Blue Carbon: A transformational tool for marine management and conservation globally

Dr. Emily Pidgeon
Conservation International
The Global Carbon Cycle

- Atmosphere
- Ocean-Atmosphere Exchange
- Land-use Changes
- Photosynthesis & Respiration
- Fossil Fuel Combustion & Cement Manufacture
- Terrestrial Biosphere
- Surface Ocean
- River Runoff
- Phytoplankton
- Deep Ocean
- Sinking Particles
- Ocean Circulation

JOFS
Coastal Wetlands
Coastal Ecosystems – many critical ecosystem services

Fisheries
Coastal protection & erosion control
Coastal Water Quality
Livelihoods (tourism etc.)
Cultural value
Food
Biodiversity
Carbon sequestration and storage
Costal Ecosystems Highly Efficient at Carbon Sequestration

Modified from McLeod et al. 2011
Coastal Ecosystem Have Rich Carbon Stores

Mean carbon storage above and belowground

(Fourqurean et al. 2012; Pan et al. 2011; Pendleton et al. 2012)
Coastal blue carbon ecosystems are found along the coasts of every continent except Antarctica. Mangroves grow in the intertidal zone of tropical and subtropical shores (Figure 3). Countries with

Tidal marshes are intertidal ecosystems occurring on sheltered coastlines ranging from the sub-arctic to the tropics, though most extensively in temperate zones (Figure 3), mainly in Europe, North-America, Australia and in the higher latitudes of South-America and Africa.

Where are coastal marine ecosystems found?

Table 1. Estimates of carbon released by land-use change in coastal ecosystems globally and associated ecosystem health and function. (Modified from Pendleton et al. 2012).

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Global extent (Mha)</th>
<th>Current conversion rate (% yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangroves</td>
<td>13.8-15.2 (14.5)</td>
<td>0.7-3.0 (1.9)</td>
</tr>
<tr>
<td>Tidal Marsh</td>
<td>2.2-40 (5.1)</td>
<td>1.0-2.0 (1.5)</td>
</tr>
<tr>
<td>Seagrass Meadows</td>
<td>17.7-60 (30)</td>
<td>0.4-2.6 (1.5)</td>
</tr>
<tr>
<td>Total</td>
<td>33.7-115.2 (48.9)</td>
<td></td>
</tr>
</tbody>
</table>
## Globally significant emissions from Coastal Ecosystems

Table 1. Estimates of carbon released by land-use change in coastal ecosystems globally and associated environmental impacts.

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Global extent (Mha)</th>
<th>Current conversion rate (% yr⁻¹)</th>
<th>Near-surface C susceptible (top meter sediment+biomass, Mg CO₂ ha⁻¹)</th>
<th>C emissions (Pg CO₂ yr⁻¹)</th>
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<tbody>
<tr>
<td>Mangroves</td>
<td>13.8-15.2 (14.5)</td>
<td>0.7-3.0 (1.9)</td>
<td>373-1492 (933)</td>
<td>0.09-0.45 (0.24)</td>
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<tr>
<td>Tidal Marsh</td>
<td>2.2-40 (5.1)</td>
<td>1.0-2.0 (1.5)</td>
<td>237-949 (593)</td>
<td>0.2-0.24 (0.06)</td>
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<tr>
<td>Seagrass Meadows</td>
<td>17.7-60 (30)</td>
<td>0.4-2.6 (1.5)</td>
<td>131-522 (326)</td>
<td>0.5-0.33 (0.15)</td>
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<tr>
<td><strong>Total</strong></td>
<td>33.7-115.2 (48.9)</td>
<td></td>
<td></td>
<td><strong>0.15-1.02 (0.45)</strong></td>
</tr>
</tbody>
</table>

For comparison:
Tropical deforestation net emissions = 4.8 Pg CO₂ yr⁻¹

(Modified from Pendleton et al. 2012; Pan et al. 2011).
Can coastal “blue” carbon leverage better management, conservation and restoration of coastal ecosystems?

