CALIFORNIA STRATEGIC GROWTH COUNCIL

Climate Change Research Program

QUARTERLY PROGRESS REPORT

2020

QTR 2

Progress Report # 3 **For the reporting period:** April 1, 2020 **to** June 30, 2020

Grantee Institution: University of California, Irvine **Agreement #** CCR20021

Research Grant Title Innovation Center for Advancing Ecosystem Climate Solutions

Signature Line (authorized representative): _____

RESEARCH GRANT PROGRESS SUMMARY

Provide information for each task in the research grant's scope of work, noting zero if work has not been started on a specific task:

Task # or Description	Description	Percent of Work Completed for this Period	Percent of Work Completed to Date	Reimbursement Amount Charged for this Period	Reimbursement Amount Charged to Date
1.1	Collect and homogenize data layers	5%	45%	$15,000.00	$171,052.50
1.2	Test, improve, and update data layers	10%	30%	$35,000.00	$92,623.72
2.1	Prepare data analysis	10%	45%	$25,513.48	$90,403.40
2.2	Analyze historical and current data	10%	20%	$15,000.00	$44,000.00
2.3	Extend data analysis via data science and machine learning	5%	5%	$5,000.00	$5,000.00
3.1	Actively engage stakeholders	10%	25%	$30,000.00	$81,244.11
3.2	Produce decision-making tools	5%	10%	$10,000.00	$12,000.00
3.3	Communication	10%	25%	$17,000.00	$34,000.00
4.1	Develop valuation framework	10%	20%	$13,000.00	$19,000.00
4.2	Develop and implement valuation tools	0%	0%	$0	$0
4.3	Develop financing strategies	0%	0%	$0	$0

PROVIDE A SUMMARY STATEMENT DESCRIBING THE MILESTONES (INCLUDE GO/NO GO MILESTONES), ACCOMPLISHMENTS, SUCCESSES, BARRIERS, AND OBSTACLES THAT HAVE OCCURRED WITHIN THE CURRENT REPORTING PERIOD:

The CECS Project team continued to make great progress in Q2 2020. Subgroups working on Tasks 1, 2, 3, and 4 have met frequently to discuss strategy and make steps toward deliverables.

For Task 1, the Continuous Change Detection Algorithm (CCDC) has been finalized, all historical management layers have been run through it, and a process for validating this algorithm and its output via use of Collect Earth Online has been devised. An analysis of historical management has begun, and Version 1 of our "grand table" of all our model input data and desired output variables has been developed.

For Task 2, we have decided to implement a new CASA-based model to create more accurate surface fuel layers for California, which will run in our several different methods of predicting fire probability. The machine learning component of Task 2 is also spinning up, and integrating data from Task 1 into Task 2 has begun.

For Task 3, the needs assessment survey has been finalized and will be distributed to stakeholders and the general public online in July and August. Several more informal agency calls have been hosted with CARB and USFS to get feedback on our progress to date and guidance as we move forward. Several other partner organizations, such as Blue Forest Conservation, Google Earth Engine, and Spatial Informatics Group have come to be more incorporated into our project's work. Additionally, we have begun considering how our commercialization plan can best be created, and have reached out to the Larta Institute and UCI Beall Applied Innovation to learn how they can support these efforts. Furthermore, our "Beyond the Brink: California's Watersheds" film has received further acclaim and was made available to PBS stations nationwide via the National Educational Telecommunications Association starting May 16th, having been shown dozens of times throughout California, and even in locales such as Oregon and Florida. In addition, we welcomed our first Ecosystems & Climate Change Summer Internship cohort of 11 undergraduate students, who started in the last week of Q2, and who will virtually engage with the CECS for 8 weeks this summer, assisting with both the geospatial analyses and science communications portions of the project.

As part of Task 4, a perspective paper was initiated, and recruitment of postdoctoral researchers has begun.

Several papers have been published this past quarter as part of this project, and several more are in draft form and will be submitted to journals in Q3 2020.

Aside from a slight delay in our timeline in some instances due to COVID-19, and ever-changing regulations on the hiring front for the few postdoctoral researchers yet to be brought on, significant progress continues to be made.

ACHIEVING PROGRAM GOALS

1. Briefly discuss any successes the research has achieved in furthering the Climate Change Research Program's Program Goals:

   Through a collaboration between Kyle Hemes at Stanford, and Mike Goulden, Jon Wang, and Carl Norlen at UC Irvine, we have continued to build the infrastructure for a multi-decadal analysis of the impacts of fire and management on ecosystem services in California – specifically the water, carbon, and land surface temperature implications.

