Satellites, biodiversity, and blue carbon, Oh My!

Science to support climate change mitigation and adaptation, coastal resilience, and habitat conservation

Dr. Ariana Sutton-Grier
Ecosystem Science to Support Climate and Conservation Policy

1. Blue Carbon (and satellites!)
2. Biodiversity and Human Health
3. Natural Infrastructure
Our Changing Carbon Cycle

Black Carbon (human emissions)

Green Carbon (terrestrial biota)

Coastal Blue Carbon

Coastal habitats:
Salt marshes
Mangroves
Sea Grasses

Blue Carbon (coasts and oceans)

www.pmel.noaa.gov/co2/story/Research
Coastal Habitats Sequester Carbon

- Smaller total area, but much greater sequestration in coastal blue carbon habitats
- Coastal habitats ~equivalent annual sink to forest systems

Coastal Habitats Store Carbon

In coastal habitats, most carbon is stored in sediments and less in biomass.

Rapid Loss of Coastal Carbon Services

• From 2004-2009, U.S. coastal watersheds lost wetlands at an average rate of 80,000 acres/year

• Worldwide, rates of loss range from 0.7 – 7% annually

• Coastal carbon emissions ~3-19% those of deforestation annually (Pendleton et al. 2012)
Blue Carbon Research Needs

- Extent of seagrasses and health of all three ecosystems
- **Carbon sequestration and storage in all three ecosystems, as well as emissions**
- What happens to the fate of carbon in wetlands that are drowning with sea level rise?
- How quickly can we restore carbon services when we do coastal restoration?
**“Blue” Carbon Monitoring System**

Linking Satellite and Soil Data to Validate Coastal Wetland 'Blue Carbon' Inventories: Upscaled Support for Developing MRV and REDD+ Protocols (October 2014-17)

Lead PI: Lisamarie Windham-Myers (18 Science PIs, all but 1 PhD)

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“Blue” Carbon Monitoring System

Product 1: National Scale stock-based 30m resolution C pool maps (1992-2011) via NOAA’s C-CAP (NLCD) linked with regional SLR and SSURGO 1m soil data
**“Blue” Carbon Monitoring System**

Goal:
- IPCC National Greenhouse Gas Inventory
  Need demonstration of approaches for SBSTA, 2017
- REDD+ development (international)
  Need protocol for stock-based soil C
- Carbon market (voluntary and regulatory)
  Need projections of baseline and activity budgets

Example wedges of GHG benefits
Biodiversity and Human Health

- Arguments to preserve biodiversity for intrinsic value or products (food, etc)
- New evidence suggests that there are reasons to preserve biodiversity
- Important connections to human health and well-being
- Human health is “ultimate ecosystem service”
- Working with Paul Sandifer
Questions

1. Is there convincing evidence that experiencing more natural settings, even briefly or vicariously, can improve psychological and physical health?

2. Does exposure to biodiverse nature result in measurable health responses?

3. Can biodiversity provide humans and animals protection from infectious and/or allergic and inflammatory diseases?

(Sandifer, Sutton-Grier and Ward, In Review)
Results: Nature and Human Health

Range of positive health responses to environments that are more natural

- Reduces stress, blood pressure
- Improves mood, self-esteem, energy, pleasure
- Improves recovery from surgery
- Decreases prevalence of asthma, anxiety
Biodiversity and Human Health

- Limited but growing evidence that not just exposure to nature, but contact with diverse natural habitats and many different species, has important positive impacts for human health.

  - Reflection, sense of identity, and sense of place increased with plant and bird diversity. Fuller et al. 2007

  - Greater decrease in heart rate and more improvement in mood with fish diversity. Cracknell 2013

  - Preference for outdoor activity in biodiverse environments. Dallimer 2012
Chronic Diseases and Biodiversity

- Allergy results from a lack of exposure to microbes which leads to hyper-responsiveness to bioparticles → microbe-rich environments confer health benefits especially to children

- “Biodiversity” or “Hygiene” hypothesis: loss of macrodiversity leads to loss of microdiversity which leads to changes in human microbiota and results in variety of disorders

Conclusions: Policy and Planning

Ideally, want to place human health and well-being as the *central purpose* of urban planning

WHO Healthy Cities and Healthy Urban Planning Initiatives
Biodiversity Take Homes

• Biodiversity may have direct, positive impacts on human health.

