal Investigators:	Miriam Marlier, Ph.D.
Contract Type:	Interagency Agreement
Budget:	$500,000
Contract Term:	24 Months

For further information, please contact Dr. Barbara L. Weller at (916) 324-4816

I. Summary

Although often examined individually, multiple climate stressors, such as wildfires, air pollution and extreme heat, can simultaneously affect California populations. Also combined exposures can have interactive impacts and have the potential to cause greater health harms than individual exposures. Exposure to multiple climate stressors may make health conditions for the exposed individuals and communities worse and are known to disproportionately affect vulnerable populations, but researchers have not thoroughly evaluated these effects. The objective of this project is to understand the combined effect of multiple climate stressors and the variability seen across vulnerable communities in different regions of California. The contractor will review the literature on the impacts of individual and combined climate stressors on health outcomes and will map regional variations in exposures to climate stressors across California over the past fifteen years, with a particular focus on heat, air pollution, wildfires, and precipitation extremes. These exposures will be linked to multiple health outcomes to quantify health impacts and health care costs across the life course of different populations. The contractor will investigate how social and environmental inequalities in vulnerable groups may increase the impacts of

climate-related health concerns. This work will support CARB in quantifying comprehensive health co-benefits of actions to reduce California's greenhouse gas emissions and identify pathways to protect vulnerable populations throughout the State.

II. Technical Summary

Objective

In this project, the contractor will address the following objectives:

- Quantify acute and chronic exposures to individual and multiple climate stressors in different regions of California, focusing on exposures to wildfires, air pollution, extreme heat, and precipitation extremes.
- Assess the total and interactive health outcomes and economic burden associated with individual and multiple climate stressor exposures in different regions of California.
- Investigate whether social and environmental justice factors, such as race, ethnicity, income, and other social vulnerability metrics would modify the associations between health outcomes and climate stressor exposures.

Background

The frequency and intensity of climate hazard exposures (e.g., wildfires, heat, air pollution, and extreme precipitation) in California have increased over the past several decades, a trend that is expected to continue under future climate change scenarios. When these exposures overlap in space and time (i.e. compound climate events), there is potential for joint effects that could worsen exposures and adversely affect health. Further, individual communities across California may have different responses to the same climate exposures due to burdens in these communities such as additional environmental exposures, community characteristics that decrease resources and increase stressors, or both. For better estimations of health co-benefits associated with California's climate actions, addressed in CARB's 2022 Scoping Plan, it is critical to move beyond individual and often static health assessments of climate stressors. This project will use an extensive analysis of multiple, interacting climate exposures on health impacts in different regions of California to better address these health impacts. This project aims to

understand the potential joint effects of multiple climate change stressors and the heterogeneity across vulnerable communities in California. The contractor will address the following research questions:

- *Task 1:* What is the current state of the knowledge and research needs on the individual and combined influence of climate stressors on population health in California?
- *Task 2:* What is the exposure burden of multiple climate stressors in different locations in California over the past fifteen years?
- *Task 3:* What are the region-specific health and economic impacts of combined climate stressors over this period?
- *Task 4:* How do social determinants in vulnerable communities modify climate-health impacts?

The results of this project will help CARB to develop information on the burden of climate change stressors and their health and economic impacts in California. CARB can use this information to develop methods to estimate and monetize health co-benefits associated with strategies to reduce greenhouse gas emissions, especially in vulnerable communities, and to better communicate the benefits of the climate programs.

Proposal Summary

Task 1: Assess Current Knowledge and Identify Research Needs in Climate-Health Studies

The contractor will conduct a thorough literature review and the results from this literature review will be used in subsequent tasks to: 1) characterize dominant climate stressor exposures in different regions of California in Task 2; 2) identify the most important health outcomes to be included in Task 3; and 3) examine community vulnerability characteristics that could modify the health and economic outcomes in Task 4.

Task 2: Assess Combined Climate Stressor Exposure

The contractor will map regional variations in exposure to individual and combined climate stressors across different community characteristics at acute and chronic scales using a novel statistical approach incorporating ground monitors, satellite observations, and atmospheric models. The

contractor will leverage the daily climate datasets developed in their previous work that modelled surface air pollution concentrations, extreme heat, precipitation extremes, and meteorological extremes from 2006 to 2020 in California. Individual and combined exposure indices (i.e. a sum of the rankings for exposure frequency, duration, and intensity) will be computed for climate stressors at the census tract and zip-code level. Differences in exposure indices across community characteristics (e.g., the proportion of racial/ethnic groups, CalEnviroScreen scores, etc.) will also be examined.

Task 3: Estimate Health Impacts of Combined Climate Stressors and Associated Economic Burdens

The contractor will obtain health data from two California datasets, Study of Outcomes in Mothers and Infants for birth outcomes, and California Department of Health Care Access and Information for various health endpoints (e.g., cardiovascular and respiratory diseases, heat illness, and mental illness). With the health data, the contractor will conduct three sets of health impact estimates of combined climate stressors (including heat, wildfire smoke, and ambient air pollution):

1. Estimating zip-code level spatially varying synergistic effects (i.e. interactions) between pairs of climate stressors;
2. Estimating the state-level and region-level joint (i.e. total effects of stressors) and synergistic effects between pairs of stressors; and
3. Estimating the state and region-specific total health impacts of multiple (>two) climate stressors.

The (1) and (2) estimates will provide the contractor the opportunity to further explore mechanisms and interactions among the climate stressors and spatial heterogeneity. The (3) estimate will provide the total effect of all dominant climate stressors.

Moreover, the contractor will calculate the number of hospitalizations attributable to climate stressors and then estimate the associated cost of health care. The contractor will also examine how long-term patterns of other climate stressors (e.g., annual patterns of drought and precipitation regimes) might modify the health impacts.

Task 4: Investigate Social Determinants of Climate-Health Equity

The contractor will explore the potential impacts of personal characteristics (e.g., age, gender, and race/ethnicity) and community characteristics (e.g., per capita income and the proportion of race/ethnicity groups) on the effect estimates of combined climate stressors (estimated in Task 3).

Task 5: Deliver reports, data, and outreach materials to CARB

The contractor will submit quarterly progress reports and a final report, as well as associated data, and all the data analyses results to CARB. The contractor will develop a 1-page project summary and fact sheets of the scientific publications using plain-language to be used in public outreach.

Deliverables:

This project will produce climate exposure datasets hosted in Google Earth Engine that is an online platform for analyzing and visualizing geospatial datasets. The datasets will include data of climate exposure stressors (heat, wildfire smoke, and ambient air pollution) across all census tracts and ZIP codes in California for 15 years (~2006-2020). The contractor will also produce summary tables to identify regional patterns, by air basin and climate zone for dominant climate stressors. For health impacts, the contractor will produce maps of ZIP-code specific synergistic effects between pairs of climate stressors, and maps and tables that summarize total health and economic impacts at the state, air basin, and climate zone levels. To facilitate access to above results, the contractor will publish an online platform via R shiny to visualize and access health impact data.

III. Staff Comments

A research concept for estimating the impacts of multiple climate change stressors on health in California was developed and then a detailed scope of work was developed for the CARB Fiscal Year 2023-2024 Research Project Solicitation to the Universities of California or California State Universities. A preproposal from this team of investigators was submitted and was selected to be developed into a full proposal because it aligned with CARB's suggested scope of work. The full proposal was then reviewed by CARB staff in the Research Division, and client agencies, including the California Department of Public Health and the California Office of Environmental Health Hazard Assessment. The reviewers were supportive of the project and had no major concerns on this proposal. Most of the comments were for

clarification, especially asking more detailed technical information and addressing limitations of the methods. The investigators have addressed the comments in the current proposal.

Investigator Qualifications

1. The PI, Dr. Miriam Marlier, is an Assistant Professor of Global Environmental Change in the Environmental Health Sciences Department at the UCLA Fielding School of Public Health. Dr. Marlier's research examines the intersection of climate change and human health outcomes. Dr. Marlier uses satellite remote sensing data and atmospheric modeling techniques to map linkages between human-caused environmental changes and health outcomes in various locations around the world. In California, Dr. Marlier examines the exposure of vulnerable populations to multiple climate-related hazards, including wildfires, drought, and extreme heat, to support policy measures that protect public health.

2. The Co-PI, Dr. Tarik Benmarhnia, is an Associate Professor of the University of California San Diego's Scripps Institution of Oceanography and School of Medicine. Dr. Benmarhnia has a unique niche of combining expertise in epidemiology study design and health risk assessment with climate and econometric models, in addition to clear understanding of health policy and a passion for social science and equity as they relate to public health. Dr. Benmarhnia conducted multiple projects related to the impacts of extreme heat and wildfire smoke on various health outcomes in California and globally.

Staff believes that the PI and co-PI's expertise in exposure modeling and environmental epidemiology and their work on climate health and equity research make them the best persons qualified for this research project.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this proposal for $500,000.

