CALIFORNIA STRATEGIC GROWTH COUNCIL

Climate Change Research Program

QUARTERLY PROGRESS REPORT

2020

QTR 3

Progress Report # 4 **For the reporting period:** July 1, 2020 **to** September 30, 2020

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

Research Grant Title Innovation Center for Advancing Ecosystem Climate Solutions

Signature Line (authorized representative): Shelley E. Scallan

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	15%	60%	$67,733.73	$238,786.23
1.2	Test, improve, and update data layers	10%	40%	$53,000.00	$145,623.72
2.1	Prepare data analysis	5%	50%	$25,000.00	$115,403.40
2.2	Analyze historical and current data	5%	25%	$20,000.00	$64,000.00
2.3	Extend data analysis via data science and machine learning	5%	10%	$6,000.00	$11,000.00
3.1	Actively engage stakeholders	10%	35%	$65,000.00	$146,244.11
3.2	Produce decision-making tools	5%	15%	$12,000.00	$24,000.00
3.3	Communication	10%	35%	$32,000.00	$66,000.00
4.1	Develop valuation framework	15%	35%	$30,000.00	$49,000.00
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 Q3 2020. Subgroups working on Tasks 1, 2, 3, and 4 have met frequently to discuss strategy and make steps toward deliverables. Additionally, a 2-day Annual Meeting, hosted virtually in mid-August, helped to get all CECS team members realigned on project goals and deliverables.

For Task 1, we refined the CCDC machine learning algorithm so that it incorporates a metric of disturbance severity that is associated with each disturbance event. The model has been refined and applied across the whole state, and we are now in the process of validating it and analyzing the trends and interactions between disturbances across the ecoregions of California. Additionally, we continued to build initial versions of the Gross Primary Production (GPP) geospatial dataset, as well as input carbon and water monthly layers for the new CASA-based model.

For Task 2, we have continued work on developing a new CASA-based model to create more accurate surface fuel layers, and have started to build out the computing structure to run the model for all of California. We have also analyzed the spatial pattern of wildfire ignitions, as well as how rate of fire spread can be affected by pre-fire dieoff. We started to incorporate on-ground validation in chaparral ecosystems as well.

For Task 3, the needs assessment survey was distributed and we received over 1,200 responses, and engaged more than 30 partner organizations in the process. Additionally, our first stakeholder workshops were planned, and the structure has been finalized and tested. Several more calls have been hosted with CNRA and Blue Forest Conservation on feedback on our progress to date and guidance as we move forward. Other partner organizations, such as Spatial Informatics Group and the Nature Conservancy, have come to be more incorporated into our project's work as well. In addition, we hosted our first Ecosystems & Climate Change Summer Internship cohort of 11 undergraduate students who contributed greatly to both the geospatial analyses and science communications portions of the project. They produced innovative communication pieces and added to our team's scientific findings, and had a chance to engage with numerous researchers, project staff, and project partners in the process. This internship program was one of our largest successes of Q3.

As part of Task 4, a perspective paper was nearly completed. Additionally, two new postdoctoral researchers joined our team and have already begun to dive into their research.

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 Q4 2020. There will be over ten American Geophysical Union conference talks and poster presentations based on this project's research, primarily research done in Q3 2020.

Aside from a slight delay in our timeline in some instances due to COVID-19, 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:

   Postdoctoral researcher Kyle Hemes at Stanford, and PhD candidate Carl Norlen at UC Irvine have improved the Google Earth Engine layers for a decadal analysis of the impacts of fire and management on ecosystem services in California, specifically the water, carbon, and land surface temperature implications. Postdoctoral researcher Jon Wang at UC Irvine and PhD candidate Clarke Knight at UC

Berkeley have continued to build out the underlying historical management layers and further refined the Continuous Change Detection (CCDC) algorithm.

At UCD, postdoctoral researcher, Bin Chen, used the maximum entropy model (MaxEnt) driven by both biophysical and anthropogenic variables to predict the spatial distribution of wildfire ignitions in statewide California at 1-km spatial resolution. He also generated the decadal changes of ignition probability from 2000 to 2010 (two base maps), which are distinguished by human- and lightning-caused ignitions. These derived maps and resulting variable importance analysis have implications for understanding the shifts and controls on contemporary wildfire ignition distribution and collective fire management.

