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The role of Seagrass in Climate Change Mitigation and Adaptation

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Photo: Rachel Sussman

What are seagrasses?

- Angiosperms (flowering plants) adapted to life in the sea (down to 60 m).
- About 60 species worldwide
- Present in all continents covering between 200,000 and 600,000 Km^2 globally.
- Clonal plants with extended life span (oldest living organism: seagrass clon , *Posidonia oceanica*, in the Mediterranean, Formentera Island, > 50,000 years old).
- Highly productive and develop massive belowground biomass (roots and rhizomes)

Photo: Joan Costa (www.joancostaphoto.com)

Key Role as Carbon Sinks

- 1: High net primary production and sediment trapping capacity.
- Entangled network of roots and rhizomes prevents erosion
- 2: Low decomposition rate in O2 deficient sediments.
- high C/N/P ratios.
- absence of fires underwater!.

Photo: Joan Costa (www.joancostaphoto.com)

Assessing Carbon storage

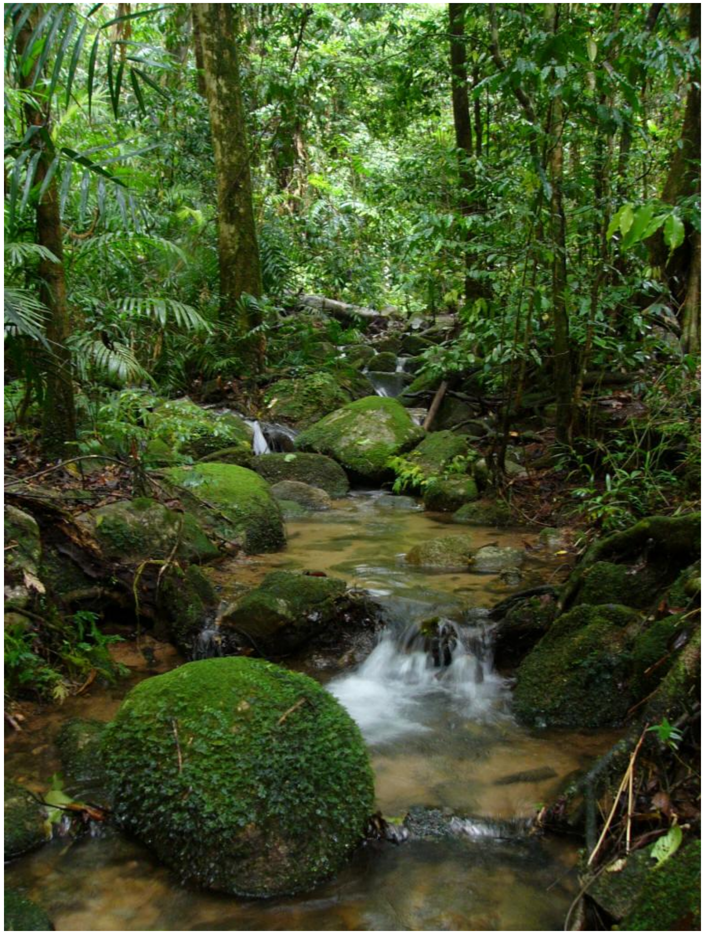
- 1: Estimate of organic carbon concentration (CHN analyzer, high precision) and bulk density in soils.

- 2. Estimate of time-at-depth using ^{210}Pb dating (high precision).

- 3. Combination of 1 & 2 to derive Carbon burial rates (and variability over time).

Seagrass meadows are strong natural C sinks:
even greater than the pristine Amazonian forest

1.02 t C ha^{-1} $year^{-1}$ (Grace et al. 1993)



Up to 17 t C ha^{-1} $year^{-1}$ (Duarte et al. 2005)

Long-term C burial in vegetated soils is 2 orders of magnitude higher in coastal marine than terrestrial ecosystems

