Can Rice and Tule Wetlands Help Manage a Changing Delta?

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The Sacramento-San Joaquin Delta plays a critical role in conveying water to 3 million agricultural acres and over 25 million drinking water users. Conveyance faces ever-increasing challenges: sea level rise, land subsidence, increasing flood risk - particularly along the urbanized fringe, and failing fisheries. Coupled with these enormous challenges is a regional desire to maintain the local agricultural-based economy, recreation, and rural nature of a 700,000-acre open space located within an hour of several major metropolitan areas. Our team is examining the efficacy of shifting agricultural land uses towards a critical mass of rice and wetlands in the Delta to mitigate or reverse subsidence and greenhouse gas emissions and reduce hydrostatic pressures on levees, thereby reducing risk to water conveyance while supporting the Delta ecosystem and local agronomic economy. We compare three 'book-end' scenarios to help articulate the potential benefits, risks, and complexities associated with expanding rice agriculture and managed carbon sequestration wetlands in the Delta: (1) Business as Usual Delta (BAU), (2) Conveyance Delta (minimizing conveyance risk), (3) Agrarian Delta (where/how can rice and wetlands improve conditions for local producers). An important fourth scenario, Ecosystem Delta (where/how can rice and wetland distribution maximize ecological function and wildlife habitat), will be considered in the next phase of this project. Based on existing and new information gathered on GHG emissions from Delta BAU, rice, and carbon sequestration wetlands , economic impacts, and levee failure risk, we present Delta-wide maps identifying three tiers of potential strategic locations of rice and wetland land use (recommended, neutral, discouraged) for each scenario. Using findings on surface and groundwater flow models, soil carbon and subsidence, and an analysis of farm-scale management options and constraints from Twitchell and Bouldin Islands, we present island-scale best management strategies for developing rice and wetlands in the central-western subsided Delta.

Keywords: Carbon sequestration, wetlands, rice, agriculture, regional and island scales, GHGs

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Counting Carbon: Methane and Carbon Dioxide Emissions from Agricultural and Restored Delta Peatlands

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Over the past century, the practice of drained agriculture has resulted in extreme peat subsidence and sustained emissions of carbon dioxide from Delta islands. Reverting lands back to flooded conditions is an attractive intervention to abate further subsidence and improve ecosystem carbon storage in the Delta, since flooding inhibits peat oxidation to carbon dioxide. However, inundation also creates ideal conditions for the production of methane, a potent greenhouse gas and additional pathway of carbon loss. Quantification of the trade-offs between carbon dioxide and methane emissions from different Delta land uses is the first step towards understanding whether flooded landscapes can sustainably reverse the trend of chronic carbon loss in terrestrial Delta ecosystems.

In this study, we measured continuous carbon dioxide and methane fluxes at the landscape scale at four Delta sites with varying degrees of inundation: a drained pepperweed pasture (2007-2012) and a restored wetland (2010-2012) on Sherman Island, and a drained corn field (2012) and a rice paddy (2009-2012) on Twitchell Island. The sites experienced the same weather and climate due to their close proximity, so inundation was the strongest environmental contrast. The pasture and corn field were net carbon dioxide sources to the atmosphere in all years measured, and the pasture periodically emitted large amounts of methane from drainage ditches surrounding the field. The rice paddy was a slight sink for carbon dioxide and emitted relatively low amounts of methane in all years. The restored wetland was a net sink for carbon dioxide, although it was the largest emitter of methane of the four sites. Overall, flooded landscapes experienced less peat subsidence and carbon loss compared with the drained landscapes.

Keywords: carbon flux, land use dynamics, subsidence, methane emissions

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Greenhouse Gas Emission from Rice: A Crop to Address Water and Subsidence Issues in the Delta

