Remote Sensing and the Development of Blue Carbon Initiatives

Dr. Emily Pidgeon
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Conservation International
Oceans play a vital role in controlling greenhouse gases

Deforestation + Fossil Fuels

Atmosphere 46%

Land 29%

Oceans 26%
Coastal Wetlands
Coastal ecosystems have high sequestration rates.
Coastal habitats store large amounts of carbon
These ecosystems are being rapidly lost

<table>
<thead>
<tr>
<th>COASTAL HABITAT</th>
<th>EST. GLOBAL AREA (km sq)</th>
<th>ANNUAL LOSS</th>
<th>TOTAL LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrasses</td>
<td>300,000</td>
<td>2%</td>
<td>29%</td>
</tr>
<tr>
<td>Salt Marshes</td>
<td>400,000</td>
<td>2%</td>
<td>50%+</td>
</tr>
<tr>
<td>Mangroves</td>
<td>152,000</td>
<td>1.8%</td>
<td>35%</td>
</tr>
</tbody>
</table>

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Numerous causes of degradation and destruction

Aquaculture

Agriculture

Development

Pollution
Globally significant emissions.

<table>
<thead>
<tr>
<th></th>
<th>Global Extent</th>
<th>Loss</th>
<th>Carbon Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangroves</td>
<td>137,760 km²</td>
<td>30–50% in the last 50 years</td>
<td>0.02 – 0.12 Pg C yr⁻¹</td>
</tr>
<tr>
<td>Seagrasses</td>
<td>300,000-600,000 km²</td>
<td>1.5% annually</td>
<td>0.06 – 0.3 Pg C yr⁻¹</td>
</tr>
</tbody>
</table>

For comparison: Tropical deforestation net emissions = 1.3 Pg C yr⁻¹

Pan et al. (2011)
How can blue carbon lead to conservation and restoration of coastal ecosystems?

• Increase recognition of climate change significance
• Improve management and regulation
• Provide basis for incentives to conserve or restore
The International Blue Carbon Initiative

Increased conservation, restoration and sustainable management of coastal blue carbon ecosystems

http://thebluecarboninitiative.org/
Considering “Coastal Carbon” in Existing U.S. Federal Statutes and Policies

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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 greenhouses 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.

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Develop and support policy and management that conserves and promotes sustainable use of the mangroves.

In next year

- Assessment fisheries and blue carbon value
- Community mangrove restoration
- Capacity building in sustainable fisheries and alternative livelihoods
Implementing Blue Carbon – Remote Sensing Needs

Global and National Scales
What is the extent of Blue Carbon eco systems?
What are the rates of ecosystem loss and hotspots of that loss?
What are the associated carbon emissions?

Regional to Site Scales
Accurate estimates of ecosystem extent, condition and carbon
Systematic, repeatable assessments of ecosystem extent and condition
  Estimates of rate of ecosystem change
  Estimates of carbon change
  Monitoring

Minimal Cost  Limited technical capacity
Mangroves – Global Extent

Giri (2011)
Mangroves – Local mapping

Coastal Landcover Classification of Timika City and Surrounding Areas

Legend
- Dryland Forest - Some Riparian Forest
- Swampy Grassland
- Swampy Shrubland
- Mixed Swampy Forest-Sago
- Wetland Forest
- Grassland
- Settlement
- Oil Palm Plantation
- Water
- Cloud
- Soil
- Rhizophora sp
- Avicennia sp
- Brugmansia sp
- Other Mangrove species

Elevation > 150 meter

Rahman 2014
Mangroves – Aboveground Carbon

Mangrove Tree Height

Mangrove Biomass

Simard et al 2006
### Table 2. Area of mangrove cover and mean biomass per hectare per country.