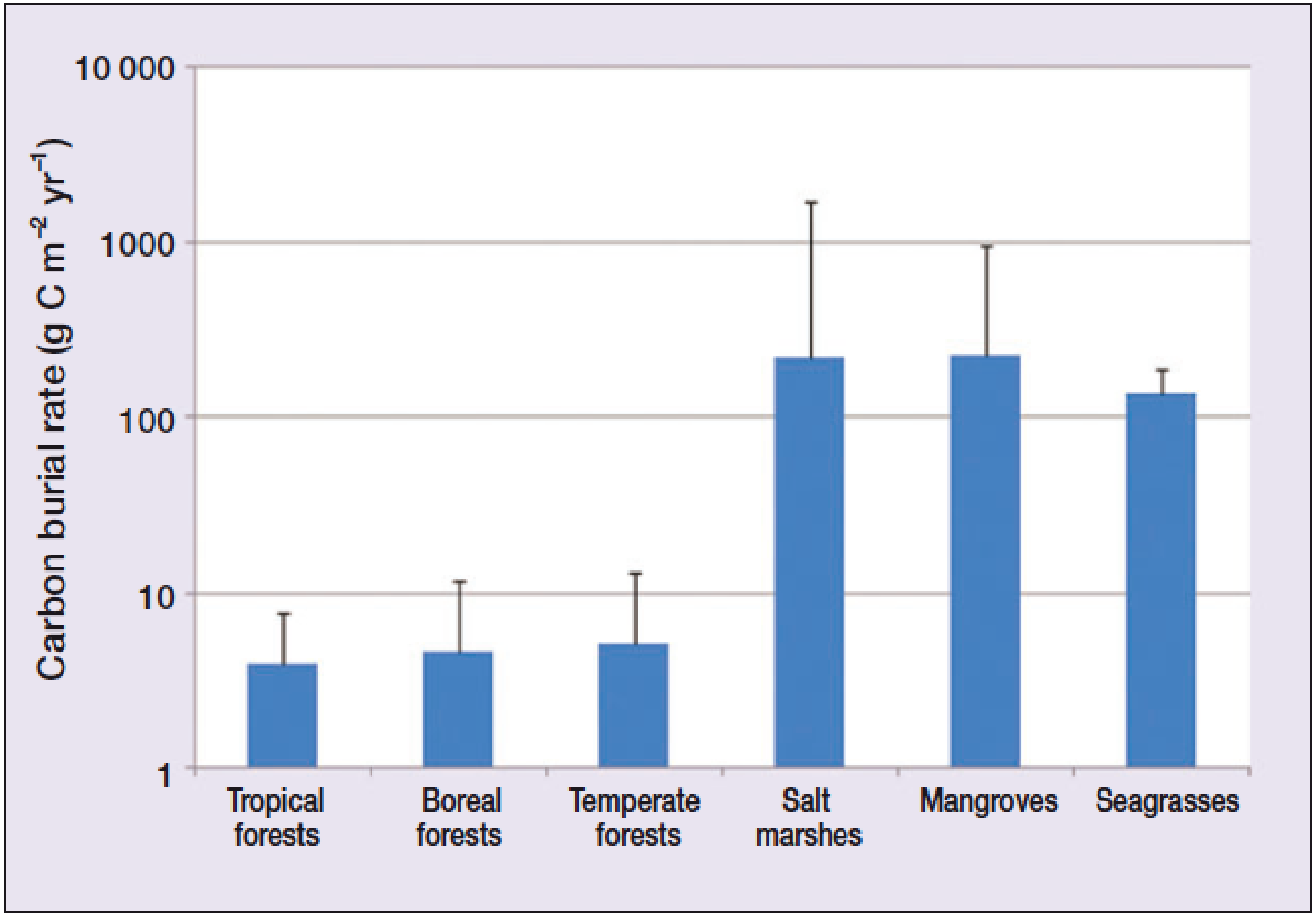
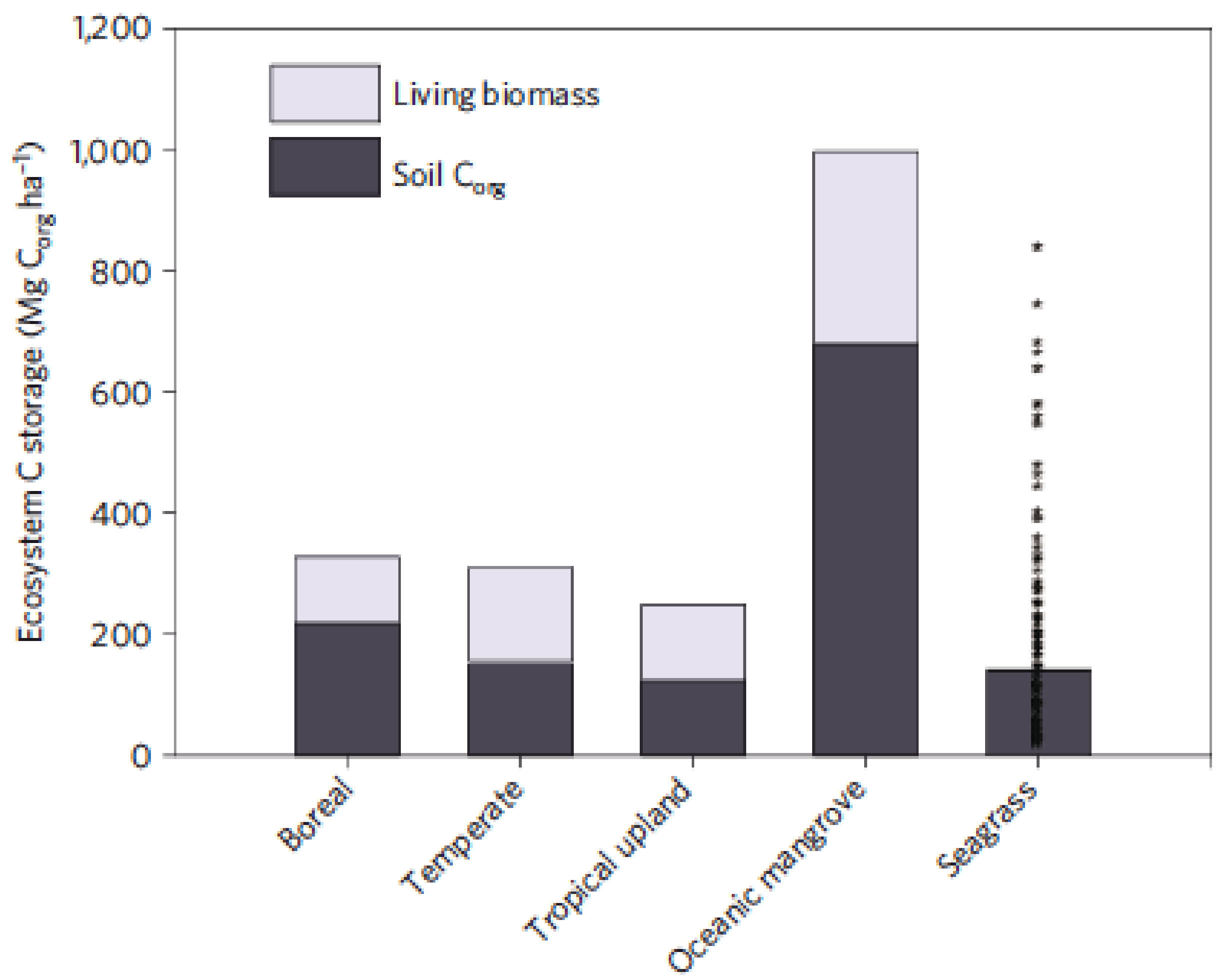