Item No.: II.3
Date: November 17, 2023
Proposal No.: 2877-309

Staff Evaluation of a New Research Project

Title:	Unlocking Health Benefits for Californians through Active Land Management Strategies
Prime Contractor:	University of California, Merced
Subcontractor:	Desert Research Institute
Principal Investigators:	John Abatzoglou, Ph.D.
Contract Type:	Interagency Agreement
Budget:	$549,316
Contract Term:	36 Months

For further information, please contact Dr. Barbara L. Weller at (916) 324-4816

I. Summary

The implementation of natural and working land (NWL) management strategies improves public health and the environment. The objective of this project is to develop and expand CARB's ability to quantify the health benefits from future climate actions that promote healthy forests and other natural lands and reduce the frequency and negative impacts of wildfire events. The University of California, Merced (UCM) and Desert Research Institute (DRI) will work closely with CARB staff to build on previous CARB-funded research, the 2022 Scoping Plan, and existing models and data to develop streamlined methods. These methods will quantify the annual health impacts of future wildfire emissions under various climate and management scenarios in forests, shrublands, and grasslands. The research team will conduct a literature review to identify associations between health impacts and exposure to wildfire fine particulate matter (PM2.5) and develop new health impact effect estimates for birth and maternal health outcomes to be used in the health analysis. The research team will translate CARB-derived wildfire emission scenarios into a fine scale resolution and use historic climate data and smoke dispersion modeling to develop air quality maps of PM2.5 for each scenario. Using the identified effect estimates

for health impacts of wildfire and the developed air quality maps of PM2.5, the health benefits for each scenario will be quantified using standardized methods from the open-source program BenMAP-CE (Environmental Benefits Mapping and Analysis Program-Community Edition). The results of this project will be used by CARB in the development of future climate policies and implementation of NWL management strategies that maximize health benefits, reduce the risk of wildfire, and promote resilience to climate change.

II. Technical Summary

Objective

The objective of this project is to develop an updated methodology for quantifying the health benefits of NWL management scenarios that reduce emissions from wildfire. To meet this goal, the research team will: 1) Conduct a literature review to update and identify health impacts for wildfire PM2.5 and develop new health associations for wildfire PM2.5 exposure for perinatal (both birth and maternal impacts) outcomes; 2) Develop a quantitative approach to calculate air quality impacts of wildfire emissions from future statewide land management scenarios for 2025-2045; and 3) Quantify the health benefits from future statewide land management strategies that reduce emissions from wildfire .

Background

California's natural and working lands cover approximately 99% of the state and include forests, grasslands, shrublands and chaparral, agricultural lands, wetlands, and the green spaces in urban and built environments. California's NWL provide a multitude of benefits, including biodiversity, recreation, food, economic prosperity, human health benefits, and many others. Natural and working lands are also an important component in California's fight to achieve carbon neutrality. The majority of California's NWL carbon stocks are in forests, shrublands, and grasslands. Improving the health of these lands can maximize their ability to sequester and store atmospheric carbon and limit the release of future GHG emissions. Continued, business-as-usual management of NWL, particularly in forests, shrublands, and grasslands, leaves them more vulnerable to future climate change impacts such as wildfire.

California's 2022 Scoping Plan for Achieving Carbon Neutrality indicates that California is projected to lose carbon stocks from NWL over the coming decades. A major driver of this loss is from wildfire, which

has been increasing in size and severity over the last two decades. The unprecedented scale of emissions from recent wildfires and the subsequent air quality impacts from wildfire smoke has caused serious and widespread harm to public health and the resulting impacts costing billions of dollars per year. However, increasing the pace and scale of climate smart land management in California will reduce the GHG emissions from the NWL sector, including emissions from wildfire.

To understand more completely the benefits of actions that will be taken in California to reduce emissions from NWL, it is critical to measure the health impacts of these strategies. In the 2022 Scoping Plan, the health benefits of various land management scenarios in forests, shrublands, and grasslands to reduce future wildfire PM2.5 emissions were quantified. These benefits were calculated for various health endpoints including mortality, respiratory and cardiovascular endpoints. CARB's analysis showed that increasing specific forest and land management actions reduces wildfire emissions and avoids PM2.5 emission-related health effects. To expand upon this work for future analyses of NWL management scenarios, this project will develop improved air quality and health analysis methodology to quantify annual health benefits with methods that are more computationally efficient and spatially and temporally refined. The project will also analyze the health impacts in vulnerable groups. This methodology will better quantify how resilient landscapes can reduce the amount and intensity of wildfire emissions and reduce health impacts.

Proposal Summary

Task 1. Literature review

UCM will conduct a literature review to update and expand upon the health impact associations identified and developed from CARB contracts 19RD015 and 21RD003 on the health impacts from wildfire. UCM will also conduct an original epidemiological study to develop associations for health impacts of wildfire PM2.5 exposure for perinatal outcomes. The perinatal outcomes include fetal death, infant death, gestational diabetes, and gestational hypertension. All health impact functions identified in Task 1 will be used in Task 3 of the project.

Task 2. Develop a Quantitative Approach to Calculate Air Quality Impacts of Wildfire Emissions from Future Statewide Land Management Scenarios for 2025-2045

The goal of Task 2 is to create a reproducible methodology that will be sufficiently simplified to allow for efficient calculation of air quality on thousands of future wildfire emissions scenarios. Given that future scenario modeling is not designed to provide specific predictions of exact fire location, timing, and behavior, and instead identifies and maps general dispersion patterns over regions and time frames of decades, the methodology will not require the detailed information that traditional air quality and dispersion modeling require. The methodology will be able translate emissions from each scenario into maps of likely air quality impacts, generated within a reasonable compute time. UCM and DRI will work closely and iteratively with CARB throughout the duration of the contract to ensure that the methodology developed fits CARB's needs.

UCM and DRI will obtain total monthly wildfire emission scenarios from CARB. CARB will provide emissions for every year from 2025 to 2045 for 400 wildfire emissions scenarios which take into account different NWL management and climate scenarios. The research team will obtain fuel type and historical fire data, and convert CARB's wildfire emissions, supplied at the ecological unit (ecounit) scale, into a 2-km resolution. UCM and DRI will do dispersion modeling for California using historic 40-year climatology to develop maps of probable smoke dispersion that will show where smoke is likely to go if produced in a specific location. Combining the maps in relation to future monthly emissions will allow the investigators to obtain PM2.5 concentration estimates for each scenario at a 2-km resolution and will be summarized at statewide, ecounit, and zip-code levels.

Task 3. Quantify the Health Benefits from Future Statewide Land Management Strategies that Reduce Emissions from Wildfire

UCM will use the health effect estimates from Task 1 and PM2.5 concentrations developed from Task 2 as inputs into BenMAP-CE to model future annual health impacts of NWL management scenarios from 2025 - 2045, including the economic value of avoided health impacts at statewide, ecounit, and zip-code scales. UCM will quantify the avoided impacts to vulnerable communities by disaggregating to the census tract scale and conducting a spatial overlay-based analysis with CalEnviroScreen scores and calculated health impacts for all scenarios.

Task 4. Interim Meetings and Reporting

UCM will hold monthly meetings with CARB staff, submit quarterly progress reports, and provide interim reports for tasks 2 and 3. The investigators will also meet with CARB staff on an as needed basis to collaborate and coordinate the work the project.

Task 5. Final Report and Sharing of Results

UCM will submit a draft final report, a final report, as well as all data, geospatial data layers, workflows, documented code, and instructions of methodology to CARB.

III. Staff Comments

The solicitation for the research project was released in April 2023 as a part of CARB's Fiscal Year 2023-2024 research funds and a preproposal from this team was selected from the two preproposals submitted, for development into a proposal. The submitted proposal was reviewed by CARB staff in the Research Division, Industrial Strategies Division, and the Air Quality Planning and Science Division. The proposal was also reviewed by staff at the California Department of Public Health. The proposal has gone through several rounds of revisions.

Staff comments consisted of dividing major tasks into subtasks for Task 1-3 and including more detail and description of the methods. Specifically, the changes requested included expanding on the methods for developing health effect estimates for perinatal outcomes for wildfire PM2.5 for Task 1, clarifying the language and specifying deliverables for Task 2, and for Task 3 adding more details on health prevalence/incidence data, setting up BenMAP-CE, and analysis with CalEnvioScreen. All comments have been addressed in the proposal. Staff believes this proposal will build on prior CARB research and provide a methodology to calculate valuable health information on future wildfire scenarios to inform CARB's climate programs.

Investigator Qualifications

Dr. John Abatzoglou, PI, is a Professor of Climatology at the UC, Merced. He received his bachelor's degree in Atmospheric Science from UC Davis, doctorate in Earth Systems Science from UC Irvine. Dr. Abatzoglou's academic interests are primarily focused around climate science and impacts in the American West. His Climatology Lab works on a diverse set of research questions spanning climate

science and meteorology as well as their impacts on systems including water resources, wildfire, and agriculture. The research group also develops web-based climate services to help scientists and practitioners improve climate readiness.

Dr. Sandie Ha, Co-PI, is an Assistant Professor of Public Health at UC Merced. Dr. Ha's research focuses on studying how various environmental exposures (e.g., air pollution, extreme temperature, pesticides) affect pregnancy and perinatal health outcomes including but not limited to gestational complications, stillbirth, preterm birth, and birth defects. She's also interested in investigating how exposures during windows of developmental plasticity (e.g. pregnancy and early life) influences the risk of neurodevelopment in early childhood. Her other research interests include cardiovascular complications, asthma, cancer, and health disparity.