   At SDSU, Walter Oechel's lab used GIS layers and modeling parameters from previous quarters to estimate the effect of harvesting on carbon stock and sequestration in chaparral ecosystems. Previous and ongoing biomass sampling justified existing allometry models of chaparral via eMapR. Collected

GIS layers were used to target specific human-chaparral interfaces for additional UAV-based sampling and possible treatment.

At UC Davis, Bin Chen's work on fire ignition has provided insights on ways to reduce fire risk via land use planning and fire management, and contributes to more realistic fire behavior simulations. The prediction of future ignition risks will also benefit the communities' adaptation strategies. Yuhan Huang's finding about the impacts of fuels, climate, and topography on fire severity, and prediction of higher probability of severe burns during drier periods, is expected to help the prioritization of the community fire mitigation activities under future climate change. And Marga Huesca's study demonstrated the potential of the capability of the imaging hyperspectral data in detecting dead trees and providing early warning signatures of tree mortality in California, critical for information for rapid response by local communities and land managers.

In addition, a multi-benefit literature review of forest restoration has begun as a joint effort amongst project researchers at UC Merced, Stanford, and project partner, Blue Forest Conservation.

2. Describe any successes made in advancing the objectives of the applicable research focus area (i.e., carbon dioxide removal, methane reduction, or heating, cooling, and thermal storage):

Additional progress has been made by Stanford's Chris Field and Kyle Hemes, as well as UC Irvine's Jon Wang and Carl Norlen in working towards understanding the carbon implications of wildfire and forest management across California. This will help us understand the importance of fire fuels management in avoiding catastrophic wildfires and keeping carbon stored in California's forests. It will also help quantify in what ways the state can expect to count on forests and working lands as a long-term carbon sink.

At SDSU, Walter Oechel's lab has examined carbon flux measurements of microsite soil respiration, species-specific primary productivity, and net ecosystem exchange to continually improve our understanding of chaparral carbon flux under changing climatic conditions. Work completed in this quarter begins to utilize mechanistic and machine learning models of carbon flux. This modeling provides the basis for distinguishing the effects of fuel-load treatment in chaparral from those in forest systems. This quarter's expansion of modeling and the tie-ins to remote sensing databases have improved our understanding of how the management of chaparral systems must differ from alpine forests, particularly under changing climate.

At UC Davis, Bin Chen's work on fire ignition advanced our understanding on the spatial and temporal patterns of ignitions caused by human activities and lightning and the associated drivers for the whole state of California. Yuhan Huang's work improved our understanding of the effects of multiple environmental factors on fire behaviors, especially tree mortality-related variables. The findings can be linked with the impact of forest management practices on tree resilience or vulnerability to drought and subsequent fire risks. Marga Huesca's work identified the most important remote sensing metrics on identifying tree die-off. It will provide complementary tools and products to ADS surveys and Landsat-based monitoring, to track forest condition and mortality, inform rapid response to forest stress, and ultimately develop adaptive forest management practices to improve the resilience and sustainability of California's natural ecosystems.

3. Summarize efforts taken during this report period to conduct Meaningful Engagement:

Meaningful engagement is a key piece of our project, and we continued to engage with project partners, State agencies, and other stakeholder groups in Q2. All of the engagement efforts listed below were completed entirely virtually, unless otherwise noted, to preserve the health of all parties involved.

We continued outreach to California State Agencies this quarter, focusing our attention primarily on the California Air Resources Board. More than 20 project team members spoke with Alan Talhelm, Grey Mayeur, Alex Yiu, and Shelby Livingston in the Offsets group, and Adam Moreno, Anny Huang, Klaus Scott, and Megan Miranda in the Emission Inventory group on two separate calls. The goal of both calls was to learn about each of these groups' needs and science bottlenecks, as well as familiarize them with the CECS Project's work and start forming a collaborative relationship. Since these calls, in early April and early May, respectively, we have had concrete follow up with Adam Moreno and Klaus Scott to share data layers. We'll continue to engage CARB and share our refined historical management layers and our Beta decision support products with them once available. They have indicated that these will be very helpful in contributing to their Scoping Plan update.

