UNIVERSITY OF CALIFORNIA

Annual Progress Report - L22CR4529 Coastal Wetland Restoration a Nature Based Decarbonization Multi-Benefit Climate Mitigation Solution

Grant Year: 1

Institution: University of California, Santa Cruz

CG Review Date: 2023-01-25

Approved Date:

Approved By:

Application ID: L22CR4529

Project Title: Coastal Wetland Restoration a Nature Based Decarbonization Multi-Benefit Climate Mitigation Solution

Award Amount Modification:

Progress Details

Progress Report Abstract

This interdisciplinary project includes physical, biological, economic, and social science aspects as well as field and lab work and ecosystem and climate modeling and education and public outreach components. It integrates environmental justice considerations, policy, and governance approaches to develop a framework and guidelines for incorporating coastal wetland restoration and conservation into adaptation and development plans, facilitating the inclusion of coastal wetland restoration in carbon credit markets while considering multiple co-benefits.

We have established clear and effective communication strategies including an in-person kickoff meeting, quarterly work-package workshops, and monthly group meetings. We developed a project website and a students' discussion channel. Specific progress includes: (1) developing a list of desired parameters (air, water and soil) to be collected at the field sites and methods to do that; (2) collection physical and biological data and assessment of microbiome identity and activity; (3) creating a database of regional wetland restoration projects, analysis of this data, selection of case studies, and construction of a social network; (4) literature review to better understand how restoration projects work in practice and development of a toy model that controls flood risk; (5) modeling the effectiveness of different extents of wetlands for flood mitigation and looking at historical and proposed policy mechanisms around payments for ecosystem services; (6) conducted a geospatial analysis of wetlands distribution and social vulnerability across the state of California (7) summarizing the key model parameters most relevant to coastal wetland models; and (8) identifying websites with available authentic data to be used in our climate and data literacy course.

The main challenge we encountered is the inability to recruit graduate students dedicated to this project in the middle of the academic year and the exuberant process to recruit and hire the postdocs for the project. These challenges will be resolved with the start of the new academic year. In the next year we will continue the research towards achieving our ultimate goal to offer nature-based adaptation opportunities and enhance community resilience and environmental justice is key to safeguard livelihoods in the face of climate change.

Narrative Report of Progress

The objective of this project is to construct a set of recommendations that will enable wetland restoration projects to consider C sequestration and ecosystem services in their design/management. This is achieved by collaborative work done through four integrated work-packages (WP). (1) Carbon Dynamics in Wetland; (2) Carbon Economics and Ecosystem Services; (3) Policy, Governance and Justice; (4) Ecosystem and Climate Modeling; and (5) Education, Outreach and Climate Literacy. Below

we list report the progress made by each team and provide an outline of the team's next year's research plans.

Carbon Dynamics in Wetland - The goal of this WP is to collect data on C dynamics in wetlands. The data includes measurements of CO2 and CH4 emissions and a suite of meteorological data, collected by eddy covariance towers, soil and water chemistry and microbiology. The important environmental parameters linked to high net C burial will be identified and the data will inform process-based ecosystem models that will help determine favorable restoration conditions. We collected and processed greenhouse gas flux data in wetlands at the Delta, Eden Landing and Elkhorn Slough. Ancillary water and soil data are also continuously recorded. At the Delta we conducted a 24-hour water sampling campaign at Dutch Slough and conducted microclimate studies to examine the degree that adjacent wetlands are providing a cooling effect. At Edan Landing, we installed multi parameter water sensors as well as ADCPs to test best ways to quantify lateral C loss in tidal wetlands and found that about 45% of the C in the system is transported laterally. At Elkhorn Slough a soil and water sampling campaign at 3 wetland sites during the dry seasons was conducted. We collected 36 soil cores, extracted porewater and collected samples for dissolved gases in the soil. The >500 discrete water/soil samples are being analyzed for a multitude of variables. We have also installed a water sensor to measure water quality and dissolved inorganic C. The microbiology team (LLNL-LANL) has focused on establishing a baseline assessment of microbiome identity and activity at Elkhorn Slough and will use this as a model for the other sites. We are quantitatively comparing the identity of metabolically active vs. inactive microbes between a pristine and restored site. Cores from vegetated areas were collected and processed for deoxyribonucleic acid quantitative stable isotope probing by addition of H218O, which is assimilated solely into cells that are synthesizing DNA and thus metabolically active and growing.

Carbon Economics and Ecosystem Services - The economics team (UCSB, UCB, UCSC) is working on an economic model of wetlands restoration. We want to answer the broad questions: How, when, and where should investment in restoration be done to optimally mitigate flooding risks that are increasing under climate change? What additional ecosystem services can be generated by restoration projects designed to address flooding risk? During the first year of the project, the UCSB team has focused on conducting a literature review to better understand how restoration projects work in practice, with the goal of informing a model of restoration. We have also developed a toy model of a project that controls flood risk by choosing the optimal width of a vegetation band. The team has also devoted time to learn more about optimization algorithms in R that will ultimately be used for the analysis. In addition, the team has been looking at historical and proposed policy mechanisms around payments for ecosystem services. Data collection and analysis are underway for a forthcoming journal article that analyzes the literature on coastal wetland ecosystem service valuations as a case. The draft article places the

broader literature on ecosystem service valuations in conversation with questions of historical and environmental justice. Much of the conceptualization and analysis are complete, and we anticipate a finished draft by the end of the winter quarter 2023.