• Potential to implement these findings to enhance human well-being and develop increased public support for biodiversity conservation and restoration.
Enhancing Disaster Resilience by Valuing Nature's Defenses

Working with Katya Wowk and Holly Bamford
Sandy: A Turning Point?
Coastal ecosystems provide a suite of valuable benefits (ecosystem services) on which humans depend for food, economic activities, inspiration, and enjoyment.
Rebuild By Design: “Big U” Project is Climate Adaptation and Recreational Opportunities

- Hard and soft infrastructure
- Nature-as-buffer approach
- Synthesis paper (Sutton-Grier et al., In review) on benefits of natural and hybrid infrastructure
Other benefits of coastal habitats: habitat, recreation, erosion protection, carbon storage
Overall Conclusions

- Lots of 21st century challenges to tackle
- Lots of opportunities to do science that can help to inform policy and management
- Takes effort, engagement, perseverance to incorporate science into policy and management
- But it’s worth it!
Questions?
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Podcast:
http://oceanservice.noaa.gov/podcast/may14/mw124-bluecarbon.html

For more information see:
http://www.habitat.noaa.gov/coastalbluecarbon.html
Other benefits of blue carbon habitats: Storm Protection

U.S. coastal wetlands provide $23.2 billion storm protection benefits annually (Constanza et al., 2008)
“Blue” Carbon Monitoring System

Pendleton et al. 2011

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<th>(depth&lt;200m = 4.7% of ocean)</th>
<th>Pg C yr⁻¹</th>
<th>% ocean total</th>
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<tr>
<td>Primary Production</td>
<td>6.5</td>
<td>12</td>
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<tr>
<td>Export Production</td>
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<td>21</td>
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<tr>
<td>Burial</td>
<td>0.67</td>
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Figure 1: Blue carbon sinks

- Mangroves: 0.2 Pg C yr⁻¹
- Seagrasses: 0.3 Pg C yr⁻¹
- Salt marshes: 0.4 Pg C yr⁻¹
- Estuaries: 1.8 Pg C yr⁻¹
- Deep sea: 26.6 Pg C yr⁻¹

Finland Adolescent Study

- Analyzed land-use types within 3km radius of homes
- Loss of contact with diverse natural world is making us sick
- Kids with allergies had lower environment diversity and fewer kinds of Gram-negative gammaproteobacteria on their skin (Hanski et al. 2012)

Conclusions: Research Needs

• Specific mechanisms for biodiversity affects human health
• Best ways to measure biodiversity to determine human exposure?
• Which metrics of health would be the best indicators of biodiversity-human health impacts?
• Better monitor biodiversity and integrate info into public health and natural resource management and policy
• Need for large, community-wide health datasets and over longer periods of time
Interest in “green infrastructure” and “living shorelines” for storm protection

- “Protecting the city, before next time” New York Times, Nov. 3, 2012

- Blue carbon habitats, A LOT MORE THAN JUST CARBON SINKS!
**Minimal Defense**
Many communities have developed right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.

**Natural**
Natural habitats that can provide storm and coastal flooding protection include salt marsh, oyster and coral reefs, mangroves, seagrasses, dunes, and barrier islands. A combination of natural habitats can be used to provide more protection, as seen in this figure. Communities could restore or create a barrier island, followed by oyster reefs and salt marsh. Temporary infrastructure (such as a removable sea wall) can protect natural infrastructure as it gets established.

**Managed Realignment**
Natural infrastructure can be used to protect built infrastructure in order to help the built infrastructure have a longer lifetime and to provide more storm protection benefits. In managed realignment, communities are moving sea walls farther away from the ocean edge, closer to the community and allowing natural infrastructure to recruit between the ocean edge and the sea wall.

**Hybrid**
In the hybrid approach, specific built infrastructure, such as removable sea walls or operable flood gates (as shown here) are installed simultaneously with restored or created natural infrastructure, such as salt marsh and oyster reefs. Other options include moving houses away from the water and/or raising them on stilts. The natural infrastructure provides key storm protection benefits for small to medium storms and then when a large storm is expected, the built infrastructure is used for additional protection.