Dr. Tim Brown, subcontractor, is a Research Professor and conducts applied research and applications development at the Desert Research Institute (DRI) in Reno, Nevada. His primary academic interests include wildland fire-climate and fire-weather connections; the wildfire environment; applications development for wildland fire management planning, decision-making and policy; the interface between science and decision-making; and user engagement through the deliberate co-production of knowledge. Dr. Brown is Director of the Western Regional Climate Center, and established and directs the Program for Climate, Ecosystem and Fire Applications at DRI.

Dr. Crystal Kolden, Co-PI is an Associate Professor at UC Merced. Dr. Kolden's research focuses on characterizing and understanding wildfire intersections with the human-environment system through geospatial, temporal, and mixed-methods approaches.

Dr. Adeyemi Adebiyi, Co-PI is an Assistant Professor in the Department of Life and Environmental Sciences at UC Merced. Dr. Adebiyi's research focuses on understanding the impacts of atmospheric aerosols, such as dust and smoke, on the regional and global climate.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this proposal for $549,316.

Item No.: III.1
Date: November 17, 2023
Contract No.: 22RD010

Staff Evaluation of a Proposed Contract Augmentation

Title:	Impacts of Air Pollution Exposure on Metabolic Health Outcomes for California Residents
Prime Contractor:	University of California, Berkeley
Principal Investigators:	Jason Su, Ph.D.
Contract Type:	Interagency Agreement
Additional Budget:	$50,000
Contract Term:	**24 Months**

For further information, please contact Dr. Hye-Youn Park at (916) 323-2177

I. Summary

The California Air Resources Board (CARB) routinely quantifies adverse health endpoints associated with particulate matter (PM) exposure. Research has shown that numerous adverse health effects are associated with exposure to criteria pollutants and toxic air contaminants. In April 2020, CARB adopted Board Resolution 20-13 directing staff to expand their methodologies to include additional air pollutants and health endpoints associated with pollution exposure.

This is an augmentation of a contract previously approved by the RSC on October 14, 2022. Under the RSC-approved contract, investigators are developing models to estimate statewide concentration-response (C-R) functions between exposures to air pollutants and metabolic health endpoints and valuation of resulting health outcomes. The information gained through this contract will support CARB's ability to evaluate the effects of its policies and programs to reduce air pollution and estimate a wide range of public health benefits.

In this contract augmentation, CARB will provide $50,000 in additional funding to include economist Dr. Timothy Brown at University of California, Berkeley (UCB) as a subcontractor for conducting the

economic valuation component proposed in Task 6 of the initial approved contract. The main objective and tasks of the approved contract remain unchanged.

II. Technical Summary

Objective

The main objective of the approved contract is to increase understanding of metabolic health effects and resulting economic benefits in association with exposure to air pollutants throughout California. A specific aim is to develop California-specific C-R functions, between exposures to air pollutants and metabolic health endpoints. The objective of the proposal has remained unchanged. However, CARB will provide $50,000 in additional funding to UCB for conducting the economic benefits analysis proposed in Task 6 of the approved contract.

Background

Epidemiological studies suggest that short- and long-term exposures to air pollution increase metabolic dysregulation, incidence of diabetes, and diabetes-related deaths. Those studies, however, are largely focused on a city or metropolitan area, with coarse air pollution resolution. Based on the American Diabetes Association's report, approximately 10.5% of the adult population in California have diagnosed diabetes. In addition, an estimated 33.4% of the adult population have prediabetic conditions. Currently, there are no statewide population-based studies on metabolic health outcomes related to air pollution exposures at finer spatial resolution. The approved study intends to fill this gap. The research will further help us better understand the relationship between air pollutants and their associated health impacts that focus on metabolic outcomes and economic benefits from reducing exposure to air pollution. The project will provide CARB with important health analysis information to support its regulation, strategies, and programs.

Proposal Summary

This contract augmentation does not modify the initial approved contract. The research contract previously approved will develop California-specific C-R functions between exposures to air pollutants and metabolic health outcomes (e.g., incidence of diabetes incidence, diabetic medication use, diabetes-related emergency department (ED) visits, hospitalizations, and death) and estimate economic benefits. The approved contract involves six tasks (tasks 1-6), which include conducting systematic literature reviews; developing land use regression (LUR) models for criteria pollutants and air toxics; estimating statewide C-R functions between air pollutants, including PM2.5, NO2, and O3, and metabolic health data as well as combinations of air pollutants and metabolic health data; evaluating the health effects in racial and ethnic subgroups in addition to statewide average population health effects; and estimating economic impacts such as healthcare costs associated with the five metabolic health endpoints.

The initial approved contract did not include an expert in economic analyses on the research team to perform Task 6 (estimate economic benefits from reducing air pollution exposures on metabolic health outcomes, stratified by race/ethnicity, and neighborhood deprivation status in California). During the contract kick-off meeting, Dr. McConnell, one of the advisors, suggested hiring an economic expert to assist in the economic analysis, and staff agreed this would be an important addition to the project. To address the request, the contractor will add the economic expert to the team if funding is approved. In this contract augmentation, CARB will provide $50,000 in additional funding to include an economic expert to conduct Task 6.

III. Staff Comments

The project was initiated in response to Board Resolution 20-13, which directed the board to more comprehensively evaluate the health impacts of air pollution and climate change, and as part of this effort, to expand health analysis methodologies to include additional air pollutants and health endpoints. For this project, Dr. Su at UCB is leading a research team that includes researchers from the Methodist Hospital Research Institute (Houston, Texas), and the University of California, Los Angeles. CARB supported $475,000 for the initial approved contract in which the research team will estimate statewide C-R functions between air pollutants and metabolic health endpoints in California and estimate the

economic value of reduced health outcomes. The initial approved contract did not include an expert in economic analyses on the research team to perform Task 6 to estimate the economic benefits. Staff believes the augmentation will improve the contract and strengthen the deliverables that will be provided to CARB.

The research team has strong expertise in air pollution exposure modeling and metabolic health outcome analysis. Dr. Timothy Brown, an Associate Adjunct Professor of Health Economics, and the Associate Director for Research at the Berkeley Center for Health Technology at UCB, will join the research team. Thus, in this contract augmentation, CARB will provide $50,000 in additional funding to include Dr. Brown at UCB as the key person for performing the economic benefits analysis in Task 6.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this contract augmentation for $50,000.

Item No.: III.2
Date: November 17, 2023
Contract No.: 20RD012

Staff Evaluation of a Proposed Contract Augmentation

Title:	Total Exposures to Air Pollutants and Noise in Disadvantaged Communities
Prime Contractor:	University of California, Berkeley
Subcontractor:	University of California, Merced
Principal Investigators:	Elizabeth Noth, Ph.D.
Contract Type:	Interagency Agreement
Additional Budget:	$75,000
Contract Term:	**36 Months**

For further information, please contact Dr. Pat Wong at (279) 208-7295

I. Summary

The primary investigator of the California Air Resources Board's (CARB) previously approved contract "Total Exposures to Air Pollutants and Noise in Disadvantaged Communities", also known as SPHERE, is requesting a contract augmentation and changes to the statement of work due to unexpected circumstances which led to project delays and unanticipated expenses. Some of the factors that significantly affected the contract timeline were:

- Supply chain issues and access to field sites due to the COVID-19 pandemic
- The loss of Little Manila Rising (LMR), our community subcontractor in Stockton, who was responsible for recruiting and collecting data for participants in Stockton
- Unanticipated leaves of absence for health issues encountered by both PIs
- The UAW Graduate Student Researcher (GSR) strike in November-December 2022
- Amendment delays due to staffing changes at UCB and excessive workload at CARB

Two community groups were enlisted as subcontractors to carry out key tasks within the contract (tasks 4-7). The Central California Asthma Collaborative (CCAC) and Little Manila Rising (LMR), in Fresno and Stockton respectively. The tasks for both subcontractors were to:

- Obtain participant consent
- Conduct initial visits and set up monitors
- Conduct follow up visits and collect samples
- Train participants to collect urine samples
- Store and prep samples for analysis by CDPH
- Upload data and track paperwork

The most significant setback to the contract was the loss of LMR as a subcontractor mid-study. LMR struggled from the beginning with the technical challenges of their sub-contract (budget of $60K), such as conducting field visits in a timely manner and the collection and submission of samples for analysis. Ultimately, LMR only completed 12 visits of the required 45 before informing both the PI and CARB that they would not be able to fulfill the tasks in their subcontract. Less than 25% of their workload was completed. The primary investigator, Dr. Betsey Noth, and the co-PI Dr. Asa Bradman, feel that the loss of LMR as a subcontractor and community liaison, at a crucial point in the study, has caused too many delays to complete the recruitments and visits for the Stockton cohort and it would require exorbitant expense to restart recruitments with another community group or with UCB staff. The proposed contract augmentation will allow contractors to complete the analysis on visits already completed and complete the key deliverables in the contract.

II. Technical Summary

Objectives

The objectives of this study are to characterize the exposure patterns of people living in disadvantaged communities (DACs) to particulate and toxic air pollutants such as PM2.5, ultrafine particles, and VOCs, as well as noise both outdoors and indoors and to identify potential sources that may contribute to higher exposures. In addition, survey data will be used to determine whether factors such as housing stock, consumer product choices, social and environmental factors or other factors may be responsible

for elevated exposure to certain air pollutants and risks for adverse health effects. This research will address knowledge gaps by providing information on how behaviors (cooking, cleaning, etc.) and other determinants (building characteristics, types of appliances, ventilation and filtration, etc.) affect personal and total pollutant exposures. The results will help inform whether elevated risk to particular air pollutants necessitate more stringent regulations/standards as well as optimal exposure mitigation strategies for the protection of residents in DACs.

