DATE: January 12, 2021

TO: Pyregence Technical Advisory Group

FROM: Leroy Westerling, Workgroup #4 Lead, Pyregence Project (and Workgroup #4 members)

RE: Long-Term Climate and Global Emissions Scenarios (mid-century and end of century)

The Pyregence Project Consortium, a collaborative group of forest and fire scientists and modelers, is in the process of developing the next generation of statistical and dynamical wildfire and landscape models. These models simulate potential future wildfire risks and vulnerabilities under **projected climates** and under different land use and vegetation management scenarios. Pyregence is undertaking this work through an EPIC grant (#EPC-18-026) administered by the California Energy Commission, with the goal of producing models for use in California's 5th Climate Change Assessment and other wildfire-related strategic planning efforts.

Desired Outcome from this Memo

We seek your input — even if just a sentence or two—via email (sromsos@sig-gis.com with a CC to lwesterling@ucmerced.edu). If you would prefer to talk over the phone we will happily arrange 15 or 30 minute one-on-one calls to collect your thoughts. Your feedback will help us to select and design the most useful and relevant data and tools for the upcoming California 5th Climate Assessment.

Purpose of Long-Term Climate and Global Emissions Scenarios

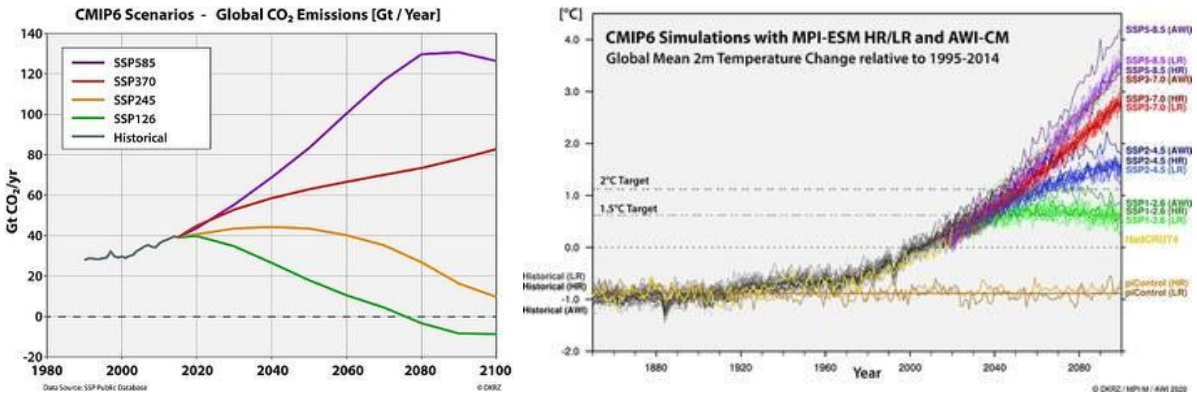
We seek your advice on scenario selection in order to:

- Better understand what scenario characteristics are most relevant in your strategic planning, recognizing that climate and global emissions are interrelated. For example, is the global emissions scenario (RCP) most relevant to your work, or the temperature trajectory regardless of how it is reached?
- Align with recent/prior efforts in order to facilitate cross-study comparisons and understanding of our modeling results. We would like to align our work with climate scenarios you routinely reference or use as benchmarks. For example, RCP4.5 as a low CO2 emissions scenario and RCP8.5 as a high scenario would be consistent with Cal-Adapt, California Public Utility Commission (CPUC) decisions, and other prior modeling efforts we review.
- Align with your most current thinking on the most relevant climate and emission scenarios.
- Prioritize realistic temporal ranges or endpoints that would be most helpful to your strategic planning efforts. Through mid-century we can model a broader range of scenarios, but between mid-century and end of century we would like to limit to a small number (no more than two) of climate/emissions scenarios given our budget and scope of work limitations.