A graduate student researcher at UC Davis, Yuhan Huang, analyzed effects of tree mortality on fire progression. He found a strong impact of elevation, wind, fuel continuity, and tree mortality percentage for each line segment along the fire line. He also worked on developing a model for tree mortality detection from high resolution remote sensing data at 1-meter spatial resolution.

In addition, a multi-benefit literature review of forest restoration has almost been completed, through joint effort from project researchers at UC Merced and 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.

Additionally, Bin Chen's work at UC Davis elucidates the spatial patterns of wildfire ignitions and highlights which factors are shaping wildfires in California. It has implications for understanding the controls on wildfire ignition distribution and possibly also targeting forest. His research also provides region-specific guidance for forest management in the state. Given the severity of the 2020 wildfires, this timely investigation could limit risk in future years in California.

Yuhan Huang's work promotes the understanding of wildfire behaviors in California. Considering the massive tree death after the extended warm drought in Sierra Nevada, together with the increasing number of destructive wildfire events. His research on tree mortality mapping will also provide an approach for dynamic monitoring of the forest health and could provide guidance for spatial changes of landscapes and potential carbon cycle in forest ecosystems.

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

Despite challenges to outreach and engagement during the COVID-19 pandemic, we have continued to build new connections and strengthen previously-established partnerships. All of the engagement efforts listed below were completed entirely virtually, unless otherwise noted, to preserve the health of all parties involved.

Roger Bales participated in a July 6 listening and briefing with California Forest Watershed Alliance members. Roger, along with Safeeq Khan and Martha Conklin, led a French Meadows partners

science briefing in August, which was followed up with a site visit and partners meeting in late September. Roger additionally participated in the Tahoe Central Sierra Initiative (TCSI) public briefing on September 1, contributing to their project planning, which included explaining the potential uses of CECS decision support tools currently in development.

During this quarter, UC Merced Stakeholder Engagement Specialist Jaquelyn Lugg met with the following 8 groups with the purpose of distributing the stakeholder needs assessment survey and building connections for future meetings: Tulare Basin Wildlife Partners, Olam Spices, USDA Natural Resource Conservation Service, Central Valley Partnership, Blue Forest Conservation, California Natural Resources Agency, CalMAIN Platform Working Group, Governor's Forest Management Task Force, Sierra and Eastside Regional Prioritization Group. The needs assessment survey was completed by 1,200 responses across a sample of agency representatives, public and private landowners, nonprofit organizations, and the general public, amongst others.

San Diego State University (SDSU) Professor Walter Oechel, along with graduate student Kyle Lunneberg and lab, met with the Center for Lands Management to cooperate on a multispectral-drone-based vegetation classification model using their historic transect data. Drone data was provided to them free of charge and assisted in their vegetation health monitoring program. They additionally met with members of the Los Coyotes Band of Cahuilla and Cupeño Indians to hear their input on our current research efforts and to offer drone surveys of the reserve. To further cooperative efforts, they also met with the director of the South West Climate Adaptation Science Center to look for crossover with existing fire-related modeling efforts, and met with members of University of California Riverside to look for cooperative measurements of overland, lateral carbon flows.

Kyle Hemes, Jon Wang, and Carl Norlen have been in touch with CNRA Environmental Scientist Loretta Moreno through multiple calls to liaise about how the CECS project's analysis aligns with the AB 1492 Legislative Report. Kyle and Jon have also been organizing an AGU session they will be chairing on project-related themes.

Several Executive Committee members met with Vibrant Planet and associates about an ecosystem management platform idea. They walked us through the UX, and their plans for the different packages geared toward specific stakeholders, and noted that they would like us to collaborate on the ecosystem valuation piece, would like Roger's thoughts on the water layers, and would like to feed CECS data into this. We will be having a follow up call in 1-2 months.