Background

This project was approved by the Research Screening Committee in 2020 and is the first in California to measure indoor and outdoor noise levels concurrent with air quality and develop cumulative exposure metrics characterizing exposures to mixtures of air pollutants and noise. This study also provides information to CARB staff to help identify the top sources of air pollutant and noise exposures in DACs which could inform future mitigation strategies. This research is essential to provide guidance and best practices for reducing total exposure to air pollution and noise in DACs, and possibly guide the development of building-related regulations to improve public health.

Proposal Tasks and Progress to Date

To assess total exposures to air pollutants and noise in disadvantaged communities, the original tasks for this study were:

Task 1. Complete Literature Reviews (task complete)

A literature review was conducted of population and community studies examining air pollution exposures nationally and in California DACs and non-DACs. The review summarizes information on disparities based on CalEnviroScreen scores, historical information on pollution trends by region in California, and the impact of regulatory approaches to reduce disparities, such as diesel emission regulations.

Task 2. Identify vulnerable communities for Exposure Studies and Develop Outreach Plan (task complete)

Study partners in the communities of Stockton and Fresno were identified, as well as AB 617 selected communities to focus the study activities. Other locations based on CalEnviroScreen air pollution scores

and study logistics were also considered. The studies focus on neighborhoods along the Stockton cross-town highway 4 and South-Central Fresno AB 617 selected communities.

Task 3. Develop Sampling and Project Protocols (task complete)

Project protocols for recruitment, data collection, and sampling were developed to document study procedures and methods and ensure training of study staff. The protocols described recruitment, consent, and confidentiality procedures; questionnaire and home inspection procedures; detailed information on collection of real-time monitoring data, including equipment operation, and quality control (QA/QC) procedures.

Task 4. Develop Study Instruments and Obtain Human Subjects Approval (task complete)

For this task, home inspection forms, participant questionnaires, recruitment and consent forms, translated study instruments (into Spanish) and human subject approval were attained. Final IRB approval was given in April 2022. Ongoing IRB modifications have been made to accommodate small updates, and as study personnel have changed.

Task 5. Recruitment of Study Participants (task modified)

The targeted enrollment for the study was initially 90 households, split between Stockton and Fresno. The loss of the Stockton subcontractor means that only 64 participant visits will be completed in total. (52 in Fresno and 12 in Stockton). A subset of 8 participants (originally 30) will receive a second study visit, for a total of 72 study visits (originally 120).

Task 6. Conduct Field Sampling and Data Collection for the Full Study (task modified due to reduced households)

UCB will conduct an approximately nine-month field sampling campaign that will span both warm and cool seasons. UCB will collect and evaluate 64 households for a total of 136 days of air sampling. Real time measurements will include:

a. PM2.5, O3, NO2, and CO
b. Black Carbon
c. Noise levels

The investigators also collected VOC and PAH samples, but analysis of these samples was not part of the original contract. The investigators will now provide information on relevant VOC and PAH exposures following review of the data.

Task 7. Data Management and Data Analysis (to be completed)

Task 8. Health Risk Characterization (to be completed)

a. Non-cancer risk estimation
b. Cancer risk estimation
c. Exposure to noise

Task 9. Interim, Draft and Final Report (to be completed)

Task 10. Disseminate Findings and Prepare Manuscripts for Publication (to be completed)

II. Staff Comments

The recommendation by Drs. Noth and Bradman is to cease the field work (which would require the support of at least 2 Graduate Student Researchers) and move forward with the significant work required to complete tasks 7 through 10. They have also offered to augment task 6 of the study to include PAH analysis, which was not included in the original scope of work. The original award for the contract was $799,981. The Pis are requesting to rebudget the money left from the LMR subcontract (approximately $47K) to help complete the outstanding contract tasks, and they are also requesting an additional $75,000. The additional funds are needed to hire a Staff Research Analyst to help complete the data analysis and reports (tasks 7-9) and to support staff salaries for the period of the contract extension. The contractors are also requesting a contract extension to give the investigators time to compensate for the unforeseen delays they encountered and to complete the final report. With the proposed augmentation, the analyses in the original contract will still be conducted, but there will be a reduction in the number of participants from 90 to 64. The contractors believe, and staff agrees, that while the sample size will be less than originally proposed, the SPHERE study will still have all the expected strengths and novelty:

- Real time and time-integrated measurements of many key indoor and outdoor air pollutants in DACs

- The opportunity to compare diesel exhaust exposure near freeways with heavy truck use (i.e., I880) to freeways with less truck traffic
- The first study in California to measure indoor and outdoor noise levels concurrent with air quality.
- Comparison of noise measurements to noise levels predicted by the U.S. DOT National Noise Map
- Development of cumulative exposure metrics characterizing exposures to mixtures of air pollutants and noise
- The opportunity to examine associations between individual and cumulative environmental exposure metrics with reported respiratory and other health outcomes
- Data to inform CARB policies for decarbonization. Exposure from a variety of sources will be assessed, including consumer products, cooking, and appliances such as gas burning stoves.

In conclusion, this contract augmentation is needed to provide additional funding and time to complete the contract. A Staff Research Analyst will be hired for the data analyses and to help make up for multiple delays encountered during the study. We will also obtain a time extension so that there is ample time to complete the remaining tasks for the contract.

IV. Staff recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this contract augmentation for $75,000.

Item No.: III.3
Date: November 17, 2023
Contract No.: 22RD004

Staff Evaluation of a Proposed Contract Augmentation

Title:	Understanding and Characterizing Emission Factors from Burning Structures in California Due to Wildfires
Prime Contractor:	University of California, Berkeley (UCB)
Subcontractor:	Aerosol Dynamics, Inc (ADI)
Principal Investigators:	Allen Goldstein (PI), Ph.D. Michael Gollner (Co-PI), Ph.D. Nathan Kreisberg (Co-PI), Ph.D.
Contract Type:	Interagency Agreement
Additional Budget:	$300,000
Contract Term:	36 Months

For further information, please contact Dr. Dongmin Luo at (916) 277-0834.

I. Summary

A contract augmentation is requested to conduct additional laboratory experiments with more fuels to be compared to large-scale measurements to provide a broad emission factor (EF) dataset applicable to more structure types. The recently CARB-funded study will determine emission factors and chemical speciation from burning structures typical of those located in California due to wildfires. However, this data will be collected for a very specific construction type with limited materials, providing only a starting point to determine the wildland-urban interface (WUI) emissions across a diversity of vulnerable communities across the State. In this contract augmentation, the investigators will conduct additional experiments by burning specific building materials in the UCB Fire Research Lab under varying burning conditions. These controlled environments will be modified to represent non-ideal but realistic burning conditions by varying both heating rates and ambient oxygen to understand the effect of under-ventilated conditions on emissions. Laboratory materials tested will include a broader array of common building materials, many overlapping with large-scale tests, as well as older samples to represent

different states of construction across the State. This study provides a unique opportunity where an array of laboratory samples burned under different states can be compared directly to large-scale burns to better isolate the effect of materials and conditions on overall emissions of large-scale fires and improve our understanding of the complex processes contributing to these emissions. The results of the full-scale structure burn along with this proposed laboratory study will help determine the contribution of individual components of structure burn experiments to overall fire emissions. Thus, it will improve our understanding of fire behavior and its role in emissions for developing and testing effective strategies and policies for mitigating the impacts of wildfires in California.

II. Technical Summary

Objective

To perform additional laboratory experiments to augment both laboratory testing of WUI fuels as well as on vegetative fuels that would be present either in wildland fires or ornamental vegetation in the WUI. The steady-state combustion apparatus will be used to test fuel combustion under a variety of ventilation, oxygen, and heating conditions.

Background

The original project was approved by the Research Screening Committee in July 2022 and augmented in February 2023 to add laboratory experiments with more fuels to be compared to large-scale field measurements to provide a broad emission factor dataset applicable to more structure types. The overall goal of this project is to advance CARB's research needs related to emission factors and chemical speciation from burning structures typical of those located in California due to wildfires, and help improve the characterization of WUI structure fire emissions that are needed in California's Natural and Working Lands (NWL) model and First Order Fire Effects Model (FOFEM). The improvement of these models will allow CARB to better predict wildfire spread in different ecosystems and conditions and economic outcomes from future policy and climate scenarios.

In WUI fires, numerous structures containing household materials, in addition to biomass fuels, are burned or heated. Within WUI fires, emissions can vary significantly depending on the material or structure burned. Fires can emit high levels of trace gases (such as intermediate, semi-, and volatile

organic compounds; and primary (directly emitted) PM. The quantities and properties of the emitted compounds are highly variable and largely dependent on fuel type and burn conditions, thus differences in emissions are expected between natural land fires and WUI fires. In real wildland or WUI fires spread occurs rapidly and can result in non-ideal burning conditions at the flame front, such as reduced oxygen availability compared to the ambient. The increasing prevalence of extreme, large-scale fires such as mass fires occurring after extensive tree mortality in the southern Sierra Nevada or during numerous community-scale conflagrations in WUI push the limits where these conditions may be exacerbated and dominate burning conditions. Unfortunately, these extreme conditions are projected to become more prevalent under a changing climate. Due to the increasing prevalence of these conditions, it is important to further understand the effects of non-ideal burning conditions on emissions factors.