We have also continued to work with the USFS Pacific Southwest Research Station, involving postdoc Nicholas Povak, in addition to Pat Manley, and Joseph Wagenbrenner. They will be a key stakeholder group who we will further engage later this year by sharing refined data products and Beta decision support tools.

We additionally continued discussions with Loretta Moreno at California Natural Resources Agency, who joined several of our "Group 1" biweekly calls. Loretta will be referencing the CECS Project in a new RFP scheduled to be released sometime late summer 2020, and our team will work in close collaboration with whomever is awarded the project.

We continued our quarterly calls with Salo, Spatial Informatics Group (SIG), and the UCLA Cal Eco Futures project. This fire science-focused collaborative was formed to chare updates and data products, as well as to find synergies in our work. From this call we realized the potential for a mutually-beneficial closer relationship with SIG, and had a follow-up call with them to discuss daily fire progression and fire probability modeling. We will continue to engage with SIG to share ideas and data. Calls with all three projects will continue on a quarterly basis.

Another organization that has come to be a key partner is Blue Forest Conservation. We have engaged with Blue Forest primarily on Task 4 thus far, and they are contributing to a perspectives paper on ecosystem services and valuation. Blue Forest is a nonprofit focused on funding forest restoration projects, and their projected project benefits will be greatly served by our decision support tools and the science behind them. We are in active discussion with Blue Forest on how our efforts can be complementary. We will have monthly calls with Blue Forest going forward and will work to cross-promote each other's efforts when appropriate.

Additionally, we started to heavily rely on Google Earth Engine for running analyses and storing data layers this quarter, so we started to coordinate directly with Google Earth Engine via Nicholas Clinton. Nicholas provided our team with troubleshooting advice and additional data storage capacity. We shared the project's goals and objectives and discussed potentially hosting our refined management data layers on Google Earth Engine for public access.

Kyle Hemes presented recent work to the Land Use Change lab at UC Berkeley, guest-lectured in the course "Advanced Topics in Remote Sensing" at UC San Diego's Global Policy and Strategy School, and presented recent work at the Stanford Field Lab. Additionally, Kyle, Mike Goulden, and Jon Wang proposed and were accepted for an American Geophysical Union Fall Meeting session entitled: "Immense Pressures and High Expectations: Managing Forest Ecosystems for Multiple Benefits in the Anthropocene". This session will focus on the themes of the project, and bring many scientists working on similar topics together. Several other CECS project team members plan to submit abstracts to this session.

The Oechel lab at SSDU met with NOAA administration and CESSRST stakeholders at the 4th Annual CESSRST Meeting, presenting current carbon flux research and chaparral work conducted by graduate students at SDSU, who are also part of the CECS project. Additionally, the Oechel lab had two cooperative field-sessions with NEOS LTD to take high-resolution UAV-based measurements of human-chaparral interfaces. They met with the Climate Science Alliance to compare chaparral biomass models, and met with Preserve Calavera, a small San Diego-based nonprofit, to help track issues with gold-spotted oak borers (*Agrilus auroguttatus*) while collecting UAV data for carbon flux. The Oechel group also met with the California Chaparral Institute, an environmental nonprofit and advocacy group, to plan educational cooperation and hear their input on current chaparral fire-treatments. And lastly, they assisted with a Girl Scout Gold Award by teaching 1st-12th grade students about climate science and CECS project work across three weeks.

Roger Bales continued meetings and coordination with the Tahoe Central Sierra Initiative (TCSI) team around data needs to advance forest restoration projects and contributed to TCSI Current Conditions report. Meanwhile, Safeeq Khan continued meetings with Tulare Basin Watershed Partnership Network and had a successful network launch on June 26, 2020 with over 35 stakeholders/ participants providing feedback on the network charter

Meanwhile, Roger Bales and Martha Conklin continued working with the Chronicles Group to distribute the film “Beyond the Brink: California’s Watershed” to PBS stations statewide and nationwide. As of June 30, nearly all of California’s stations have shown this 27-minute film, with most having multiple screenings. Stations in Oregon and Florida have also shown it, or plan to. Production has begun on the follow-on film, which will be more focused on solutions to forest management.

Additionally, we have begun considering how our commercialization plan can best be created, and have reached out to Bandhana Katoch at the Larta Institute and Sophia Lin at UCI Beall Applied Innovation to learn how these organizations may support these efforts. We have determined that the UCI I-Corps program may be a beneficial avenue for determining our potential customer base and market reach, and will follow up with them later in 2020 to discuss participating in their next I-Corps cycle. We may follow up with the Larta Institute for ad-hoc services.