- Increase recognition of mitigation value
- Improve management and regulation
- Provide basis for incentives to conserve or restore
Increased conservation, restoration and sustainable management of coastal blue carbon ecosystems

http://thebluecarboninitiative.org/
Coastal ‘Blue’ Carbon: Science to Policy and Management

International Climate Change Actions
- GHG emissions reporting
- UNFCCC mechanisms
- Funding

National Actions
- Climate Change Policy
- Other Policy

Site/Project Actions
- Financing
- Management
Synthesize the Science.....

Science International Blue Carbon Scientific Working Group
Mangroves among the most carbon-rich forests in the tropics

Daniel C. Donato*, J. Boone Kauffman, Daniel Muriyarso, Sofyan Kurnianto, Melanie Stidham and Markku Kanninen

Mangrove forests occur along ocean coastlines throughout the tropics, and support numerous ecosystem services, including

REVIEWS REVIEWS REVIEWS

A blueprint for blue carbon: theoretical understanding of the carbon storage in vegetated coastal habitats in the tropics

Elizabeth McLeod†, Gail L. Chmura, Steven Bouillon, Rodney Salm, Catherine E. Lovelock, William H Schlesinger, and Brian R. Silliman

Recent research has highlighted the valuable role that coastal and marine carbon dioxide (CO₂). The carbon (C) sequestered in vegetated coastal seagrass beds, and salt marshes, has been termed “blue carbon”. Although mangrove forest area is increasing, the carbon storage in seagrass meadows contains 13% of the yearly estimated C storage in the soils can be preserved for millennia

Seagrass ecosystems as a globally significant carbon stock


The protection of organic carbon stored in forests is considered an important method for mitigating climate change. Terrestrial ecosystems, coastal ecosystems store large amounts of carbon, and there are initiatives to protect these blue carbon stores. Organic carbon stocks in tidal salt marshes and mangroves have been estimated, but uncertainties in the stores of seagrass meadows—some of the most productive ecosystems on Earth—hinder the application of marine carbon conservation schemes. Here, we compile published and unpublished measurements of the organic carbon content of living seagrass biomass and underlying soils in 946 distinct seagrass meadows across the globe. Using only data from sites where full inventories exist, we estimate that, globally, seagrass ecosystems could store as much as 19.9 Pg organic carbon, according to a meta-analytical approach, which was integrated with data from carbon pools and depth-distributed density from soil organic matter.

How much carbon? Where? What are the potential emissions?

1The Nature Conservancy, Honolulu, HI (emcleod@tnc.org); Resources Institute (V. H. McLeod)

2USDA Forest Service, Merrill B. Day Research Station, Nebraska (V. H. McLeod)
Outreach & Communication
United Nations Framework Convention on Climate Change (UNFCCC)

"stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (1992)

Overarching framework for other treaties or protocols (e.g. Kyoto Protocol, Bali Action Plan……)

How to integrate coastal ecosystems?
International Blue Carbon Policy Working Group

• Provide guidance for blue carbon policy development

• Build integrated blue carbon community
Chapter 4
Coastal Wetlands

Coordinating Lead Authors
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Lead Authors
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Review Editors
Nuria Marba (Spain) and Georgi Karl Hiebaum (Bulgaria)
Coastal Ecosystems in UNFCCC mechanisms

Nationally Appropriate Mitigation Actions (NAMAs)
- Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions
- Funding through multi-/bilateral initiatives providing fast-start finance
- Coastal Carbon projects should be eligible

Reducing emissions from deforestation and forest degradation (REDD)
- Mechanism for recognizing the climate mitigation value of forest management within developing countries
- Climate mitigation value must be measured, monitored and verified
- Numerous funding sources support readiness activities including improving data on carbon content and drivers of deforestation and degradation
- Mangrove systems are eligible (generally)
# Climate Change Mitigation Funding

Funds exclusively supporting REDD+ (USD millions)