Policy, Governance and Justice - The Governance and Policy team (UCD, UCSC) developed a research design to examine governance and policy in California Bay Delta wetland restoration with a mixed methods approach using case studies, stakeholder interviews, a regional survey, and social network analysis. A database of regional wetland restoration projects was created from EcoAtlas. An interview tool was developed to collect original data to answer questions of procedural equity in the creation and implementation of wetland restoration projects. These interviews are currently undergoing internal review board evaluation. At UCI the group conducted a geospatial analysis of wetlands distribution and social vulnerability across the state of California. This distributive justice-focused investigation found that while wetlands areas have lower cumulative environmental impacts and social vulnerability, there are exceptions – including sites of industrial activities or recently de-industrialization – that do not follow this pattern. This analysis emphasizes the need and value of comprehensive environmental justice assessments for any wetlands site where restoration investments for carbon sequestration are being considered. The publicly available data sources used for this activity and several of the California-specific environmental justice literature referenced were catalogued. This analysis is complete and is being prepared for journal submission.

Ecosystem and Climate Modeling - The goal of the modeling team is to conduct sets of modeling experiments using ecosys and ATS and investigate how different coastal wetland restoration options and climate change will impact net carbon sequestration potential. We use observations to parametrize and benchmark the modes and predict greenhouse carbon exchanges, carbon burial, and plant dynamics. The team focused on hiring postdoc researchers, summarizing model parameters, communicating with the project group about data needs, and discussing methods on setting up model experiments in the study sites. Specifically, (1) we recruited two postdoc researchers who will work on the ecosys and ATS modeling. (2) we developed a list of key model parameters relevant to coastal wetland ecological, hydrological, and geochemical processes. (3) we analyzed the annual mean precipitation, temperature, and elevation across the observation sites and summarized the availability of climate data across the sites for site selection. We also identified other data needs such as soil properties, topography and plant traits that will be used to initialize the models.

Education & Outreach - In the first year of the project despite the challenge of recruiting students mid academic year we have included seven graduate students and five undergraduate interns and provided them with hands on experience in collaborative research. We have established an outward looking

project website which includes information about the project as well as resources like news items and videos. The publicly available data sources used for this activity and several of the California-specific environmental justice literature referenced were catalogued for inclusion in the climate and data literacy course. As from this project has been used in an NSF supported project (DIG CAMP) which provides high school students from underprivileged schools to Climate and Data literacy experience. The high school students as well as a group of climate-concerned community members visited our field site at Elkhorn Slough. We have also established collaborative relationships with the new UC–CSU ECCLPs Climate and Environmental Justice Literacy Initiatives a UC–CSU partnership that focuses on advancing PK-12 climate and environmental literacy, justice, and action to build NGSS aligned climate and data literacy curricula.

We have encountered some significant obstacles. Because of the mid-academic year start date, it was not possible to recruit new students dedicated to the project and some hired students had other funding sources. This resulted in slower progress on some project aspects, and not all GSR support was used. In addition, although we have started the process of hiring the postdocs in March, due to backlog in the HR office and the time it takes to process visas the selected postdocs are still not in the USA. We hope that the visas will be processed, and we are planning to recruit several new students for the project in the coming academic year. No aims have been discontinued and we are progressing as planned with a small delay in the modeling due to the delay in postdoc hires.
In the next year we will continue to collect and analyze the field data at all sites and expand on the microbiology work. The economics team will focus on developing a full model of the flood risk and producing preliminary results. The team will also include other ecosystem services beyond flood mitigation such as fishery/bird habitat, localized cooling for urban-adjacent areas, and improvements to water quality in the model. The cost of land acquisition/restoration depending on the restoration method will also be included. The policy team plans to use the survey at select other regions to allow comparisons with the Bay-Delta findings and networks and do more analyses focused on the environmental justice dimensions of wetlands restoration. A short policy report/set of recommendations exploring the implications of these findings for wetland restoration projects' siting, funding, and relation to social equity goals and two papers will be submitted for publication. The postdoc researchers will be on board, and the modeling team will focus on selecting an experiment site to conduct model simulations. We will start with a transect-scale simulation to understand the dynamics of C, surface and subsurface hydrology, and geochemistry with and without restored wetlands.

Key Personnel

Key Personnel

Last Name	First Name	Email	Degrees	Title	Department	Institution	Role on Project	% Effort	Institution Type	Out of State Effort?	No Longer on Project	Status	Updated
Payt an	Adi na	apayta n@uc sc.edu	Ph.D	Rese arch er	IMS	UC SC	Applic ant Princip al Investi gator		Acade mic/Re search Institut ion			Sub mitte d - Unlo cked	2023 -01-2 0 06:30
Arn old	Gwer	gbarn old@u cdavis .edu	Ph.D	Assis tant Prof.	Environmen tal Science & Policy	UCD	Co-Princip al Investi gator		Acade mic/Re search Institut ion			Sub mitte d - Unlo cked	2023 -01-2 0 06:30
Zilb erm an	David	zilber1 1@ber keley. edu	Ph.D	Prof.	Agricultural and Resource Economics	UCB	Co-Princip al Investi gator		Acade mic/Re search Institut ion			Sub mitte d - Unlo cked	2023 -01-2 0 06:30
Plati nga	And rew	plantin ga@br en.ucs b.edu	Ph.D	Prof.	Bren School of Environmen tal Science and Manageme nt	UC SB	Co-Princip al Investi gator		Acade mic/Re search Institut ion			Sub mitte d - Unlo cked	2023 -01-2 0 06:30