In the WUI, fires do not occur in the open but rather spread between structures and other flammable items distributed across an urban area. The majority of burnable material, other than vegetation, is located in structures or vehicles. Their enclosed nature also allows for trapped heat and significantly higher temperatures and heating rates than occur in the open. As fuel becomes depleted, the compartment fire starts to decay and burning rates decrease. A large portion of the fuel burning inside structures, therefore, burns under high heat, oxygen-limited conditions. While the fire dynamics occurring under these conditions are well understood, emissions occurring under these burning conditions are not.

While the under-ventilated conditions occurring in structures have been recognized for many years, until recently it was often assumed that fires through vegetation occurred under well-ventilated conditions due to their access to ambient air. Some studies, however, have hypothesized that oxygen availability may be limited at the flame front during combustion due to flames blocking the entrainment of ambient oxygen to the flame, especially as the size of flames increases. Therefore, the assumption that open burning conditions exclusively occur in either compartments or even vegetation fires may no longer be fully appropriate. With large mass fires occurring more often due to fuel buildup and large-scale tree mortality, larger flame fronts with reduced oxygen conditions may be even more prevalent. This has great importance when considering emissions as, for some species, these might vary extensively based on burning conditions but have yet to be characterized.

Despite the occurrence of these conditions, there are few studies addressing emissions from burning fuels under these conditions, with even fewer studies available only characterizing several major species for a limited selection of fuels. CARB is developing various land management scenarios to help develop targets for California's NWL. To accurately predict emission reductions from preventing structure fires during wildfires, we require specific data on emission factors related to structural fires. Hence, model performance which is based on model assumptions and inputs, should be evaluated against real-world field or laboratory observations to make sure it represents reality. Therefore, this is critical to conduct new measurements of gaseous and particulate emissions to improve predictions of structure fire emissions.

Proposal Summary

In the UCB original project, the Contractor will conduct airborne sampling of structure burn emissions to determine emission factors and chemical speciation and assess how emissions relate to fire or structure characteristics through collaboration with the Insurance Institute for Building & Home Safety (IBHS), funded by the California Department of Forestry and Fire Protection (CALFIRE). Additional experiments will be conducted by burning specific building materials in the UCB Fire Research Lab under varying burning conditions. The research plan included five tasks:

1. Prepare for Structure Separation Experiments
2. Collect Emissions Measurements
3. Laboratory-Scale Emissions Measurements
4. Analyze collected SSE Samples and Data
5. Prepare draft Final Report

The proposed augmentation will allow the research team to systematically adjust heating, oxygen, and flow rate conditions while maintaining steady combustion to directly isolate the influence of burning conditions on emissions. This is important to isolate and understand the impacts of this effect and whether emission factors of some fuels or effluents should be adjusted for extreme burning conditions. The small fuel sample size and ability to easily collect gaseous and particulate samples for speciation allows for a detailed study of conditions to be undertaken.

The research team will perform additional WUI fuels found in older building types, as well as on vegetative fuels that would be present either in wildland fires or ornamental vegetation in the WUI. One sample of each WUI fuel type (such as exterior paneling, framing, composite wood, interior furnishings, carpet, and asphalt shingles) will be tested under varying oxygen and heating conditions to understand how a wide variety of effluents changes under these conditions. An additional extension to work will involve the study of fuels from older construction, including six selected samples of furnishing, wall samples with paint, etc. that may have very different emissions profiles including lead, polycyclic aromatic hydrocarbons (PAHs), benzene, etc. that aren't present in other new materials. To represent the possible oxygen-limited conditions in either large wildland fires or intermix WUI zones, representative vegetative fuels from five different biomes, including ponderosa pine, eucalyptus, scrub oak, grasses, and chaparral will be taken and studied under similar heating and oxygen-limited conditions. In total 17 materials will be sampled over a range of conditions, forming an incredibly extensive database.

For all experiments, real-time emissions will be sampled using the same instrumentation as described in the original proposal, including real-time sensing: solid-state sensors, a particulate mass analyzer, and a Fourier Transform Infrared Spectroscopy (FTIR). The result of all tasks performed in this project will be a unique dataset of emissions measurements including large-scale burns of full-scale accessory dwelling units built to the California Building Code, a full sampling of emissions from individual materials, and changes depending on burning conditions. Comparing these results across the range of conditions proposed may allow not only for a useful dataset but also for some explanation of different effluents and their source, tracing species due to both materials and potential burning conditions.

Through a combination of structure and laboratory material burns, this project aims to establish specific tracers for structure burns, which will aid wildfire emission analysis. Overall, the benefit of laboratory test data is that the emission profiles can be generated at a rapid rate compared to large-scale experiments and under much more controlled conditions. These can then be combined to estimate different construction methods representative across the State. The publicly available results will provide improved estimates of EF to CARB and allow researchers and the public to learn about emissions from structure fires.

III. Staff Comments

An earlier version of the UCB full proposal was reviewed by the staff from CARB's Air Quality Planning & Science Division, Industrial Strategies, and Research Divisions, and the current version has incorporated staff comments to improve its clarity. The reviewers generally recognized the quality of the proposed research effort and the practical importance of the results. The reviewers stated that the assembled team has extensive experience and resources to apply to the project and the results will be well worth the resources.

Dr. Goldstein (UCB) will serve as the principal investigator coordinating and synthesizing the efforts of other task leaders. He will oversee the collection and analysis of particle-phase organic chemicals, and the drone-based sampling, and participate actively in the management and coordination of the overall project. The Co-PI, Dr. Gollner, will be responsible for the augmented tasks. His fire research team has broadly investigated fire-related science problems, utilizing experiments and combustion and fluid dynamics theory to solve problems related to fire spread in the wildland and built environments, material flammability, sustainable/green building fire safety and smoke and toxic product transport. His several research projects are currently supported by the National Science Foundation, the Department of Homeland Security, the US Forest Service, and the National Fire Protection Association's Fire Protection Research Foundation.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this contract augmentation for $300,000.

Item No.: IV.1
Date: November 17, 2023
Contract No.: 19RD015

Staff Evaluation of a Draft Research Final Report

Title:	A Scenario Tool for Assessing the Health Benefits of Conserving, Restoring and Managing Natural and Working Lands in California
Prime Contractor:	University of California, Berkeley Los Angeles
Principal Investigator:	Michael Jerrett, Ph.D.
Contract Type:	Interagency Agreement
Budget:	$536,124
Contract Term:	48 Months

For further information, please contact Dr. Barbara Weller at (916) 324-4816.

I. Summary

California contains landscapes that include forests, grasslands, shrublands, agricultural lands, wetlands, and the green spaces in urban and built environments. Together these landscapes are known as natural and working lands (NWL) and can provide a variety of benefits to the environment and the well-being of Californians. This contract was developed to create a health scenario tool that calculates the potential health impacts of climate actions in NWL. To develop the tool, the research team conducted a literature review of health studies on wildfire, urban green space, and benefits of NWL in improving human health. Using health impact associations identified from the literature review, the research team calculated the health impacts of changes in urban greening and the health effects from wildfires in the past and the potential health impacts of future levels of wildfire in the State. The health endpoints investigated include death, life expectancy, and birth outcomes for the urban greenspace, and death and respiratory outcomes for wildfire. The final health calculation tool is able to assess the health benefits of NWL management scenarios that reduce wildfire and increase greening in urban areas. The NWL Health Scenario Tool shows that increasing land management to reduce wildfire and increasing urban greening has the potential to greatly improve human health, supporting future statewide climate actions in NWL.

II. Technical Summary

Objective

The objective of this study was to develop a NWL Health Scenario Tool that can quantify the beneficial health effects of changes in both wildfires and urban green spaces due to management and improvement programs. By using the results of comprehensive literature reviews and health impact assessments, the tool is able to quantitatively evaluate how different NWL management scenarios in urban green space and wildfire regions within California can result in health and economic benefits.

Background

California's natural and working lands cover approximately 99% of the state and include forests, grasslands, shrublands and chaparral, agricultural lands, wetlands, and the green spaces in urban and built environments. California's NWL provide a multitude of benefits, including biodiversity, recreation, food, economic prosperity, human health benefits. Natural and working lands are also an important component in California's fight to achieve carbon neutrality. California's 2022 Scoping Plan for Achieving Carbon Neutrality indicates that California is projected to lose carbon stocks from NWL over the coming decades. However, conserving, restoring, and managing NWL can improve the health of these lands and maximize their ability to sequester and store atmospheric carbon and limit the release of future GHG emissions. To understand more completely the benefits of climate actions that will be taken in California's natural and working lands, it is critical to measure the health benefits of these strategies. The goal of the contract was to develop a tool that can calculate the health impacts and economic costs of these impacts from reduced wildfire and increased urban greening scenarios.