We have had calls with Blue Forest Conservation at least monthly to discuss various topics of mutual interest. In one call, Blue Forest's CEO, Zach Knight spoke more to their investment strategy, as well as to the need for ecosystem valuation tools. A follow-up call was had with Communication Specialist Jessica Alvarez and Jaquelyn Lugg about communication strategy and how CECS and Blue Forest can best collaborate to share and expand the reach of each other's work. On another call 28 CECS team members joined to learn about Blue Forest's goals, the FRB, and Yuba Project. Blue Forest also let us know about some of their main bottlenecks, their beneficiaries, and their next steps. On another call, Blue Forest intern, Micah Elias, talked about his work on carbon offset markets, elucidating a few key points for one of our graduate student researchers, Shane Coffield, who is focusing on this topic. On a large science-focused call, about 10 members of the CECS team dove deep into the details of the research with the Blue Forest science team.

Several Executive Committee members met with Kristen Wilson, Dan Porter, Angel Hershlet, Michelle Passero, David Edelson, and Ed Smith of The Nature Conservancy for an introductory call to show them the overview of our project and learn more about their current work in TCSI and with nature-based

climate strategies. They offered to help us identify areas of more ecological management/ what we'd hopefully like to see on the landscape for analyses. Kristen and Dan will speak with the full CECS group in October.

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 share updates and data products, as well as to find synergies in our work. On this quarter's call we also involved Loretta Moreno from CNRA and Caroline Thomas Jacobs, Christopher Meyer, and Melissa Semcer from the California Public Utilities Commission. Discussion revolved around Salo's newly-released California Forest Observatory high-resolution canopy data, which we intend to utilize in some of our analyses. CECS and other groups shared updates as well, and found even further synergies with SIG and their Pyregence consortium. They want to collaborate with CECS on fire perimeter data, surface fuels, and using Landis and Lucas models. Good questions were asked by Loretta and the CPUC Wildfire Safety Commission folks, which should serve to make our project better and more useful to their efforts.
Calls with all three projects will continue on a quarterly basis, and we will continue to invite agency folks as deemed appropriate.

We have begun to further strengthen our partnership with Spatial Informatics Group on a call where 30 CECS team members joined David Saah and Shane Romsos to learn more about the Pyregence consortium, the details of the science behind his models, and the areas of overlap and lessons they've learned which we can apply to the CECS Project. Additional coordination will occur in Q4.

CECS Director, Mike Goulden, and Project Coordinator, Raiven Greenberg also met with Elea Becker Lowe, Gina Ford, and Jim Falter from CNRA's Monitoring & Stewardship division. On this introductory call, we learned more about their efforts to develop a geodatabase that will contain information on State bond-funded projects from pre-award through post-award monitoring. Mike shared CECS overview and how we are going to set up our tool, showed how we can utilize some of their information on shapefiles of past management, and also provide some analyses to show how project areas may fare 30 yrs. into the future. We plan to follow up with them to share additional details on the data outputs of the CECS project.

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 worked on advancing the remote sensing-based dataset of disturbance types in California, which will support an analysis of the historical trends of the forest ecology and disturbance rates for 1984 - 2019. More specifically, Jon refined the CCDC machine learning algorithm so that it incorporates a metric of disturbance severity (the change in tree canopy cover) that is associated with each disturbance event. The model has been refined and applied across the whole state, and we are now in the process of validating it and analyzing the trends and interactions between disturbances across the ecoregions of California. This dataset is being supplied to the data visualization group, who will host it on the web, and will support a presentation at the American Geophysical Union (AGU) conference in December.

As additional work toward tasks 1.1 and 1.2, Clarke Knight compared the historical management layers with the first iteration of the CCDC algorithm raster outputs. This work entailed slimming down the historical management layers to the most important variables and combining the large datasets from multiple administrating bodies into one cohesive dataset. Clarke also merged raster tiles into annual state-wide units, converted those units to polygons, and added supplementary data to those polygons

such as the polygon size (m^2). Given the large size of the raster data, this process was not trivial or quick; however, Clarke developed a workflow combining QGIS and R that proved efficient. She also began statistically comparing the algorithm outputs to the historical datasets, which is the topic of the paper she is writing with Jon Wang and UC Berkeley Professor John Battles. Preliminary results suggest large differences in reported/documented disturbances compared to remotely-sensed disturbances. Clarke submitted an AGU abstract on this idea, which was accepted for the December 2020 meeting. Clarke is also working on calibrating and validating the CCDC algorithm, and to this end supervised two undergraduates as they created hand-drawn polygons to train the algorithm and to start validating the CCDC algorithm on Collect Earth Online.