Figure 5. Mean long-term rates of C sequestration (g C m^{-2} yr^{-1}) in soils in terrestrial forests and sediments in vegetated coastal ecosystems. Error bars indicate maximum rates of accumulation. Note the logarithmic scale of the y axis. Data sources are included in Tables 1 and 2.

Vegetated coastal communities are responsible of the 46.9 % of the total carbon burial in the ocean

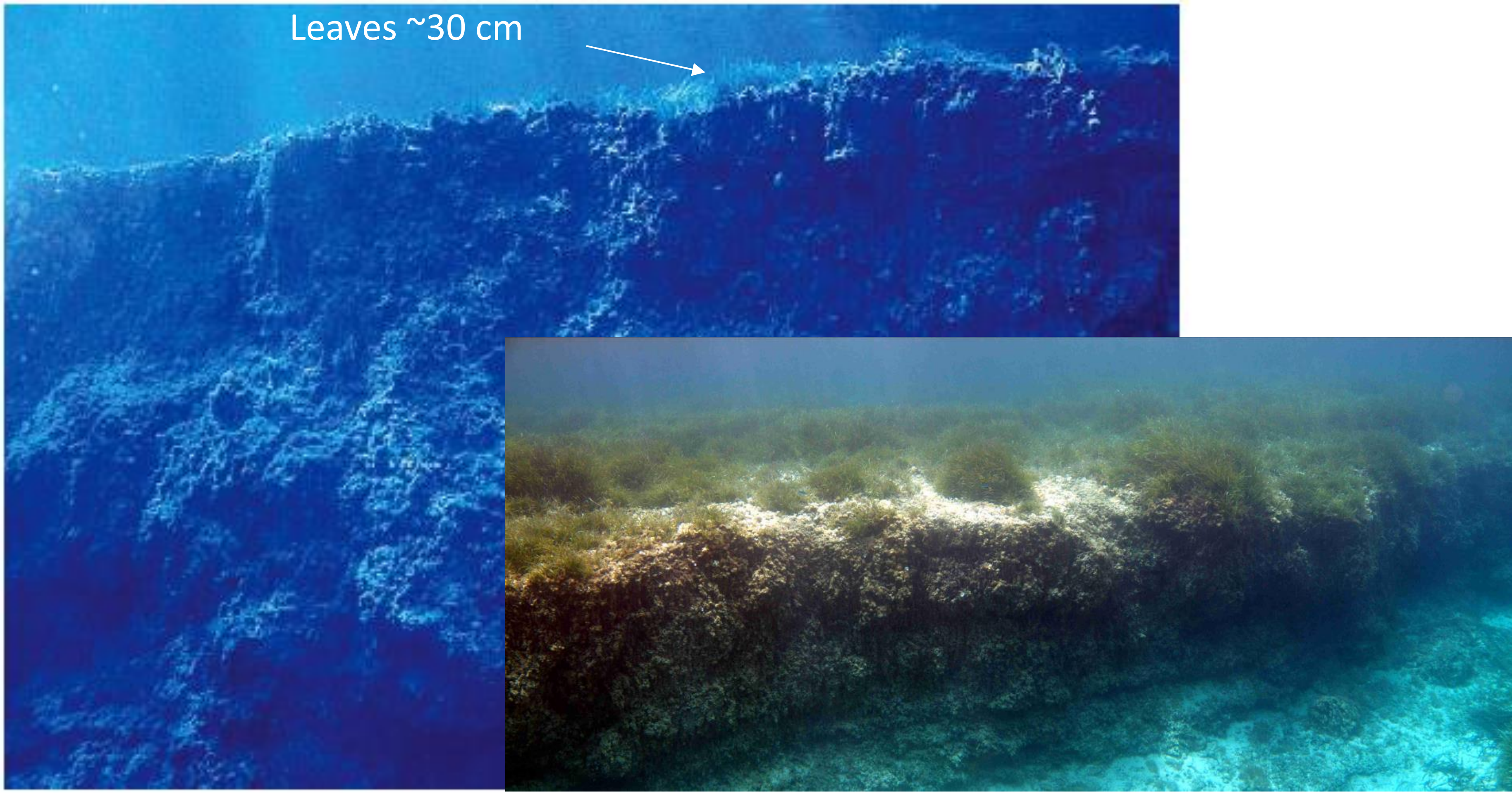
McLeod et al (2011)

