Satellites, biodiversity, and blue carbon, Oh My!

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

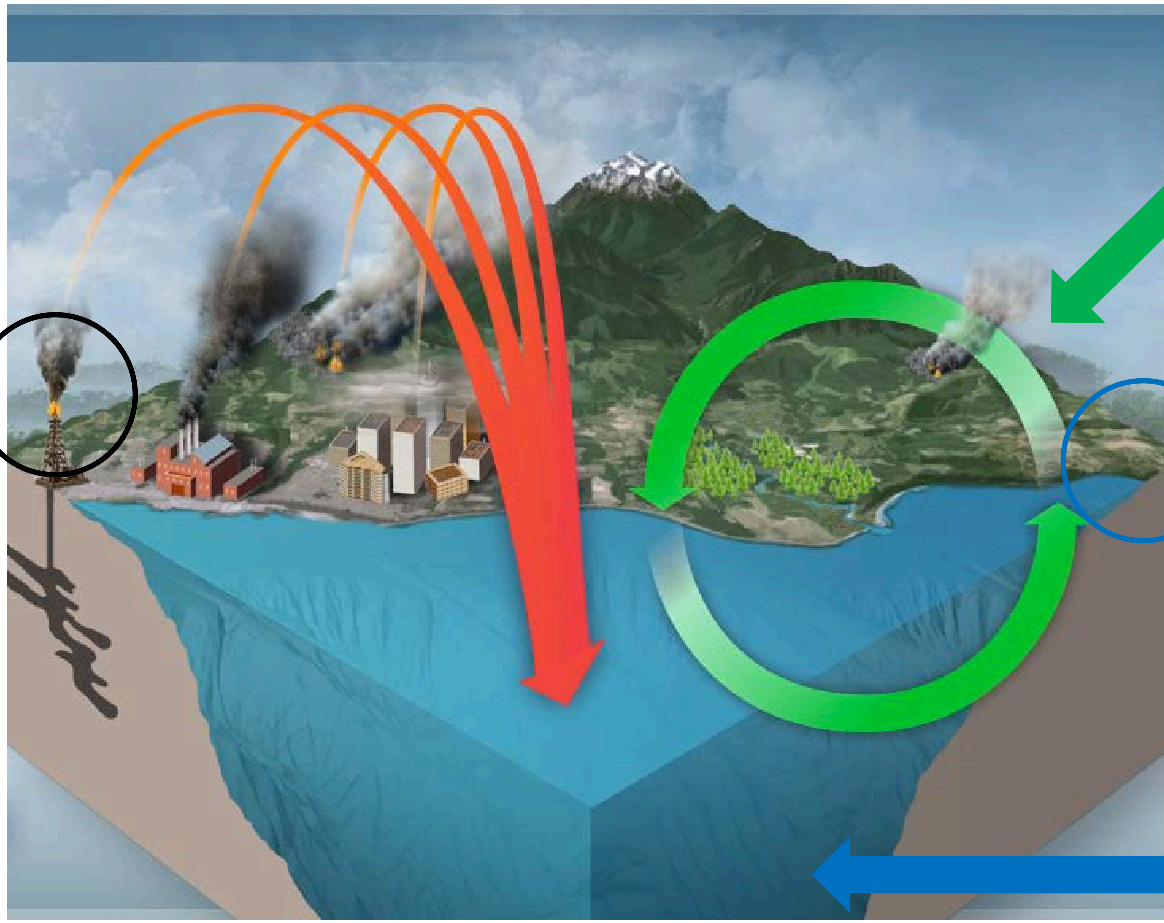
Dr. Ariana Sutton-Grier

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

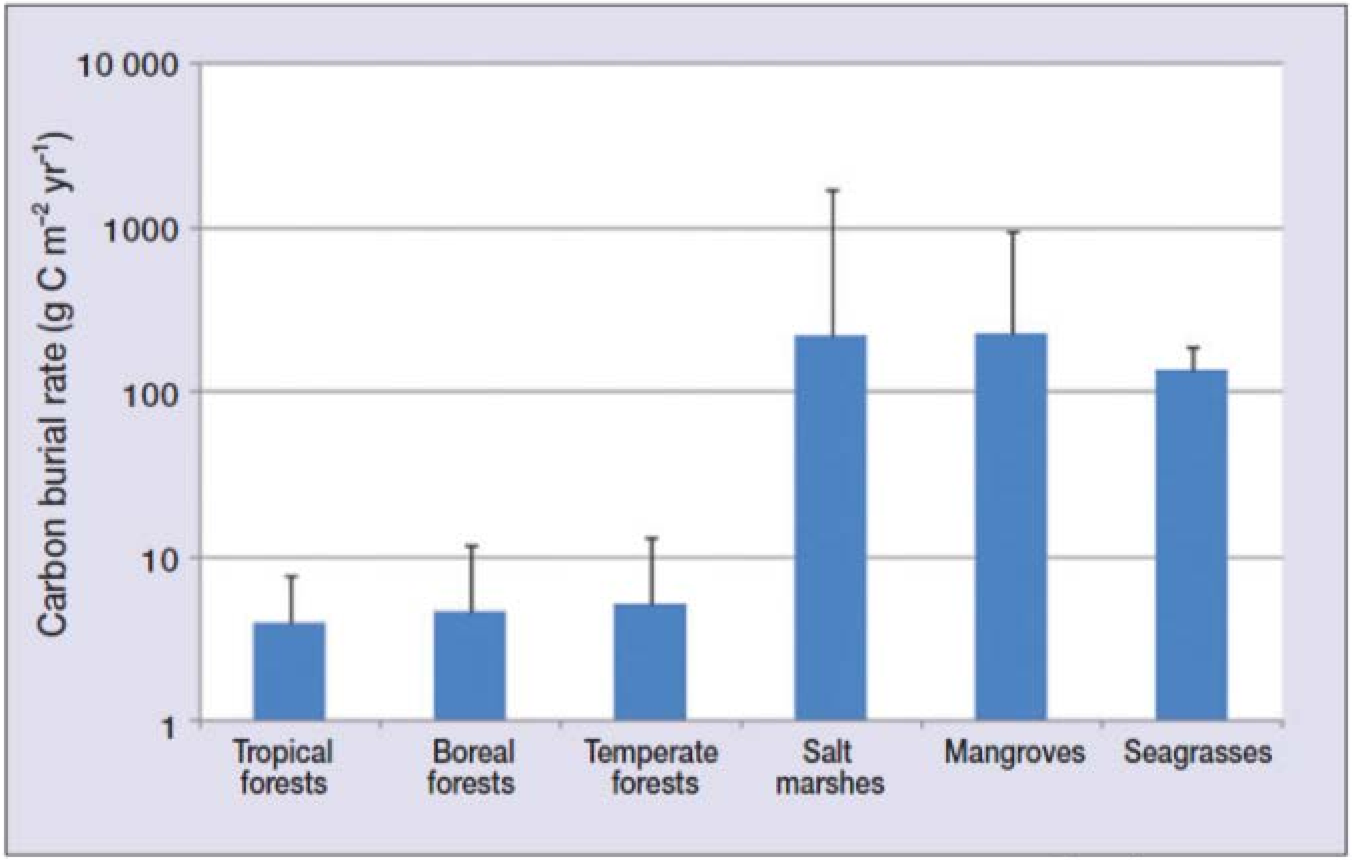
Coastal habitats:
Salt marshes
Mangroves