Matthew	Richard	rmatthew@uci.edu	Ph.D	Prof.	Urban Planning and Public Policy, and Political Science	UCI	Co-Principal Investigator	Academic/Research Institution			Submitted - Unlocked	2023-01-20 06:30
Pett-Ridge	Jennifer	pettridge2@llnl.gov	Ph.D	Group Leader	Environmental Isotope Systems	LLNL	Co-Principal Investigator	Government			Submitted - Unlocked	2023-01-20 06:30
Kroeger	Marie	mkroeger@lanl.gov	Ph.D	SFA Co-lead	Terrestrial Microbial Carbon Cycling	LANL	Co-Principal Investigator	Government	- Select One-	This person is no longer with the project.	Submitted - Unlocked	2023-01-23 09:18
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Angelo	Hillary	hangelo@ucsc.edu	Ph.D	Assistant Prof.	Sociology	UCSC	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
Seto	Katherine	hangelo@ucsc.edu	Ph.D	Assistant Prof.	Environmental Studies	UCSC	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
Lubell	Mark	mnlubell@ucdavis.edu	Ph.D	Prof.	Environmental Science & Policy	UCD	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
Baldocchi	Dennis	baldocchi@berkeley.edu	Ph.D	Prof.	Environmental Science & Policy	UCB	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
Tague	Naomi	ctague@bren.ucsb.edu	Ph.D	Prof.	Bren School of Environmental Science and Management	UCSB	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
Mayali	Xavier	mayali1@llnl.gov	Ph.D	Deputy Group Leader	Environmental Isotope Systems	LLNL	Co-Investigator	Government		Submitted - Unlocked	2023-01-20 06:30

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Kang	Qinjun	qkang@lanl.gov	Ph.D	Researcher	Earth and Environmental Sciences Division	LANL	Co-Investigator	Government		Submitted - Unlocked	2023-01-20 06:30
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Nico	Peter	psnico@lbl.gov	Ph.D	Staff Scientist	Earth and Environmental Sciences Area	LBNL	Co-Investigator	Government		Submitted - Unlocked	2023-01-20 06:30
Arias Ortiz	Ariane	aariasortiz@berkeley.edu	Ph.D	Post Doc	Environmental Science, Policy and Management	UCB	Co-Investigator	Academic/Research Institution		Submitted - Unlocked	2023-01-20 06:30
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Garrison	Jessica	jdgarris@uci.edu	Ph.D	Assistant Prof.	Urban Planning and Public Policy, and Political Science	UCI	Co-Investigator	Academic/Research Institution			Submitted - Unlocked	2023-01-20 06:30
Mendez	Michael	mamende6@uci.edu	Ph.D	Assistant Prof.	Urban Planning and Public Policy, and Political Science	UCI	Co-Investigator	Academic/Research Institution	- Select One-	This person is no longer with the project.	Submitted - Unlocked	2023-01-23 09:18
Saltikov	Chad	saltikov@ucsc.edu	Ph.D	Prof.	METOX	UCSC	Co-Investigator	Academic/Research Institution			Submitted - Unlocked	2023-01-20 06:30
Hanson	Buck	bhanson@lanl.gov	PhD	Scientist 2		LANL	Co-Principal Investigator	Government	- Select One-		Submitted - Unlocked	2023-01-25 04:30

Roy	Avis pa	avipsar@uci.edu	PhD	Assistant Prof.	Department of Urban Planning and Public Policy	UCI	Co-Investigator	Academic/Research Institution	- Select One-			Submitted - Unlocked	2023-01-25 04:30

Publications

List all Publications

Add

Publication Type	Publication Title	Identifier	Authors	Publication Year	Publication Status	Status
Other	Performance of Restored Tidal and Nontidal Wetlands on the Exchange of Carbon	AGU Abstract	Ariane Arias Ortiz, Robert Shortt, Tianxin Wang, Kaniska Mallick, Daphne J. Szutu, Joseph G Verfaillie and Dennis D Baldocchi	2022	Published	Submitted - Unlocked

Patents and Licenses

List all Patents

Nothing to Report

Human Subjects Use

Assurance Status	IRB Approval Date	IRB Expiration Date	Assurance Number	Status
Exempt	2022-05-04	2025-04-14	1781342	**Approved**

Leveraged Funding

List all Leveraged Funding

Add

Achievement Type	Total Amount	Funding Organization	Year Received	Status
Leveraged Grant	$406,100	NSF	2022	**Submitted - Unlocked**
Leveraged Grant	$184,760	NSF	2021	**Submitted - Unlocked**

Signature

Principal Investigator Signature

I certify that the statements herein are true, complete and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application.

Applicant Electronic Signature (Type in your full legal name)

Adina Paytan

Date

01/25/2023

C&G Officer Signature

I certify that the statements herein are true, complete and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application.

C&G Officer Electronic Signature (Type in your full legal name)

