A Research Agenda for Coastal Blue Carbon Approaches for Carbon Dioxide Removal and Sequestration

*Negative Emissions Technologies and Reliable Sequestration: A Research Agenda by the Committee on Developing a Research Agenda for Carbon Dioxide Removal and Reliable Sequestration*

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Study Motivation

• 2015 National Academies report recommends R&D investment to improve methods of CDR and sequestration at scales that matter, in particular to:
  – minimize energy and materials consumption
  – identify and quantify risks
  – lower costs
  – develop reliable sequestration and monitoring

• Need for detailed research and development agenda to assess benefits, risks, and sustainable scale potential; and increase commercial viability

• Sponsors: DOE, NOAA, EPA, USGS, V. Kann Rasmussen Foundation, Incite Labs, NAS, Linden Trust for Conservation
Statement of Task

• **Identify** the most urgent unanswered scientific and technical questions needed to:
  – assess the benefits, risks, and sustainable scale potential for carbon dioxide removal and sequestration approaches in terrestrial and coastal environments
  – increase the commercial viability of carbon dioxide removal and sequestration

• **Define** the essential components of a research and development program and specific tasks required to answer these questions

• **Estimate** the costs and potential impacts of such a research and development program to the extent possible in the timeframe of the study

• **Recommend** ways to implement such a research and development program
Study Process

• Information gathering workshops
  – Coastal Blue Carbon Approaches (July 2017)
  – Bioenergy with Carbon Capture and Storage Approaches (Oct. 2017)
  – Direct Air Capture (Oct. 2017)
  – Geologic Sequestration and Mineral Carbonation Approaches (Nov. 2017)

• Additional webinars

• Committee meetings to develop report

• Extensive external peer review
How large is potential market for NETs likely to be? 
Or equivalently, how much carbon uptake is needed to meet Paris Agreement goals?

~10 GtCO₂/y globally by midcentury
~20 GtCO₂/y globally by the century’s end

UNEPA, 2017
Existing options cannot provide the amount of negative emissions needed to meet demand/need without unprecedented levels of adoption or changes in land use that could affect food availability and biodiversity.

<table>
<thead>
<tr>
<th>Negative Emissions Technology</th>
<th>Estimated Cost ($/tCO₂)</th>
<th>Upper Bound* for Safe* Potential Rate of CO₂ Removal Possible Given Current Technology and Understanding and at &lt; $100/tCO₂ (GtCO₂/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L = 0-20</td>
<td></td>
</tr>
<tr>
<td>Coastal blue carbon</td>
<td>L 0.02</td>
<td>US 0.02</td>
</tr>
<tr>
<td>Afforestation/Reforestation</td>
<td>L 0.15</td>
<td>Global 0.13</td>
</tr>
<tr>
<td>Forest management</td>
<td>L 0.1</td>
<td>US 0.1, Global 1.5</td>
</tr>
<tr>
<td>Agricultural soils</td>
<td>L to M 0.25</td>
<td>US 0.25, Global 3</td>
</tr>
<tr>
<td>BECCS</td>
<td>M 0.5</td>
<td>US 0.5, Global 3.5-5.2</td>
</tr>
<tr>
<td>Direct air capture</td>
<td>H 0</td>
<td>US 0, Global 0</td>
</tr>
<tr>
<td>Carbon mineralization</td>
<td>M to H unknown</td>
<td>US unknown, Global unknown</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.02</strong></td>
<td><strong>9.13-10.83</strong></td>
</tr>
</tbody>
</table>

*Assumes full adoption of agricultural soil conservation practices, forestry management practices, and waste biomass capture.