Sea Grasses

Blue Carbon
(coasts and oceans)

www.pmel.noaa.gov/co2/story/Research

Coastal Habitats Sequester Carbon

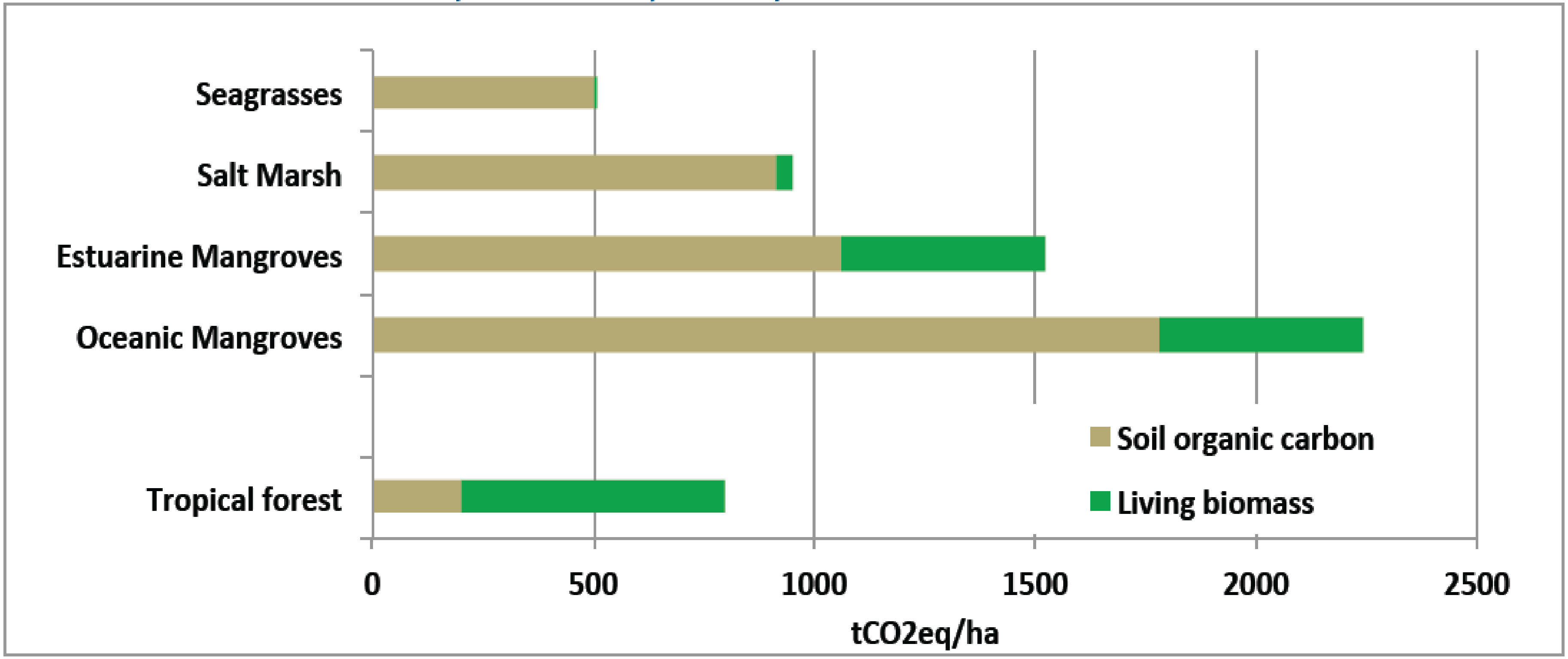
- Smaller total area, but much greater sequestration in coastal blue carbon habitats
- Coastal habitats ~equivalent annual sink to forest systems