Project Summary

Task 1. In-depth Review

The contractor conduced literature reviews examining the health impacts of wildfires and urban green spaces. The focus of the reviews was on the association between mortality and morbidity outcomes and exposure to wildfire smoke particulate matter and urban green space exposure in California. The literature reviews found evidence of strong associations between both levels of urban green space and wildfire smoke exposure with several health outcomes. For urban green space, the literature review was focused on both peer reviewed meta-analyses and review papers and found evidence for improvements in mortality, birth outcomes, mental health, and cardiovascular health, with inconsistent evidence for physical activity and respiratory health. For wildfire smoke, few reviews and meta-analyses were identified, but several primary epidemiological studies found consistent evidence for detrimental effects on mortality and respiratory health, with mixed evidence for cardiovascular health, though there is a growing trend for a positive association between increased cardiovascular impacts from wildfire smoke exposure. The research team identified dose-response values from the literature on health impacts from wildfire and urban greening that could be used to conduct health impact assessments in the health scenario tool.

Task 2: Develop the NWL Health Scenario Tool

Urban Green Space Scenarios

Dose-response functions from primary studies and meta-analyses were used to estimate changes in mortality, life expectancy, and low birth weight incidence from various green space exposure scenarios within the urban areas of California. The two primary scenarios were overall increases in green space of 0.1 units of normalized difference vegetation index (NDVI) and bringing all urban areas up to the statewide mean of NDVI. Impacts were calculated for mortality, life expectancy, and low birth weight outcomes. Additional scenarios were an increase of 10% in statewide tree canopy and bringing the tree canopy up to the statewide mean in urban areas for life expectancy. Results of the analysis estimated 7,378 avoided deaths, 20,649,279 years of life expectancy gained, and 5,385 avoided low birth weight deliveries with increased urban green space exposure. All of the scenarios and the results on the benefits

to mortality, life expectancy, and low birth weight were included in the draft final report and can be calculated in the NWL Health Scenario Tool.

Historic Wildfire (2008-2018) on Mortality and Morbidity

The contractors used modeled wildfire fine particulate matter (PM2.5) concentrations from CMAQ (Community Multiscale Air Quality Modeling System), high resolution mortality data, and a chronic dose-response coefficient for wildfire PM2.5 exposures and mortality to estimate premature deaths due to wildfires from 2008-2018. To investigate the effects of historic wildfire on other health outcomes, the most appropriate dose-response values from the literature and daily wildfire PM2.5 concentrations from CMAQ were used in the open-source BenMAP-CE program (Environmental Benefits Mapping and Analysis Program-Community Edition) to estimate the impacts of wildfire PM2.5 on various health outcomes. The health outcomes investigated were emergency room visits for asthma and respiratory outcomes, and hospitalizations for asthma, chronic lung disease, and respiratory outcomes. The results of the mortality analysis estimated between 52,600 to 56,140 premature deaths attributable to wildfire PM2.5 over the eleven-year period, with the largest impacts occurring during high fire years. The incidence and economic costs of the mortality and morbidity outcomes from wildfire for each year from 2008-2018 were included the draft final report and can be calculated in the NWL Health Scenario Tool.

Wildfire Scenarios

Using the methods and health endpoints from the historic wildfire health assessment and the atmospheric transport model STILT (Stochastic Time Inverted Lagrangian Transport Model) to model the impact of multiple emissions scenarios on air quality, the health impacts of several hypothetical management scenarios were investigated. These scenarios are based on changes to modeled historical 2018 wildfire emissions and include: 5%, 10%, and 15% across-the-board reductions in 2018 wildfire emissions state-wide, and reductions in emissions only from the Sierra Nevada. The incidence and economic costs of the mortality and morbidity outcomes for these scenarios can be calculated in the NWL Health Scenario tool.

The investigators also conducted an analysis on the mortality impacts from 2018 prescribed burn emissions with scenarios of 25%, 50%, and 100% increases in the 2018 prescribed burn emissions. The

draft final report shows the mortality results for 2018 prescribed burn emissions which estimated 25 excess deaths, a substantially smaller effect compared to the 1,684 excess deaths attributable to wildfire emissions that same year. The analysis did not investigate the net health benefits from prescribed burns preventing future wildfires, but the investigators stated that even a 5% reduction in wildfire from prescribed burning would result in 84 deaths avoided, resulting in a net benefit more than 3 times greater than the deaths attributed to prescribed burns themselves. The mortality impacts of all the prescribed burn scenarios can be calculated in the NWL Health Scenario Tool.

NWL Health Scenario Tool

The NWL Health Scenario Tool is available through the online Google Earth Engine platform and comprises both an urban green space and a wildfire component. The urban green space tool quantitatively evaluates the potential health and economic benefits linked with increased urban greening scenarios and is mapped at zip-code and census tract levels. The wildfire tool quantitatively evaluates the health impact of wildfire PM2.5 using two atmospheric modeling simulations: (1) zip code-level health and economic costs from historical fire emissions using CMAQ, and (2) county-level health and economic benefits from possible wildfire management strategies using STILT.

Task 3: CARB Derived Scenarios

For the 2022 Scoping Plan, the contractor worked with CARB to provide a preliminary analysis of the health impacts of CARB's NWL management scenarios to reduce wildfire. These results were included in the 2022 Scoping Plan for 2045. The contractor is completing a final analysis to quantify the health benefits of the chosen NWL management scenario in forests, shrublands, and grasslands for 2025, 2035, and 2045 from the 2022 Scoping Plan compared to the business-as-usual on mortality and morbidity outcomes using the health impact assessment methods developed for the NWL Health Scenario Tool and GEOS-Chem (Goddard Earth Observing System Chemical Transport Model) to model the impacts of future fire emissions on air quality. These results will be available in January 2024.

III. Staff Comments

CARB received the draft final report in September 2023. The report was reviewed by staff in the Research Division and has gone through two revisions. Main comments from staff consisted of requesting

significant reorganization to follow CARB's final report guidelines, formatting the document, and editing the language for cohesiveness and consistency, and inclusion of more results from the tool into the report and the link to the final tool for use by CARB. The draft final report will be sent to staff from the California Department of Public Health (CDPH) and the Office of Environmental Health Hazard Assessment (OEHHA) for their review. The compiled comments from CDPH and OEHHA will be sent to the investigators. CARB staff will work with the investigators on how they will address the comments. This information will be presented to the RSC.

The majority of the work on this contract and all the work on the Natural and Working Lands tool is presented in this report, and staff recommends RSC review of the report at this time. While Task 3 will not be completed in full until January 2024, this contract task is a separate and defined task to estimate future wildfire smoke health impacts, and estimations have already been included in the 2022 CARB Scoping Plan. The ongoing work on this task includes further refinements of the health estimations and additional years. CARB staff will provide the full report when completed, but do not think the additional task would merit an additional full review of the report by the RSC.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this draft final report for $536,124 contingent upon completion of task 3 and receipt of all deliverables.

Item No.: IV.2
Date: November 17, 2023
Contract No.: 19RD008

Staff Evaluation of a Draft Research Final Report

Title:	Understanding and Mitigating Wildfire Risk in California
Prime Contractor:	University of California, Berkeley (UCB)
Subcontractors:	University of California, Riverside (UCR) Aerosol Dynamics, Inc. (ADI)
Principal Investigators:	Allen Goldstein, Ph.D. Kelley Barsanti, Ph.D. John Battles, Ph.D. Scott Stephens, Ph.D. Robert York, Ph.D. Tom Kirchstetter, Ph.D. Nathan Kreisberg (Co-PI), Ph.D.
Contract Type:	Interagency Agreement
Budget:	$900,000
Contract Term:	46 Months

For further information, please contact Dr. Dongmin Luo at (916) 277-0834.

I . Summary

In the dry forests of the American West, long-term policies of wildfire suppression and early harvesting practices have led to the accumulation of understory fuels in forests, including in California. This century-long shift in forest structure in tandem with a warming climate greatly increases the potential for destructive fires. Fuel treatments, such as prescribed fire and the mechanical removal of vegetation, are often implemented to reduce the spread and intensity of large wildland fires. To balance the trade-off between reducing fire hazards and limiting exposure to criteria pollutants, an accurate means to predict fire emissions from prescribed burning is essential. In this research project, the experiments occurred at University of California's Blodgett Forest Research Station (BFRS), a mixed conifer forest representative of large regions of the western slope of the Sierra Nevada. The researchers conducted measurements

via ground- and airborne-based (drone) sampling platforms during prescribed burn activities, and developed datasets for use by air quality management and scientific communities by characterizing smoke emissions as a function of land management practices. Gas and particle concentration data were converted to emission factors (EFs; i.e., mass of pollutant emitted/mass of fuel consumed) using well-established carbon balance methods that account for the fraction of carbon in the fuels. The observed EFs were used to validate those used by CARB in the First-Order Fire Effects Model (FOFEM) for modeling atmospheric emissions from prescribed burns. Furthermore, using time-resolved observations from the PurpleAir sensor network in California, analyses of fine particulate matter (PM2.5) indoor infiltration ratios during non-fire and wildfire days were completed. The results of this research project along with its unique database will be a valuable resource for the community for identifying specific chemicals in air masses impacted by biomass burning plumes and understanding the dominant source materials burned, fire characteristics, atmospheric transformations, and health implications.