For Tasks 1.2 and 2.1 Carl Norlen, Kyle Hemes, and CECS Director Mike Goulden worked to continue to build initial versions of the Gross Primary Production (GPP) geospatial dataset for California using Google Earth Engine (GEE). This is an initial version of one of the data sets that will be produced using the CASA-based model, which is currently in development. Kyle has also been preparing input carbon and water monthly layers for the new CASA-based model, using Landsat inputs. Carl and Mike, along with Jon Wang and UCI Project Specialist Mahnoor Khan, started building the UCI High Performance Computing Cluster (HPC) infrastructure to be able to run the full CASA-based model for the whole state, which included transferring datasets from GEE to the UCI HPC. Carl is preparing a poster for the AGU Fall Meeting 2020 based on work looking at how wildfire history effects vulnerability to forest die-off. The research question for the abstract focuses on how wildfire disturbance history impacts vulnerability to forest die-off. Carl is also finalizing a manuscript on the impact of multiple droughts on forest health and drought resistance that uses many of the geospatial data sets we are preparing for the CECS project (ET, die-off, precipitation). The findings should provide useful information for managers on how drought disturbance will impact future resistance to drought.

As part of Tasks 1.2-2.3, SDSU continued their work focusing on chaparral at Sky Oaks. Soil respiration chambers collected data throughout July and portions of August at 30-minute resolution. Additionally, soil samples were extracted in September and were analyzed for water content, soil organic content, and fine root biomass. Using three eddy covariance towers, the team also collected landscape-level carbon flux measurements in chaparral. PhD student Kyle Lunneberg began statistical analyses on carbon flux data to determine the effects of drought, fire, and stand age on chaparral stands. He identified and graphed temporal trends in carbon flux on daily, monthly, seasonal, and annual scales for presentation to regulatory agencies, partitioning flux into GPP and ecosystem respiration for ongoing remote sensing projects.

Kyle also worked with Kyle Hemes to start integrating GPP, evapotranspiration, and meteorological data from three chaparral stands into the LUE-type scaling of GPP in a group-wide CASA-based model. He also began comparing “ground-truth” measurements of soil and plant carbon flux to tower-level measurements to improve partitioning models. Kyle collected monthly multispectral-drone measurements of the three tower footprints, as well as collected leaf-level carbon flux measurements for three dominant shrub species during California’s record summer temperatures. This demonstrated modern temperature stresses strongly affecting carbon fluxes. The Oechel lab also began installation of a fourth eddy covariance tower in coastal sage scrub habitat. This tower will contribute to a limited carbon dataset for coastal sage scrub.

For Tasks 2.1-2.3, Bin Chen at UC Davis examined the spatial patterns of wildfire ignitions in California from 1992 to 2015, using multi-source geospatial datasets of ignitions, and human, climatic and biophysical variables. A machine learning approach (maxent model) was applied to estimate ignition probability and analyze the importance of drivers controlling the historical spatial patterns of fires. He

also developed random forest machine learning models to estimate the monthly ignition frequency and ignition probability in California. Additionally, Yuhan Huang quantified the spread of each fire line from daily burned data and developed a machine learning model (XGBoost) to understand how the progression of the fire in Sierra Nevada can be influenced by pre-fire mortality from different geospatial datasets. To better quantify spatial patterns of tree mortality, he is also using a deep-learning-based model, Mask RCNN, to segment dead tree crown instance from high resolution NAIP images.

As part of task 2.2, intern Cassandra Vo worked with PhD candidate Shane Coffield at UC Irvine to analyze data from the California Air Resources Board's forest carbon offsets program. They found that the ground-based inventories report greater increases in carbon stocks than is observed with the remote sensing record, and that generally trends in carbon do not change when projects initiate. This brings into question the short-term effectiveness of the offsets program. Shane and Cassandra will also be thinking about potential long-term effectiveness by analyzing disturbance history and vulnerability to climate change. This fits in with the overarching ecological goals of the CECS project, to understand the present and future of management impacts on California's natural carbon stocks. This work will be presented at this year's AGU conference and will be written into a manuscript for publication in the coming months.