<table>
<thead>
<tr>
<th>Fund / Initiative</th>
<th>Pledged</th>
<th>Deposited</th>
<th>Approved</th>
<th>Disbursed</th>
<th>No of projects approved</th>
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<td>Amazon Fund</td>
<td>1032.44</td>
<td>102.79</td>
<td>168.71</td>
<td>45.94</td>
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<td>Forest Carbon Partnership Facility - Carbon Fund (FCPF-CF)</td>
<td>218.3</td>
<td>138.1</td>
<td>0.57</td>
<td>0.2</td>
<td>1</td>
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<tr>
<td>Forest Carbon Partnership Facility - Readiness Fund (FCPF-RF)</td>
<td>239.4</td>
<td>212.59</td>
<td>31.03</td>
<td>11.46</td>
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<td>Forest Investment Program (FIP)</td>
<td>612</td>
<td>446</td>
<td>50.96</td>
<td>3.59</td>
<td>24</td>
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<tr>
<td>Norway International Climate and Forest Initiative (ICFI)</td>
<td>1,607.82</td>
<td>1,607.82</td>
<td>533.21</td>
<td>276.44</td>
<td>13</td>
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<td>UN-REDD</td>
<td>151.49</td>
<td>118.89</td>
<td>116.13</td>
<td>97.93</td>
<td>18</td>
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<tr>
<td>Australia’s International Forest Carbon Initiative (IFCI)</td>
<td>216.27</td>
<td>67.06</td>
<td>125.54</td>
<td>31.7</td>
<td>9</td>
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<tr>
<td>Congo Basin Forest Fund (CBFF)</td>
<td>165</td>
<td>165</td>
<td>95.38</td>
<td>18.59</td>
<td>37</td>
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</tbody>
</table>

Schalatek et al 2012

**Nationally Appropriate Mitigation Actions (NAMA) Facility**
- Initial funding $100 million (UK and Germany)

**Green Climate – 2020 Fundraising Goal**
- $100 billion per year
UNFCCC recognition of coastal ecosystems

October 2013 Workshop
“Ecosystems with High-Carbon Reservoirs Not Covered by Other Agenda Items under the Convention”
• Current scientific knowledge sufficient to include coastal systems in UNFCCC efforts
• Support developing countries to include coastal systems in GHG inventories

December 2014
• Endorsed IPCC guidelines on GHG accounting in wetlands

June 2014
• General Recognition of mangroves in REDD
• Increasing recognition of coastal ecosystems generally
US EPA - inclusion of wetlands in National GHG inventories

Considering “Coastal Carbon” in Existing U.S. Federal Statutes and Policies

LINWOOD H. PENDLETON,1,2 ARIANA E. SUTTON-GRIER,2 DAVID R. GORDON,1 BRIAN C. MURRAY,1 BRITTA E. VICTOR,1 ROGER B. GRIFFIS,2 JEN A.V. LECHUGA,2 AND CHANDRA GIRI3

1The Nicholas Institute for Environmental Policy Solutions, Duke University, Durham, North Carolina, USA
2The National Oceanic and Atmospheric Administration, Silver Spring, Maryland, USA
3U.S. Geological Survey, USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, USA

Coastal ecosystems such as mangroves, salt marshes, and seagrasses provide important ecosystem services, including nursery habitat for fish, shoreline protection, and the recently recognized service of carbon sequestration and storage. When these wetland ecosystems are degraded or destroyed, the carbon can be released to the atmosphere, where it adds to the concentration of greenhouse gases (GHGs) that contribute to climate change. Many federal statutes and policies specifically require that impacts on ecosystem services be considered in policy implementation. Yet, no federal statute, regulation, or policy accounts directly for the carbon held in coastal habitats. There are a number of federal statutes and policies for which coastal carbon ecosystem services could reasonably be added to environmental and ecosystem considerations already implemented. We look at a subset of these statutes and policies to illustrate how coastal carbon ecosystem services and values might affect the implementation and outcomes of such statutes generally. We identify key steps for the inclusion of the ecosystem services of coastal habitats into the implementation of existing federal policies without statutory changes; doing so would increase the degree to which these policies consider the full economic and ecological impacts of policy actions.