II. Technical Summary

Objective

The objectives of this contract were to: 1) analyze gaseous and particulate organic carbon emission samples from California wildfires collected by CARB staff using their mobile platform in coordination with the Fire Influence on Regional and Global Environments Experiment–Air Quality (FIREX-AQ) aircraft campaign; 2) evaluate biomass burning EFs in FOFEM for climate pollutants (e.g., carbon dioxide-CO2); criteria pollutants (e.g., oxides of nitrogen-NOX, carbon monoxide-CO, and PM2.5); and 3) quantify EFs of criteria pollutants, volatile organic compounds (VOCs), and selected air toxics from prescribed burns. Calculated EFs were compared with those from wildfires in order to understand how reducing fire risk through prescribed burn also alters emissions.

Background

Fires can emit high levels of trace gases and primary (directly emitted) particulate matter. During plume evolution, some of the gases react to form ozone and secondary PM (i.e., secondary organic aerosol, SOA), thereby degrading air quality downwind and potentially endangering human health. A recent study shows that increasing wildfires are erasing decades of air pollution gains in U.S. Northwest, including rural parts of northern California. Climate change will sharpen the problems involving wildfires in the

western U.S. Given its cost-efficiency, prescribed fire is often the preferred fuel treatment. Yet there are critical public health and social justice concerns about the emissions associated with a greatly expanded program of prescribed fire. Improvements in model representation of fuels and emissions are needed to advance the scientific understanding and allow reliable predictions of the linkages between fire and land management practices and fire emissions and impacts.

Fires emit PM directly along with hundreds of gaseous compounds. The emissions are variable from fire to fire and depend on fuel type, fuel moisture, fire conditions, temperature, weather, and other factors. This variability is a major challenge for understanding the emissions, chemistry, and subsequent impacts of smoke. Once emitted, wildfire smoke undergoes chemical transformations in the atmosphere, which alters the mix of compounds and generates secondary pollutants, such as ozone (O3) and secondary organic aerosol (SOA).

In their earlier studies, through Joint Fire Science Program and National Oceanic and Atmospheric Administration (NOAA) funded projects, researchers demonstrated that collaborative application of advanced instrumentation can yield significantly improved estimates of gaseous and particulate compounds emitted from fires. For their previous research projects, particle-phase compounds, researchers published emission factors (EFs), scalable by modified combustion efficiency, for elemental and organic carbon (EC and OC, respectively), and speciated organic compounds. This detailed emission characterization was an important part of the joint FIREX-AQ campaign, which combined in-situ surface and airborne observations with remote sensing data. The leveraging of the contractors' NOAA-FIREX efforts provided critical information to improve model predictions of the impacts of fires on chemistry and climate.

In current models used to support air quality decisions, the ability to represent air quality and climate effects of fires is severely limited. Researchers recently compared predicted emissions using the FOFEM from six wildfires in California with field data. In general, FOFEM performed reasonably well in estimating fuel consumption and relevant emissions for air quality. However, for most fuel characterizations tested, the model underestimated flaming emissions and overestimated smoldering emissions. Thus, the quantities and properties of the compounds emitted depend on combustion conditions (e.g., flaming

versus smoldering), as well as the characteristics of the fuel. Therefore, as demonstrated in this research project, there is a critical need to link accurate measurements of pre-fire fuel conditions, post-fire fuel consumption, and gaseous and particulate emissions in order to improve predictions of fire emissions and their effects on air quality and climate. Quantifying the chemical composition and properties of biomass burning emissions is also needed to improve the modeling of their impact on human health, visibility, and climate.

Project Summary

This project provides emissions from a representative set of prescribed burns in a mixed conifer forest in California and compares with emissions from prescribed fires and wildfires in the western U.S. Measured EFs were used in collaboration with CARB staff to evaluate FOFEM model estimates of short-lived climate pollutants and other air pollutants and will be used to improve model estimates in the future. Outcomes include improved EFs from prescribed burns of managed and previously unmanaged forest; and comparison to emission factors from wildfires, including recently measured and published values.

The work conducted for each of the five tasks identified in the contract is briefly summarized below:

Task 1: Plan prescribed burns: Designed experimental plan, identified appropriate plots for prescribed burns at BFRS, planned the suite of ground-based measurements and prepared required instruments, planned the drone-based measurement system and built drone sampler, prepared burn plan and submitted to CALFIRE for approval, and assessed FOFEM model inputs and treatment of EFs, including as a function of fuel type, fuel moisture, and burn characteristics.

Task 2: Analyze FIREX-AQ samples collected by CARB from California wildfires: During the period of the FIREX-AQ field campaign, researchers provided a sampler for collection of gas- and particle-phase organic carbon to CARB staff for collection during wildfires. Wildfire smoke samples were collected from two fires in August and November 2019 by CARB using their Mobile Measurement Platform: Springs Fire

(5,000 acres burned) and Kincade Fire (78,000 acres burned). VOC samples were analyzed at UC Riverside. PM2.5 samples were analyzed at UC Berkeley.

Task 3: Complete prescribed burns: Prescribed burns were completed in April 2021. Three plots were successfully burned, and all burns were conducted during the daytime. Measurements of above-ground pre-fire carbon pools were completed including detailed fuel measurements. A sampling protocol was developed and applied for above-ground biomass stocks (duff, litter, fine woody debris, coarse woody debris, shrubs, and trees).

Task 4: Analyze prescribed burns samples and data: Analysis of samples and data from prescribed burns were completed. Researchers measured biomass in each plot before and after prescribed burns to determine the amount and type of fuel consumed. Speciated particle phase organics were analyzed from filter samples at UCB and EFs were calculated for ground and drone samples. Speciated VOCs were analyzed at UCR from sorbent tube samples and EFs were calculated for ground and drone samples. Analysis of BC in smoke from prescribed burns and wildfires was completed. FOFEM model runs were completed. Calculated consumption, EFs, and total emissions from FOFEM were compared with observations. Analysis of already-collected data during the 2018 and 2020 wildfires in California was completed for BC and PM2.5. Using time-resolved observations from the PurpleAir sensor network in California, analyses of PM2.5 infiltration ratios during non-fire and wildfire days were completed.

Task 5: Draft final report: The researchers delivered to CARB a draft version of the final report. Specific contracted deliverables that will be submitted later will include 1) database of chemical species collected on filters and sorbent tubes 2) calculated EFs for bulk gaseous and particulate compounds (e.g., total PM), for individual species and for classes of compounds (e.g., 'PAHs') in gas and particle phases; EF database includes metadata to link EFs with fuel characteristics and burn conditions; 3) temporal profiles of online gaseous chemical species (e.g., CO, CO2); and 4) pre-fire fuel characterizations including mass and moisture content by component along with burn conditions and fuel consumption for the prescribed fires at Blodgett Forest Research Station.

Overall, the results indicate that the spring prescribed burns at BFRS successfully met land management goals. The mass of litter and fine woody debris was reduced by 65%, total ground and surface fuel load

was reduced by 53% with the lower rates of combustion (<50%) occurring in the heavy fuels (i.e., duff and coarse woody debris). Further, crown scorch never exceeded 32% and only one of the 63 trees > 50 cm diameter breast height was killed in the fire. While surface fuel loads were meaningfully reduced, carbon losses were relatively low compared to values reported in the literature for similar treatments in comparable forests. The fires proceeded through flaming and smoldering combustion phases and smoke samples were collected from ground- and drone-based platforms. The drone generally sampled a wider range of combustion conditions, from flaming to smoldering, resulting in generally higher VOC mixing ratios and PM mass concentrations. The EFs, however, between the ground and drone samples were relatively consistent.

Emission profiles were characterized by two distinct types of prescribed fires: third-entry burns (burned twice previously for management purposes) in a mature, second-growth mixed conifer forest and first-entry burns in a second-growth mixed conifer forest. These two extremes capture what will in the future become a gradient in management status. The first-entry burns are representative of the majority of burn projects that are being proposed currently, that is, introducing fire in forests that have been unburned since the policy of fire suppression was implemented a century ago. The third entry burns represent the desired future goal, that is, a forest that is being maintained with light burning in perpetuity. Overall, EFs between first and third-entry burns were also relatively consistent, suggesting that the composition of emissions was similar between these types of burns. The emissions depended on how much fuel was used in these burns, which is very important for predicting emissions from planned burns and wildfires.

III. Staff Comments

An earlier version of the UCB final report was reviewed by staff from CARB's Air Quality Planning and Science, Industrial Strategies, Monitoring and Laboratory, and Research Divisions and the current version has incorporated staff comments to improve its clarity. The final report accurately describes the completed work and its implications and identifies future research needs. The reviewers' comments generally recognized the quality of the research effort and the practical importance of the results. The project successfully completed the stated objectives, and the report does an excellent job of

documenting the findings. Reviewers stated that the report contains several valuable information to share, both on the carbon and smoke modeling fronts. It highlights that while the emissions models are not perfect, it is the fuel inputs that really hamstring our abilities to properly quantify them. The investigators also prepared a detailed "Response to Comments" file that addresses comments made by the review team, which is inserted in the UCB draft final report as ”Attachment A”. In addition to preparing this final report, the investigators have published their results in several peer-reviewed journals.

The results of this project indicate that characterization and quantification of biomass burning emissions are needed to improve the modeling of their impact on human health and climate. Furthermore, fuel manipulation and reduction treatments are a vital tool for reducing fire severity, and likely the most effective way of reducing future biomass burning emissions in a hotter, drier, and more variable climate. Hence, there is an urgent need to reduce fuel loading in forests to better understand the impacts of wildfire and prescribed burning on the atmosphere and climate, and for policy-relevant science to aid in the process of managing fires.