Carbon storage in seagrass soils can also exceed that in land forests



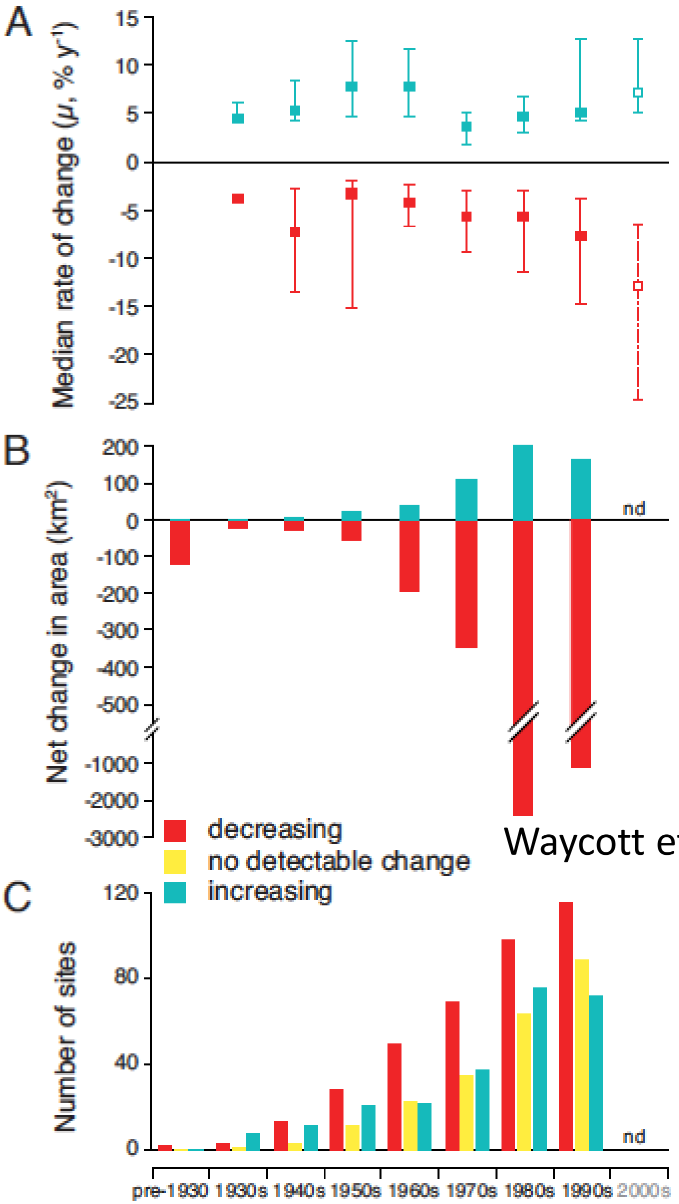
Foruqurean et al (2012)

Seagrass can develop massive reefs (e.g. 4 m tall *Posidonia oceanica* reef in Formentera, Spain, 11 m in Port Lligat, Spain)



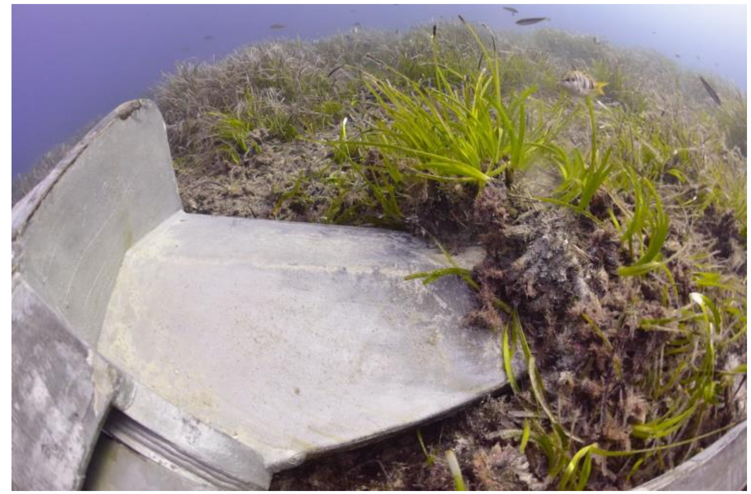
Raise the seafloor with organic-rich materials that are preserved over millennia (if seagrass meadow is conserved) at rates of 06. to 6 mm year^{-1} (Duarte et al. 2013)

Seagrass meadows are declining at fast rates



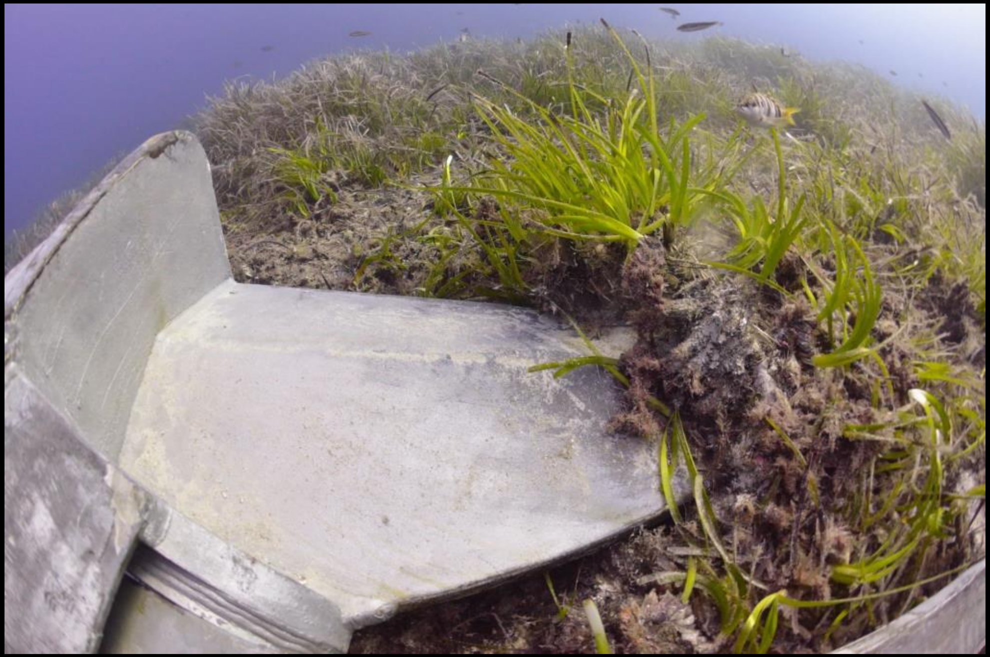
Waycott et al (2009)