Both Pendleton and Sutton-Grier contributed equally to this article.

This article was only possible with the help of many individuals at several federal agencies who provided their expertise via interviews. The following individuals provided extensive time and insight in support of this analysis. Their contributions to this article do not indicate any action or recommended action by any federal agency. Inclusion on this list only recognizes contribution of facts regarding federal statutes and policies and does not imply individual or agency approval of any of the recommendations listed in this article. Aileen Smith, NOAA; Charley Chesnutt, U.S. Army Corps of Engineers; Dwight Trueblood, NOAA; Marie Bundy, NOAA; Steve Kokkinakis, NOAA; Robyn Colosimo, U.S. Army Corps of Engineers; Peter Edwards, NOAA; Carolyn Currie, NOAA; Alison Leschen, Waquoit Bay National Estuarine Research Reserve; Tibor Vegh, The Nicholas Institute for Environmental Policy Solutions, Duke University. We also thank Megan Jungwiwattanaporn for her help formatting the article. The ideas and opinions contained in this article represent those of the authors and not those of the National Oceanic and Atmospheric Administration.

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National Environmental Policy Act
Includes a mandate to consider impacts on coastal habitats and ecosystem services in planning federal actions

Clean Water Act
Requires compensatory mitigation for unavoidable impacts
Impacts to carbon stores not currently considered

Coastal Zone Management Act
Programs could consider including carbon
Priority Agenda

Enhancing the Climate Resilience of America’s Natural Resources

COUNCIL ON CLIMATE PREPAREDNESS AND RESILIENCE

Key Themes and Commitments Moving Forward:
This Agenda identifies four priority strategies to make the Nation’s natural resources more resilient to a changing climate. For each strategy, the Agenda documents significant progress and provides a roadmap for action moving forward. Highlights of the key actions agencies will undertake in the near term to implement each of the four strategies are described below and in Table 1.

1. **Foster climate-resilient lands and waters** – Protect important landscapes and develop the science, planning, tools, and practices to sustain and enhance the resilience of the Nation’s natural resources.

   Key actions include the development of a Resilience Index to measure the progress of restoration and conservation actions and other new or expanded resilience tools to support climate-smart natural resource management. Agencies will identify and prioritize landscape-scale conservation opportunities for building resilience; fight the introduction and spread of invasive species; and partner internationally to promote resilience within the Arctic. Throughout, agencies will evaluate resilience efforts to inform future actions.

2. **Manage and enhance U.S. carbon sinks** – Conserve and restore soils, forests, grasslands, wetlands, and coastal areas that store carbon. Maintain and increase the capacity of these areas to provide vital ecosystem services alongside carbon storage such as clean air and water, wildlife habitat, food, fiber, and recreation.

   Key actions include the development of improved inventory, assessment, projection and monitoring systems for important carbon sinks and the development of estimates of baseline carbon stocks and trends to inform resource management. A number of actions will secure the continued health of the Nation’s natural resources that provide carbon biosequestration, including forests, agricultural lands, and inland and coastal wetlands.

3. **Enhance community preparedness and resilience by utilizing and sustaining natural resources** – Harness the benefits of nature to protect communities from harm and build innovative 21st century infrastructure that integrates natural systems into community development.

   Federal agencies will take action to encourage investment in natural infrastructure to improve resilience and enhance natural defenses through new federal guidance on ecosystem services assessment, an actionable research agenda, rigorous program evaluation, and expanded decision support tools and services. Federal agencies will increase assistance to states, tribes and localities interested in pursuing green stormwater management solutions and will expand partnerships that reduce wildfire risk and protect critical drinking water supplies, promote irrigation efficiency and water efficiency,  

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1 See page 19.
and 3). Below-ground C storage was positively but weakly accounted for 71–98% and 49–90% in soil dominated, exceptionally high compared to mean C storage of the tropics (sample-wide mean: 1,023 Mg C ha

relative importance of allochthonous (river sediment) versus marine-edge settings, often the coasts of islands with fringing mangroves. Rhizophora can exhibit both conditions (see Supplementary Table S1).

