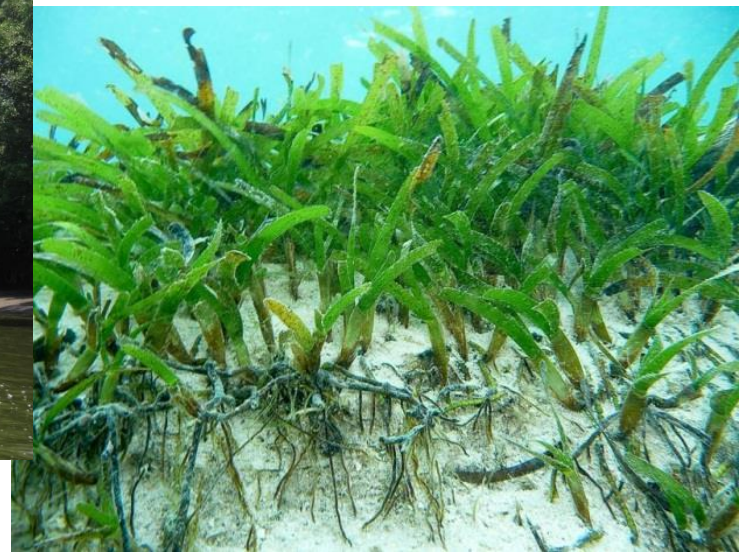
How can carbon stored by coastal ecosystems help to mitigate climate change, enhance coastal protection or fisheries?

PRIFYSGOL BANGOR UNIVERSITY

Hilary Kennedy

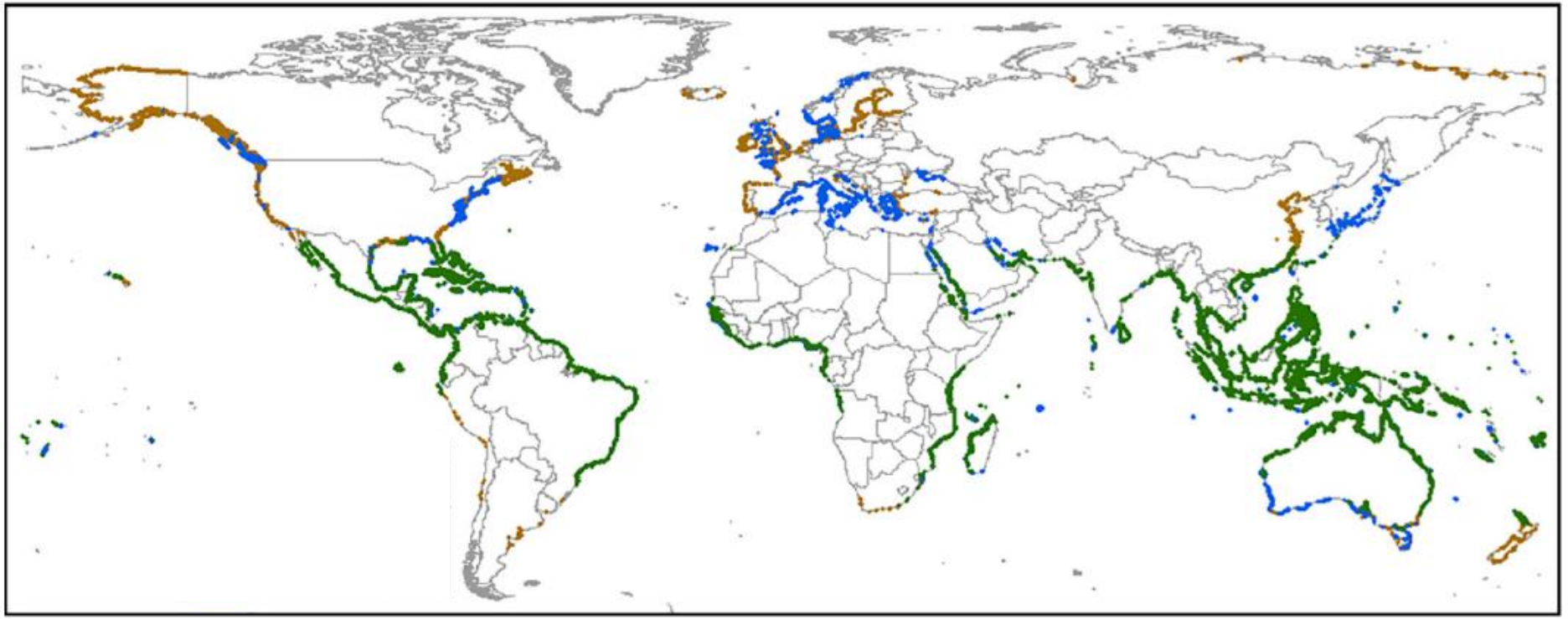
Tidal Marshes

Mangroves



Seagrass Meadows

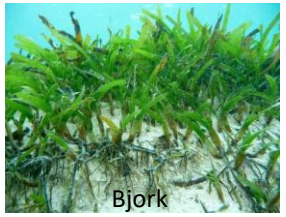
Location of vegetated coastal ecosystems