Fig. 1. Decadal trends in seagrass areal extent. Sites were categorized as declining in area, as increasing in area, or as having no detectable change (i.e., ±10% of initial area). Values for the 2000s (dotted line) include 2000–2006 data only. nd, not determined because of incomplete data. (*A*) Median % rate of change (μ) by decade across sites. Error bars represent 25% and 75% quartiles. (*B*) Measured net change in seagrass area, calculated as the net



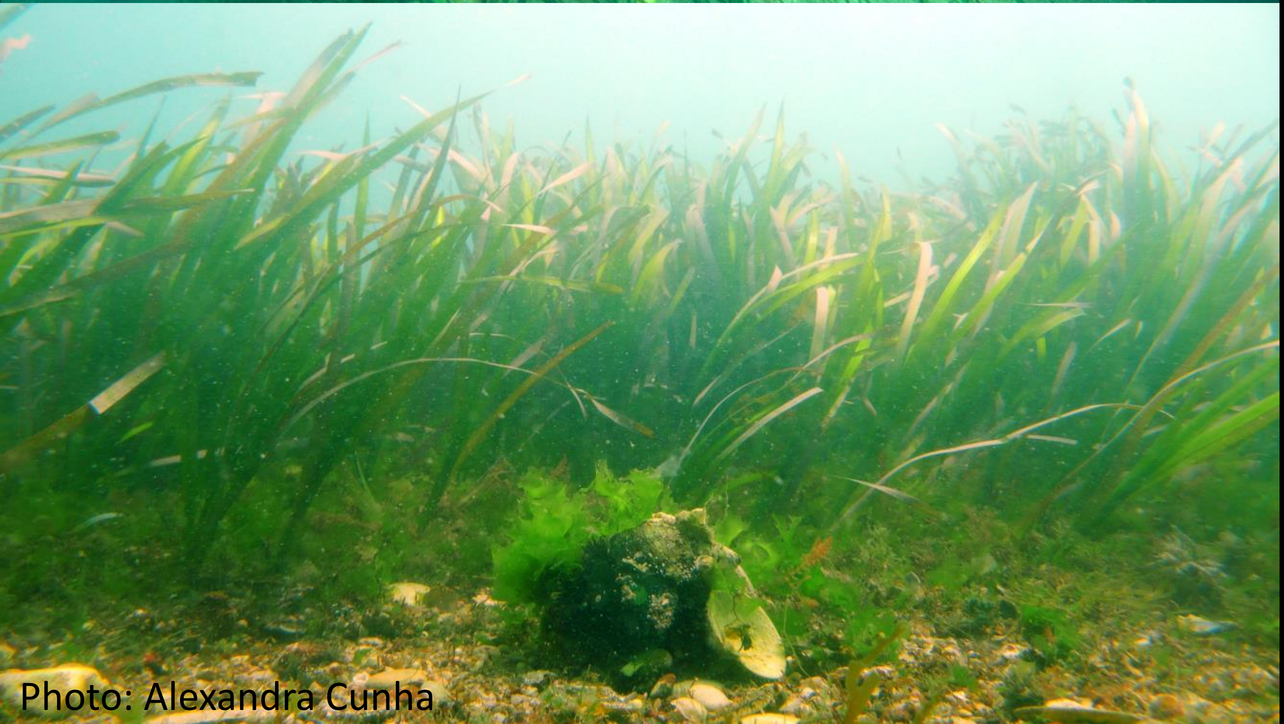
The global current loss rate of vegetated coastal habitats represents a significant loss of CO_2 sink capacity

McLeod et al (2012)



And the risk of potential emissions of CO_2 of up to 299 Tg carbon per year

Fourqurean et al (2012)