McLeod et al. 2011. Frontiers in Ecology and Environment

Coastal Habitats Store Carbon

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



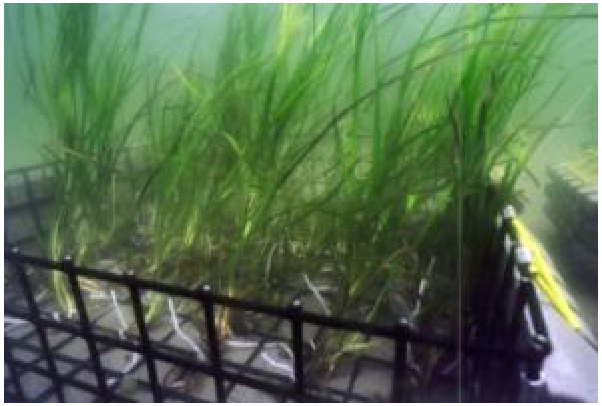
Source: Murray, Brian, Linwood Pendleton, W. Aaron Jenkins, and Samantha Sifleet. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NI R 11-04.

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

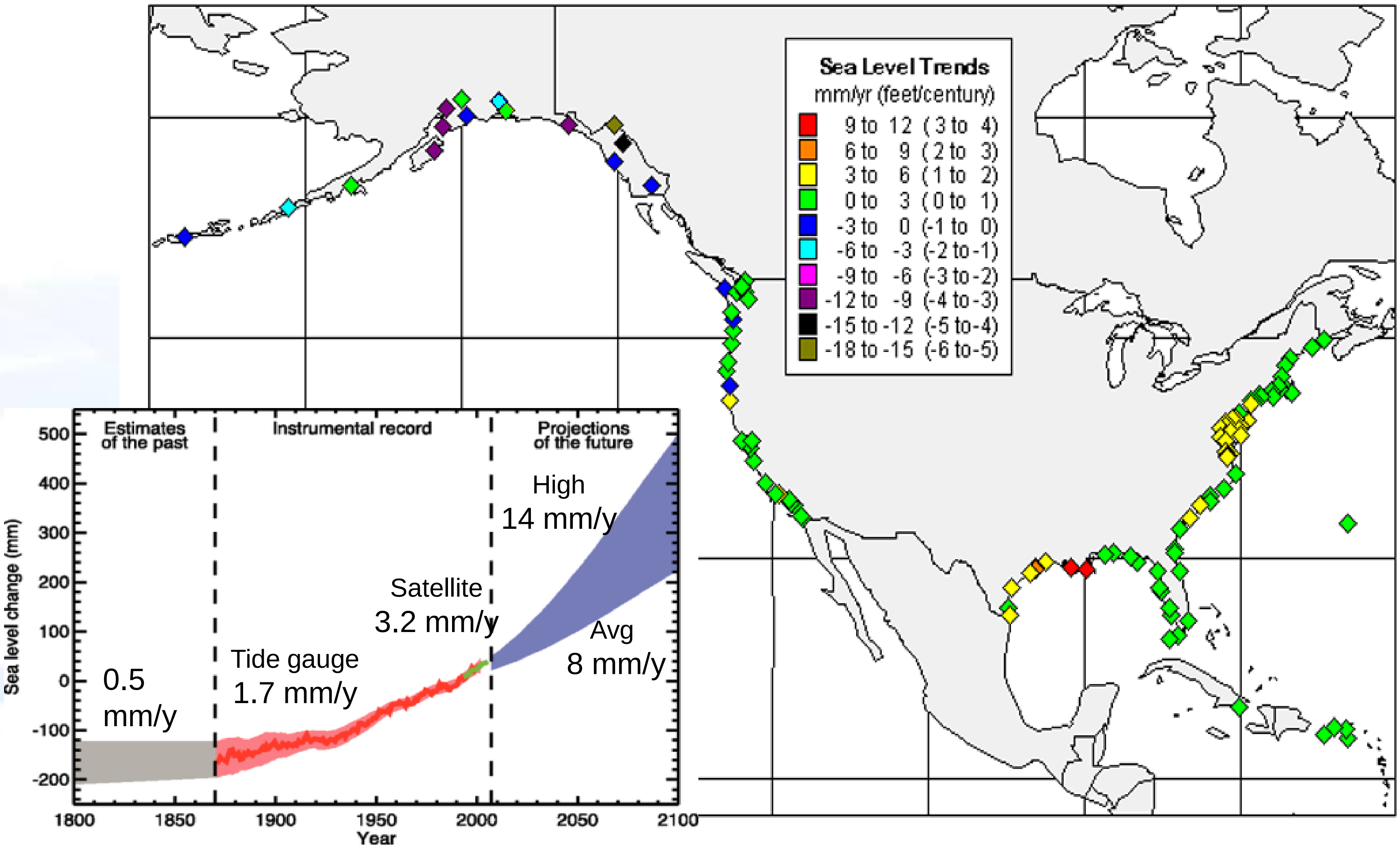
Linking Satellite and Soil Data to Validate Coastal Wetland 'Blue Carbon' Inventories: Upscaled Support for Developing MRV and REDD+ Protocols (October 2014-17)