Distribution of

Mangroves

Tidal marsh



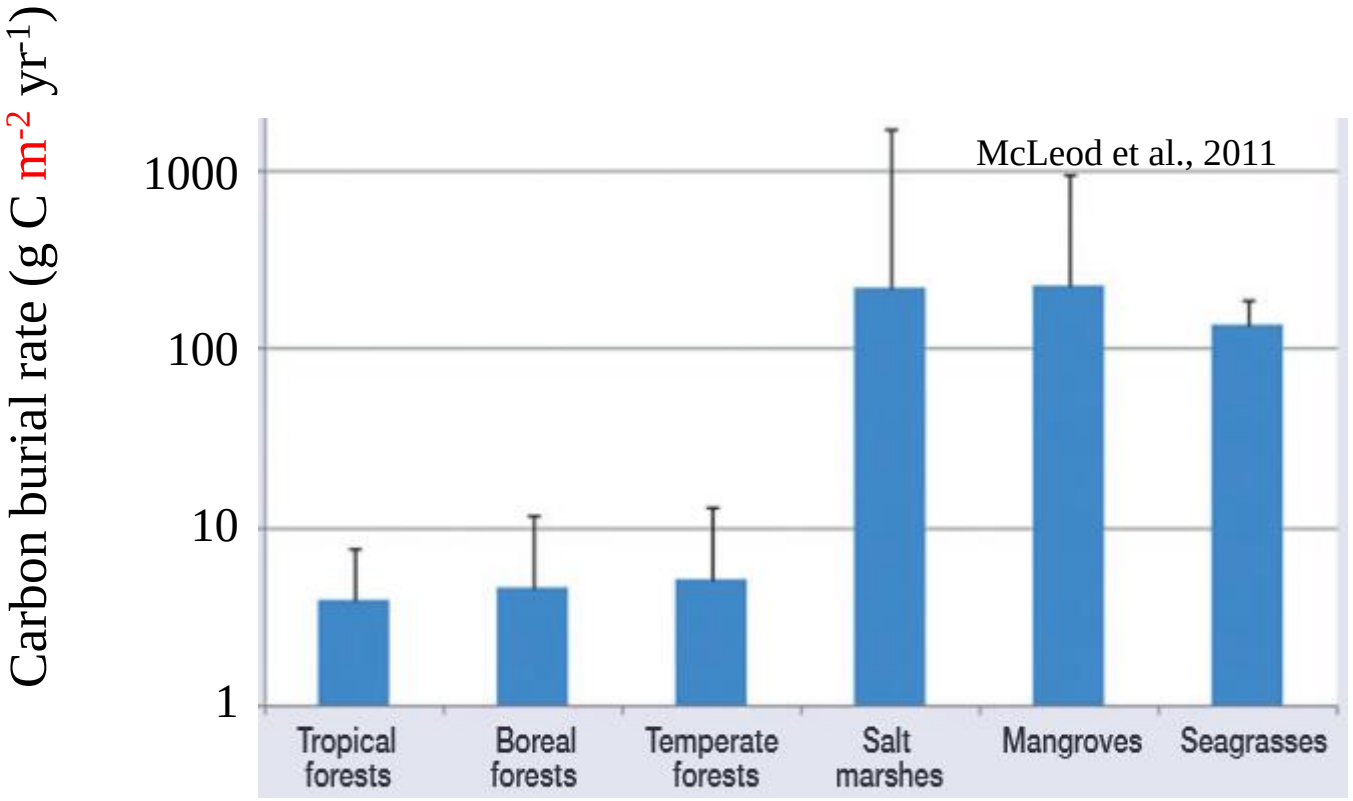
Seagrass

Himes-Cornell et al., 2018

Ecosystem	Areal extent (km^2)
Tidal marsh	22,000-400,000
Mangrove	137,760-152,361
Seagrass	177,000-600,000

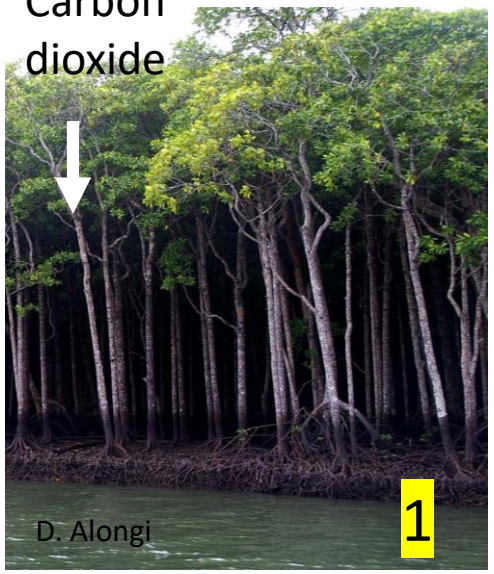
Duarte et al., 2013

Comparing equal plot sizes, coastal ecosystems are disproportionately important in CAPTURING carbon when compared with terrestrial forests.



Global burial rate $tgCyr^{-1}$	915	370	53	10.1	13.7	14.7	(Taillardat et al., 2018)
	78.5	49	53	5-87	22-25	48-112	(Duarte et al 2013, McLeod et al 2011)

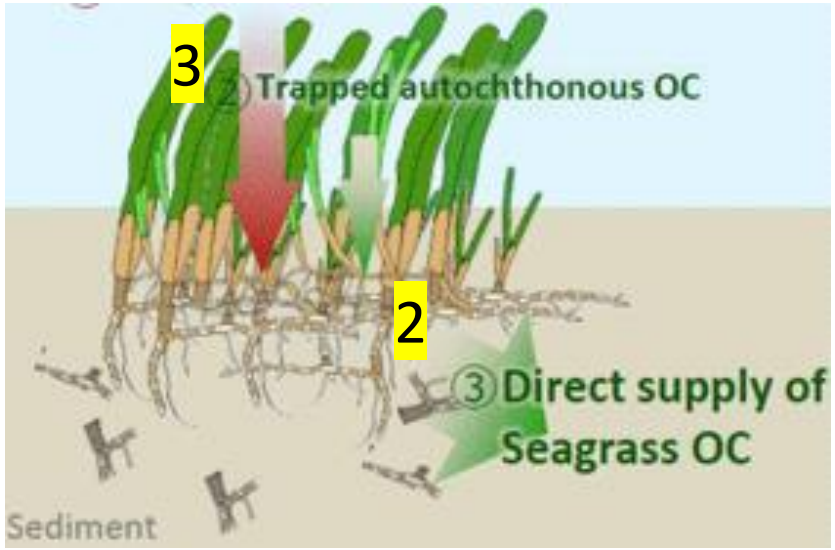
Carbon capture and storage in mangroves, tidal marshes and seagrass meadows.



1. are very productive and remove large amounts of carbon dioxide (CO_2) from the atmosphere and fix it in their tissues (autochthonous).

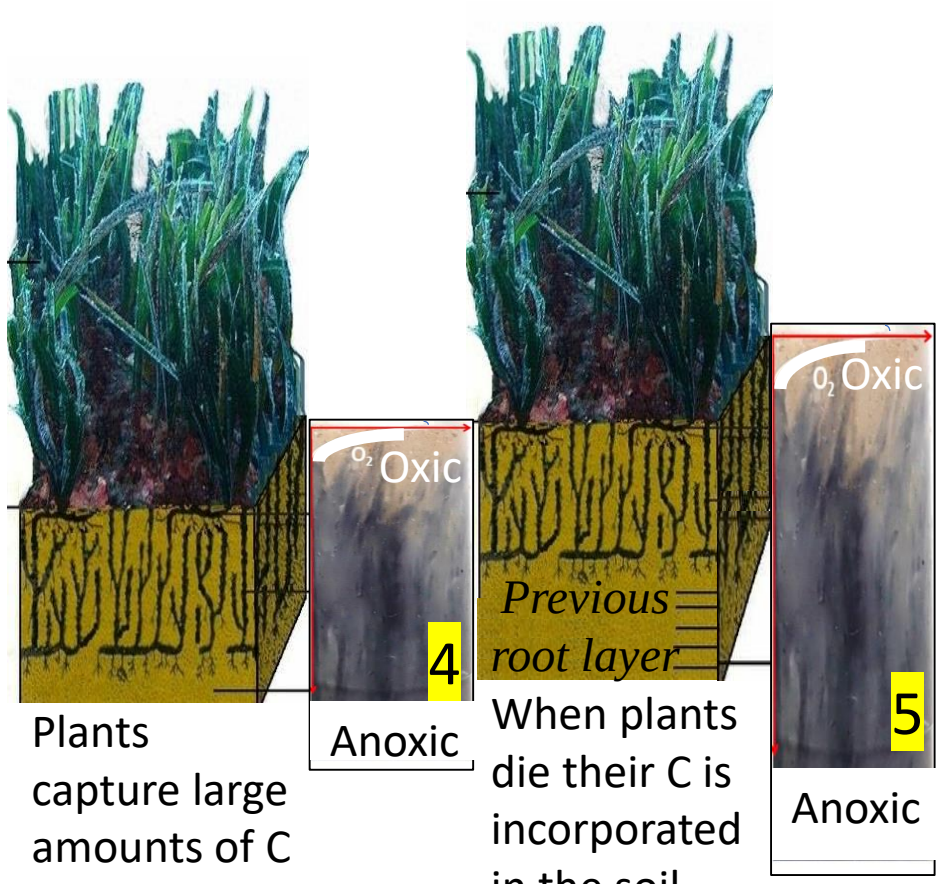
2. A fraction of the dead leaves, branches, roots, rhizomes become buried in the soil.

3. The plants also trap C that was produced elsewhere (allochthonous) and bury it in the soil.



Tanaya et al.,2018

Carbon capture and storage in mangroves, tidal marshes and seagrass meadows.