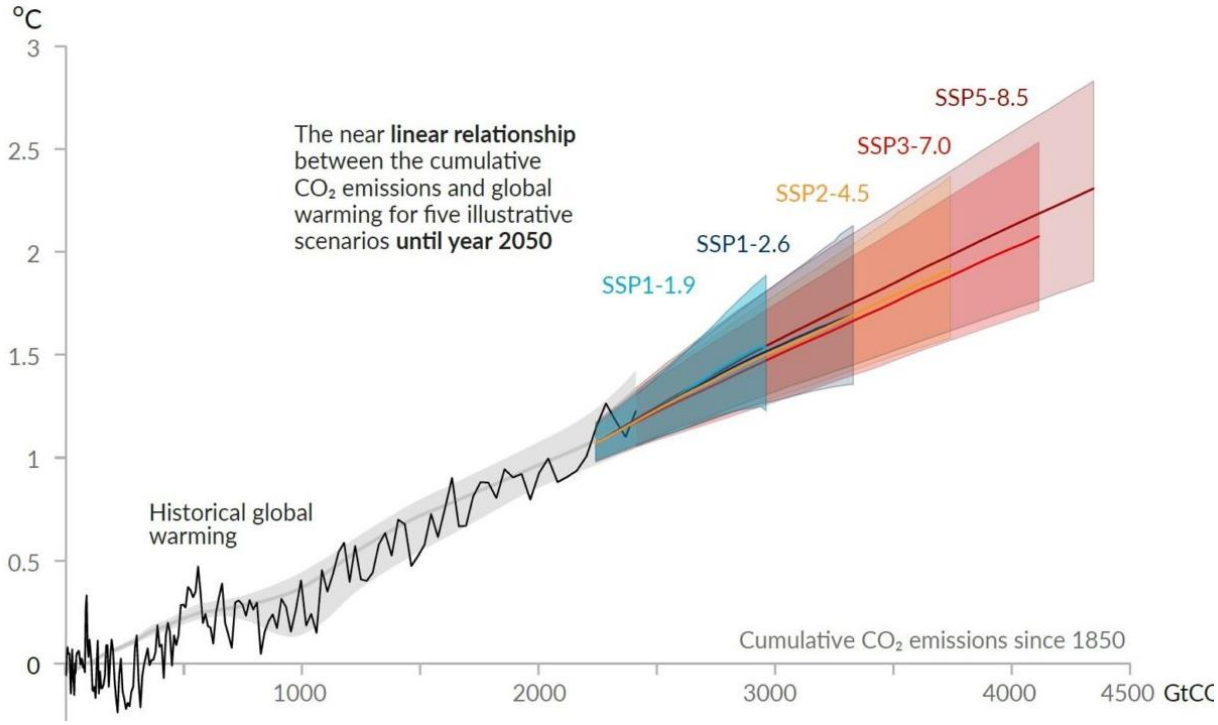
Overview of Scenario Options

Long-term CO2 emissions scenarios are helpful in understanding the direction and severity of potential atmospheric and temperature changes by the end of the century, and provide useful context for conversations about investments in climate change mitigation (reducing the rate of change in the long term). Realistically, time horizons for policies to manage our exposure to (and ability to adapt) climate change are shorter – extending through mid-century at most. These kinds of policy conversations, such as forest treatment decisions for the next several decades, are better informed by exploring the effects of variability in drought and precipitation extremes more generally, coupled with near-term trends in temperature, expected population growth, and scenarios for development footprint and land management. The differences between the impacts of various global emissions trajectories on temperatures – and thus wildfire – in the near-term (i.e., through mid-Century) are potentially modest compared to the impacts of drought timing, severity and duration coupled with the effects of investments in reducing our exposure to fire risks via fuels management and development footprints. Over the longer term, uncertainties related to unanticipated changes in population and urban development (for example, people moving from urban to suburban or rural areas during a pandemic) and global emissions trajectories can dramatically impact end of century wildfire risks and our exposure to them, rendering end-of-century fuels management planning now potentially costly and less useful. For example, long term trajectories of emissions scenarios vary a great deal (see Panel A below). They change the timing and end point of global temperature increases and they have a similar relationship with global mean temperature outcomes (Panels B and C), but with a lag. However, the range of temperatures across those scenarios over the next several decades is modest compared to the potential impact on wildfire of different scenarios for drought over the same time period. Regional and more local scenarios for variability in precipitation help us to explore impacts of drought variability coupled with temperature trends on wildfire through mid-century.