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (km²)</th>
<th>Total biomass (Mg)</th>
<th>Mean biomass (Mg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>154</td>
<td>1,441,200</td>
<td>93</td>
</tr>
<tr>
<td>Benin</td>
<td>18</td>
<td>137,719</td>
<td>76</td>
</tr>
<tr>
<td>Cameroon</td>
<td>1,483</td>
<td>25,334,900</td>
<td>171</td>
</tr>
<tr>
<td>Congo</td>
<td>15</td>
<td>267,603</td>
<td>178</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>32</td>
<td>406,516</td>
<td>124</td>
</tr>
<tr>
<td>Djibouti</td>
<td>17</td>
<td>1,653,170</td>
<td>90</td>
</tr>
<tr>
<td>DRC</td>
<td>183</td>
<td>51,570</td>
<td>140</td>
</tr>
<tr>
<td>Egypt</td>
<td>1</td>
<td>8344</td>
<td>117</td>
</tr>
<tr>
<td>Equatorial Guinea</td>
<td>181</td>
<td>2,922,420</td>
<td>161</td>
</tr>
<tr>
<td>Eritrea</td>
<td>49</td>
<td>640,038</td>
<td>129</td>
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<tr>
<td>Gabon</td>
<td>1,457</td>
<td>23,840,000</td>
<td>162</td>
</tr>
<tr>
<td>Gambia</td>
<td>519.11</td>
<td>5,509,300</td>
<td>106</td>
</tr>
<tr>
<td>Ghana</td>
<td>76</td>
<td>742,925</td>
<td>97</td>
</tr>
<tr>
<td>Guinea</td>
<td>1,889</td>
<td>18,153,800</td>
<td>108</td>
</tr>
<tr>
<td>Guinea Bissau</td>
<td>2,806</td>
<td>31,712,300</td>
<td>113</td>
</tr>
<tr>
<td>Kenya</td>
<td>192</td>
<td>2,294,820</td>
<td>119</td>
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<tr>
<td>Liberia</td>
<td>189</td>
<td>2,141,860</td>
<td>113</td>
</tr>
<tr>
<td>Madagascar</td>
<td>2,059</td>
<td>24,856,900</td>
<td>121</td>
</tr>
<tr>
<td>Mauritania</td>
<td>0.4</td>
<td>4156</td>
<td>95</td>
</tr>
<tr>
<td>Mozambique</td>
<td>3,054</td>
<td>30,974,100</td>
<td>101</td>
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<tr>
<td>Nigeria</td>
<td>8,573</td>
<td>94,788,000</td>
<td>111</td>
</tr>
<tr>
<td>Senegal</td>
<td>1,200</td>
<td>11,462,100</td>
<td>95</td>
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<tr>
<td>Sierra Leone</td>
<td>955</td>
<td>10,655,600</td>
<td>112</td>
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<tr>
<td>Somalia</td>
<td>30</td>
<td>436,907</td>
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<td>Sudan</td>
<td>4</td>
<td>135,626</td>
<td>113</td>
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<td>South Africa</td>
<td>12</td>
<td>40,018</td>
<td>100</td>
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<tr>
<td>Togo</td>
<td>2</td>
<td>15,861</td>
<td>78</td>
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<tr>
<td>Tanzania</td>
<td>809</td>
<td>11,037,800</td>
<td>136</td>
</tr>
<tr>
<td>Africa</td>
<td>25,960</td>
<td>301,665,553</td>
<td>116</td>
</tr>
</tbody>
</table>
Mangroves – Monitoring Change

Figure 3: Spatial distribution of mangrove deforestation in Ayeyarwady Delta, Burma, during 1975–90, 1990–2000 and 2000–05.

Giri et al 2007
Salt Marshes
Mapping Seagrasses
Seagrasses – Challenges for remote sensing

Fourqurean (per comm)
Seagrasses – Challenges for remote sensing

The water acts as a distorting filter
- Depth
- Suspended particles
  - Phytoplankton
  - Sediment
- Colored dissolved organic matter (CDOM)
- Light attenuation
- Spectral distortion

Seagrass leaves are green (Chlorophyll) but they often have highly variable spectral properties.
Figure 5. Seagrass species composition map produced for 2004 (left) and 2007 (right).
Remote Sensing in Blue Carbon Ecosystems – Current Status

<table>
<thead>
<tr>
<th></th>
<th>Global / Regional Extent and Change</th>
<th>Local Extent and Change</th>
<th>Above-ground Carbon</th>
<th>Total Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrove</td>
<td>✔</td>
<td>✔</td>
<td>Some</td>
<td>✗</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>Now possible!</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Seagrass</td>
<td>✗</td>
<td>In shallow, clear water with significant ground-truthing</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
Thank you

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http://thebluecarboninitiative.org/