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Blue Carbon Ecosystem- A Mitigating Tool for Climate Change

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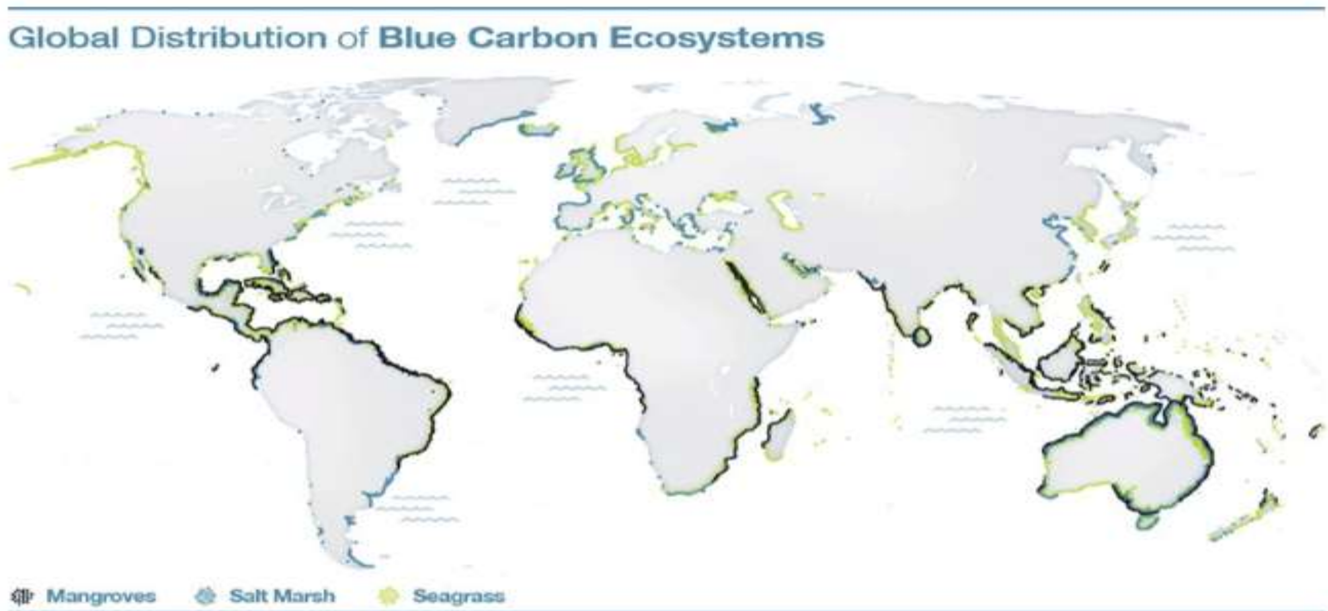
SUMMARY

Blue carbon ecosystems, including mangroves, seagrasses, and salt marshes, are vital for addressing climate change and supporting environmental and economic stability. These ecosystems are exceptional carbon sinks, capturing and storing carbon dioxide from the atmosphere at rates significantly higher than terrestrial forests. Their ability to sequester carbon for centuries makes them critical tools for mitigating global greenhouse gas levels. Additionally, they serve as natural buffers, protecting coastlines from erosion, storm surges, and rising sea levels, thereby enhancing the resilience of coastal communities to climate impacts. Beyond their economic value, they offer cultural and social significance to many coastal and indigenous communities. Furthermore, these ecosystems improve water quality, filter pollutants, and play a crucial role in nutrient cycling, benefiting adjacent ecosystems.