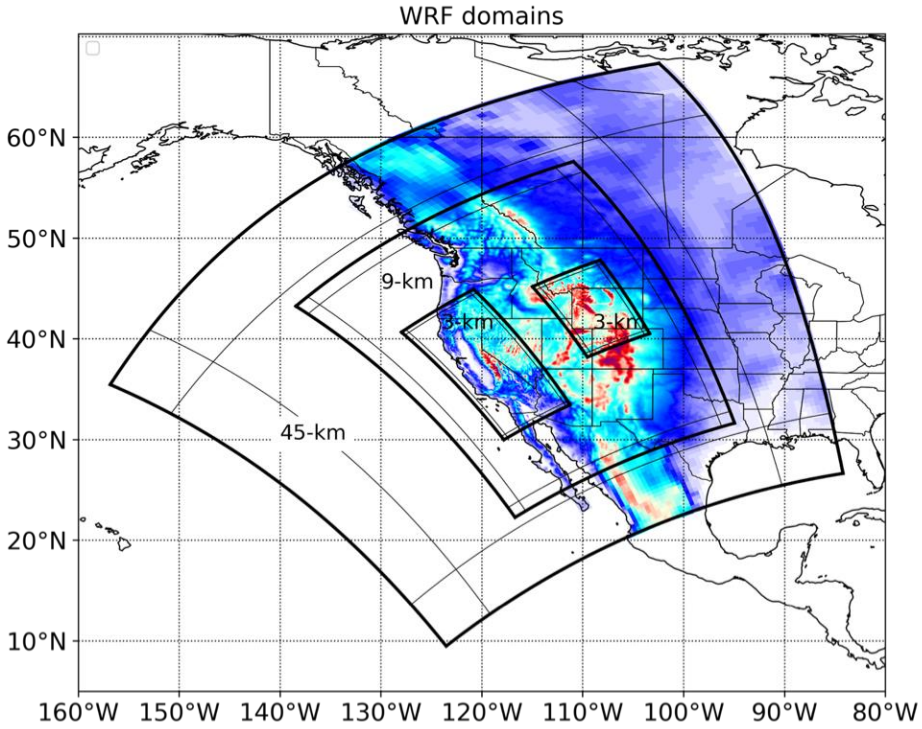
A: Coupled Model Intercomparison Project 6 (CMIP6) Emissions Scenarios through End of Century



B: Global Temperature Increase as a Function of Cumulative CO2 Emissions



C: Granularity of Climate Scenarios



Proposed Scenarios

We propose modeling:

- At least two CO2 emissions scenarios through mid-century (from among SSP2-4.5, SSP3-7.0, and SSP5-8.5), but with an expansive range of climate models that explore variability in precipitation extremes through mid-century. The project team prefers evaluating SSP-4.5 and SSP5-8.5 through mid-century in order to capture the lower and upper range in likely emission scenarios.
- A high and low emissions scenario through the end of the century (from among SSP2-4.5, SSP3-7.0, SSP5-8.5), but with potentially fewer climate models.

For vegetation management, we vetted the following two scenarios with the project's Technical Advisory Committee and other stakeholders:

- High Ambition Management Scenario - This scenario models forest treatments to meet a goal of one million acres treated per year, a goal identified in a 2018 Executive Order and emphasized in the 2021 California Wildfire and Forest Resilience Action Plan; the plan prioritizes reducing fuels (i.e., through vegetation management) in areas classified by CAL FIRE as 'high' and 'extremely high' fire hazard risk zones.
- Business-As-Usual (BAU; Low Ambition) Management Scenario - This scenario represents an attempt to sustain the vegetation management/treatment approach from the previous decade (2010-2019). As such, the total average annual treatment rate across the state is approximately 440,000 acres per year, or 55 percent less activity than the high ambition scenario.

Additional Considerations

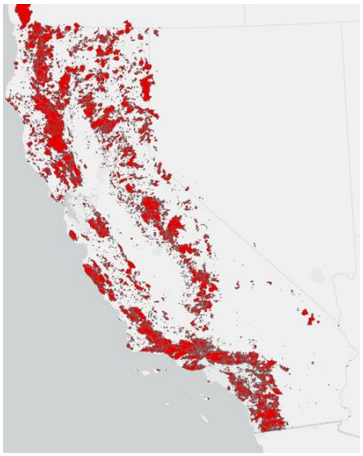
Along with scenario selection, we are seeking your view(s) on:

- **Mid-century versus end-of-century outlook.** The team is discussing how much effort is put into modeling the lattermost years of this century (2065–2100). In particular, we would suggest emphasizing long term trade-offs between low and high global emissions for the end of century scenarios. What outlook years are most important to you (e.g., 2045 for meeting clean energy goals)?
- **Extreme events.** Other than climate changes in general, how important is it to capture extreme events in your long-term models? Specifically, what types of extreme events or combinations of events are you interested in? Over what time horizons are needed and meaningful for decision making?
- **Streamlined scenarios after 2064.** The team may streamline the vegetation management and urban development scenarios after 2064. For example, maintain a low sprawl trajectory (concentrated around existing communities) for urban development footprint after 2064. For vegetation management - should we assume a vegetation treatment "maintenance mode" in terms of extent, timing and space - where fuels are maintained at a level conducive to reduced fire risk? What would be most useful to you: BAU vs. high ambition treatment rates? Low vs. high sprawl urban development?
- **Trade-offs in work effort**. Extreme events significantly influence vegetation conditions and the extent and distribution of fires. Examples of such linkages include the severe 2012-2016 drought resulting in widespread tree mortality or a combination of extreme heat and drought