Lastly, Jaquelyn Lugg was hired on as our Stakeholder Engagement Coordinator at UC Merced in mid-June and will be the key team member planning and facilitating much of our stakeholder outreach going forward, helping us to greatly expand our outreach efforts in the second half of 2020.

CURRENT STATUS OF THE RESEARCH

4. Summarize the efforts taken during this report period to accomplish the task objectives for each project in the grant:

For Tasks 1.1 and 1.2, Jon Wang finalized the refined management polygons, including data from an updated run of the Continuous Change Detection and Classification (CCDC) algorithm that was refined based on the previous results. The polygons represent the combination of satellite remote sensing and agency databases for understanding the location and timing of forest management actions. Jon worked with UC Berkeley PhD candidate, Clarke Knight, towards a protocol for validating these polygons using Collect Earth Online, including both expert assessment of high-resolution imagery and the development of hand-drawn polygons that will act as the basis for assessing the accuracy of these management polygons.

For Tasks 1.2 and 2.1 Kyle Hemes, Carl Norlen, and Jon Wang have been involved in collecting and homogenizing existing data layers, developing Google Earth Engine workflow, and preparing structure to produce Version 2 carbon and water results in our "grand table" for FRAP fires back to 1950. The current version produces temporal data for each FRAP polygon. For Task 2.2, initial analyses of multi-decadal fire impacts are being explored using the whole library of FRAP fires.

As part of Tasks 1.2 and 2.1, UC Berkeley PhD candidate Clarke Knight has been involved in analyzing California's historical management layers, developing a workflow to validate those management layers using Collect Earth Online, and providing a training dataset of management polygons. She has met with interested stakeholders at CARB (Adam Moreno, Klaus Scott, and Anny Huang) and USFS (Nicholas Povak) to discuss these findings and their implications.

Clarke cleaned and merged four main datasets concerning California's management, including: Facts' timber harvests and hazardous fuel reduction, as well as Cal-Fire's timber harvest plans and non-industrial timber management plans. These datasets comprise of 286,000 management events ranked qualitatively by intensity and span the twentieth century to the present day. Clarke's efforts to describe the type and frequency of treatments is ongoing, but has preliminary findings, described in section #6 of this report.

As part of tasks 1.2-2.3, SDSU finished collecting modeling parameters to estimate the effect of biomass harvesting on old-growth chaparral. They have collected a full year of primary productivity data for the dominant shrub species, measured soil respiration responses through the rainy season, collected high-resolution multispectral data of human-chaparral interfaces, and continued measuring eddy covariance data at Sky Oaks. Together, these measurements create a holistic view of carbon flux in chaparral across a fire-induced age gradient. They have begun relating these measurements to the ACASA mechanistic model and a recurrent-neural-network. They have also worked to verify state-wide GIS layers in chaparral to improve overall estimations of biomass and carbon sequestration.

As part of Tasks 2.1-2.3, Bin Chen at UC Davis has been working on wildfire ignition models for the purpose of understanding the drivers for the spatial and temporal variation in human- and lightning caused ignitions. He is also collaborating with Stijn Hantson at UC Irvine to incorporate this into fire behavior simulations. Yuhan Huang is in the process of expanding fire severity modeling and prediction from Northern Coastal mountains to the Sierra Nevada range. He also started to investigate how die-off affects fire progression and other fire behavior metrics in the Sierra Nevada through a machine learning approach using multi-source remote sensing and environmental data. Marga Huesca has been refining and testing a generalized model to detect and explain tree mortality along the Sierra Nevada, using imaging spectroscopy, climatic and topographic data, and applied the approach to larger areas of the Sierra Nevada. Marga is further quantifying the role of each metric in detecting tree mortality and exploring their capability of providing early warning signatures. A manuscript is in the process of refinement before submission.

As part of Task 2.2, UC Irvine PhD candidate Shane Coffield, with support of Kyle Hemes, UC Irvine Project Specialist Mahnoor Khan, and intern Cassandra Vo, has begun a systematic analysis of carbon and disturbance trends in California forest carbon offset project locations. They are comparing several geospatial data layers to on-the-ground inventories in these projects in order to identify vulnerabilities and larger patterns of biomass change. This work will help quantify the effectiveness of the State's carbon offsets program and of different monitoring tools. A publication on this topic is expected by year's end.