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

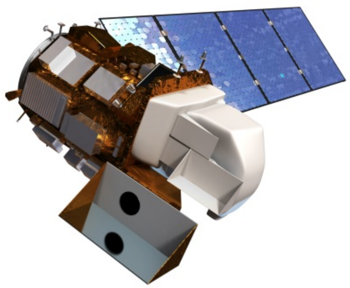
Federal		Non Federal	
USGS	Brian Bergamaschi Kristin Byrd Judith Drexler Kevin Kroeger John Takekawa Isa Woo	U. South Carolina	Jim Morris
		U. Maryland/NOAA	Ariana Sutton-Grier
		U. San Francisco	John Callaway
		Florida Intl. U.	Tiffany Troxler
NOAA-NERR	Matt Ferner	Texas A&M U.	Rusty Feagin
Smithsonian	Pat Megonigal Don Weller Lisa Schile	IUCN/RAE	Stephen Crooks
NASA-JPL	Marc Simard		

“Blue” Carbon Monitoring System

Product 1: <u>National Scale</u> <u>stock-based</u> 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



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verifiable protocol to support federal, international, and market incentives

Goal:

- IPCC National Greenhouse Gas Inventory

Need <u>demonstration</u> of approaches for SBSTA, 2017

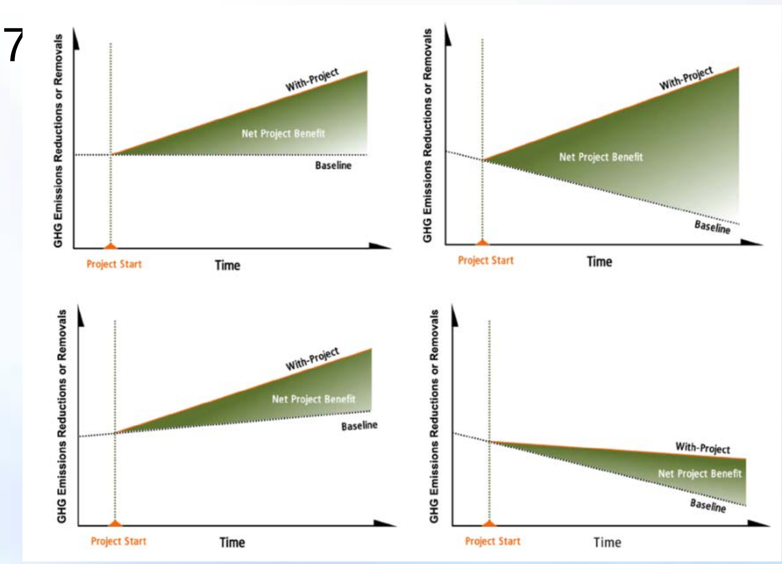
- REDD+ development (international)

Need protocol for stock-based <u>soil C</u>

- Carbon market (voluntary and regulatory)

Need <u>projections</u> 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

Biodiversity
WE ARE ALL IN THIS TOGETHER

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

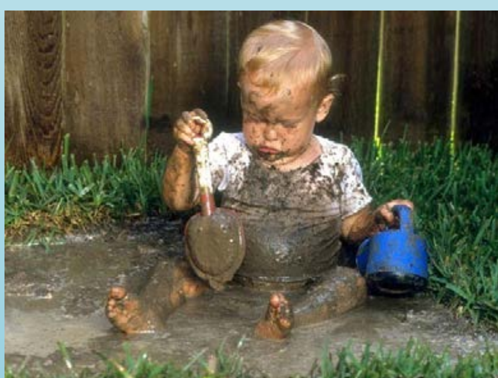
- Limited but growing evidence that not just exposure to nature, but contact with diverse natural habitats and many different species, has important positive impacts for human health

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

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

Preference for outdoor activity in biodiverse environments Dallimer 2012

Chronic Diseases and Biodiversity



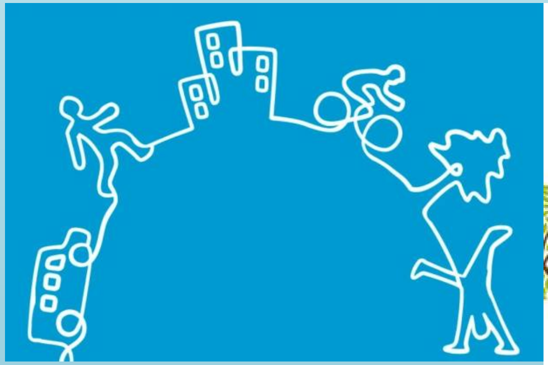
- Allergy results from a *lack* of exposure to microbes which leads to hyper-responsiveness to bioparticles→ microbe-rich environments confer health benefits especially to children
- “Biodiversity” or “Hygiene” hypothesis: loss of macrodiversity leads to loss of microdiversity which leads to changes in human microbiota and results in variety of disorders