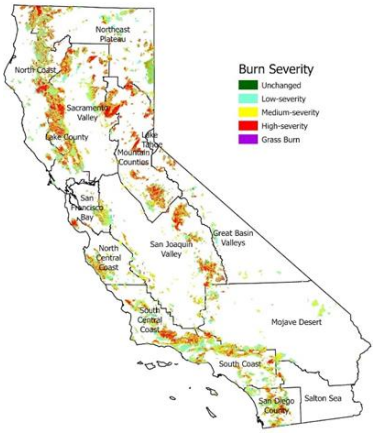
resulting in the 2020 and 2021 fire seasons. Generally, climate model outputs do not capture the frequency or magnitude of extreme events that we have recently experienced. We could consider the feasibility of using resampled climate data in lieu of an additional RCP because that approach would allow us to investigate ecosystem response and area burned in response to increasingly frequent extreme events. What should the minimum set of scenarios through the end-of-century look like? How much additional detail should we incorporate through mid-century with fully coupled fire and vegetation models? Is there a preference to generate outputs that better reflect variability in extreme events or is there a preference to stick to selected RCPs and the range of precipitation variability available in the existing climate model runs?

- **Spatial prioritization of vegetation management efforts.** We previously proposed prioritizing reducing wildfire risk through vegetation management at the wildland-urban interface (WUI) and in areas designated with high wildfire threat. Under this prioritization scheme, WUI areas with high fire threat classification would be prioritized for fuels reduction treatment first. As those acres are completed, areas beyond the WUI that are classified as high fire threat would be addressed next and so on. The graphics below show CAL FIRE's historical large wildfire burn perimeters (Panel D), our estimates of historical burn severities (Panel E), and projections (from 2014) of mid-century PM2.5 emissions (Panel F) for reference on where most vegetation management would be generally modeled.

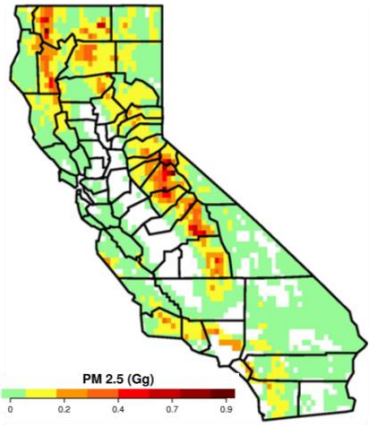
D: Cal FIRE historical large wildfire burn perimeters



E: Historical Burn Severity

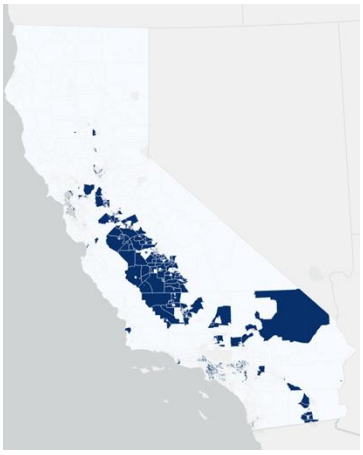


F: 2014 Projection of Mid-Century PM2.5 Emissions



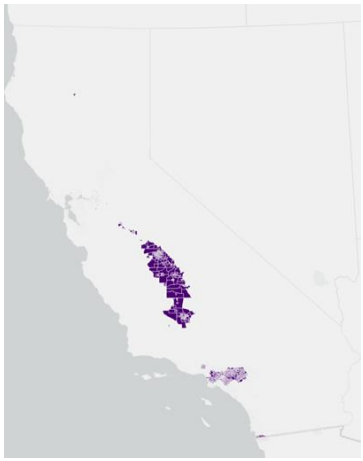
We have also been asked to include socioeconomic factors under our "high ambition" scenario of treating one million acres per year in the vegetation management prioritization scheme. The graphics below show the distribution of 1) disadvantaged communities (Panel G), 2) the top 25th percentile of communities in terms of poverty burden (Panel H), and 3) the top 25th percentile of communities in terms of PM2.5 burden (2.5; Panel I) according to CalEnviroScreen 4.0 (October 2021).