Nick Theodosis

Date

01/25/2023

C&G Officer Comments

Submitted By: Betsy QuayleMaryAnn MorganNicholas TheodosisVicky Bender

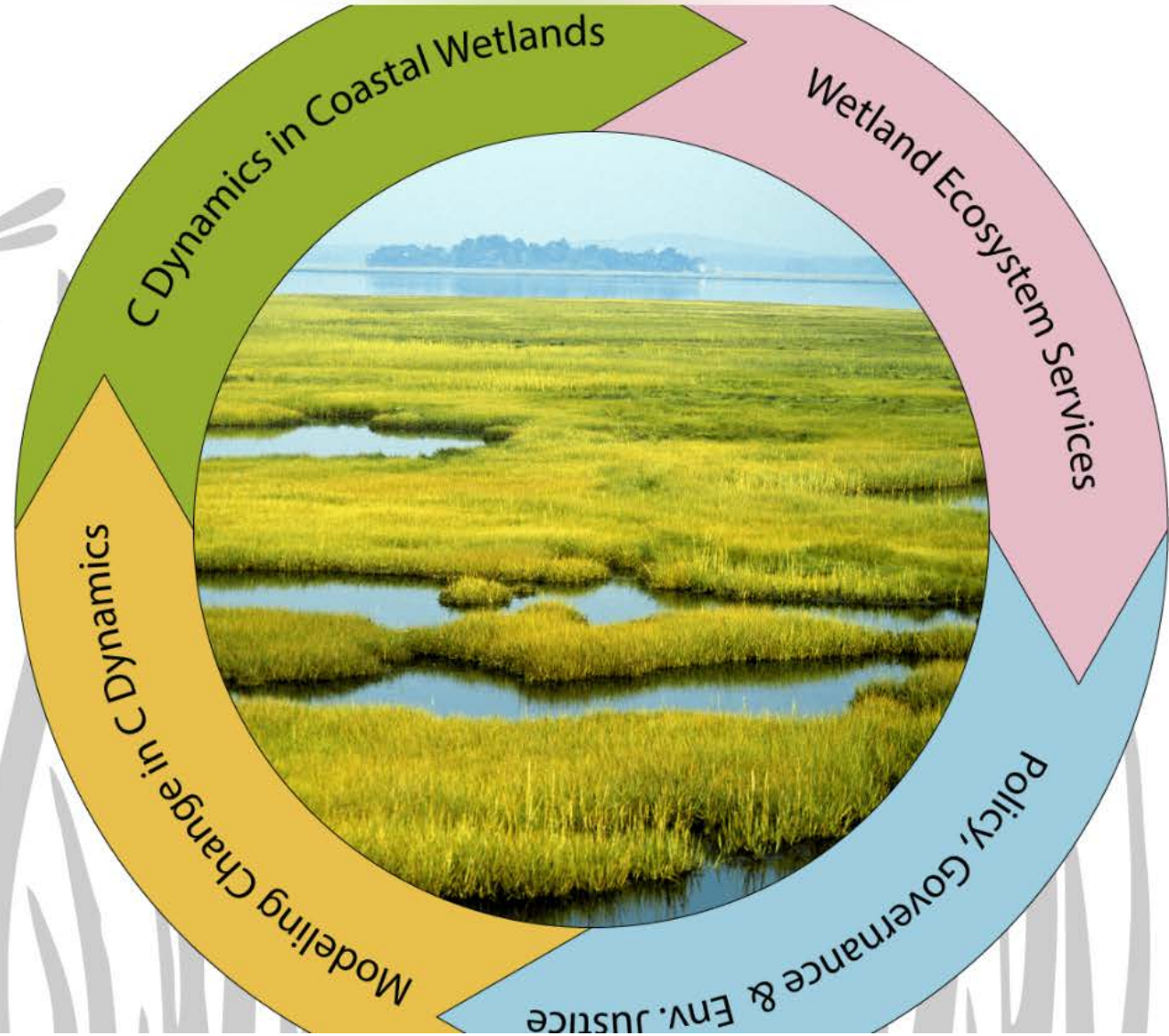
Project webpage - https://wetlands.ucsc.edu/

Coastal Wetland Restoration

Coastal Wetland Restoration

A Nature-Based Decarbonization Multi-Benefit Climate Mitigation Solution

Carbon Dynamics | Ecosystem Services | Policy & Governance | Carbon Modeling

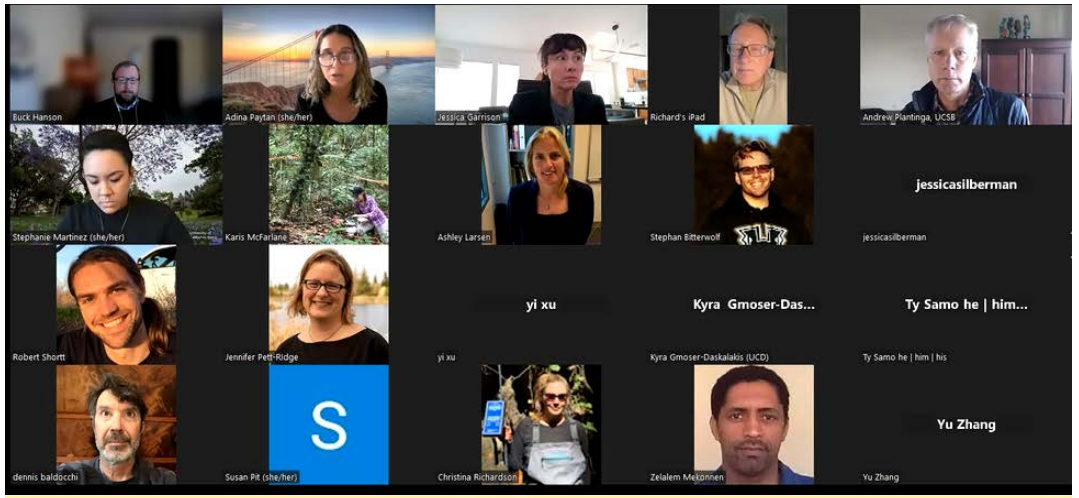


Webpage example for resources - https://www.youtube.com/watch?v=CR4Anc8Mkas&vl=en

Coastal Wetland Restoration

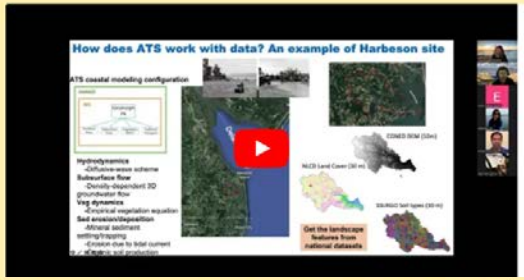
Measuring Wetland Carbon Dynamics with Eddies

Recorded Group Zoom Webinars and Presentations



Meeting 3: Dec. 20th

Ariane presents on her research understanding carbon fluxes within tidal and non-tidal restored wetlands in the San Francisco Bay-Delta



Meeting 2: Nov. 15th

Members of the modeling team give the group an update on modeling approaches.

Meeting 1: Oct. 18th

In this first meeting each team gives an update on their status.