(Hanski et al. 2012, Rook 2010, Strachan 1989)

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



HEALTHY CITIES
FOR BETTER LIFE

UK Healthy Cities
NETWORK

Biodiversity Take Homes

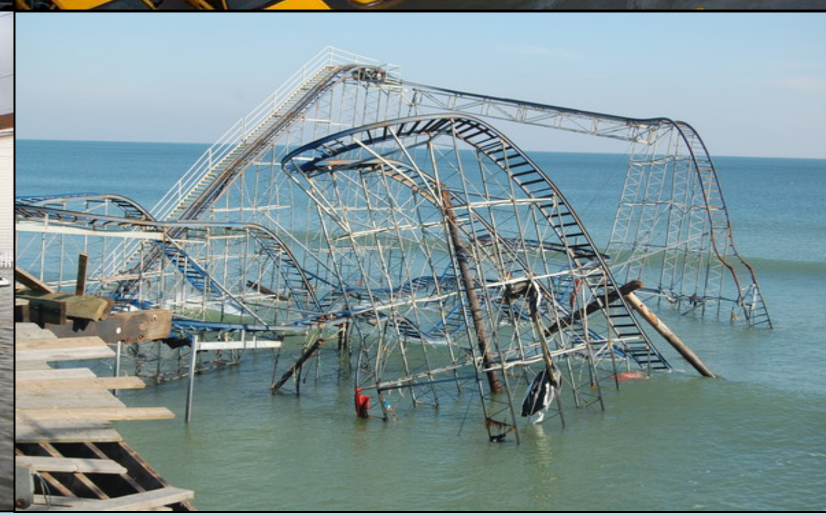
- Biodiversity may have direct, positive impacts human health
- Potential to implement these findings to enhance human well-being ***and*** develop increased public support for biodiversity conservation and restoration

Enhancing Disaster Resilience by Valuing Nature's Defenses

Working with Katya Wowk and Holly Bamford

Sandy: A Turning Point?



Coastal Ecosystem Services

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

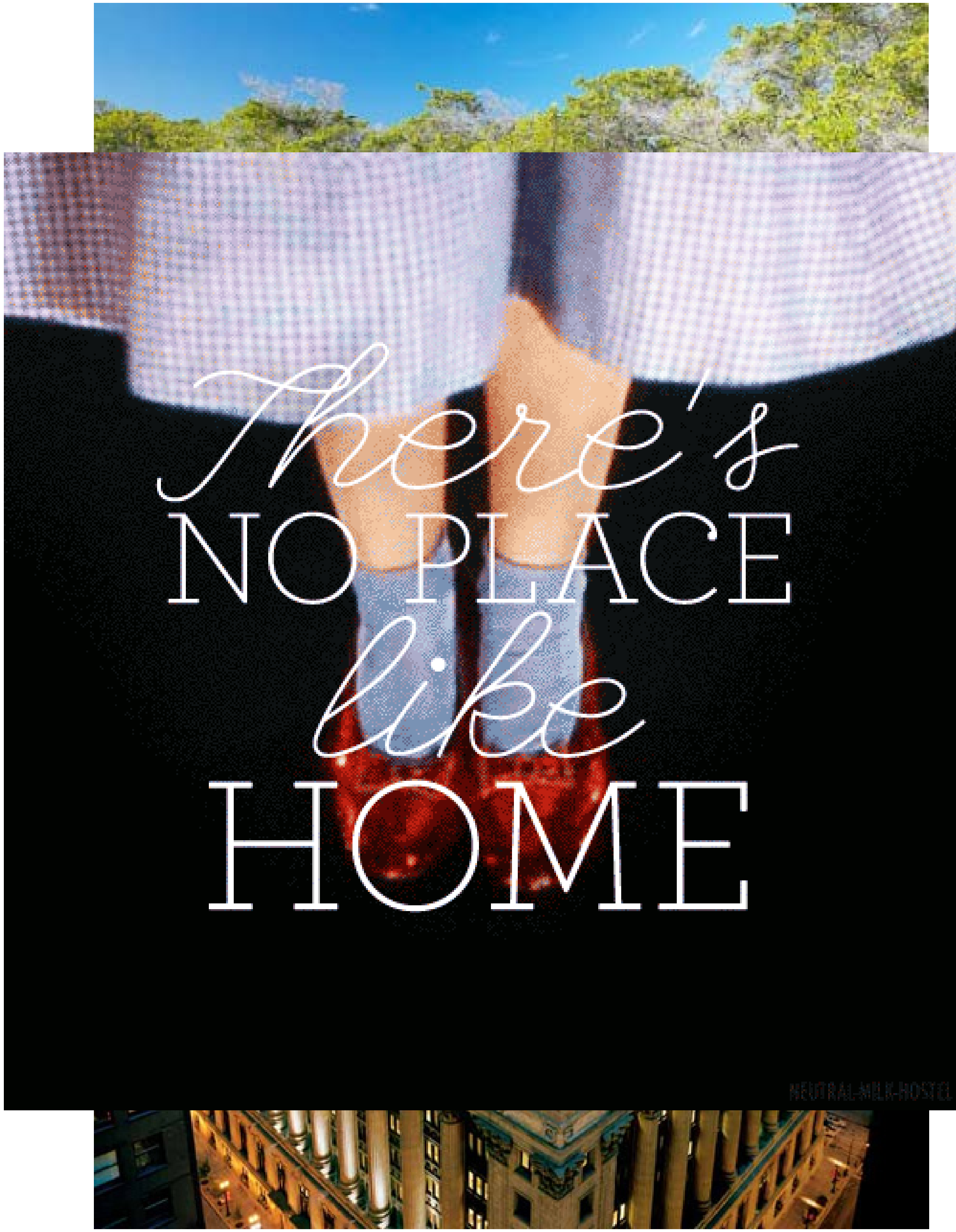
- Hard and soft infrastructure
- Nature-as-buffer approach
- Synthesis paper (Sutton-Grier et al., In review) on benefits of natural and hybrid infrastructure