For Task 2.3 Kyle, Jon, and Carl worked with Mike Goulden, UC Irvine graduate student Ved Bhoot, UC Berkeley graduate student Greta Miller, and UC Irvine Project Specialist Mahnoor Kahn to begin

collaboration with the fire and machine learning subgroup. Discussions began about how to use the grand table outputs to predict the effects of recent and future fires as well as recent and proposed management actions, while integrating the CASA model. Also as part of Task 2.3, UC Irvine Computer Science graduate student, Casey Graff, along with Shane Coffield, and professor Padhraic Smyth, are in the process of tuning and evaluating their machine learning-based fire spread model's performance. They will systematically compare their model to other existing process-based fire spread models like FARSITE for large fires in California.

For Task 3.1 Safeeq Khan, Tapan Pathak, Toby O'Geen, and Roger Bales pilot tested Max Eriksson's needs assessment survey, relying on a sample of students and the CECS research team. They and Max then finalized the survey. They additionally continued compiling the stakeholder lists for distributing the need assessment survey, reached out to approximately 40 representatives of stakeholder groups, and initiated survey distribution. Surveys will be open for 3 weeks for each organization. This same group of Khan, Pathak, O'Geen, Bales, and Eriksson continued design of stakeholder workshops and COVID-19 adaptation (planning for workshops to be hosted virtually), and initiated contacts with potential workshop participants.

For Task 3.2 programmer Mike Walkinshaw and UC Davis professor Toby O'Geen put heightened effort into planning for and developing the decision support tools. Currently they envision a pallet of tools accessible from one main webpage. This decision was made based on virtual listening sessions we organized with various stakeholders. The four classes of tools we anticipate are as follows:
1. Data download tool that clearly displays all available spatial information for users to access.
2. Data/map visualization tool functioning as an interactive map that allows users to visualize geospatial trends of key attributes that define the physiographic state of the project area.
3. Decision support tool which is also an interactive map, but with functionality to deliver an assessment of change after disturbance/forest management practice for fire risk, above ground carbon, drought resilience, and evapotranspiration (as a proxy for water yield).
4. If time and resources allow, a site-specific ecosystem valuation tool with similar functionality as #3 above, but which allows for valuation of outcomes and likely site-based functionality.

During this quarter we developed two beta versions of apps: 1. A fire progression app which allows users to choose a major fire and visualize the daily progression of aerial extent of each fire over time; and, 2. A data download tool, which has the functionality to allow users to choose data layers, clip these layers to a watershed area, and download the data. The planning and evolution of this suite of tools will evolve as we learn more about user needs through the stakeholder survey, and workshops.

As part of Task 3.3, Roger Bales and Martha Conklin continued working with Chronicles Group, which initiated filming for follow-on film to California's Watershed, which will be more solutions-oriented.

We initiated a science communication internship for five students in the last week of Q2, which will run for 8 weeks. All of these student interns come from underrepresented groups relative to STEM fields. Each student is identifying a science topic to lead, including: 1. The effects of wildfire or California's ethnically diverse communities; 2. Management options to promote climate resilient forests; 3. Effects of forest management on above ground carbon sequestration; 4. Climate change, drought and forest die-off; 5. Effect of forest management on river water quality and water yield. Student interns are being trained to deliver scientific information in a variety of ways including: a message box that organizes key ideas for an elevator speech, an infographic that visually synthesizes the issues of their topics, a written policy brief, and "something new" which will be an innovative communication style that relates to their generation. The internship is organized in a way where students work individually to develop content but as a team to provide feedback on each other's

products. They receive weekly feedback from Dr. O'Geen and Jaq Lugg and then incorporate all feedback into refined products. Six other student interns have just begun working with the research teams across UC Irvine, Merced, Davis, and SDSU to further graduate student and postdoctoral research on this project in the realm of tree mortality, carbon fluxes, and carbon offsets, amongst others, and will contribute something new to the analyses.

Lastly, as part of Task 4.1, Roger Bales, Martha Conklin, Catherine Keske, and Kyle Hemes initiated bi-weekly partner meetings with Blue Forest Conservation & related INFEWS project team around valuation of ecosystem services, to prepare a framework paper. In addition, and in support of Tasks 4.2 and 4.3, Roger and Martha also visited the North Yuba site with Blue Forest to assess methods for valuing ecosystem services, expanding financing partnerships, and critical data needs for forest restoration projects.