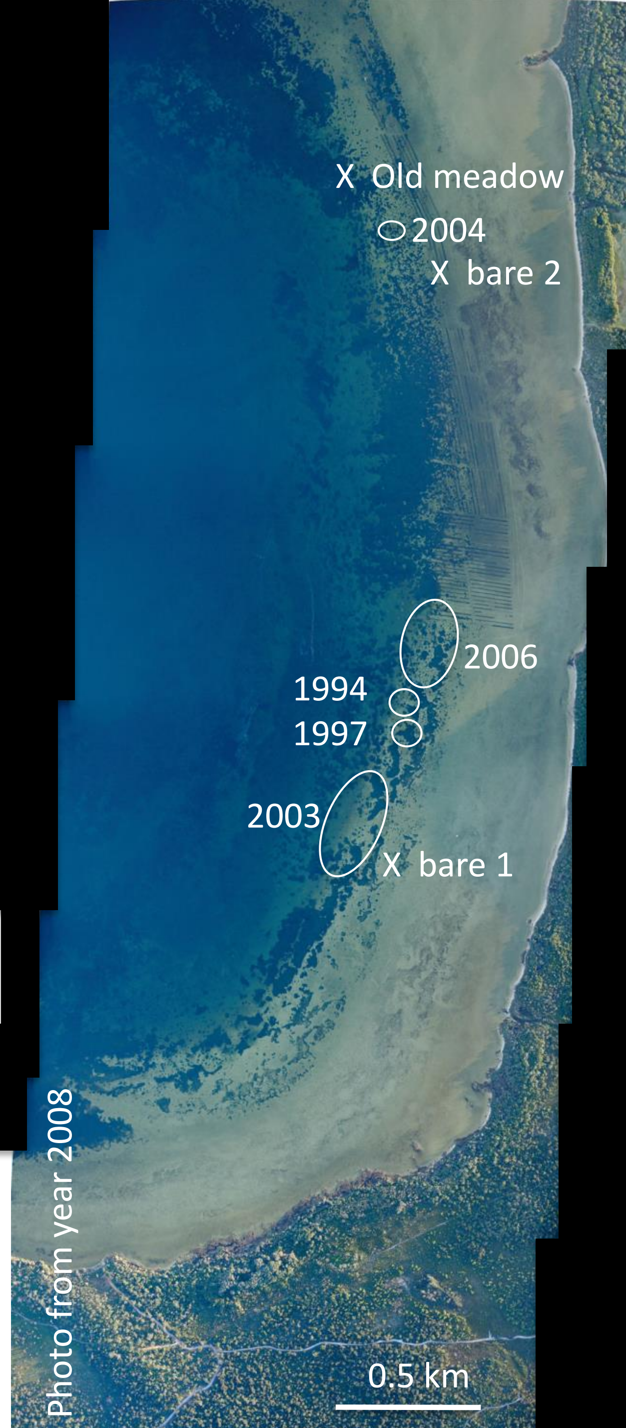


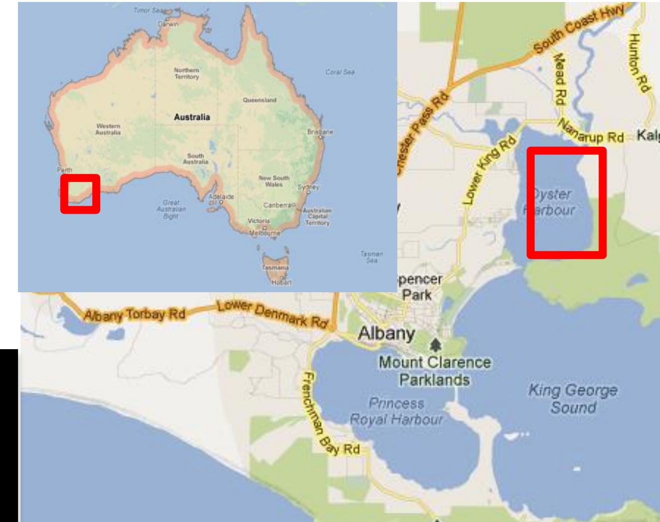
Recovery of lost coastal carbon sinks and creation of new ones (in areas suitable for vegetation growth) can be catalyzed through planting projects.

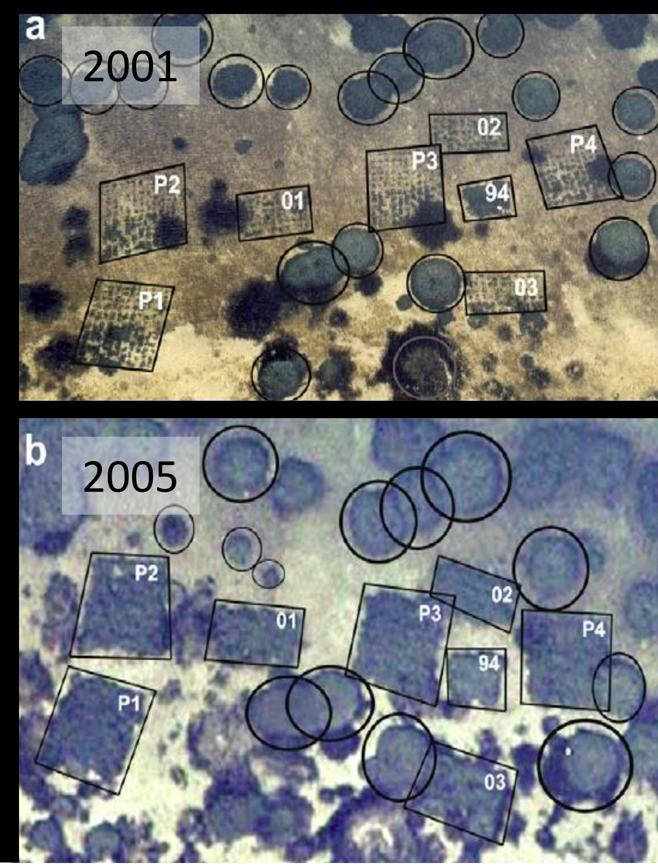
Seagrass revegetation at Oyster Harbour (WA)