As part of Task 2.3, UCI Professors Efi-Foufoula Georgiou, Jim Randerson, and Padhraic Smyth, along with Shane and PhD candidate Casey Graff, developed a model for forecasting wildfire activity one to five days into the future using satellite fire counts and weather data. The model consisted of two-Poisson regression models that separately represent new ignitions and the dynamics of existing fires. The model showed significant improvement over persistence-based models and revealed vapor pressure deficit (VPD) as an especially effective weather predictor. This same team, along with UCI Project Scientist Yang Chen, and colleagues at NASA, developed a global fire emissions forecasting system with lead times of 1 to 6 months using an ARIMAX (Autoregressive Moving Average with Exogenous parameters) modeling framework, based on past data (endogenous predictors) and climate variables (exogenous predictors). The forecast system considered region-specific seasonality, long-term trends, recent fire observations and climate variables representing both large-scale climate variability and local fire weather. The model explained 52% of the variability of global fire emissions and resolved detailed spatial patterns of anomalies in regions with significant fire activity.

As part of Task 3.1, the CECS outreach team forged connections with representatives at over 30 agencies, nonprofits, local collaboratives, and private companies for participation in needs assessment, continually works toward meaningful engagement. Our team completed needs assessment survey data collection, receiving over 1200 responses. UCANR Specialist Safeeq Khan, UC Merced Project Scientist Max Eriksson, and Stakeholder Engagement Specialist Jaquelyn Lugg also developed and finalized needs assessment workshop format and content. Workshops will be held October through November 2020.

For task 3.2 we hired on a new postdoctoral researcher, Jian Lin, at UC Merced to help in the translation of research into our web tools. Meanwhile, our app developer, Mike Walkinshaw, improved on the Fire Progression Visualization tool, which displays time lapse animations of fire perimeters built out by UCI Project Scientist Stijn Hantson. The basic proof-of-concept functionality of this tool was completed in Quarter 2, but we have added more features and made the tool more user friendly. Users are able to select from 21 wildfires of interest, either by clicking an icon on an interactive map, or from a table-style list. The list displays each fire's name, year, and acres burned, and can be sorted by each of these properties. While viewing the fire progression animation, users can now see the high temperature and average wind speed for each day. Several base map options are available. We have also added a map overlay layer which displays areas that have burned since 1950. More overlay layers may be added

later. An online version of the Fire Progression tool is available at: https://soilmap2-1.lawr.ucdavis.edu/cecs/fire-progression/

We have also continued to build out the framework for our Data Download tool, which will allow for downloading of data layers created from this project. Users select their data layers of interest in a sidebar, where they can also view metadata for each layer. The area of interest is selected on an interactive map, with three options: full extent, extent by watershed boundary, or custom extent. When selecting by watershed, users can select by using a search box with an autocomplete feature, or by clicking the map. The custom extent feature lets users draw a rectangle on the map to define their area of interest. At this time, we are still working on the server-side code that will return the custom files to the user. A prototype of the Data Download tool can be found at: https://soilmap2-1.lawr.ucdavis.edu/cecs/demos/data-download/

For Task 3.3, Jaquelyn Lugg wrote and published four stories about project updates and recently published research by CECS project scientists, posted to our website and to UC Merced and UCANR websites, working toward the goal of increasing visibility of our project. Additionally, work commenced on our sequel film on California's forest and watershed health, called "California's Watershed: Healing", produced by the Chronicles Group. The trailer for the film can be viewed here. Production on the film is still in progress.

For task 4 work we hired on 2 new postdoctoral researchers this quarter- Min Gon Chung at UC Merced, and Charity Nyelele at UC Irvine. Roger Bales, Catherine Keske, Benis Egoh, along with Min, Charity, and UC Merced graduate student Nick Goncalves, worked with Kim Quesnel of Blue Forest Conservation to draft an ecosystem "valuation framework paper" to be submitted for peer review. This group additionally submitted an abstract to American Geophysical Union meeting and was accepted for a poster presentation.