*Without large-scale land-use change that could adversely affect food availability and biodiversity.
Coastal Blue Carbon Approaches

Practices that increase the amount of carbon stored in living plants or soils in tidal marshes, mangroves, and seagrass beds

1. **Active ecosystem management**: Maintain carbon benefits against a decreasing future baseline
2. **Restoration**: Restore lost and degraded acreage
3. **Nature-based adaptation**: Replace hardened shoreline and create hybrid natural features
4. **Managed wetland transgression**: Manage upland migration with sea-level rise
5. **Carbon-rich projects**: Augment coastal projects to increase carbon storage capacity
Coastal Blue Carbon
Carbon Potential (U.S.)

0.02-0.05 Gt/y CO₂ Removal and Storage

Plus 0.01-0.03 Gt/y CO₂ Storage only

The graph shows the projected CO₂ removal and storage potential from 2010 to 2100. The lines represent different categories:

- Natural + restoration + engineering
- Stock with C-rich materials
- 2ft managed transgression
- 4ft managed transgression
- Total Flux
Coastal blue carbon approaches provide additional services
- Recreation and tourism, fishery habitats, water quality improvements, and flood and erosion mitigation
- Coastal restoration and adaptation projects are occurring regardless of carbon benefit

Costs vary widely and may be prohibitively expensive if undertaken solely to manage carbon
- Incremental costs for monitoring storage in coastal projects <$10/tCO$_2$
Conclusion: Although their potential for removing carbon is lower than other negative emissions technologies, coastal blue carbon approaches warrant continued exploration and support. The cost of the carbon removal is low or zero because investments in many coastal blue carbon projects target other benefits such as ecosystem services and coastal adaptation. Understanding of the impacts of sea-level rise, coastal management, and other climate impacts on future uptake rates should be improved.
Coastal Blue Carbon Research Agenda

**Primary Limiting Factors:**
- Available land given coastal development and land use
- Understanding future rates with sea level rise and coastal management

**BASIC RESEARCH** ($6M/yr for 5-10 yrs)
- Fate of organic carbon
- Change in areal extent in response to climate change, sediment availability, human disturbance
- Selection of carbon rich and slow decay plants and other materials

**DEVELOPMENT**
Map and monitor coastal wetlands ($2M/yr for 20 yrs)
Data center ($2M/yr for 20 yrs)
Coastal Blue Carbon Research Agenda

DEMONSTRATION/DEPLOYMENT

Network of ~15 research sites ($10M/yr for 20 yrs)
• Demonstrate carbon-augmentation projects & conduct field experiments

Network of ~40 research sites ($40M/yr for 20 yrs)
• Determine how best to add CO₂ removal and storage to coastal engineering projects at the lowest cost and how to manage wetland transgression
• In both natural systems and coastal engineering projects
• Common set of measurements
Coastal Blue Carbon Research Agenda

DEPLOYMENT

Social science research ($5M/yr for 10 yrs)

- Response of coastal land owners and managers to CO$_2$ removal and storage incentives
- Policies to manage responsibility for carbon lost to inundation/erosion
- Policy research on incentives and barriers
- Economic linkages between actions taken to protect, restore, and expand tidal wetlands and human well-being

Need for a staged research program
Coastal Blue Carbon
Research Agenda

Sponsors and performers of the research
• Broad range of federal, state, and local government agencies, academic institutions
• Interagency academia-NGO-industry program working group for coastal blue carbon projects database
• Role for foundations and private sector in research related to demonstration and deployment
Recommendation: The nation should launch a substantial research initiative to advance negative emissions technologies as soon as practicable:

1. Improve coastal blue carbon, afforestation/reforestation, changes in forest management, uptake and storage by agricultural soils, and BECCS to increase capacity and to reduce negative impacts and costs.
2. Make rapid progress on direct air capture and carbon mineralization technologies, which are underexplored but would have essentially unlimited capacity if high costs and many unknowns could be overcome.
3. Advance NET-enabling research on biofuels and carbon sequestration that should be undertaken anyway as part of an emissions mitigation research portfolio.
Thank you!

For more information and to subscribe for updates:

http://nas-sites.org/dels/studies/cdr/

Join the conversation on Twitter: #CarbonRemoval