CSIRO Coastal Carbon Cluster

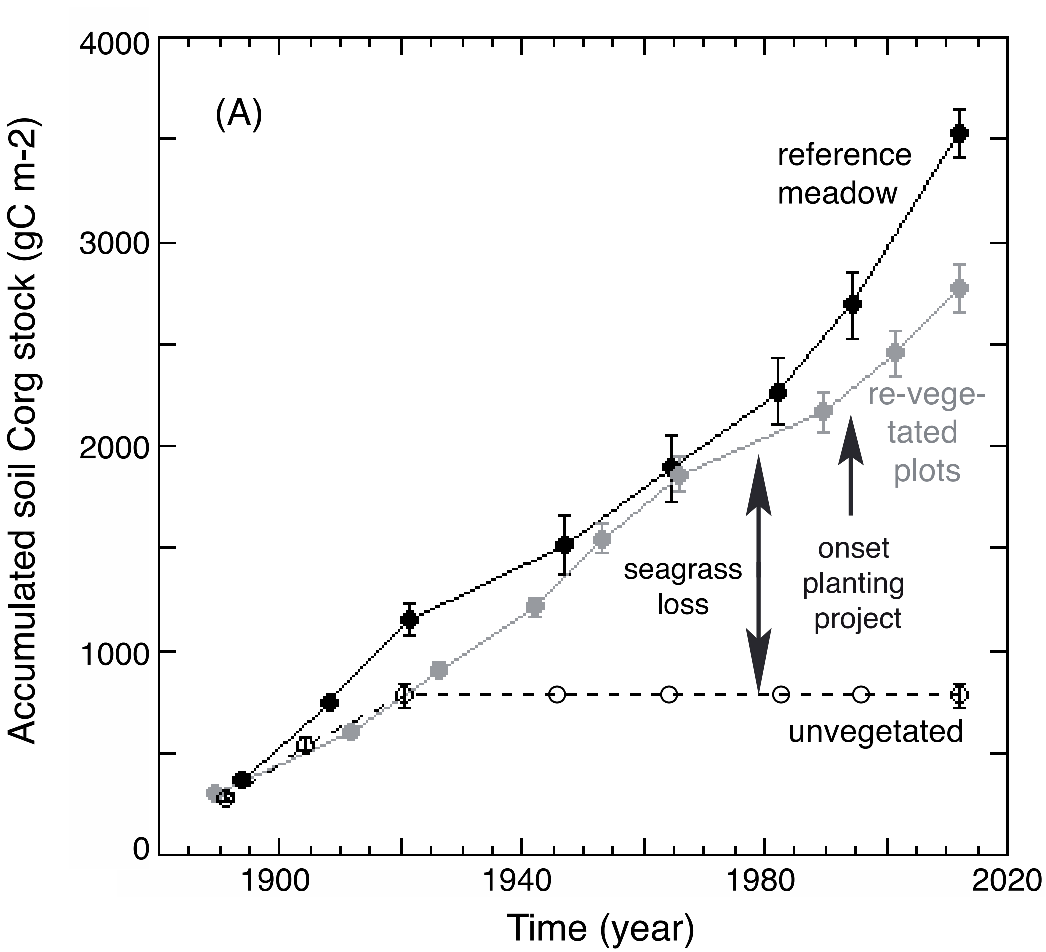
One of the few planting programs long-term (two decades) monitored







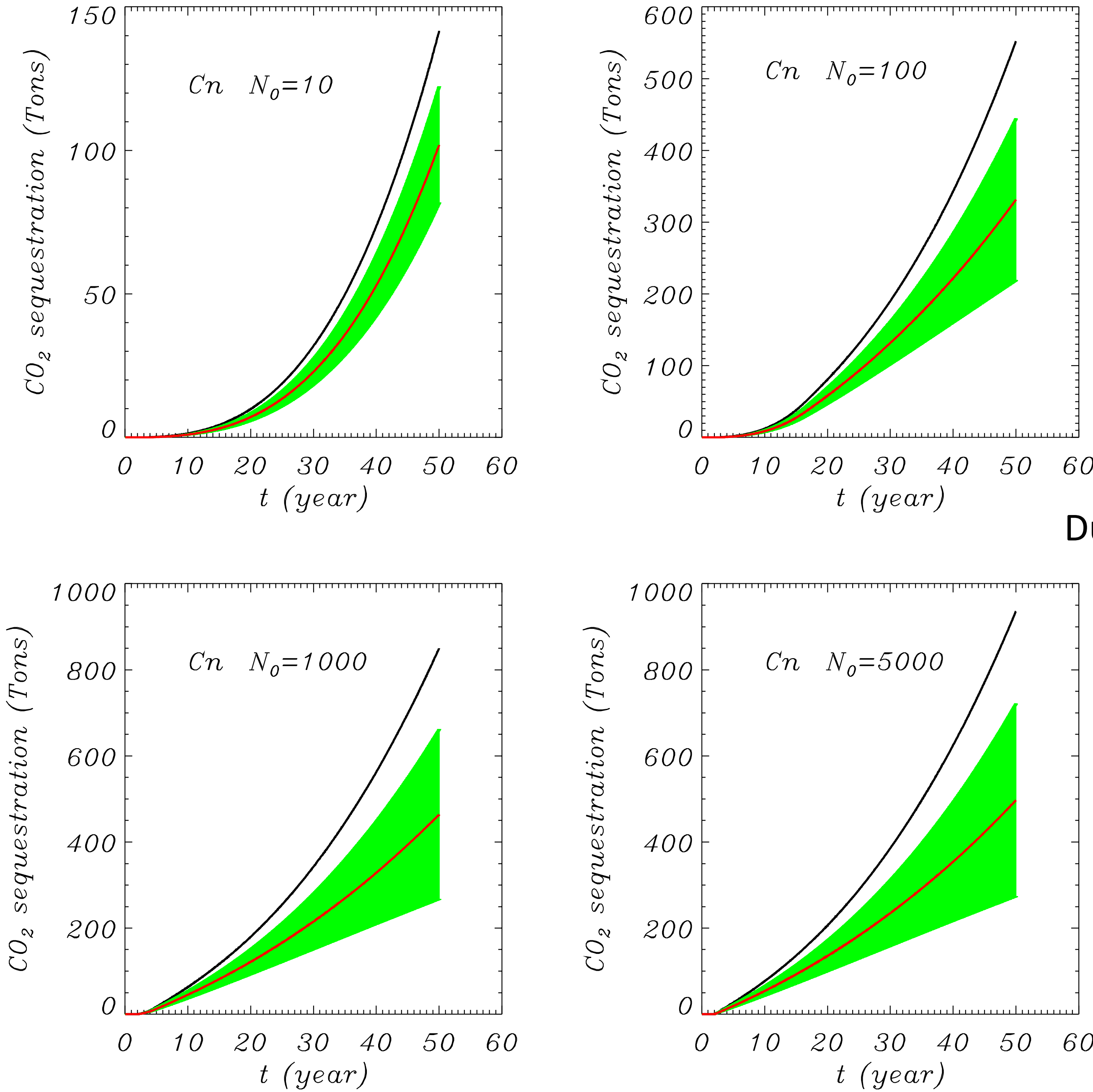
Time-course of accumulated soil C_{org} stock in the reference meadow, re-vegetated and unvegetated sediments since 1890