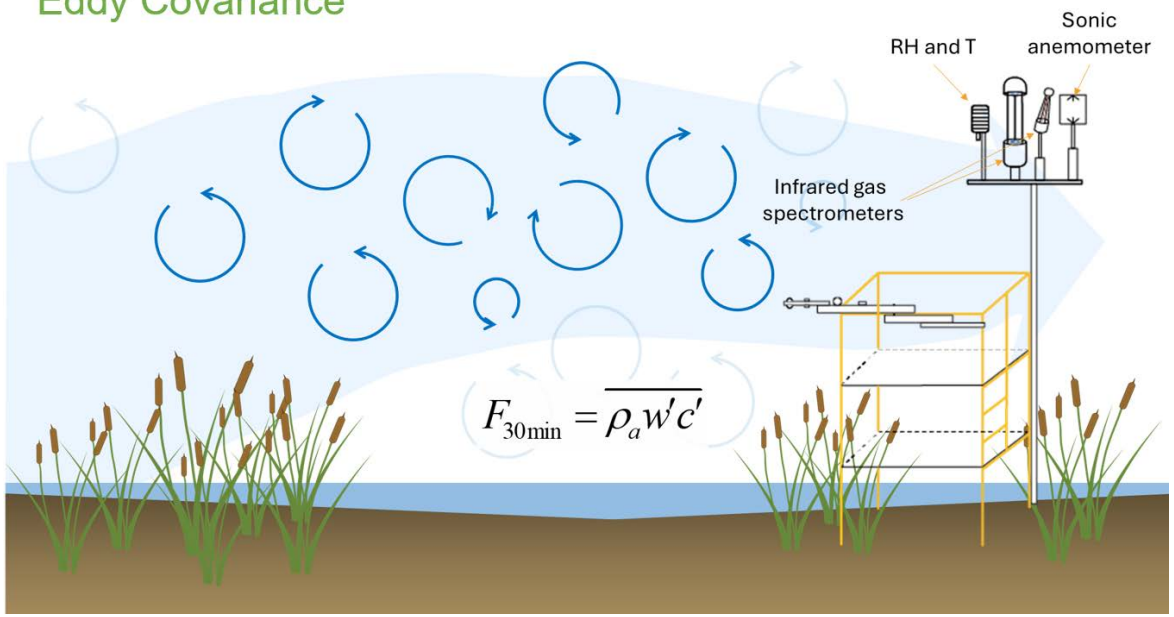
Social cost of carbon

- *"The social cost of carbon (SC-CO2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO2 emissions by the same amount in that year. The SC-CO2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts – from global climate change that result from an additional ton of CO2. These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. " – California Air Resources Board, California's 2017 Climate Change Scoping Plan*

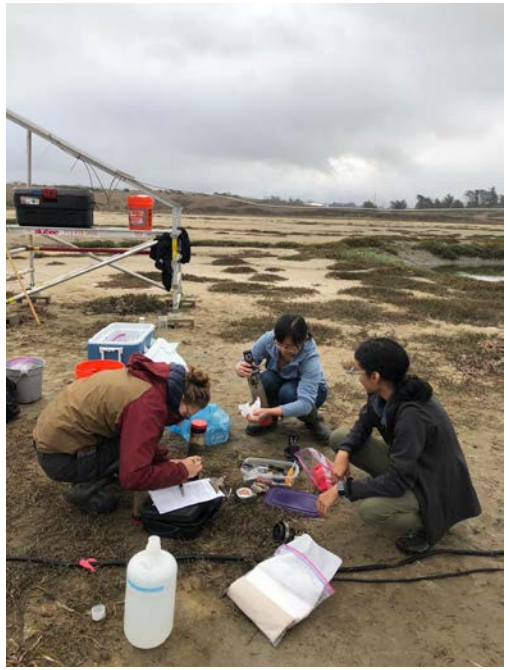
TABLE 7: SC-CO_2, 2015-2030 (IN 2007 $ PER METRIC TON)

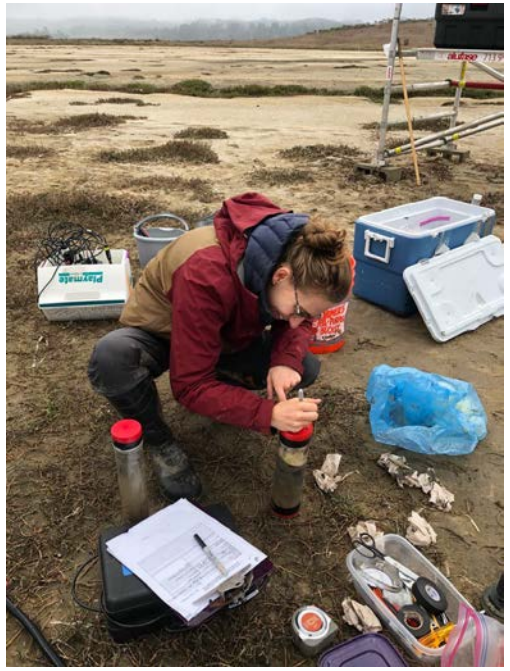
Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2015	$11	$36	$56
2020	$12	$42	$62
2025	$14	$46	$68
2030	$16	$50	$73