As part of Task 4.1, Min, with support from Roger, also updated the CECS framework that includes ecosystem services, actors, financing mechanisms, and restoration activities. This framework will help us investigate how restoration activities affect ecosystem services differently under different financing mechanisms and restoration objectives. Min additionally collected data for restoration projects (e.g., budget, specific goals, period), ecosystem services (e.g., carbon and water), economic data (e.g., social costs of carbon, water prices), and related beneficiaries (e.g., agencies, water utilities, low-income or disadvantaged communities). Additionally, Charity carried out a literature review to identify existing studies, data, models and tools on carbon storage and other ecosystem services in the TCSI study area and California in general. Besides carbon storage, she also investigated wildfire air quality and associated human health impacts, recreation, and microclimate regulation to identify data needs and modeling approaches or tools that we can use to understand the impact of restoration activities on these ecosystem services. She also began to look at how to incorporate equity and environmental justice concerns when mapping the different beneficiaries of the ecosystem services. Catherine Keske and Benis Egoh also provided input on the stakeholder needs assessment survey, specifically on sense of place and other ecosystem services, and will utilize survey output in their research.

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

Tasks related to developing methods to map carbon, wildfire spread, water balance, and forest health are being improved and are nearing completion. Kyle Hemes has been involved in collecting and homogenizing existing data layers, developing GEE workflow, and preparing the structure to produce Version 2 gap filled carbon and water results for FRAP fires back to ~1950. Initial analyses of multi-decadal fire impacts are being explored using the whole library of FRAP fires and a manuscript is in

progress. Additionally, the basic workflow to produce consistent input and output layers has been developed using Google Earth Engine. The basic infrastructure for this workflow is complete.

For Task 2, Bin Chen at UC Davis has generated static ignition probability maps at 1-km and 4-km in statewide California. These maps are also distinguished by human- and lightning-driven causes. He also generated a monthly ignition probability and frequency product in California at 8-km grids from 1992 to 2015. His paper entitled "Climate, fuel, and land use shaped the spatial pattern of wildfire in California's Sierra Nevada" has been accepted for publication in Journal of Geophysical Research: Biogeosciences, and has also been featured as AGU research spotlight. Additionally, Yuhan Huang at UC Davis developed a modeling framework for disentangling effects of environmental conditions (especially tree-mortality related conditions) on fire progression. He also quantified several metrics at fire line level representing different aspects of fire spread for large fires in Sierra Nevada.

For Task 3.1, our main achievements in Q3 include collecting 1200+ points of survey data and starting to conduct online stakeholder workshops. The data collected through our questionnaire will: 1) Allow us to identify some of the needs and barriers that natural resources managers in California are facing, as well as identify potential solutions, 2) Give us a starting point for the valuation of ecosystem services, and 3) Inform the creation of the management tool. Data from workshops to be hosted in October and November will also provide a detailed look into ecosystem services. Our data collection to date has included measurements of how experts perceive carbon storage capacity, and how management might impact carbon storage capacity.

We are working towards identifying the main barriers to efficient management of wildlands in California and potential solutions. In doing so we have identified data needs and potential organizational gaps as well as a number of issues related to how different groups perceive the value of wildlands. Data from surveys and workshops are just starting to be analyzed and we will have findings to share in the next quarterly report.

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

The success story from Quarter 3 of which we are most proud (and which is also detailed in our Annual Report) is that CECS hosted its first Ecosystems & Climate Change Summer Internship cohort virtually this summer for 8 weeks between June 22 and August 14. There were over 40 applicants to the program, and we selected 11 interns from a very diverse pool.

Five interns focused on science communication projects for CECS. Mentored by UC Davis PI Toby O'Geen and Jaquelyn Lugg, the interns learned about core science communication concepts like attention to audience, distilling complex information, eliminating jargon, and more. Each intern focused on a topic area, like die-off or carbon sequestration, and applied what they learned about science communication to create several products. These included one-pagers, short video explainers, infographics, and a TikTok channel, all of which allowed the interns to channel their creativity and insights into meaningful communications about topics the CECS project is working to address. Each week, interns worked together and with their mentors to revise their products, all of which are now featured on the CECS project website.