Loss of seagrass (with eutrophication) in the mid 1980's lead to loss of the carbon stored during the preceding 60 years.

Replanting of seagrass readily recovered the capacity to store carbon while protecting the carbon stocks from being eroded.

Marba et al. (in prep.)



Duarte et al. (2013)

Recent models show that seagrass reforestation lead to substantial CO_2 sequestration

nature climate change

REVIEW ARTICLE

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The role of coastal plant communities for climate change mitigation and adaptation

Carlos M. Duarte[1,2,3,*], Iñigo J. Losada[4], Iris E. Hendriks[2], Inés Mazarrasa[2] and Núria Marbà[2]

Marine vegetated habitats (seagrasses, salt-marshes, macroalge and mangroves) occupy 0.2% of the ocean surface, but contribute 50% of carbon burial in marine sediments. Their canopies dissipate wave energy and high burial rates raise the seafloor, buffering the impacts of rising sea level and wave action that are associated with climate change. The loss of a third of the global cover of these ecosystems involves a loss of CO_2 sinks and the emission of 1 Pg CO_2 annually. The conservation, restoration and use of vegetated coastal habitats in eco-engineering solutions for coastal protection provide a promising strategy, delivering significant capacity for climate change mitigation and adaption.

Role of marine vegetation in adaptation to sea-level rise, increased wave action and storm surges

Habitat	Impact	Habitat role
Seagrass	Sea level rise	Coastal accretion (2 mm $year^{-1}$), coastal protection from erosion and flooding.
	Increased wave action	Energy dissipation due to wave breaking, flow separation, rough and porous friction, and reflection of waves. Coastal protection from erosion.

Duarte et al. 2013, in press)

nature climate change

LETTERS

PUBLISHED ONLINE: 14 JULY 2013 | DOI:10.1038/NCLIMATE1944

Coastal habitats shield people and property from sea-level rise and storms

Katie K. Arkema[1*], Greg Guannel[2], Gregory Verutes[3], Spencer A. Wood[2], Anne Guerry[2], Mary Ruckelshaus[2], Peter Kareiva[4], Martin Lacayo[2] and Jessica M. Silver[2]

“The number of people, poor families, elderly and total value of residential property that are most exposed to hazards [in the USA] can be reduced by half if existing coastal habitats remain fully intact.”

"Coastal engineers have discovered a new material whose production, unlike that of cement, does not lead to CO_2 emissions, but rather CO_2 removal; can achieve similar efficiency for coastal protection than cement-based solutions; can repair itself; can grow; and can adapt to shifting boundary conditions. This newly discovered material to coastal engineering is no other than marine plants"

Duarte et al. (2013)

Conclusions

• Marine vegetated habitats have a great potential to help mitigate climate change as well as its impacts on coastal regions.

• Seagrasses, mangroves and salt-marshes are intense carbon sinks.

• The significant loss (> 1/3 of the global area since WWII) of coastal vegetation offer an opportunity to re-build these elements to enhance carbon sequestration and coastal protection while delivering additional significant ecosystem services and value to society, including improved water and sediment quality, enhanced biodiversity and fisheries recruitment.

• Marine vegetated habitats are effective at protecting coastlines from sea level rise and increased storminess with climate change.

• Strategies based on marine vegetation to adapt to sea level rise and its impacts are likely to be far more cost-effective for a similar level of performance than cement-based solutions, particularly when involving plants, as seagrass, with a capacity for clonal expansion.