G: Disadvantaged Communities per CalEnviroScreen



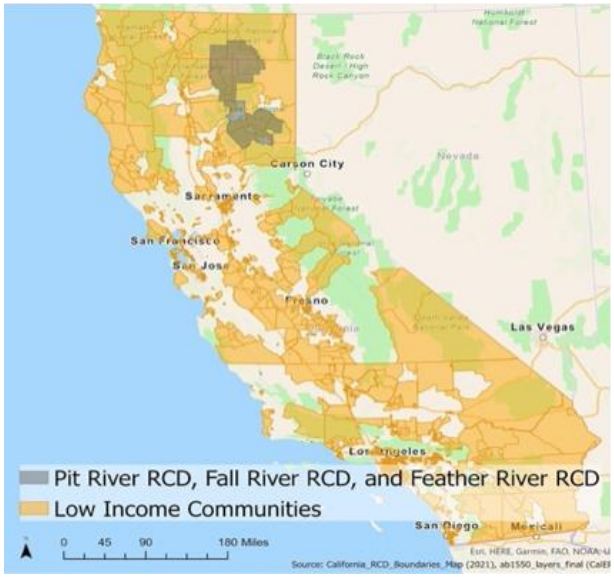
H: High Poverty Burden Communities per Housing and Community Development

I: High PM2.5 Burden Communities



The areas historically burned do not have high spatial alignment with the disadvantaged communities shown in panels G to I (predominant in California's central valley). However, additional prioritization within the WUI Interface, high wildfire threat areas, and low income communities (Panel J) may be beneficial to the extent some of the most likely or highest severity burn areas are responsible for transporting air pollutants to already burdened communities and could provide economic benefit to low-income communities within the high-fire threat context (Panel J).

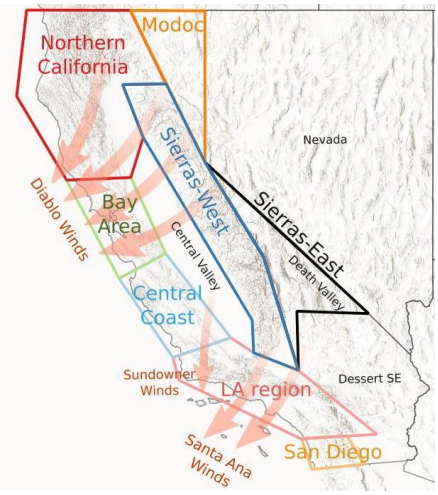
Panel J. Low-income Communities within California



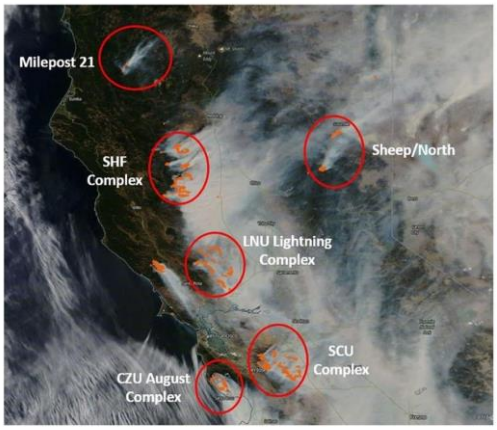
The graphic below shows two frequent extreme wind patterns in California (Panel K) and an example of 2020 historical smoke transport patterns (Panel L). Diablo and Santa Ana's extreme

wind types help illustrate the spread from distant sources of pollutants to disadvantaged communities, although we may also want to consider less extreme winds such as those in 2020.

K: Extreme Wind Patterns - Diablo and Santa Ana Wind Events



L: Sample of 2020 Smoke Transport



Credit: MISR Active Aerosol Plume-Height (AAP) Project / K.J. Noyes, R. Kahn, J. Limbacher (NASA Goddard Space Flight Center)

Do you have thoughts on how we could refine our prioritization/allocation of vegetation management efforts to better relieve disadvantaged communities or otherwise mitigate wildfire related risks to communities?

Thank you for sharing your thoughts and for providing valuable guidance to the Pyregence team. Please call or email Shane Romsos (at 530-721-7508 or sromsos@sig-gis.com) to set up a meeting to further discuss scenario options