Plants capture large amounts of C temporarily stored in their trunks, leaves, roots, & rhizomes.

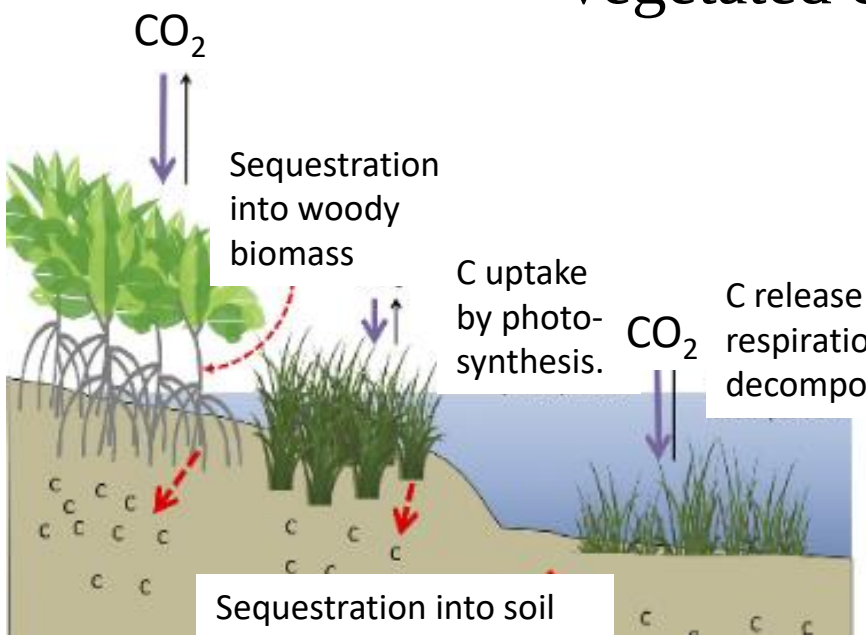
When plants die their C is incorporated in the soil.

4. The lack of oxygen in the soil and the chemical nature of buried plant tissues makes them relatively resistant to decomposition.

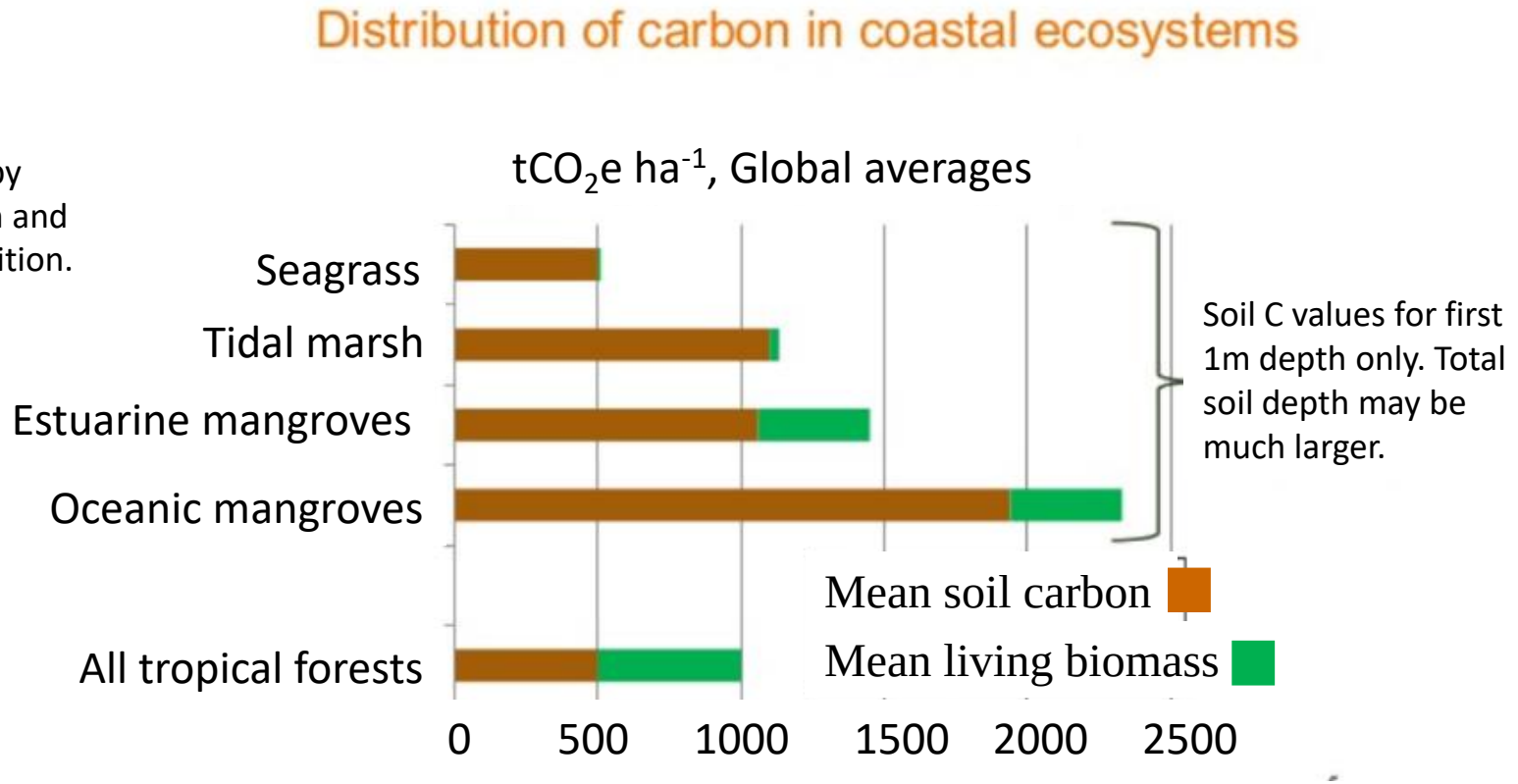
5. The level of the soil builds up and increases the amount of organic carbon stored there.

Comparing equal plot sizes carbon storage in mangroves, tidal marshes and seagrass meadows.

Vegetated coastal ecosystems store most of their carbon in the soil.



https://estuaries.org/bluecarbon/blue-carbon-science-projects/



Data summarised in Crooks et al., 2011; Murray et al., 2011, Donato et al 2011, Fourqurean et al 2012

Co-benefits or other ecosystem services provided by vegetated coastal ecosystems: coastal protection


