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White Paper on Carbon Sequestration and Tidal Salt Marsh Restoration

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Summary:

This white paper provides a brief summary of current literature on the ability of tidal salt marshes to sequester carbon. Knowledge in this field is changing rapidly, so this paper must be considered a work in progress that we will update regularly as new information is available.

From the standpoint of habitat restoration, recent research shows that restoring tidal salt marshes is one of the most effective measures for sequestering carbon that we can take. While people often look to planting trees as a way to take carbon from the atmosphere, marsh restoration may be even more efficient, per unit area, at removing carbon. Tidal marshes are extremely productive habitats that capture significant amounts of carbon from the atmosphere, large amounts of which are stored in marsh soils. Carbon content in soils, especially in deeper layers, is the best measure of long-term, continuing carbon storage. Chmura, et al. (2003) give data from Patrick and DeLaune (1990) who measured the soil carbon accumulation at Bird Island and an Alviso marsh, both in the South San Francisco Bay, at 54g C/m^2/yr and 385 g C/m^2/yr, respectively. Recent data from deeper cores at Greco Island, an ancient marsh in the South Bay, representing a 100-year time span showed organic accumulation averaging 150 to 250 g C/m^2/yr range (Callaway and Drexler, unpublished data). These are currently the best estimates of longer-term carbon sequestration in South Bay marshes.

Unlike many freshwater wetlands, saltwater tidal marshes release only negligible amounts of methane, a powerful greenhouse gas; therefore, the carbon storage benefits of tidal salt marshes are not reduced by methane production. In addition, as sea levels rise, tidal marsh plains continue to build up to match the rise in water level, if suspended sediments are adequate, continually pulling carbon dioxide out of the air in the process. While specific research is needed to quantify the carbon sequestration capacity of San Francisco Bay tidal marshes, in general, restoring tidal marshes is certainly an effective method for removing carbon dioxide from the atmosphere. Marsh restoration should be actively pursued as a method to sequester carbon. Some literature supporting this summary is given below.

In their review of North American wetlands, Brigham et al. (2006) state that, “Estuarine wetlands sequester carbon at a rate about 10-fold higher on an area basis than any other wetland ecosystem due to high sedimentation rates, high soil carbon content, and constant burial due to sea level rise.” Choi, et al. (2004) conclude that, “Because of higher rates of C sequestration and lower CH_4 emissions, coastal wetlands could be more valuable C sinks per unit area than other ecosystem in a warmer world”.

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Literature Information:

1. Salt marshes are widely recognized as some of the most productive ecosystems on earth, with primary productivity that rivals industrialized agriculture (Mitch and Gosselink, 2000). Tidal marshes can produce up to 8000 metric tons of plant material per year (Mitch and Gosselink 2000), a process by which plants continually remove CO_2 from the atmosphere and convert it to plant material. Marsh grasses and other macrophytes, microalgae on the mud surface, and phytoplankton are the three primary components of the natural community that remove CO_2. While some of this annual productivity will be consumed or decompose and therefore not stored for the long-term, some percentage of this carbon accumulates and is sequestered in tidal marsh soils. When stored in the soil, the carbon is taken out of the system as decomposition rates under anaerobic conditions are low. As a result, wetland soils are well-known as major carbon-storing ecosystems (Brigham, et al. 2006, Chmura, et al. 2003).

2. Some of the above-ground and root biomass of marsh plants becomes part of marsh soils where it is captured for the long-term. In central and southern California tidal salt marshes, aboveground vascular plant and macrophyte productivity is about 240-340 g of carbon per square meter per year and algal productivity adds an additional 185-340 g of carbon per square meter per year (Zedler 1980). Within San Francisco Bay, Mahall and Park (1976) estimated annual above ground primary productivity for *Spartina foliosa* from 270 to 690 g $C/m^2/yr$, and 550 to 960 g $C/m^2/yr$ for *Sarcocornia pacifica* (formerly *Salicornia virginica*). In comparison, Atwater et al. (1979) did not estimate annual productivity but found end-of-year biomass ranging from 500 to 1500 g/m^2 for *S. foliosa* and 500 to 1200 g/m^2 for *S. pacifica* (J. Callaway, pers. comm.).

3. Above- and below-ground plant biomass represents a *standing pool* of carbon captured by plants, which remains the same each year unless more acreage of marsh becomes vegetated. The plants themselves do not contribute to continual carbon storage because marsh plants do not build up woody material from year to year, as trees do. Thus, estimates of carbon sequestration in estuarine systems do not include contributions from the living plants (Brigham et al. 2006). Rather, carbon content in soils, especially in deeper layers, is the best measure of long-term, continuing carbon storage (Brigham, et al. 2006). Chmura, et al. (2003) give data from Patrick and DeLaune (1990) who measured the soil carbon accumulation at Bird Island and an Alviso marsh, both in the South San Francisco Bay, at 54g $C/m^2/yr$ and 385 g $C/m^2/yr$, respectively. Recent data from deeper cores at Greco Island, an ancient marsh in the South Bay, representing a 100-year time span showed organic accumulation averaging 180 to 200 g $C/m^2/yr$ range (Callaway and Drexler, unpublished data). These are currently the best estimates of longer-term carbon sequestration in South Bay marshes.

4. The Intergovernmental Panel on Climate Change (n.d.) specifically discusses restoration of former wetlands as a strategy to sequester carbon from the atmosphere. The IPCC states that restoration of former wetlands will remove CO_2 from the air and increase storage in soils. Thus, they recommend wetland restoration as a carbon sequestration strategy.

5. One concern with wetland restoration is that many freshwater wetlands emit methane (CH_4), a powerful greenhouse gas. Thus, the carbon storage benefit from freshwater wetlands can

be greatly reduced by wetland methane production. However, tidal salt marshes release "negligible amounts of greenhouse gases and store much more carbon per unit area" (Chmura, et al. 2003) due to salt water soil processes. Thus, the benefits of salt marsh restoration for carbon sequestration are great and are not offset by methane production (Brigham, et al. 2006).

6. Choi, et al. (2001) found that as sea levels rise, the marsh plains continue to build up (accrete) and, as they do, they continually store carbon in the process. Thus, not only do tidal marshes help protect uplands from storm events, but they continue to take carbon from the atmosphere as sea levels rise, as long as there a large enough input of mineral sediments to build marsh soil and keep pace with sea-level rise. Choi, et al. (2004) conclude that, "Because of higher rates of C sequestration and lower CH_4 emissions, coastal wetlands could be more valuable C sinks per unit area than other ecosystem in a warmer world". In addition, in their review of North American wetlands, Brigham et al. (2006) state that, "Estuarine wetlands sequester carbon at a rate about 10-fold higher on an area basis than any other wetland ecosystem due to high sedimentation rates, high soil carbon content, and constant burial due to sea level rise."

7. It is important to note that when wetlands are drained the once anaerobic soils become exposed to the air. Increased rates of aerobic decomposition in these drained soils will release stored carbon back into the atmosphere as carbon dioxide.

Citations

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