The project outcomes include improved emissions factors from controlled burns of managed and previously unmanaged forest; and comparison to emission factors from wildfires, including recently measured and published values. The results of this research project along with its unique database will be a valuable resource for the community for identifying specific chemicals in air masses impacted by biomass burning plumes and understanding the dominant source materials burned, fire characteristics, atmospheric transformations, and health implications.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this draft final report for $900,000.

Item No.: IV.3
Date: November 17, 2023
Contract No.: 20RD005

Staff Evaluation of a Draft Research Final Report

Title:	A Data Science Framework to Measure Vehicle Miles Traveled by Mode and Purpose
Contractor:	University of California, Berkeley
Principal Investigators:	Marta Gonzalez, Ph.D.
Contract Type:	Interagency Agreement
Budget:	$550,000
Contract Term:	36 Months

For further information, please contact Dr. Sarah Pittiglio at (916) 324-0627.

I. Summary

There is a need for reliable data sources to measure changes in vehicles miles traveled (VMT) and understand travel behavior to help curb greenhouse gas (GHG) emissions from the transportation sector. In this project, the contractor developed techniques to integrate and analyze various geo-located data sets to put in place a system to collect data on travel behavior and VMT over time. The analysis of VMT and trip purpose was performed statewide in a six-month period prior to the COVID-19 pandemic (pre-COVID), as well as at small geographic scales before, during, and after the COVID-19 pandemic (post-COVID). Overall, report findings underscore the importance of tailoring policies aimed at reducing vehicle dependency to account for regional disparities in urban, suburban, and rural regions. The findings from this report should inform best practices for contributing to more sustainable community strategies that help meet VMT, GHG, and air quality goals as mandated by SB 375. In addition, the innovative techniques that were developed in this study to integrate and analyze various geo-located data sets should support CARB staff on utilizing big data to better understand travel behavior and VMT.

II. Technical Summary

Objective

This contract aimed to explore utilizing location data generated by mobile phones to quantify changes in people's mobility and vehicle use around the impact of the COVID-19 pandemic.

Background

In 2018, California set the target to reduce the state's GHG emissions to 40% below the 1990 level by 2030. One significant contributor to these emissions is the transportation sector, particularly through the widespread use of motor vehicles. This also creates a need for reliable data sources to help quantify changes in VMT and understand people's travel behavior. The emergence of the COVID-19 pandemic brought about substantial limitations on people's mobility. A predominant shift towards remote work became the norm for many during this period, leading to a fundamental transformation in how and where people travel within cities. The pandemic also presented a unique opportunity to explore shifts in travel behavior through the lens of mobile phone data, offering a valuable opportunity to understand how people modified their vehicle usage and travel patterns during this period.

Project Summary

This report delved into the alteration of human mobility patterns in California prompted by the pandemic and the corresponding response measures. Utilizing Location-Based Service (LBS) data derived from mobile phones, the research team introduced a mode detection algorithm to explore changes in VMT statewide, categorized by trip purpose and origin tract within California. Their analysis uncovered both spatial and temporal disparities in how the COVID-19 pandemic and the California Shelter in Place Order affected VMT. The study investigated shifts in the number of commutes and the structure of the commuting flow network. The research team identified the emergence of two additional travel zones in the flow network, indicative of a growing separation among different regions in the wake of the pandemic. They also compared the average travel distance, assessed through their designed metric, before and after the pandemic's onset, capturing shifts in individual travel behaviors. The project findings confirm that not only did people reduce their overall travel due to the pandemic, but they also began to travel shorter distances. Additionally, this report examined patterns of changes in residential

locations during the COVID-19 pandemic using a two-step semi-supervised algorithm. The research team observed a higher frequency of home changes in March 2020. Users who relocated during this period tended to move over longer distances, suggesting a shift not only within the city but also within the broader region of residence. Lastly, they evaluated the feasibility of employing LBS data to assess the effectiveness of various mobility-related interventions that took place in Sacramento in 2019, employing the mode detection algorithm. The research team observed the potential to detect changes in motorized trips because of these interventions, however the sample size for traveler detection is relatively small, limiting the study's ability to draw definitive conclusions.

III. Staff Comments

This report has been shared with CARB staff from the Sustainable Transportation and Communities Division (STCD) and Research Division to review and provide comments. Staff from Caltrans, California Energy Commission, California Department of Housing and Community Development, and the Strategic Growth Council, also engaged throughout the course of this contract. The draft final report was recently submitted, which has required that the review from CARB staff, other state agencies staff, and the RSC be concurrent. STCD staff has reviewed interim reports and expressed confidence on the innovative techniques developed in this study to integrate and analyze various geo-located data sets to support CARB staff on utilizing big data to better understand travel behavior and VMT. The contract manager will provide more updates as CARB and other state agencies staff provide comments. The deadline for staff to provide comments is scheduled for November 2nd, 2023.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept this draft final report for $550,000.

Item No.: IV.4
Date: November 17, 2023
Contract No.: 20RD006

Staff Evaluation of a Draft Research Final Report

Title:	Measuring, Analyzing and Identifying Small-Area Vehicles Traveled Reduction
Contractor:	University of California, Davis
Principal Investigators:	Susan Handy, Ph.D.
Contract Type:	Interagency Agreement
Budget:	$199,500
Contract Term:	36 Months

For further information, please contact Dr. Sarah Pittiglio at (916) 324-0627.

I. Summary

Metropolitan Planning Organizations (MPOs) are required to adopt Sustainable Communities Strategies (SCSs) that lay out the strategies by which the region will achieve its greenhouse gas reduction targets, including strategies to reduce vehicle miles traveled (VMT). Strategies to reduce VMT include changes to the built environment, to both land development patterns and the transportation system, that reduce the need for driving. As one way to test the effectiveness of these strategies, this project used available data to qualitatively examine changes in travel patterns associated with changes in land-use patterns and the transportation system in three case study areas: the downtown areas of Sacramento, Fresno, and Santa Monica. Overall, the report findings underscore the importance for the state to facilitate a more robust evaluation process to accurately assess the impacts of built environment changes on VMT in specific areas that captures data on travel patterns before and after the changes occur. The findings from this report should contribute to developing best practices, including establishing robust evaluation processes, for more sustainable community strategies that help meet air quality, climate, and VMT reduction goals, as mandated by SB 375.

II. Technical Summary

Objective

This contract aimed to document on-the-ground changes in the built environment, explore the contribution of local and or regional policy change and public and private investments, and assess whether changes in vehicle miles traveled occurred over the same period in the selected downtown case study areas of Sacramento, Santa Monica, and Fresno.

Background

Senate Bill 375, signed into law in 2008, directed the California Air Resources Board to collaborate with the state's MPOs to set regional targets for reductions in greenhouse gas (GHG) emissions from passenger vehicles. The MPOs are required to adopt SCSs that lay out the strategies by which the region will achieve its GHG reduction targets, including strategies to reduce VMT. Strategies to reduce VMT include changes to the built environment, to both land development patterns and the transportation system, that reduce the need for driving. As one way to test the effectiveness of these strategies, this project used available data to qualitatively examine changes in travel patterns associated with changes in land-use patterns and the transportation system in the three selected case study areas.

Project Summary

This project documented on-the-ground changes in the built environment in three selected downtown case study areas (i.e., Sacramento, Santa Monica, and Fresno) that experienced notable changes in their transportation systems and land development patterns between 2000 and 2019. The project assessed whether changes in VMT occurred over the same period and explored the contribution of local and/or regional policy change and public investments such as transit, bike, and pedestrian infrastructure as well as private development investments to the observed on-the-ground changes. The first part of the case-study analysis focused on identifying changes to the built environment in the area and the factors contributing to those changes, including broadly defined public policies and market forces. The second part of the case-study analysis examined changes in travel patterns in the area between 2000 and 2019 using available data sources. Estimates of reductions in VMT were promising, as were estimates of increases in the shares of trips by active modes, though the small sample sizes on which estimates were

based makes them highly uncertain. In these case studies changes to the built environment were associated with changes in travel behavior consistent with the goal of reducing VMT. The study determined that to robustly evaluate the impact of built environment changes on VMT in specific areas, data on travel patterns must be collected before and after the changes occur.

III. Staff Comments

The draft final report was shared with CARB staff from the Sustainable Transportation and Communities Division (STCD), Office of Community Air Protection, and Research Division (RD) to review and provide comments. In addition to staff from Caltrans, California Energy Commission, California Department of Housing and Community Development, and the University of California Institute of Transportation. Only staff from STCD and RD provided comments. Staff requested revisions to the draft final report and pointed out concerns about drawing strong conclusions on policy based on case studies with small sample sizes and to expand on information on land use that was in an appendix in the first draft. CARB staff met with the principal investigator (PI) to share the comments and the PI agreed to address these. A revised draft final report was submitted to CARB on October 2nd. The contract manager will review the revised draft and collect any additional comments from staff by November 6th, 2023. The contract manager will provide more updates, especially if any there are any outstanding concerns.

IV. Staff Recommendation

Staff recommends the Research Screening Committee recommend that CARB accept draft final report for $199,500.