Gronas

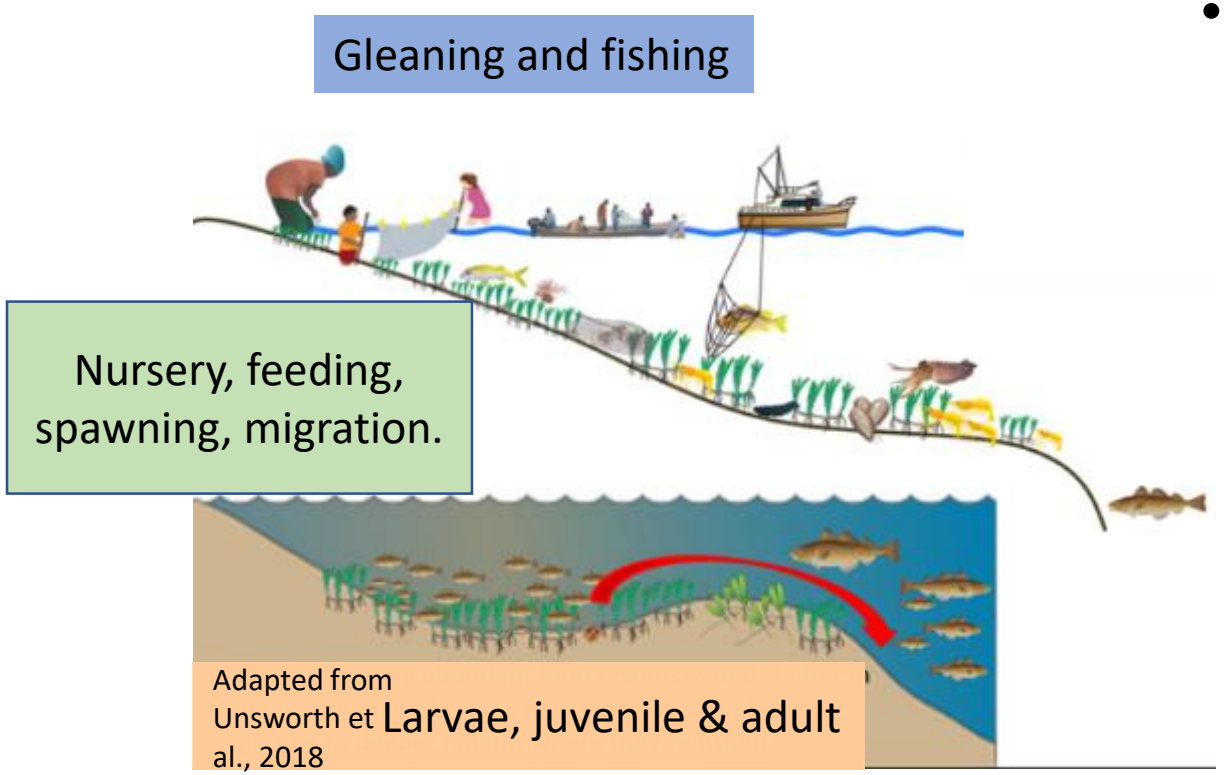

Deegan et al 2012


Bjork

- They help stabilize the coastline and reduce storm damage.
- The natural ecosystems represent an alternative to the use of hard engineering solutions.
- Flood protection by ecosystem creation and restoration can provide a cost-effective and ecologically sound alternative to conventional coastal engineering.

Spalding et al 2014, Temmerman et al., 2013, Van Coppenolle & Temmerman 2019, Lathrop et al 2019

Co-benefits or other ecosystem services provided by vegetated coastal ecosystems: fisheries

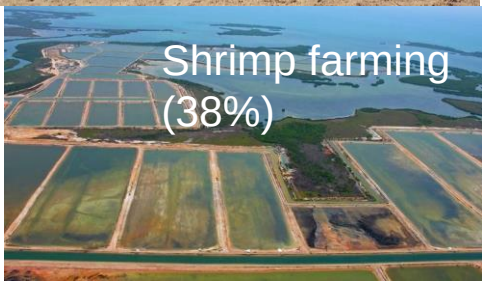


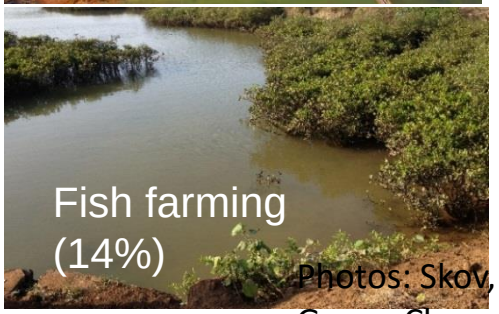
- The high productivity of mangrove, seagrass and tidal marshes provide important environments for commercially and ecologically important fish & shellfish.
- Evidence suggests that in European waters, eel, herring, European sea bass, cod, whiting, flounder, plaice, sea trout, salmon & stripped red mullet all use these ecosystems at some stage of their life
- Using chemical techniques to derive their nutritional benefit to fish, it has been estimated that the vegetated ecosystems of Australia provide, equivalent to ~48 million euros per year

Seitz et al., 2014, Janes et al., 2019, Unsworth et al., 2018.

Activities that lead to major loss of habitat and ecosystem services.

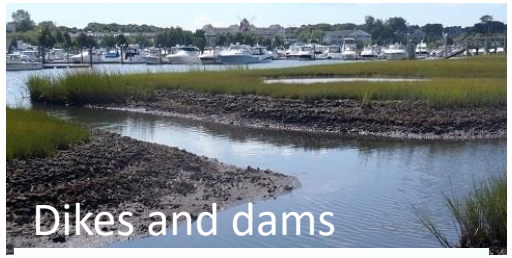
Mangrove



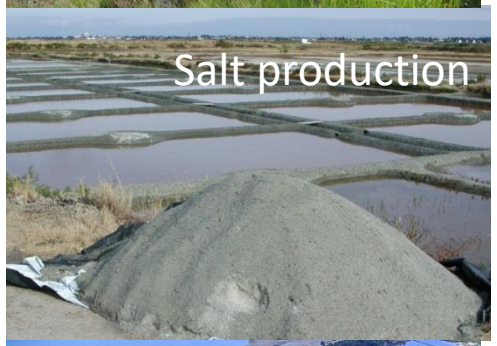


Photos: Skov, Guang Chen

Tidal marsh

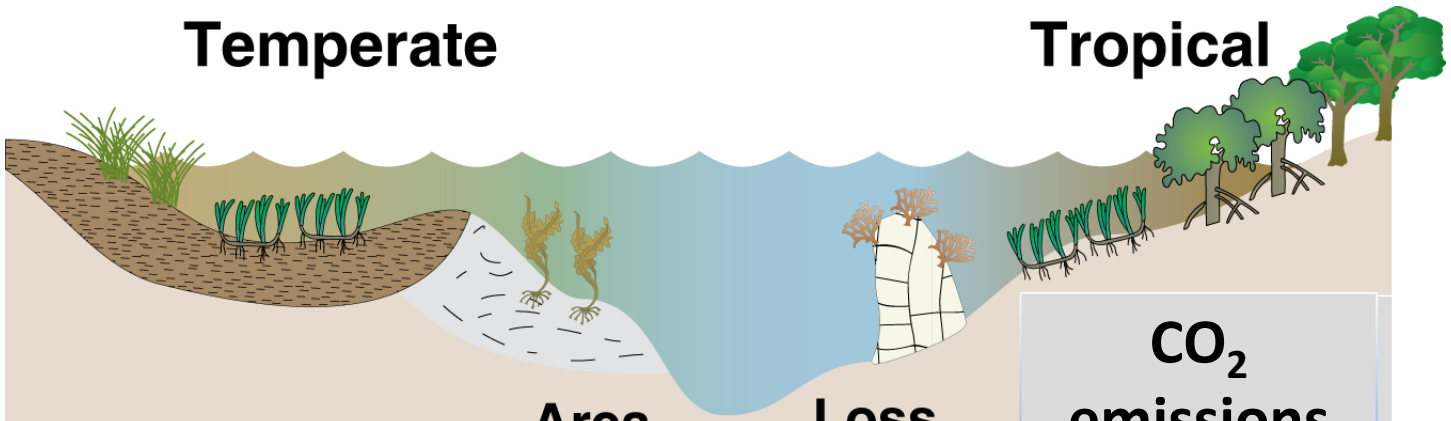


Drainage for agriculture



Seagrass meadows

Estimate of annual CO_2 emissions due to loss of vegetation and soil disturbance.