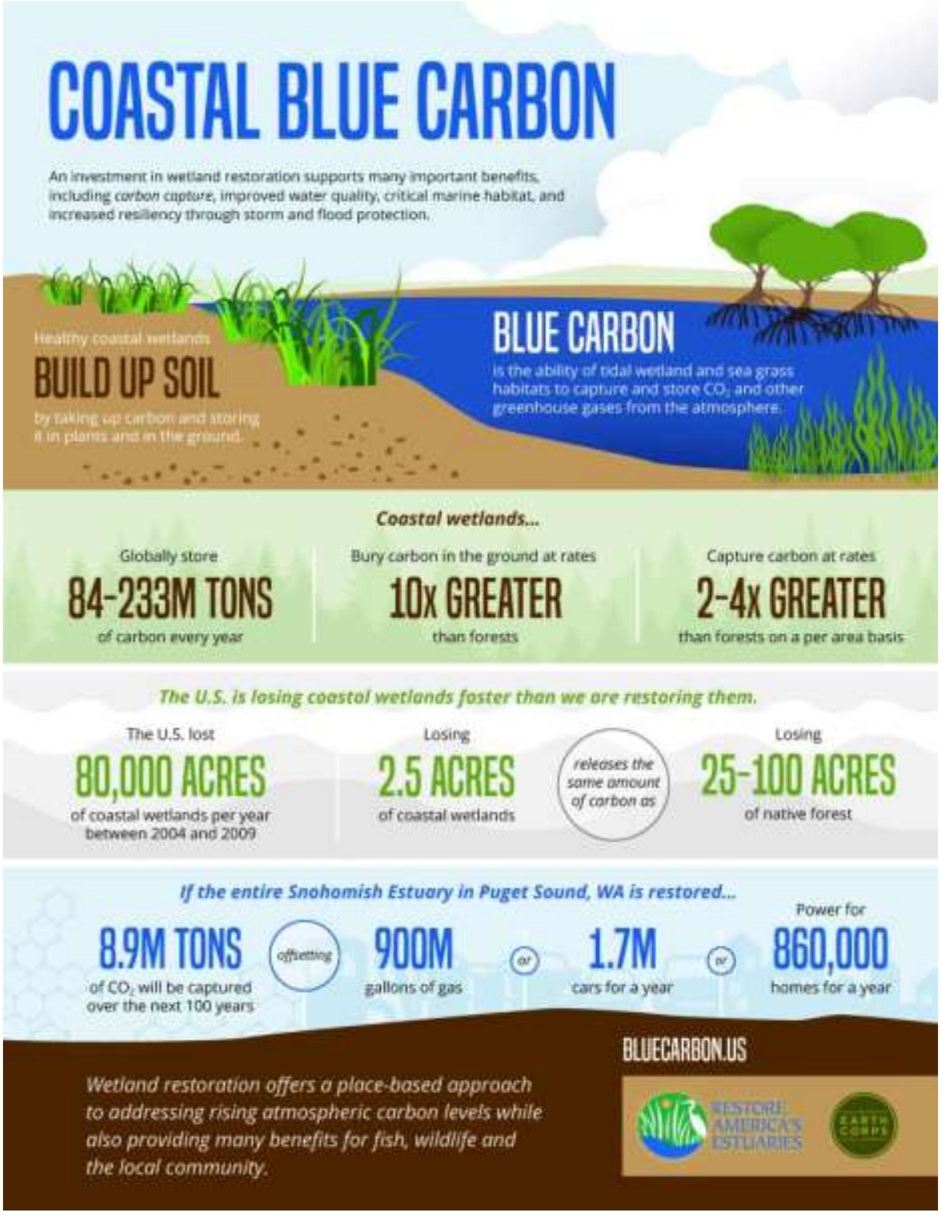
INTRODUCTION

Blue carbon is the carbon stored in coastal and marine ecosystems such as mangroves, tidal marshes and seagrasses. These ecosystems sequester and store large quantities of blue carbon in both the plants and the sediment below. The ability of these vegetated ecosystems to remove carbon dioxide (CO2) from the atmosphere makes them significant net carbon sinks, and they are now being recognised for their role in mitigating climate change. Conserving and restoring terrestrial forests, and more recently peatlands, has been recognised as an important component of climate change mitigation. Several countries are developing policies and programmes in support of sustainable development through initiatives that reduce the carbon footprint associated with the growth of their economies. The global average atmospheric carbon dioxide (CO_2) concentration rose to 387 parts per million (ppm) in December 2009 (ESRL/NOAA 2009), the highest level it has reached over the past 800000 years (Luthi et al. 2008) and more than 38% above the pre-industrial value of roughly 280 ppm (Raupach and Canadell 2008). There is a broad consensus among the scientific community that this increase in CO_2 is driven primarily by the burning of fossil fuels and changes in land use (Solomon et al. 2007). Land use change results in CO_2 emissions through clearance of natural vegetation, forest fires, and agricultural activities, as well as through the deterioration of ecosystems that serve as natural carbon (C) sinks (Solomon et al. 2007). A more recent approach suggests refocusing efforts from a single emissions reduction strategy to a plan that combines reducing anthropogenic sources of CO_2 (mitigation) with supporting CO_2 uptake and storage through the conservation of natural ecosystems with high C sequestration rates and capacity (Canadell and Raupach 2008).



Blue Carbon:

The carbon (C) sequestered in vegetated coastal ecosystems, specifically mangrove forests, seagrass beds, and salt marshes, has been termed “blue carbon”. Marine ecosystems particularly coastal vegetated ecosystems such as mangroves, seagrasses, and salt marshes have demonstrated capacity for sequestering carbon in both the plant biomass above ground and in the subsurface sediment layer. For that reason, those vegetated areas are now widely acknowledged as important natural sinks for greenhouse gases (GHGs). The first “Blue Carbon” International Scientific Working Group Meeting washeld at UNESCOHeadquarters in Paris, France 15to17 February 2011. The meeting was organized by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, Conservation International (CI), and the International Union for Conservation of Nature (IUCN). During three days, thirtyparticipants from ten countries attended to coordinate and guide the establishment of theBlue Carbon Scientific Working Group, which will distribute its recommendations through a meeting report to be published in March 2010.