Eddy Covariance

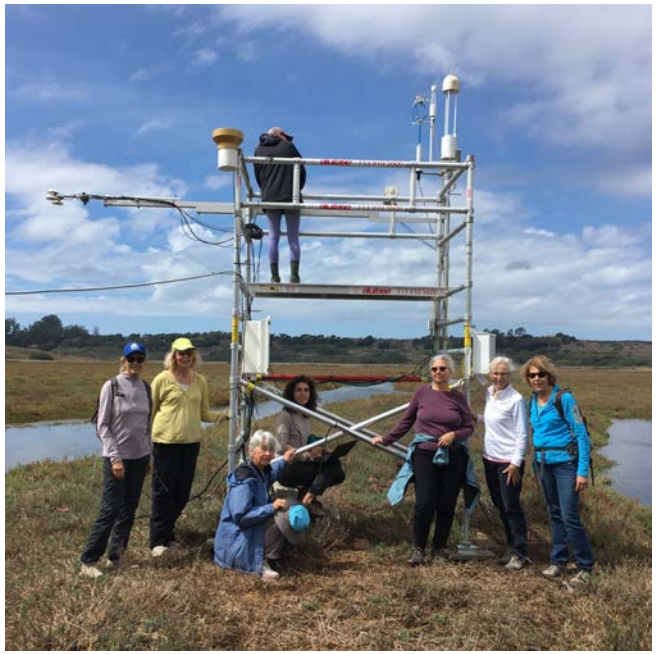


Field and Lab Work – October 2022

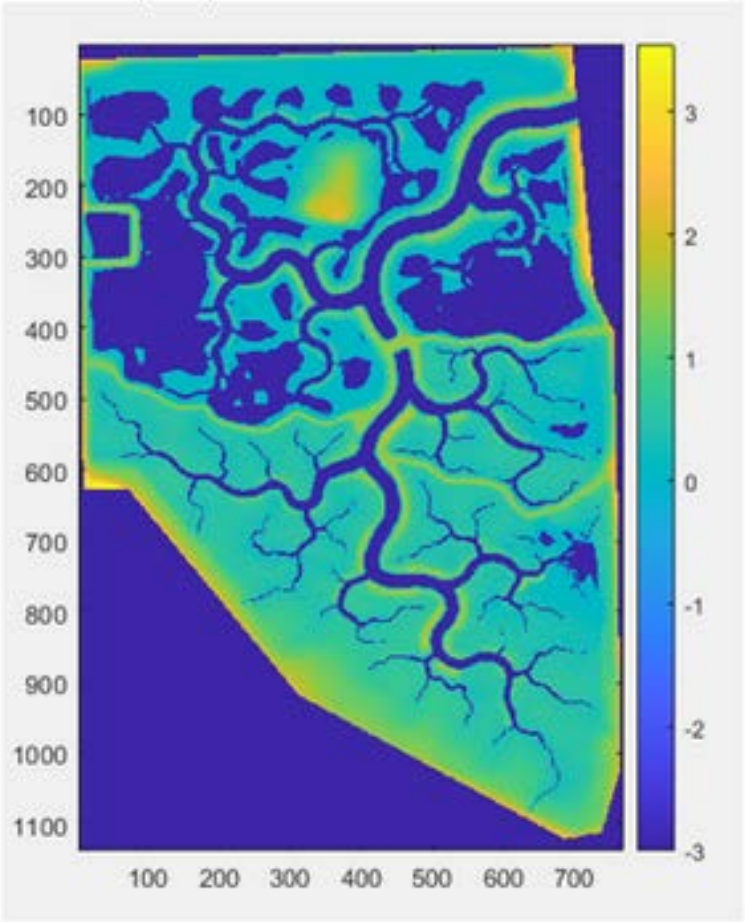




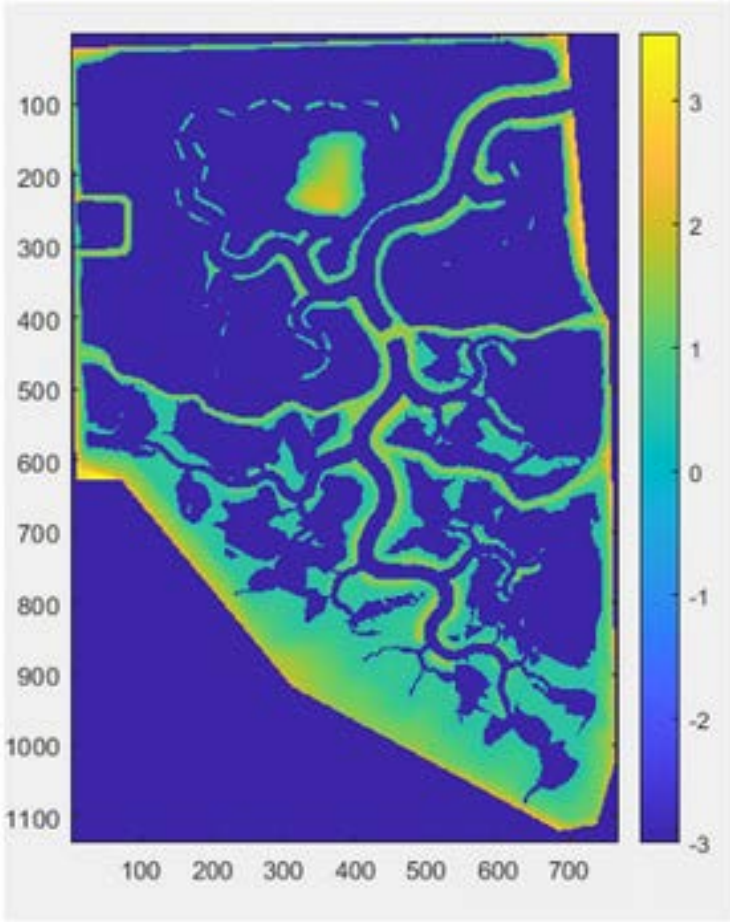
Outreach – High school students and community groups visit the field site. Undergraduate summer interns