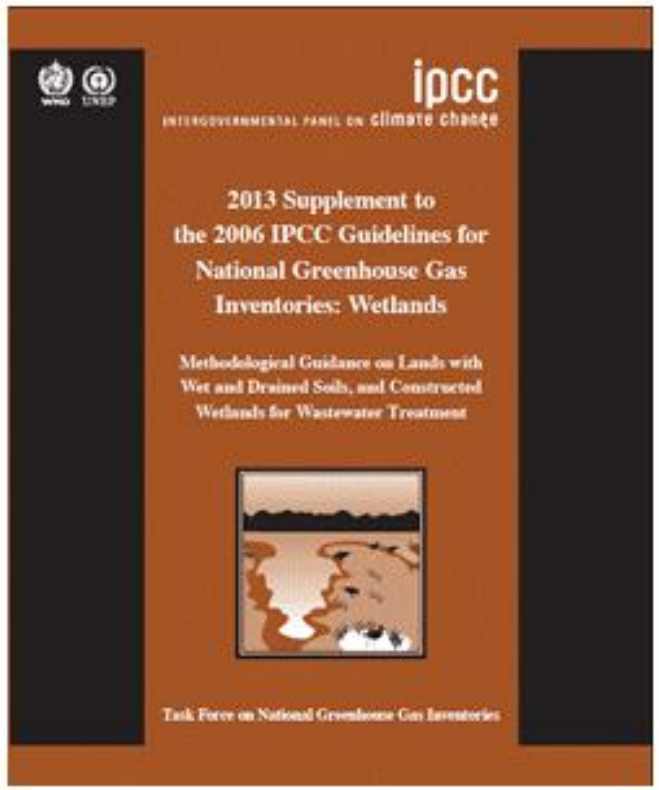
	Area 10^6 ha	Loss % yr^{-1}	CO_2 emissions 10^{12} t CO_2e yr^{-1}
Seagrass	30	1.5	0.05-0.33 *
Salt marsh	5.1	1.9	0.02-0.24 *
Mangrove	14.5	1.5	0.007†

- * Assuming 63% of organic carbon is oxidised. †Atwood et al.,2017

Roughly similar to annual CO_2 emissions for many European countries.

Pendleton et al., 2012

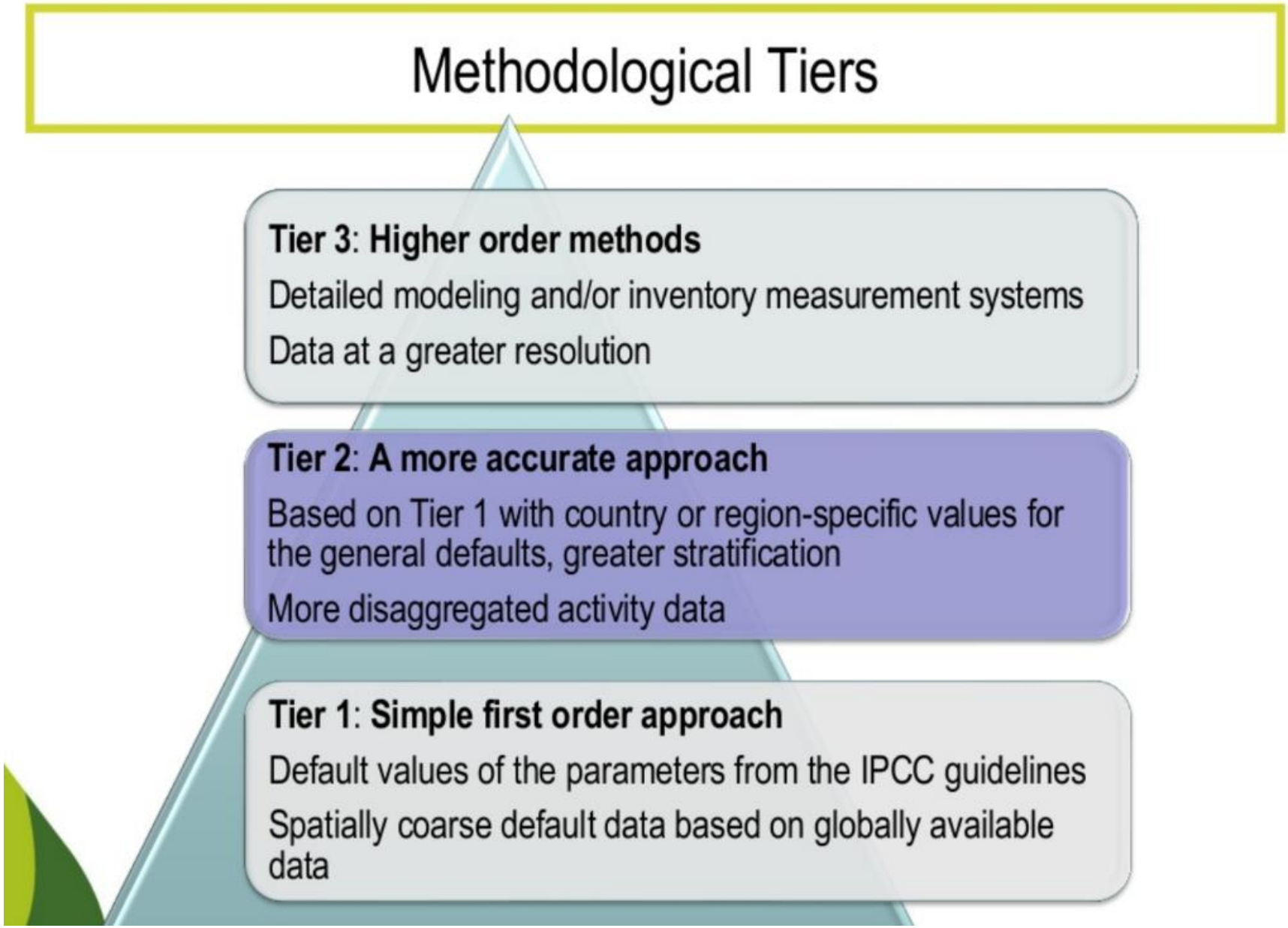
Inclusion of coastal wetlands in IPCC in a country's greenhouse gas inventory



M=mangrove, TM=tidal marsh, SM=seagrass meadow

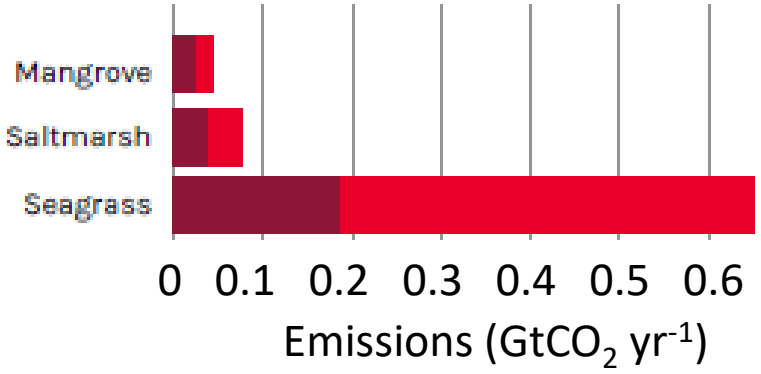
Activity	Sub-activity	Vegetation
Activities related to CO_2 emissions and removals		
Forest management	Planting, thinning, harvest, wood removal, fuelwood removal, charcoal production.	M
Extraction	Excavation to enable port, harbour & marine construction and filling or dredging to facilitate raising the elevation of the land.	M, TM, SM
	Aquaculture - construction	M, TM
	Salt production - construction	M, TM
Drainage	Agriculture, forestry, mosquito control	M, TM
Restoration & creation	Conversion from drained to saturated soils by restoring hydrology & restoration of vegetation	M, TM
	restoration of vegetation on undrained soils	SM
Activities related to non-CO_2 emissions and removals		
Aquaculture	N_2O emissions from aquaculture use	M, TM, SM
Rewetting	CH_4 emissions from change to natural vegetation following modifications to restore hydrology.	M, TM

Tier1 values have been provided for each of the management activities.