The efficient preservation of the carbon under these habitats is due to:

1. Slow decomposition rates;

2. Low nitrogen and phosphorous concentrations in plant tissues;

3. Low oxygen levels in the sediments; and the

4. Allocation of a large fraction, often exceeding 50%, of plant biomass production to roots and rhizomes that are buried into the soil.

5. In addition, the entangled network of roots (and rhizomes) and the dense canopy of coastal vegetation protect soil carbon deposits from erosion. Indeed, some vegetated coastal habitats can support organic-rice soils that deserves conservation measures.

Different Coastal Habitats

1. Mangroves

Mangroves are a type of tropical forest, found at the edge of land and sea and flooded regularly by tidal water. It occurs along the coasts of most major oceans in 118 countries, adding ~30–35% to the global area of tropical wetland forest over peat swamps alone. Renowned for an array of ecosystem services, including fisheries and fibre production, sediment regulation, and storm/tsunami protection,mangrovesare nevertheless declining rapidly as a result of land clearing, aquaculture expansion, overharvesting, and development. A 30–50% areal decline over the past half-century has prompted estimates that mangroves may functionally disappear in as little as 100years.

Mangroves are among the most carbon-rich forests in the tropics. It is estimated that the average annual carbon sequestration rate for mangroves averages between 6 to 8 Mg CO_2 e/ha (tons of CO_2 equivalent per hectare). These rates are about two to four times greater than global rates observed in mature tropical forests. Organic-rich soils ranged from 0.5m to more than 3m in depth and accounted for 49–98% of carbon storage in these systems. . Mangrove soils consist of a variably thick, tidally submerged suboxic layer (variously called 'peat' or 'muck')supporting anaerobic decomposition pathways and having moderate to high C concentration

2. Tidal Marshes

Tidal marshes are coastal wetlands with deep soils that are built through the accumulation of mineral sediment and organic material and then flooded with salty water brought in by the tides. Almost all of the carbon in tidal marsh ecosystems is found in the soil, which can be several meters deep. It is estimated that the average annual carbon sequestration rate for tidal marshes averages **between 6 to 8 Mg CO e/ha (Mg of CO equivalent per hectare)**. These rates are about two to four times greater than those observed in mature tropical forests.

3. Seagrasses

It is submerged flowering plants with deep roots that are found in meadows. Carbon accumulates in seagrasses over time and is stored almost entirely in the soils, which have been measured up to four meters deep. Although seagrasses account for less than 0.2% of the world's oceans, they sequester approximately 10% of the carbon buried in ocean sediment annually (27.4Tg of carbon per year). Per hectare, seagrasses can store up to twice as much carbon than terrestrial forests. The global seagrass ecosystem organic carbon pool could be as high as 19.9 billion metric tons. Seagrass meadows filter sediment and other nutrients from the water and are constantly building and securing sediment, which buffers coasts from erosion, storms and flooding. They are also important habitats for fisheries and flagship marine species, such as sea turtles and manatees.

CONCLUSIONS

Recent assessments suggest that about one-third of mangrove, seagrass, and salt marsh areas have already been lost over the past several decades as a result of reclamation, deforestation, engineering and urbanization, transformation to aquaculture ponds (Green and Short 2003; Duarte et al. 2005b; Silliman et al. 2009), and climate change (Woodroffe 1995; Björk et al. 2008). Coastal eutrophication, siltation, and development have led to seagrass decline (Duarte 2002; Green and Short 2003; Duarte et al. 2005b; Waycott et al. 2009), and mangroves and salt marshes have been damaged by dredging, filling, dyking, drainage, trophic cascades, and invasive species (Valiela et al. 2001; Alongi 2002; Silliman et al. 2005; Silliman et al. 2009). Sea-level rise can erode and flood mangroves and salt marshes (Woodroffe 1995; Silliman et al. 2009), and increase water depths above existing sea grass Currently, blue carbon sinks lose between ~0.7–7% of their area annually (Costanza et al. 1997; Valiela et al. 2001; Alongi 2002; Duarte et al. 2005a; Bridgham et al. 2006; FAO 2007; Duarte et al. 2008; Waycott et al. 2009; Spalding et al. 2010). While the global average annual loss of mangroves has slowed from 1.04% in the 1980s to 0.66% in the 5 years before 2005 (Spalding et al. 2010), seagrass loss rates have accelerated over the past several decades, from 0.9% per year before 1940 to 7% per year since 1990 (Waycott et al. 2009). Such losses reduce their capacity for C storage and have serious implications for human populations that depend on these ecosystems for food, livelihoods, and coastal protection.

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