5. Summarize by task any deliverable or outcome completed during the current reporting period:

Per Task 1, Kyle Hemes, Jon Wong, Clarke Knight, and Carl Norlen have been actively involved in collecting and homogenizing existing data layers via Google Earth Engine, developing a workflow, and preparing the structure to produce Version 1 carbon and water results. The Version 1 product should be complete in early Q3 2020.

At SDSU, three eddy covariance towers continued to collect landscape carbon flux data at Sky Oaks Ecological Reserve. As part of Tasks 1.2-2.2, carbon flux measurements were partitioned into gross primary production and ecosystem respiration to determine the influx and release of carbon from three chaparral ecosystems. Photosynthetic parameters for three dominant species at Sky Oaks Ecological Reserve were measured across spring and summer seasons. We began parameterizing the Advanced Canopy–Atmosphere–Soil Algorithm (ACASA) model. Two human-chaparral interfaces were surveyed with a multispectral UAV/drone. Long-term soil chambers were installed, measuring hourly soil respiration under three microsites created by inter-canopy bare soil space, and under redshank and chamise canopies. Soil temperature and soil moisture sensors were installed next to each long-term chamber and soil sensors were connected to a data logger to collect continuously half-hourly data. Soil cores were extracted in June 2020 to obtain the soil organic content and fine root biomass. Over 100 soil samples were analyzed to obtain organic content and fine root biomass. These will contribute to our on-ground validation of data layers and analyses.

At UC Davis, Bin Chen has developed models for monthly ignitions in the whole state, and produced an updated version (V2.0) of monthly ignition product at 8km in California from 1992 to 2015, for human- and lightning caused ignitions, respectively. This product will be a crucial component for fire risk analyses conducted under Task 2.2.

For Task 3, the stakeholder needs assessment survey is ready for distribution, and the first few survey links have been distributed. Survey distribution will continue over the next 2 months and be completed in Q3, when analyses of the responses will also occur. The survey responses will assist in better attuning the decision support tools and available data layers to stakeholder needs.

6. If applicable, what short-term value, interim findings or success stories can you produce as a result of your work?

At Stanford, Kyle Hemes is developing the ability to test successional theory on post-wildfire disturbed fires, with an unprecedented sample size, and a data-rich spatial control to determine the net impact of fire on regeneration. This both utilizes and contributes to our "grand table" data and analyses.

Meanwhile, in parallel to running the CCDC algorithm on historical management layers for all of California, Jon Wang developed a dataset of point locations that have experienced a land change (based on CCDC outputs) and that overlap with the vector-based datasets. This sample of approximately 125,000 points was used to train a machine learning classifier that uses the Landsat spectral information, in combination with land cover and elevation data, to predict the type of land disturbance with an overall accuracy of about 82%, and which will only improve with refinement. These disturbance types mapped include high and low intensity harvests, high and low intensity fires, drought/insect-induced die-off, post-disturbance regrowth, and urbanization/ infrastructure development. This classifier will be used to map across California to see the occurrence of various disturbance types through space and time. Next steps include developing code to scale up the outputs of this machine learning classifier and to analyze trends and interactions between these disturbance types.

Additionally, regarding historical management layers, Clarke Knight compared treatment intensity on public and private land and found that more "high" intensity management events have occurred on private land (Fig.1). Clarke also found changes in the types of treatments over time: for example, an increase in uneven-aged management compared to even-aged management at Cal-Fire (Fig. 2).