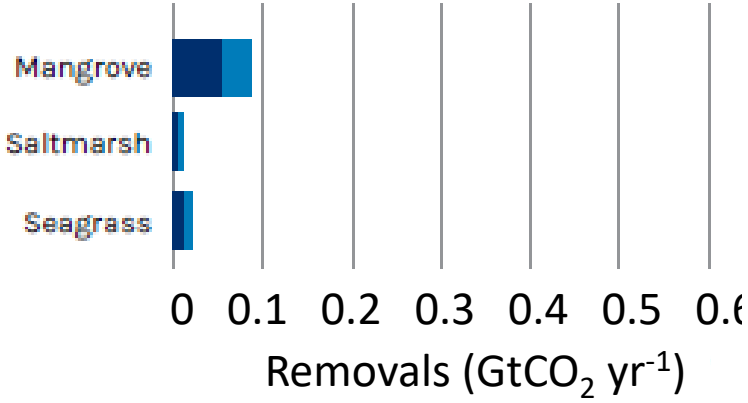


Mitigation potential for conservation and restoration of coastal ecosystems

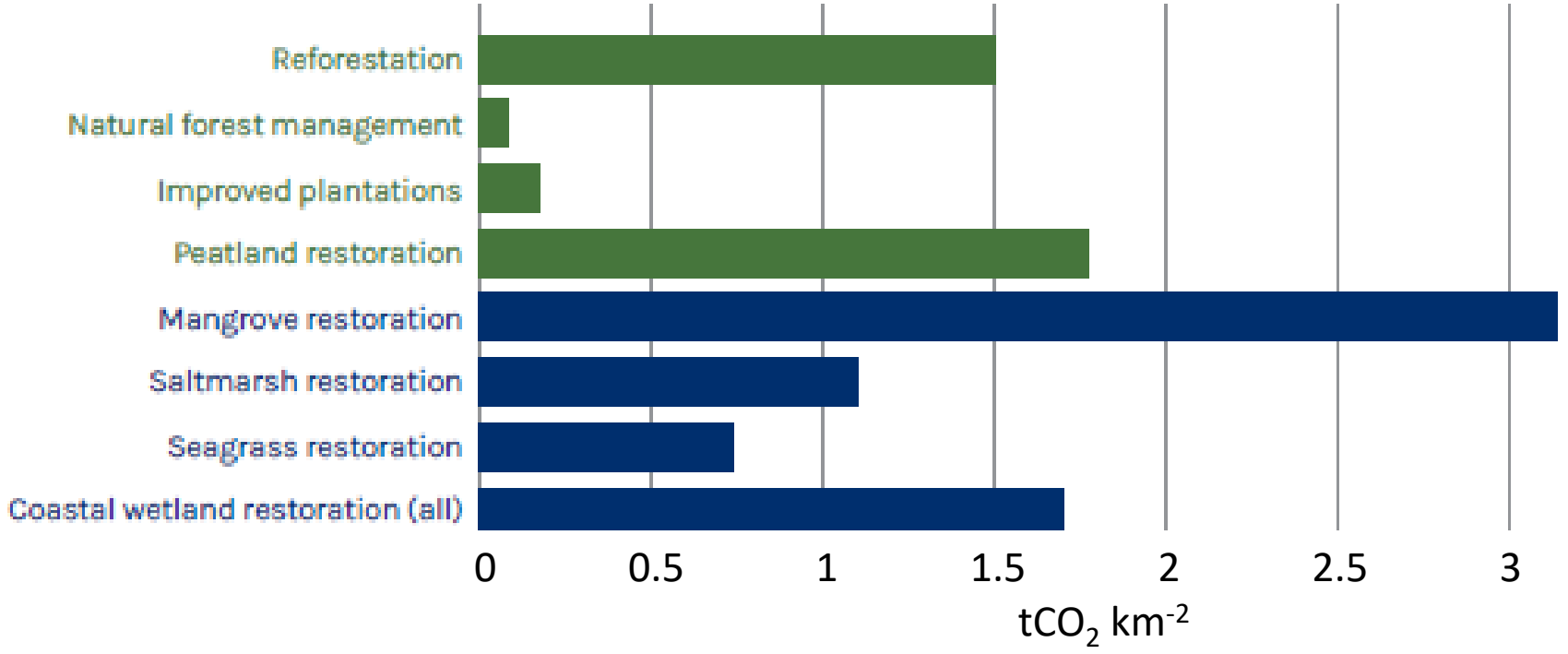
Avoided emissions through conservation



Removals associated with restoration

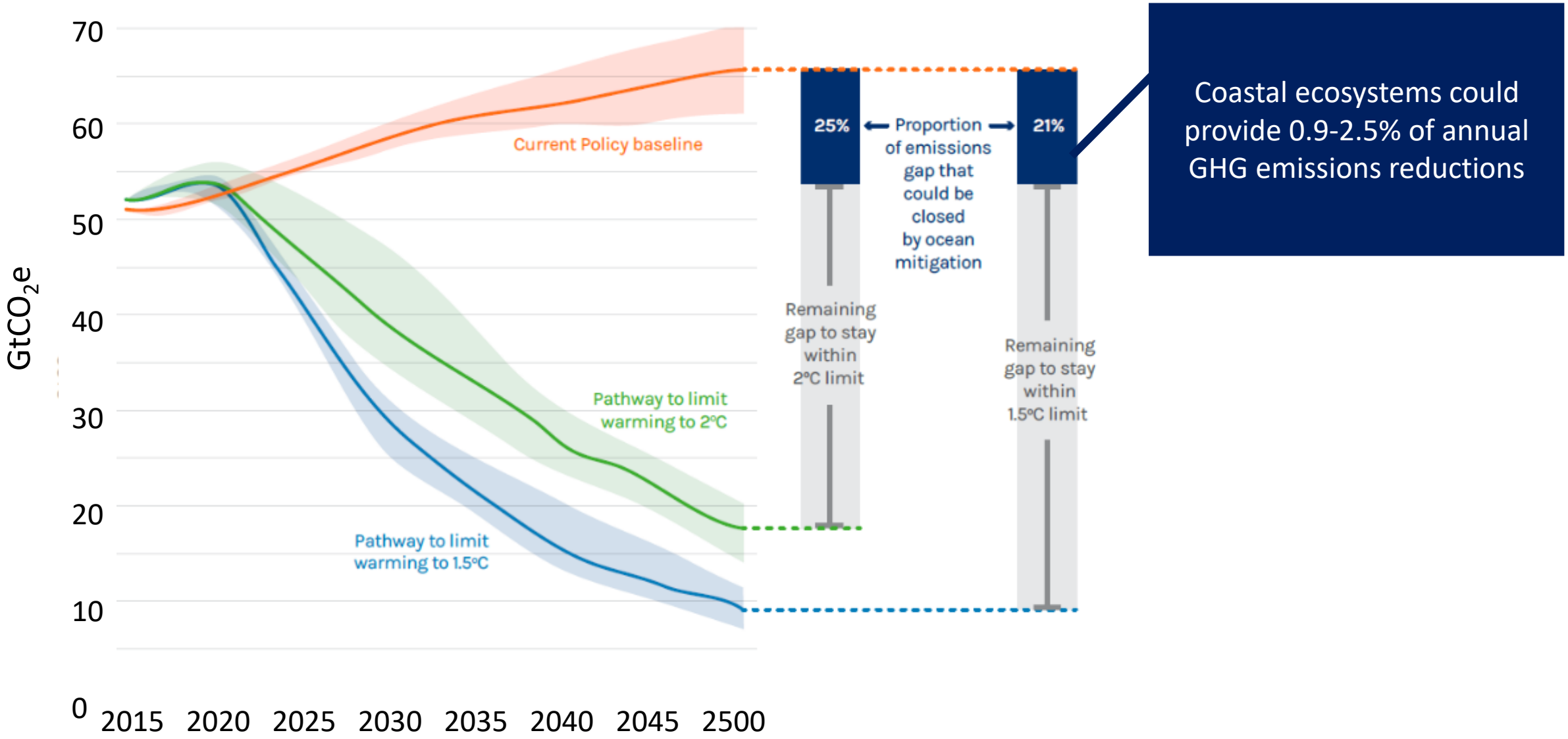


Comparison between restoration benefit between terrestrial and coastal ecosystems.