Figure 1: 8.74", 4.2"

38°59′ S New Zealand and 32°59′ S Sundarbans are located, the largest tract of mangrove forests in the world. Despite the highest population density in the world

Global Ecology and Biogeography

Caveats

types within each contain substantially higher or lower C stores of soil contains 50% of all C residing in soil

Carbon Country?

Comparison of mangrove C storage (mean ± s.d.)

2000 - 2005 Rate of loss: 50 000 ha/year (1.6%) (FAO 2007)

Mangrove Cover

<table>
<thead>
<tr>
<th>SN</th>
<th>Country</th>
<th>Area (ha)</th>
<th>% of global total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indonesia</td>
<td>3,112,989</td>
<td>22.6</td>
</tr>
<tr>
<td>2</td>
<td>Australia</td>
<td>977,975</td>
<td>7.1</td>
</tr>
<tr>
<td>3</td>
<td>Brazil</td>
<td>962,683</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>Mexico</td>
<td>741,917</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Giri et al (2011)

Donato et al (2011)
Indonesia – National Activities

Indonesia National Science Plan of Action on Blue Carbon (Jan 2014)
Expanding science program (domestic and international)

Indonesian National Council on Climate Change
The National GHG emissions scheme under development, will include coastal carbon

Ministry of Marine Affairs and Fisheries
Blue Carbon is an official activity

Not included in National GHG inventories….
Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment
Blue Carbon Field Projects

Blue Carbon Field Projects, Categorized by Activity
Develop and support policy and management that conserves and promotes sustainable use of the mangroves.

Gulf of Nicoya - Costa Rica
Since 1950
- 16% loss of mangroves,
- 2.2 million tonnes of CO2 (eq) emissions

Project:
- Mangrove restoration and conservation
- Sustainable management
- Community Education

(Cifuentes, personal comm)
Potential Carbon-Credit Values

For Comparison:

- Seagrasses
- Tidal Salt Marsh
- Estuarine Mangroves
- Oceanic Mangroves
- Tropical forest

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Carbon Sequestration</th>
<th>Avoided Emissions –</th>
<th>Avoided Emissions –</th>
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<tr>
<td></td>
<td></td>
<td>Soil C</td>
<td>Biomass C</td>
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<td>Seagrasses</td>
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<td>Tidal Salt Marsh</td>
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<td>Oceanic Mangroves</td>
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<tr>
<td>Tropical forest</td>
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</table>
To be able to submit carbon project to a carbon registry:
1. Develop Project
2. Project Validation (Does the project follow the rules of the registry?)
3. Project monitoring and carbon credit verification
4. Issuance of carbon credits

Wetlands Projects need:
Standardized Methodologies for Carbon Accounting in wetlands:
• Restoration Projects
• Conservation Projects
<table>
<thead>
<tr>
<th>Project ID</th>
<th>Project Name</th>
<th>Project Proponent</th>
<th>Country</th>
<th>Sectoral Scope</th>
<th>Estimated Annual Emission Reductions</th>
<th>Additional Certifications</th>
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<td>Guanacé: Forest Plantations on degraded grasslands under extensive grazing</td>
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</tbody>
</table>
What Policy Needs Now......

Global and local scale mapping of mangroves, salt marshes, seagrasses
- extent
- carbon
- monitoring

Emissions from healthy and degraded systems
- measurements
- Models (carbon change, ecosystem shifts…)
- Estimates of storage and emissions from priority regions (Indonesia …)

Globally accessible, quality controlled, Coastal Carbon Data Archive

Seagrasses!
- Distribution, carbon estimates, rates of loss, monitoring techniques…….

Standards and methodologies for carbon accounting, emissions estimates
Thank you

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epidgeon@conservation.org

http://thebluecarboninitiative.org/