Graphic: Rebuild By Design

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, perseverence 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

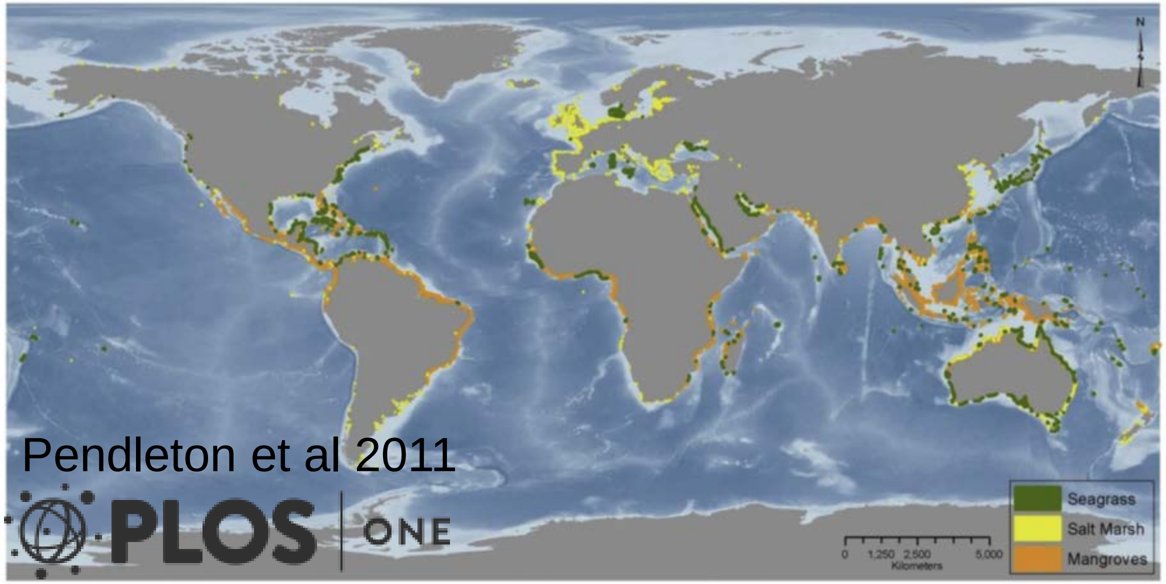
For more information see:
http://www.habitat.noaa.gov/coastalbluecarbon.html

Other benefits of blue carbon habitats: Storm Protection

U.S. coastal wetlands provide $23.2 billion storm protection benefits annually

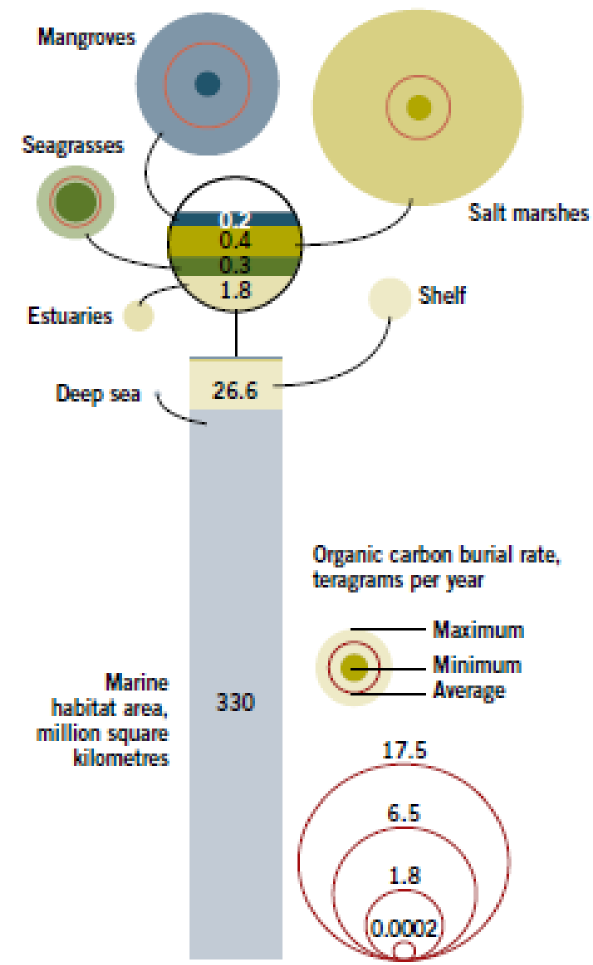
(Constanza et al., 2008)

"Blue" Carbon Monitoring System



(depth<200m = 4.7% of ocean)	Pg C yr^{-1}	% ocean total
Primary Production	6.5	12
Export Production	2.0	21
Burial	0.67	86

Figure 1 Blue carbon sinks



Sources: Brock *et al.* 2012; Nellemann *et al.* 2009.

