Pre-restoration GHG Dynamics of a Freshwater Coastal Wetland in Southeast Australia

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Coastal wetland restoration is emerging as a promising climate change mitigation solution in Australia, with recent policy and management focus on the importance of “blue carbon” ecosystems. However, little is known about the impact of tidal reinstatement on the greenhouse gas (GHG) dynamics of these ecosystems. This knowledge gap is particularly significant given the scarcity of pre-restoration data available, which limits our understanding of the restoration process and its effect on the radiative balance of coastal wetlands. Coastal wetlands can act as a sources or sinks, defined by a positive or negative overall GHG flux, which is critical to estimating the radiative balance of the ecosystem. Everlasting Swamp, located in northern New South Wales is a large (1700 ha) coastal wetland, which was tidally disconnected 100 years ago for agricultural use, and has been identified as a site with future restoration potential. In the winter of 2024 and summer of 2025, soil-atmosphere GHG fluxes (carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)) and physicochemical characteristics were measured via the opaque static chamber method across 3 transects spanning elevation and vegetation gradients to provide pre-restoration baseline. Across both seasons, Everlasting Swamp was a net source of all target gases, and highly variable (mean CO_2 = 134.1 ± 129.7 μg m^{-2} s^{-1}, mean CH_4 = 1.0 ± 2.9 μg m^{-2} s^{-1}, mean N_2O = 0.009 ± 0.01 μg m^{-2} s^{-1}), which are similar to those measured at Burdekin catchment in Queensland, Australia. Mann-Whitney U tests indicated no seasonal difference in the CO_2 flux (winter mean = 130.7 μg m^{-2} s^{-1}, summer mean = 112.6 μg m^{-2} s^{-1}, p=0.3), or N_2O flux (winter mean = 0.02 μg m^{-2} s^{-1}, summer mean = 0.005 μg m^{-2} s^{-1}, p = 0.15), but CH_4 fluxes were significantly higher in summer than winter (winter mean = 0.02 μg m^{-2} s^{-1}, summer mean = 0.1 μg m^{-2} s^{-1}, p = 0.01). Preliminary analysis of the regressions with the physicochemical variables identified the key statistically significant drivers shaping gas flux dynamics. The most significant driver of CO_2 flux was moisture content, with a strong inverse correlation (r = -0.70 p < 0.001). CH_4 was positively associated with soil moisture content (r = 0.51, p = 0.01) and porewater nitrite concentration (0.69, p = 0.010), and negatively associated with soil bulk density (r = -0.63, p = 0.001) and porewater ammonia concentration (r = -0.56, p = 0.047). None of the measured parameters showed statistically significant correlations with N_2O flux. Further analysis into the drivers controlling GHG fluxes will provide critical insights into how tidal reinstatement may alter the radiative balance of coastal wetlands in southeast Australia, informing future restoration efforts and climate change mitigation strategies.