http://www.oceanpanel.org/climate

Potential contribution of coastal ecosystems to closing the emissions gap in 2050

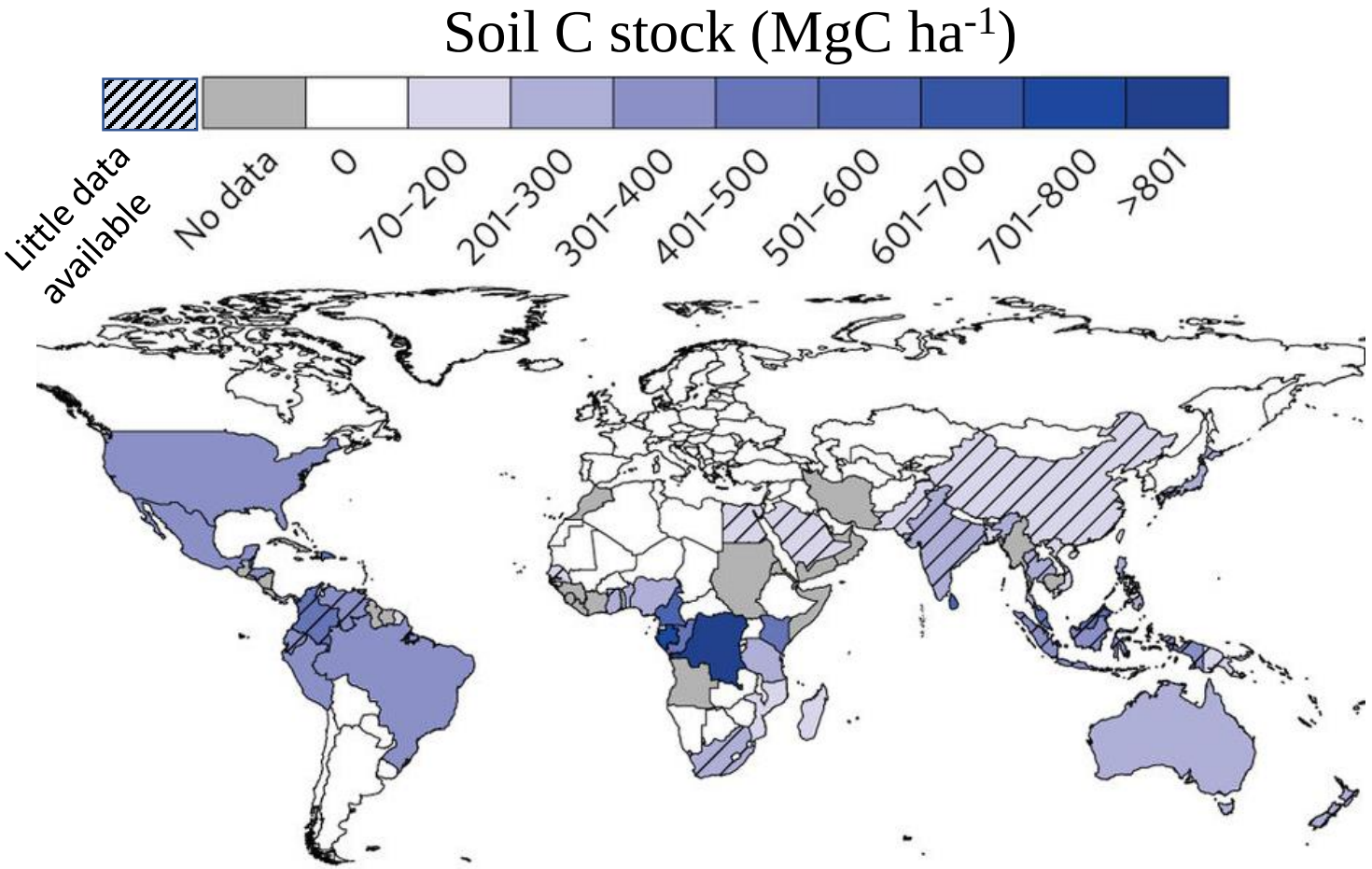


Coastal ecosystems could provide 0.9-2.5% of annual GHG emissions reductions

http://www.oceanpanel.org/climate

Potential for improving the accuracy of national GHG inventories.

Tier 2 Country specific carbon storage in mangrove soil.