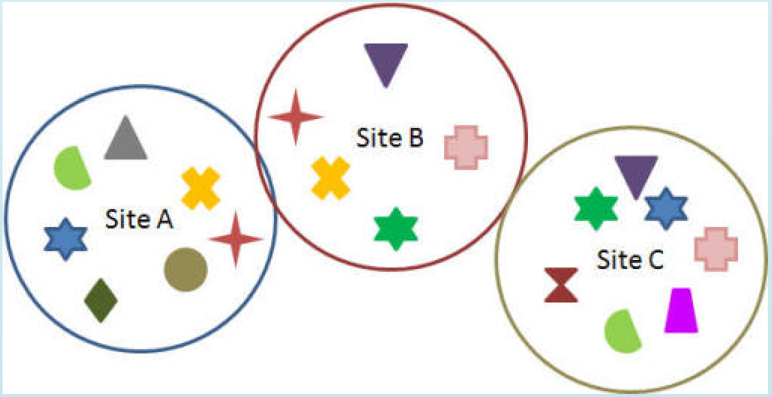
Finland Adolescent Study

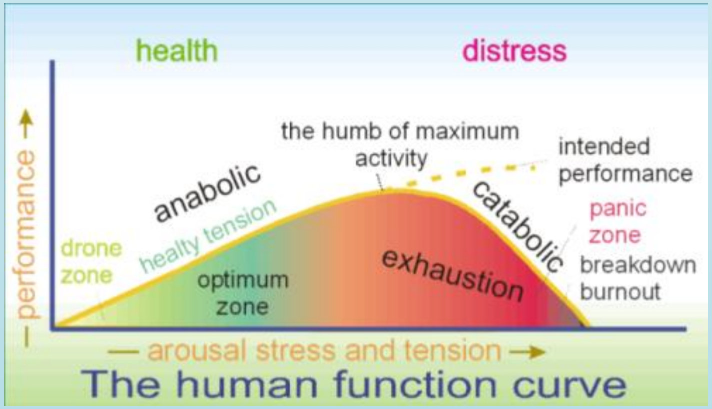
- Analyzed land-use types within 3km radius of homes
- Loss of contact with diverse natural world is making us sick
- Kids with allergies had lower environment diversity and fewer kinds of Gram-negative gammaproteo-bacteria on their skin (Hanski et al. 2012)