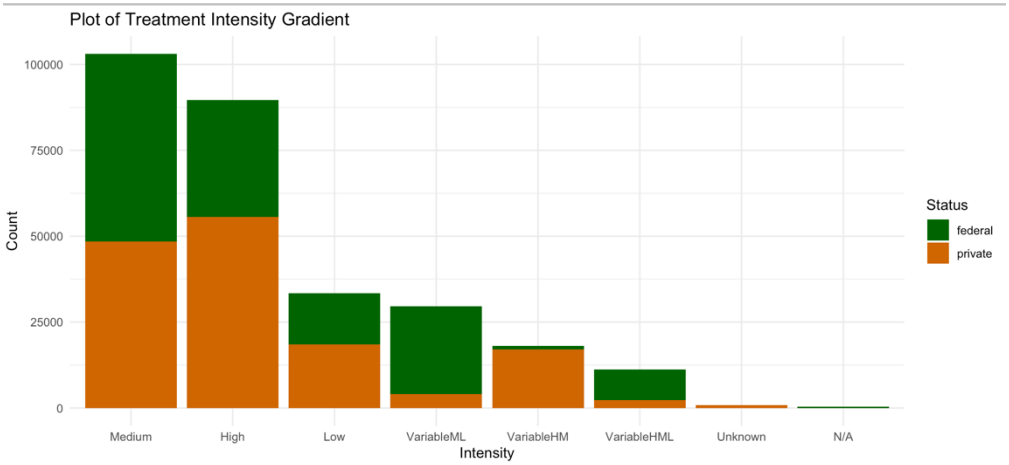

Figure 1. Treatment intensity and number of events recorded on federal (green) or private (orange) land.

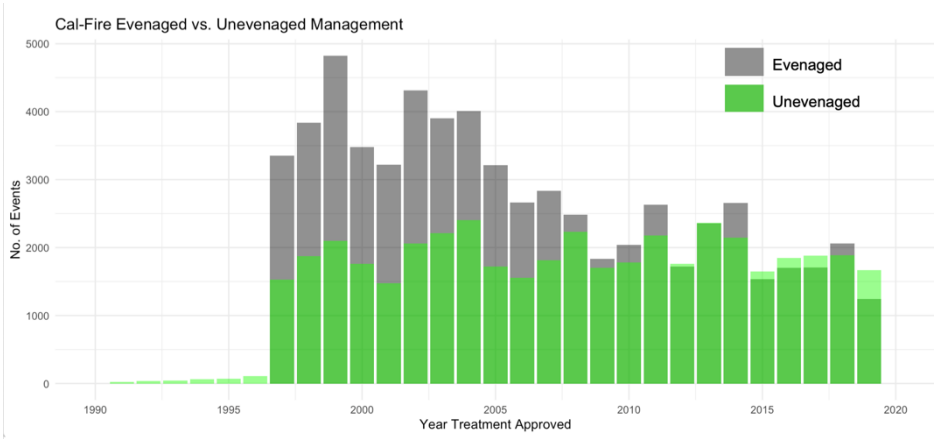

Figure 2. Even-aged (grey) and uneven-aged (green) treatment events across time on private land.

Clarke has worked closely with software engineers at Collect Earth Online (CEO), particularly Billy Ashmall, to ensure we are able to use the platform to answer our research questions. For example,

CEO added yearly NAIP imagery imbedded as a base map after we explained the need for it in our project. She developed a workflow on CEO to validate the management polygons derived from the Jon Wang's CCDC algorithm. In that workflow on CEO, analysts compare algorithm polygons to state/federal polygons and answer a series of questions to gauge the degree and direction of matching between the datasets.

Additional findings and upcoming papers include:

Shane Coffield is about a month away from submitting a manuscript on the climate-driven vulnerabilities to wildland carbon storage in California. This work combines a variety of statistical approaches and climate scenarios to make projections of future carbon stocks, its spatial variability, and quantify various sources of uncertainty. Shane has found that warming temperatures and changing precipitation patterns will likely drive ~15% decreases in total aboveground live biomass, with temperature driving most of the loss and precipitation introducing a large amount of uncertainty. Coastal regions and low-mid elevation forests are projected to be most impacted by climate change. This work will provide important insight into the climate-driven baselines for carbon storage over this century, and highlights areas of vulnerability where targeted management could have the largest impact on facilitating carbon storage.

Carl Norlen is preparing an abstract on how wildfire disturbance history impacts vulnerability to forest die-off, to be submitted to the AGU Fall Meeting 2020. He has also completed several drafts of a manuscript to understand the impact of multiple drought on forest health and drought resistance that uses many Project datasets. The findings should provide useful information for managers on how drought disturbance will impact future resistance to drought. This manuscript should be submitted in Q3 2020.

In Q2 2020 we had a few published and pending publications, which are listed below:

1. Roger Bales published a framework paper for assessing drought stress & water benefits of forest disturbance entitled "Evapotranspiration Mapping for Forest Management in California's Sierra Nevada" in the journal *Frontiers in Forests & Global Change*. The paper can be accessed here: https://doi.org/10.3389/ffgc.2020.00069.