Additionally, six interns focused on original scientific research, and were similarly mentored by a PI and graduate students whose research focus matched theirs. Topics ranged from creating a high-resolution tree mortality dataset using machine learning algorithms to examining sequestration or loss of aboveground biomass from forest projects under California's Compliance Offset Program. All interns

presented their work at our project's first Annual Meeting to a virtual audience of nearly 50 individuals. Of the interns focused on scientific research, at least three will also be presenting posters on the work that they did this summer at this year's AGU conference.

To create a richer experience for our interns, especially in the fully virtual world of the COVID-19 era, we hosted 8 virtual workshops, Q&A sessions, and panels. These included: Python, R (in a 3-part series), Google Earth Engine, QGIS, Science Communications, and a Young Professionals in STEM Panel. Interns were also able to learn from and collaborate with researchers across all 8 research institutions involved in the CECS project through weekly sub-group calls, and were also able to meet and engage with several of our partners at Blue Forest Conservation, Spatial Informatics Group, and California Natural Resources Agency.

Ten of the eleven interns we hosted this summer identified as female, and over ⅔ of our interns come from ethnic minority groups traditionally underrepresented in earth system science. Five of our interns live in or on the border of areas identified as Disadvantaged Communities as defined by Cal OEHHA. More than half are also first-generation college students.

In an exit survey, 55% of interns reported an increase or strong increase in their interest in both a career in research and in attending graduate school. 91% of interns also reported more confidence in giving a presentation on their work and in communicating their work to diverse audiences. At the end of the internship, 100% of our interns felt more knowledgeable about science communication, and 91% felt more knowledgeable about forest management strategies. For this being a fully virtual internship, we considered this a large success, which will hopefully only be improved upon in the next two years.

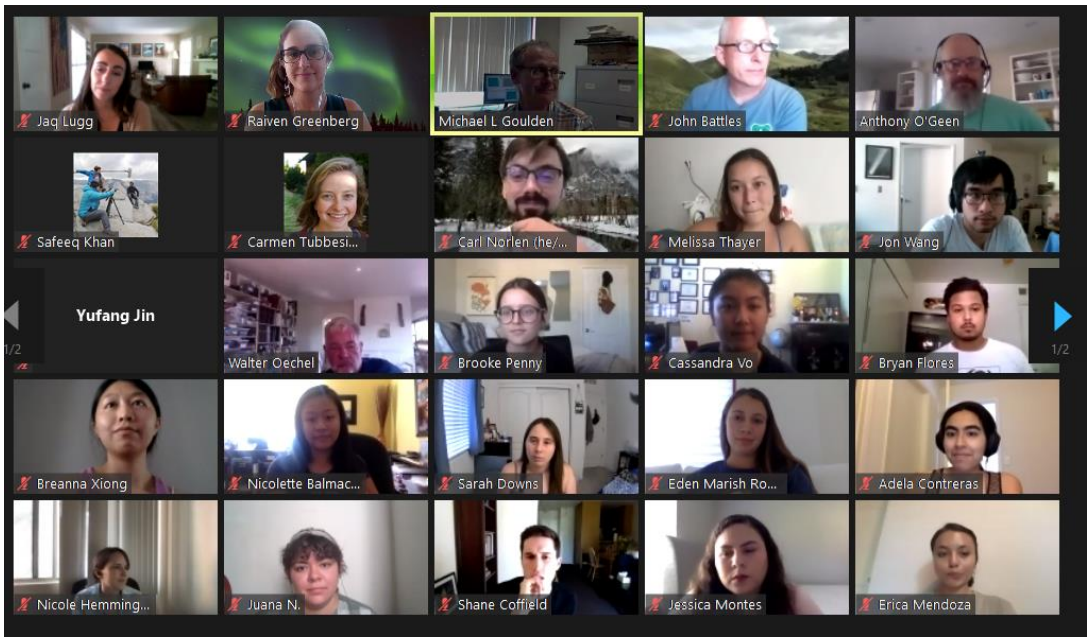

Figure 1: Interns and their mentors and PI's, along with other CECS team members celebrating the completion of their internship

The internship culminated with our first Annual Meeting, engaging nearly all of our 50+ CECS team members across 2 days in mid-August. The first day consisted entirely of presentations from interns on their work, and showed all of our PIs and graduate students just how their work contributed to the larger goal of this project, and how it can be continued and further built upon as we move forward. The second day of the meeting involved re-orienting folks to the goals of the project, as well as updates and

discussions around each science topic and each engagement strategy we are implementing. This meeting gave team members the opportunity to learn about additional research that is being done, and how it may complement their own efforts, as well as allowed us to collaboratively plan for research and engagement in the months ahead. This Annual Meeting, while mostly focused on our internal development, was highly effective in brining our team together.