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Greenhouse Gas Emissions (GHG) from corn and rice on Twitchell Island are currently being monitored. The objective is to determine the value of rice as an alternative crop to address water and subsidence issuesin the Delta. GHG are being monitored every one to three weeks. Overall, rice CH_4 emissions averaged 184 and 26 kg CH_4-C/ha for the 2010 and 2011 rice growing seasons, respectively. During 2011 most of the $CH_4$was emitted during the winter. Total CO_2 emission from bare soil was slightly higher in rice than corn during 2011 (11,200kg CO_2-Cand 9600kg CO_2-C/ha, respectively). During spring-fall 2010 period, corn averaged slightly higher than rice (6600kg CO_2-C and 7450kg CO_2-C/ha, respectively). The most significant difference between the crops was the emission of 184 and 411kg CH_4-C/ha from rice during 2010 vs. 2011 rice seasons, respectively. Total estimated residue carbon input from both crops was similar in 2011 (about 5 metric tons C/ha) but much higher for the corn in 2010 (5 and 9 metric tons C /ha in the rice and corn, respectively). The current practice in the corn system of residue removal for cattle feed by the local farmer would bring the estimated corn residue C input in 2011 to less than 1 metric tons/ha. The data presented here suggests that both systems have a net loss of C and that more than 90% of the GHG emissions in rice occur during winter when rice is not flooded. More than 90% of the N_2O and 40% of the CO_2 is emitted during the fallow period in the corn system. Since winter/spring is the highest emission period for both crops, alternative managements should be studied to reduce GHG emissions during this period.

Keywords: methane, nitrous oxide, soil organic carbon, rice, corn, subsidence reversal

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The Economics of Establishing Rice-Based Cropping Systems in the Delta

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Farming practices in the Delta over the last century have resulted in substantial subsidence of the islands, increasing levee fragility, risks to water conveyance, GHG emissions from oxidized soils, and decreasing water quality. Our goal is to demonstrate that the establishment of rice-based cropping systems is one agricultural solution for the Delta. Rice is expected to result in important environmental benefits: concurrently mitigating GHG emissions, soil loss, and subsidence while also reducing risks to California's water supply, protecting water quality and enhancing the ecosystem and agriculture. This paper explores the economics associated with converting traditional Delta grown crops, to rice.

We have estimated current and future costs and benefits of converting about 14 of the most commonly grown crops in the Delta to rice production and analyzed: 1) the net present value of converting each crop to rice over time, 2) issues associated with the conversion (changes in cultural practices, capital requirements, etc.), and, 3) projections of yields, prices and costs of production for each crop.

Taking into account the risks and uncertainties associated with rice conversion in the Delta, we have found that rice is a feasible replacement for many of the crops grown in the Delta. For crops that are not feasibly replaced by rice, we have found a number of potential strategies and alternatives.

While it is too early to come to a definitive conclusion about widespread rice production in the Delta, our current results indicate that rice can be a feasible replacement for many traditional crops currently grown in the Delta. However, there are a number of other variables that may potentially enhance, or in contrast, may have negative impacts, on the overall feasibility of establishing rice-based cropping systems in the Delta. These will form the main basis of discussion.

Keywords: Rice-based Cropping Systems, Economics, Cost and benefits, agriculture, ecosystem

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Ongoing Efforts to Develop Pilot Projects and Protocols for Verification of GHG Reductions in the Delta

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With more than 250,000 acres of deeply subsided (up to 25 feet) peat soils currently in agriculture, can managed carbon wetlands and rice cultivation in the Delta be implemented at scale to realize carbon sequestration and subsidence reversal benefits? For over 15 years a team of academics and agencies have been studying two 7 acre plots of managed wetlands planted in tule. Additional research has analyzed the economic viability of managed wetlands as compared to agriculture commodities in the Delta. These efforts indicate that conversion to managed wetlands reduces subsidence and greenhouse gas emissions associated with agriculture production practices. Carbon sequestration rates are high, variability of trace gas emissions is potentially high and requires more research, and economic viability will depend on the future of the carbon market and the development of protocols for verification of GHG reductions in the Delta. Based on these results a team of agencies, academics and nonprofit organizations is seeking to implement farm scale pilot projects at several locations in the Delta, and develop a protocol for adoption by voluntary carbon registries and for consideration in California's cap and trade program. In this session we will present the results of an economic analysis of the potential for conversion to carbon farming in the Delta. We will discuss the ongoing efforts to fund and develop pilot projects and outline the different elements required for carbon trading to take place, including science and modeling needs, greenhouse gas accounting protocols, verification requirements, and carbon pricing, and we will discuss carbon trading in voluntary and compliance markets.

Keywords: carbon sequestration, subsidence reversal, managed wetlands for carbon, GHG protocols

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