2. Yuhan Huang's manuscript on fire behavior, 'Intensified burn severity in California's northern coastal mountains by drier climatic condition', has been accepted by *Environmental Research Letters (*https://iopscience.iop.org/article/10.1088/1748-9326/aba6af). The fire severity models are available for Northern California's coastal mountains.

3. Bin Chen's manuscript entitled "Climate, fuel, and land use controls on the spatial pattern of wildfire in California's Sierra Nevada" to *Journal of Geophysical Research: Biogeosciences* has been revised based on the reviewers' comments and is currently under review.

4. Efi Foufoula-Georgiou, Jim Randerson, Padhraic Smyth, and Shane Coffield have a publication under review: "Forecasting global fire emissions on sub-seasonal to seasonal (S2S) timescales", in the *Journal of Advances in Modeling Earth Systems (JAMES)*.

Additional success was had in strengthening partnerships with CARB, USFS, and CNRA, as well as with Blue Forest, SIG, and Google Earth Engine, mutually beneficial relationships which we will continue to foster in the coming months.

A final major success in Q2 was the hiring of 11 summer undergraduate interns from diverse backgrounds, hailing from locales across California. The interns have started to engage with the

Center for Ecosystem Climate team virtually to maintain the health of all parties involved, and will continue working in a fully virtual environment throughout the internship. A successful virtual kickoff meeting was hosted on June 22, and included introduction to the Project, meetings with individual PI supervisors and graduate student and postdoctoral researcher mentors, as well as a teambuilding session. Over the course of the 8-week internship we will host weekly trainings in both hard and soft skills to further add to the intern experience.

7. Describe any challenges and/or opportunities encountered when accomplishing this portion of the Scope of Work:

The COVID-19 pandemic was the largest challenge to our project in Q2, primarily in terms of delaying hiring. Postdoc recruitment for the ecosystem valuation piece (Task 4) and decision support tool (Task 3) slowed owing to uncertainty over hiring international candidates. We did, however, interview and select three candidates. We are awaiting approval of their visas and plan for them to start between August and September 2020.

We did, however, have success in hiring a Stakeholder Engagement Coordinator, Jaquelyn Lugg, who will play a critical role in our communications and outreach going forward.

8. Is the research grant on budget and on schedule (Please refer to the Work Plan/Schedule for Implementation)? Please indicate here if a go/no-go milestone was reached this quarter, if it is behind schedule, and/or will not be met, and provide explanation. If other items are off budget and/or behind schedule, what issues need to be addressed and what steps are being taken to ensure that the grant is completed on time and on budget?

This delay in hiring three postdoctoral researchers due to visa-related issues will require some compressed effort, given the original schedule for two years of work for each. We will fill the gap by assigning additional personnel in Year 3.

There are logistical challenges, due to COVID-19 restrictions, for organizing focused group workshops related to the stakeholder needs assessment. We are working on an alternate online plan and it may require more staff time than what we originally planned. These changes will be reflected in a budget amendment request, which will be submitted in Q3.

ADMINISTRATIVE/FISCAL OVERVIEW

9. Provide a brief narrative explaining the grant's financial expenditures and budgeted amounts for this period that includes cash and/or in-kind items.

UC Irvine spent $34,850.62 in Q2, mainly on salaries and benefits for the Project Coordinator, Project Specialist and graduate student assistance, in addition to administrative overhead.

UC Merced spent $55,250.12 in Q2, primarily on Project Scientist and PI salary, associated benefits, and overhead.

UC Davis spent $57,042.83 in Q2, primarily on a Postdoctoral Researcher, Programmer, and PI salary, benefits, and overhead.

San Diego State University spent $4,062.43 in Q2 on research tech and summer intern.

Stanford spent $14,307.48 was spent for PI effort and Postdoctoral Research salary, administration, and overhead. This spending is on track with what was originally budgeted.

UC Berkeley did not invoice for their work in Q2. A larger invoice from them is expected in Q3.

Total project spending amounts to $165,513.48 for Q2 2020, and $549,323.73 in total.

10. Do you anticipate major modifications to the grant's budget or work plan in the next quarter?

A budget amendment request will be submitted with the Q3 2020 quarterly report to reflect changes in personnel allotment across several of the universities involved.

ADDITIONAL COMMENTS

We appreciate the continued support of the SGC and all of our partners during this trying time. Our project is moving forward as best as we can given the circumstances, and we have even seen an increase in engagement in Q2, as people find their work on this project continually meaningful and engaging.