Indonesia: Stock 1083±378 MgC ha^{-1}

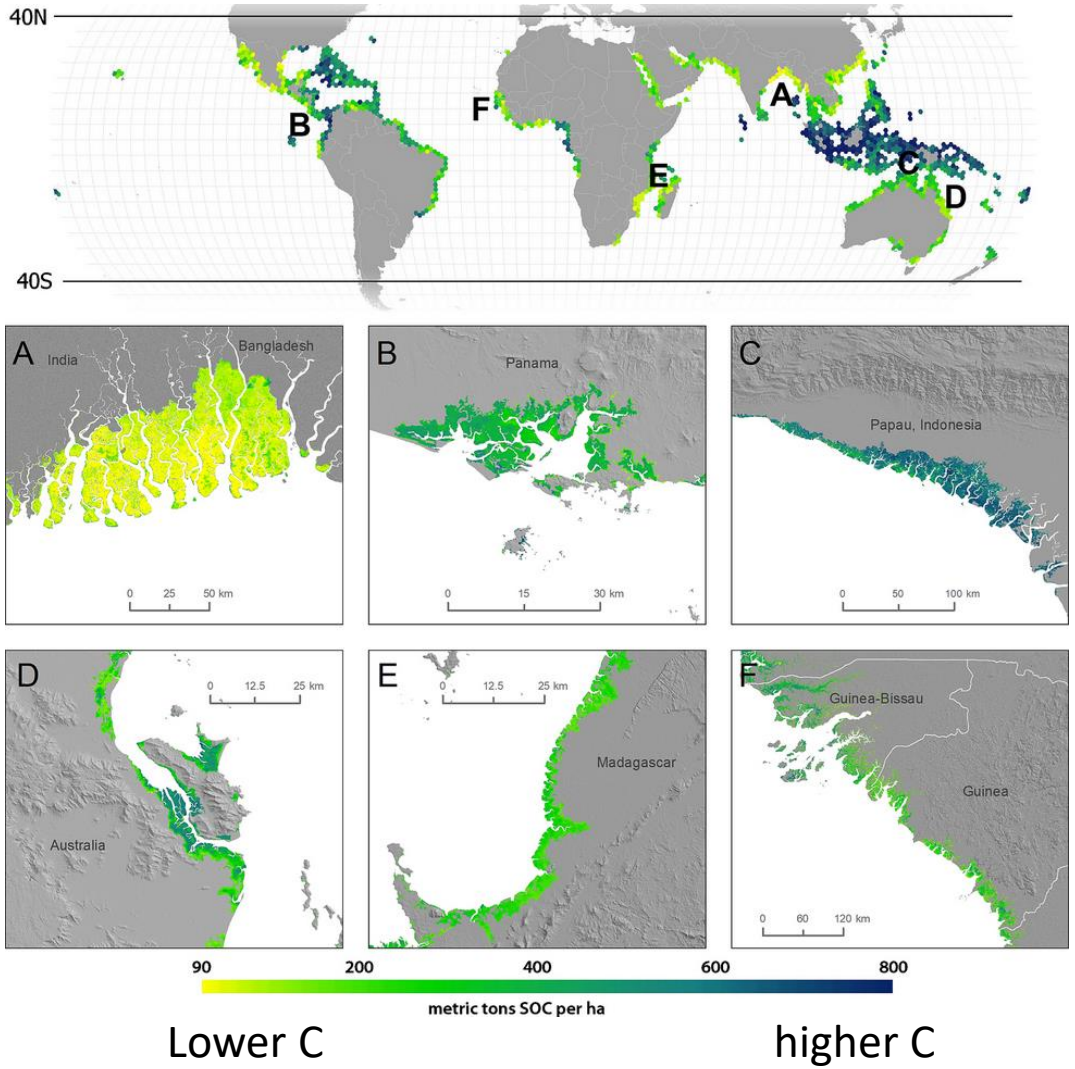
Red Sea: Stock 43±5 MgC ha^{-1}

Loss of areal extent of forest cover combined with C soil stocks can provide estimate of CO_2 emissions due to specific management.

Atwood, TB et al., 2017

Potential for improving the accuracy of national GHG inventories.

Tier 3 Modelling for regional or country specific carbon storage in mangrove soil.



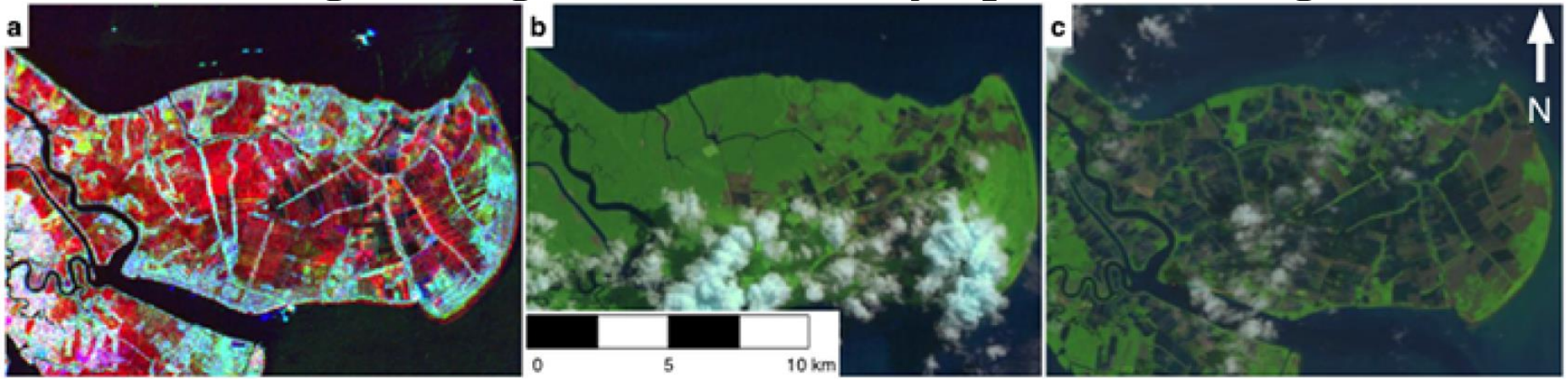
Method: Use soil carbon data base and machine learning based statistical model to predict organic carbon stock. Used environmental co-variate model to examine major drivers on stocks.

Results:Total suspended material and tidal range strong predictors of stocks.
Using remotely-sensed forest cover change data - can link to CO_2 emissions.

Sanderman et al., 2018

Potential for improving the accuracy of national GHG inventories.

Tier 3 Modelling for regional or country specific changes in land-use.



Red=loss

1996

2007-2010

Method: Remote sensing product – Synthetic Aperture Radar (SAR)

Findings: Specific examples of change and drivers of change (aquaculture/agriculture) from 1996-2010. Also shows gains in extent.

Wider implications: SAR is useful in areas of high cloud cover. Data available in the future

Thomas et al., 2017

Actionable projects for coastal ecosystems.

IPCC 2013 Wetland Supplement: Allows countries to improve GHG reporting for mangroves, and to now include tidal marsh and seagrass meadows. Australia, the US, Japan and Canada have begun implementing the Wetlands Supplement in their inventory. The methodology can assist in countries to meet their NDC commitments.

Reducing emissions from deforestation and forest degradation conservation and sustainable management of forests, and enhancement of forest carbon stocks(REDD+): Those countries that define mangroves as forests can be accounted for under their REDD+ frameworks. This framework does not include tidal marshes and seagrass meadows.

Paris agreement and Nationally Determined Contributions (NDCs): NDCs should reflect the contribution a country can make to global greenhouse gas emissions reductions. 50 countries have recognised the importance of coastal blue carbon ecosystems in their NDCs or climate action plans. Few countries currently have the necessary national data or financing to implement.

Blue carbon: Some of the knowledge gaps and uncertainties.

•There are geographical gaps in data, especially in Africa, South America, and Southeast Asia.

•While mangroves are adequately mapped, large areas containing seagrass meadows and tidal marsh remain largely unsurveyed.

•We need more data for removals during restoration and emission rates associated with specific causes of loss or degradation.

• Emissions caused by activities that lead to the loss of totally submerged ecosystems, like seagrass meadows, need to be better quantified.

CONCLUSIONS

- Coastal wetlands are now being recognised for their high rates of carbon capture and high carbon stocks. Known as “blue carbon” these ecosystems can help mitigate the rise in atmospheric CO_2.
- These ecosystems are being lost and action is needed to prevent further degradation and loss.
- Not all countries are equal in their mitigation potential and conservation and restoration strategies should be adapted to local conditions.
- The effect of ecosystem loss is not always well quantified, but where they are, they have the potential to contribute to a national government’s inventory of greenhouse gas emissions.
- Recent progress by the IPCC strengthens the position of national governments as stakeholders in the fate of coastal wetlands and provides incentives for including coastal ecosystems in their NDCs and other national approaches for GHG reductions.
- Improved scientific understanding of the factors that influence greenhouse gas emission and removals in these ecosystems is still needed to reduce uncertainties and provide country specific data.

Thank you