Q3 2020 published and pending publications, with links to view and download:

1. Chen, Y., J. T. Randerson, S. R. Coffield, E. Foufoula-Georgiou, P. Smyth, C. A. Graff, D. C. Morton, N. Andela, G. R. van der Werf, L. Giglio, and L. E. Ott, Forecasting global fire emissions on sub-seasonal to seasonal (S2S) timescales, *J. Adv. in Modeling Earth Systems (JAMES)*, 12, e2019MS001955, doi:10.1029/2019MS001955, 2020.
2. Graff C., S. Coffield, Y. Chen, E. Foufoula-Georgiou, J. Randerson, and P. Smyth, Forecasting daily wildfire activity using Poisson Regression, *IEEE Transactions in Geoscience and Remote Sensing*, doi:10.1109/TGRS.2020.2968029, 2020.
3. Huang, Y., Jin, Y., Schwartz, M., and Thorne, J, Intensified burn severity in California's northern coastal mountains by drier climactic condition, *Environmental Research Letters*, 2020.
4. Ma, Q., Bales, R., Rungee, J., Conklin, M., Collins, B., and Goulden, M., Wildfire controls on evapotranspiration in California's Sierra Nevada, Qin Ma, et al. *Journal of Hydrology*, doi:10.1016/j.jhydrol.2020.125364, 2020.
5. Safeeq, M., Gordon, G., Lewis, S., and Hayes, S., Disentangling effects of forest harvest on long-term hydrologic and sediment dynamics, western Cascades, Oregon, *Journal of Hydrology*, doi:10.1016/j.jhydrol.2019.124259, 2019.

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

While the internship program was challenging to prepare for, with the logistics of hosting student interns remotely providing a lot of uncertainty, our team actually came together quite nicely in support of this program and it ended up being a success. The COVID-19 pandemic continues to impact team member availability and focus on this project, but we continue to carry on, and work is progressing at a satisfactory rate despite all the challenging external circumstances the pandemic has created for most people. Additionally, we have found that cloud-based platforms such as Slack and Google Earth Engine have been adopted by more team members, and have allowed us to communicate and work together more effectively toward completion of project deliverables.

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?

As we received a one-year no-cost extension the expected date of project completion is now well within schedule. Budget had to this point been spent at a slower rate than anticipated, which has actually set up in a good position for Year 4 of the grant. The budget for year 3 and 4 will likely need to be amended, and an amendment request will be submitted to SGC once needs become solidified, likely in Q1 2021.

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 $213,083.12 in Q3, mainly on salaries and benefits for three PIs, the Project Coordinator, Project Specialist, Postdoctoral Researchers, Project Scientist, and graduate student assistance, in addition to administrative overhead.

UC Merced spent $26,190.21 in Q3, primarily on Project Scientist, Assistant Specialist, and PI salary, associated benefits, and overhead.

UC Davis spent $44,018.26 in Q3, primarily on a Postdoctoral Researcher, Programmer, PI, and graduate student salary, benefits, and overhead.

UC Berkeley spent $10,388.86 primarily on PI and graduate student salaries and benefits.

San Diego State University spent $1,235.94 in Q3 on salary and benefits for a graduate research technician.

Stanford spent $15,817.36 on PI effort and Postdoctoral Researcher salary, administration, and overhead. This spending is on track with what was originally budgeted.

Total project spending amounts to $310,733.73 for Q3 2020. $860,057.46 has been spent to date.

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

We anticipate modifications to the budget and a slight change in workplan timeline to account for the one year no-cost extension awarded to our project in Q3 2020. These will be submitted to relevant SGC staff likely in Q1 2021.

ADDITIONAL COMMENTS

We appreciate the continued support of the SGC and all of our project 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 Q3, as people find their work on this project continually meaningful and engaging.