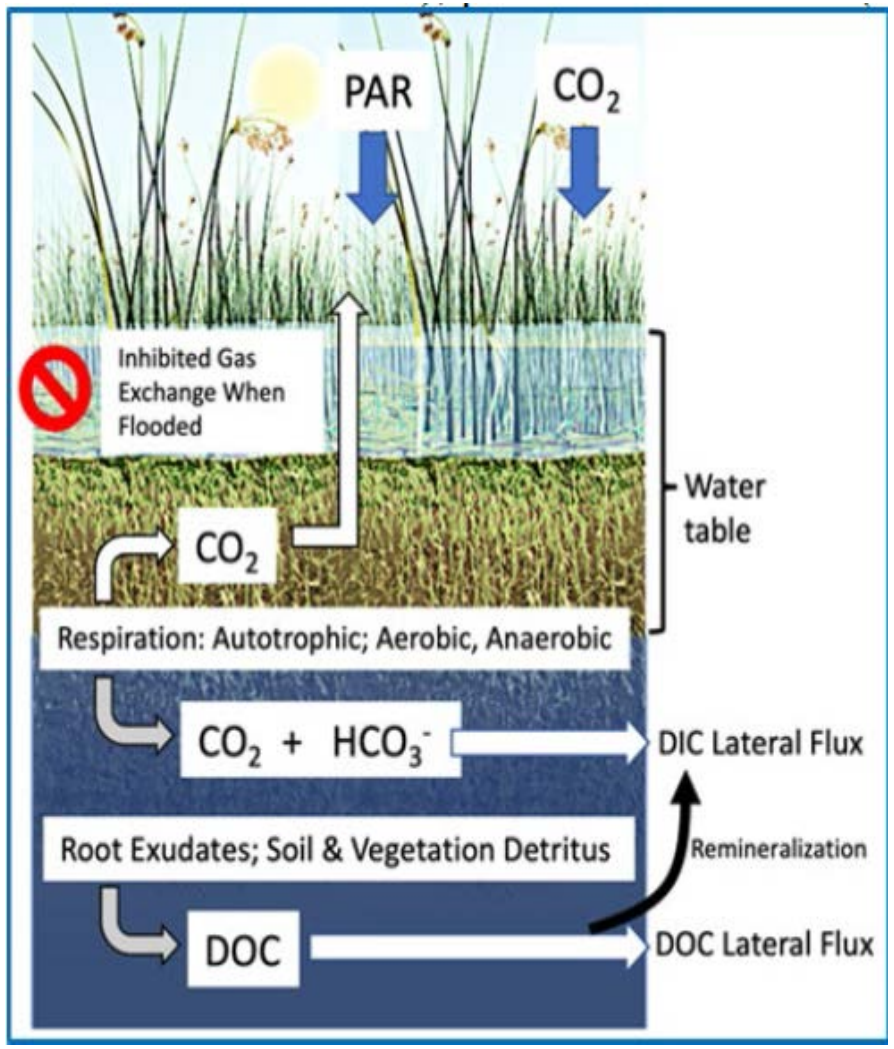
Sea level (zero): 94457 m3



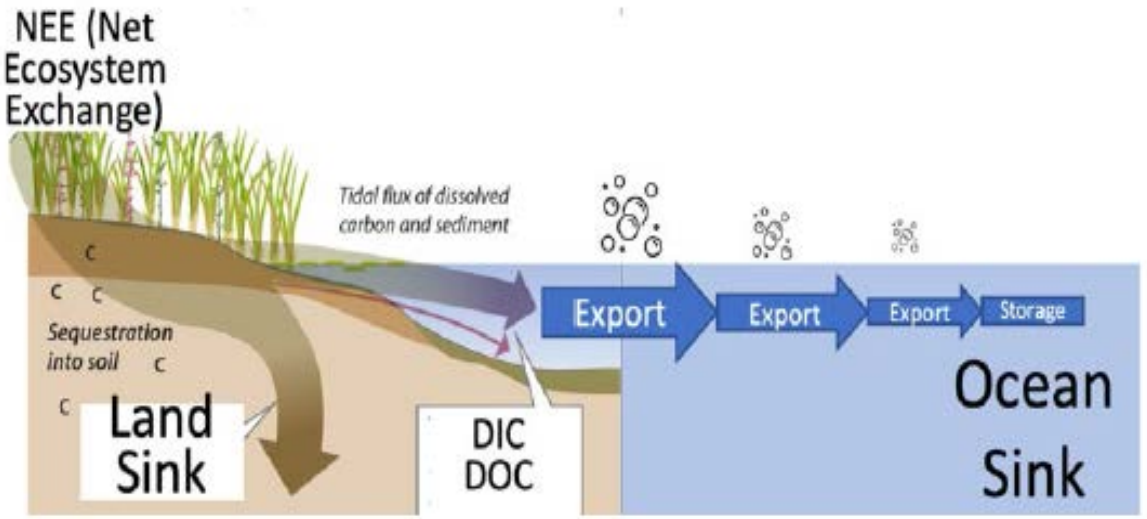
Tide at +0.5m: 253,828.5 m3



Digitized map of elevation of the wetland was produced to assess the change and volume of water as the water level rises and falls between tides. This helps us provide a constraint and independent measure of the volume flow we measure with the ACDP.