http://conservationmagazine.org/2012/09/biodiversity-under-our-skin-2/

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





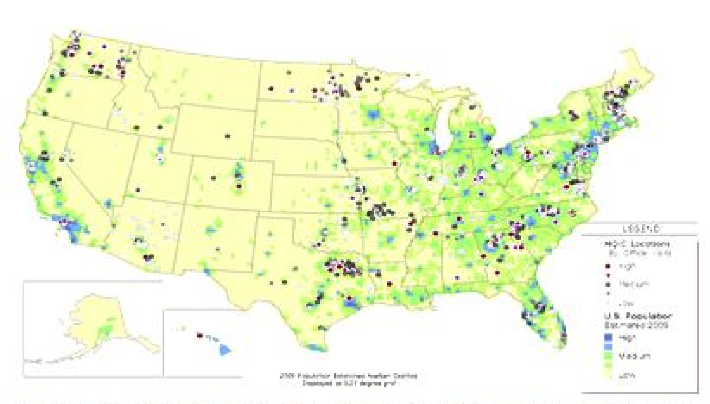
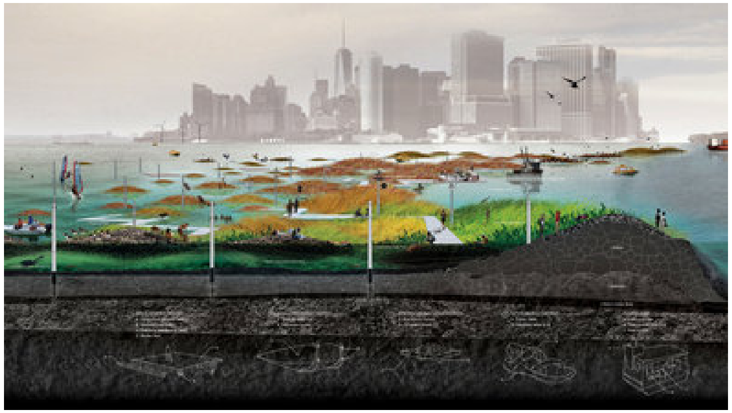
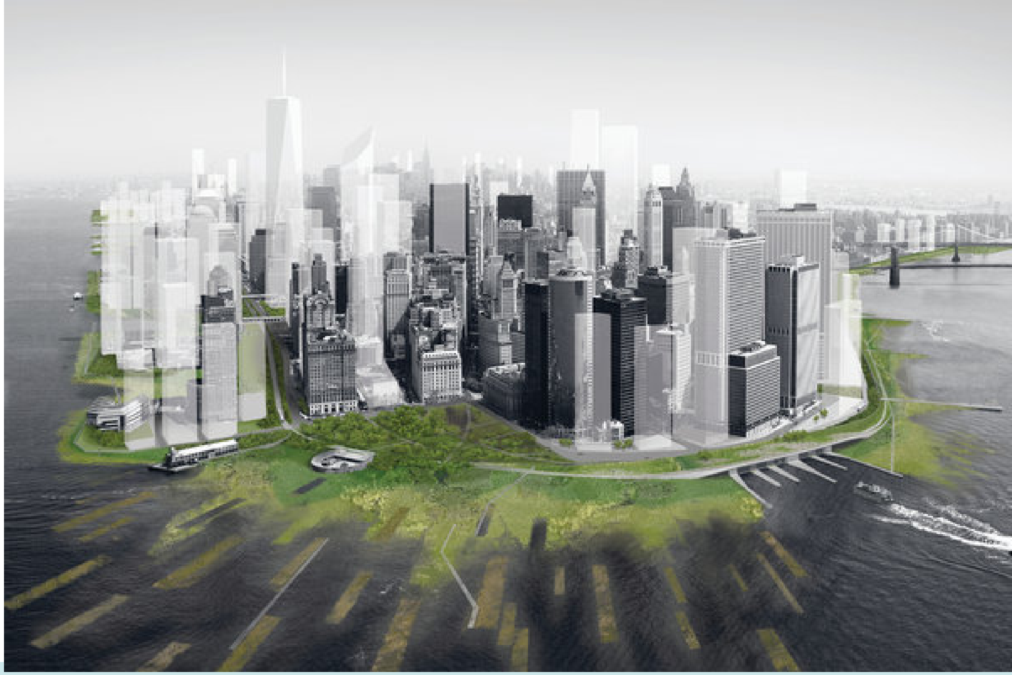


Figure 2. The Medical Quality Improvement Consortium (MQIC) comprises 35 million de-identified patient records from participating CPS and Centricity EMR practices.

Interest in “green infrastructure” and “living shorelines” for storm protection

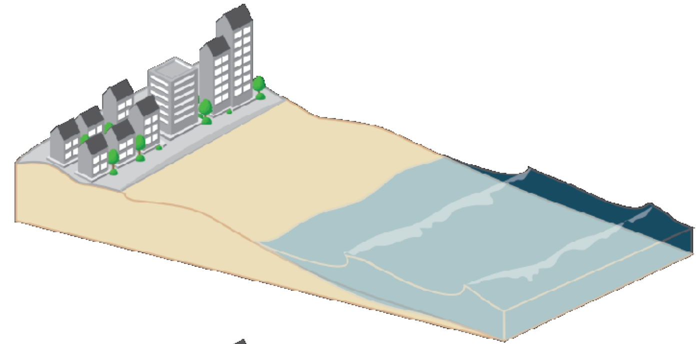
- “Protecting the city, before next time” New York Times, Nov. 3, 2012



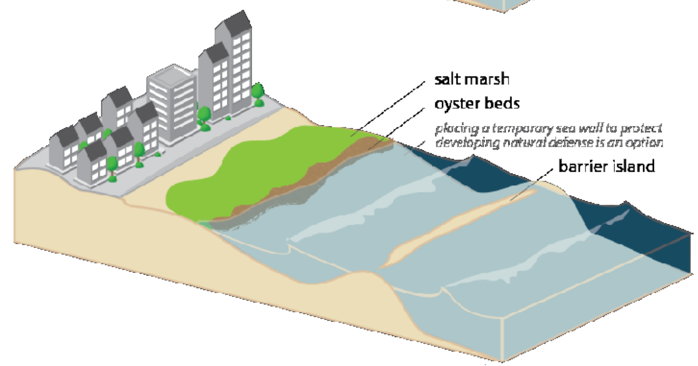


- Blue carbon habitats, A LOT MORE THAN JUST CARBON SINKS!

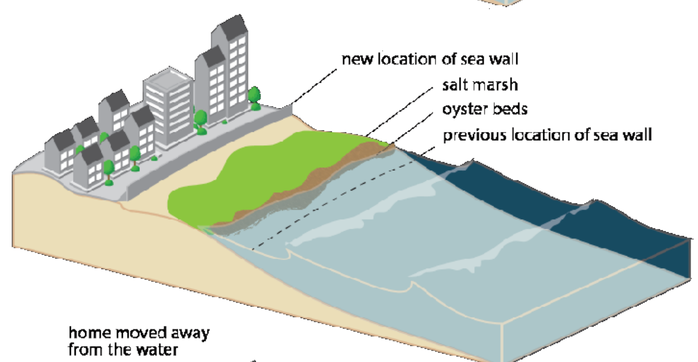
Minimal Defense
Many communities have developed right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.



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 openable 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.