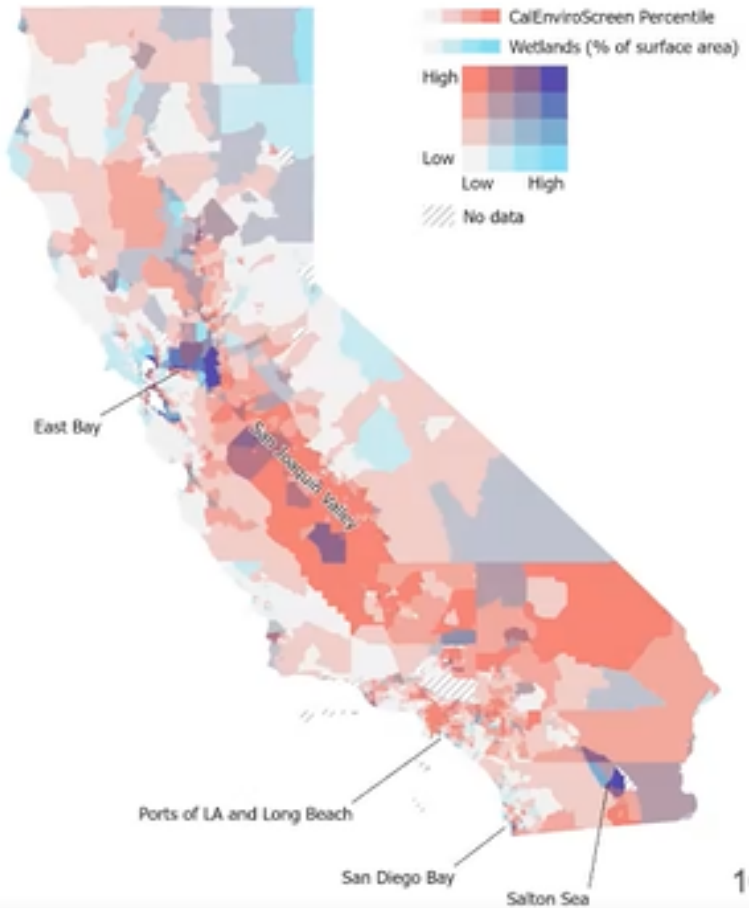
Coastal wetland sources, pathways, and mechanisms for DIC and DOC for lateral export. Variations in water table elevation relative to soil and rooting zone control the proportion of respired carbon that exits the system as vertical gaseous flux vs. lateral aquatic flux (adapted from Bogard et al., 2020 and Kroeger et al., 2022).



Areas with both high CalEnviroScreen cumulative impact score percentiles and high concentration of wetlands (% of surface area). Data source: OEHHA, 2021; *USA Wetlands*, 2022.

Finding: There are exceptions to this pattern. There are some areas of the state where wetlands coincide with significant environmental impacts and socially vulnerable communities. These include sites of ongoing industrial activities or recently de-industrialization.

- East Bay (industrial areas)
- Ports of LA/LB (pollution from port, containers, development, EJ activism)
- San Diego Bay (port-related diesel emissions)
- Salton Sea (agricultural runoff, asthma related impacts of drying lake, particularly among children)
- San Joaquin Valley
  - Kesterson National Wildlife Refuge (selenium)
  - Cantua Creek (water access and prices)
  - Tulare Lake Basin (water access and prices)



Garrison & Martinez, 2023

The new eddy covariance sites on the left and the list of all field sites in the AmeriFLux webpage on the right

Search Sites and Data Availability

Search all site info | california | Clear all search filters | Load Site Set | Load Filtered Search

Data Product All

Data Variables And Or
GPP
RECO
NEE
FC
FCH4

Data Characteristics
Data Use Policy Any Policy
Years Any in Range to
Record Length ≥ yrs

Site Characteristics
Vegetation (IGBP) Select 1 or more
Affiliated Network Select 1 or more
MAT ≤ °C
MAP ≤ mm
Lat ≤ °
Long ≤ °

Filters Applied And Or
Data Product: All
No Data Variables Selected
No Data Characteristics Selected
Search: All Metadata

More Data Variables & Filters | More Site Characterization Filters | Clear all search filters

Download Data | Export Results | Save as Site Set | Save Filtered Search

Search Results: 66 sites

Data Availability | Site Characteristics

Site Selector | Customize Columns | Map: None

Site ID	Name	Data Use Policy	AmeriFlux BASE Data	AmeriFlux FLUXNET Data	Lat	Long	Elev (m)	Veg	Clim	MAT (°C)	MAP (mm)	AmeriFlux BASE Start	AmeriFlux BASE End
US-Dmg	Dutch Slough Marsh Gilbert Tract	CC-BY-4.0			38.0015	-121.6691	1	WET	Csa	16.1	365		
US-EDN	Eden Landing Ecological Reserve	CC-BY-4.0	✔	✔	37.6156	-122.1140	null	WET	Csa			2018	2019
US-EKH	Elkhorn Slough Hester Marsh	CC-BY-4.0			36.8094	-121.7523	0.5	WET	Csb	10	894		
US-EKP	Elkhorn Slough Porter Marsh	CC-BY-4.0			36.8558	-121.7488	0	WET	Csb	10	894		
US-EKY	Elkhorn Slough Yampah Marsh	CC-BY-4.0			36.8105	-121.7487	0	WET	Csb	10	894		
US-Hsm	Hill Slough Marsh	CC-BY-4.0	✔		38.2368	-122.0212	1.113	WET	Csa	15.6	450	2021	2022
US-Myb	Mayberry Wetland	CC-BY-4.0	✔	✔	38.0499	-121.7650	-4	WET	Csa	15.9	338	2010	2021
US-Sne	Sherman Island Restored Wetland	CC-BY-4.0	✔	✔	38.0369	-121.7547	-5	GRA	Csa	16.09	311	2016	2020
US-Srr	Suisun marsh - Rush Ranch	CC-BY-4.0	✔		38.2006	-122.0264	8	WET	Csa	15.1	326	2014	2017
US-Tw1	Twitchell Wetland West Pond	CC-BY-4.0	✔	✔	38.1074	-121.6469	-5	WET	Csa	15.5	421	2011	2020
US-Tw4	Twitchell East End Wetland	CC-BY-4.0	✔		38.1027	-121.6413	-5	WET	Csa	15.6	421	2013	2021

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