Experience bringing coastal wetlands to the U.S. GHG Inventory and carbon markets

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United States Geological Survey

Carbon Monitoring System (CMS) Applications Policy Speaker Series

Photo: Jacqueline Rose

NASA Goddard Space Flight Center
June, 28, 2017

Outline

- Linking coastal climate mitigation and adaptation for coastal management.
- Coastal Wetland Carbon Projects
  - a focus of projections of carbon stock change and risk management (Micronesia case study)
- National GHG Inventories
  - a focus on contemporaneous tracking of GHG emissions and sinks (US case study)

Steve Crooks Ph.D.
Wetland Science and Coastal Management

Kris May Ph.D.
Climate Adaptation / Engineering

Mortiz von Unger Ph.D.
Climate Policy

A woman-owned small business providing consulting services, science and education on climate adaptation and mitigation.

Yanna Badet
Climate resilience, Sustainability
Environmental Planning

Igino Emmer Ph.D.
Carbon Project Development

Field Missions

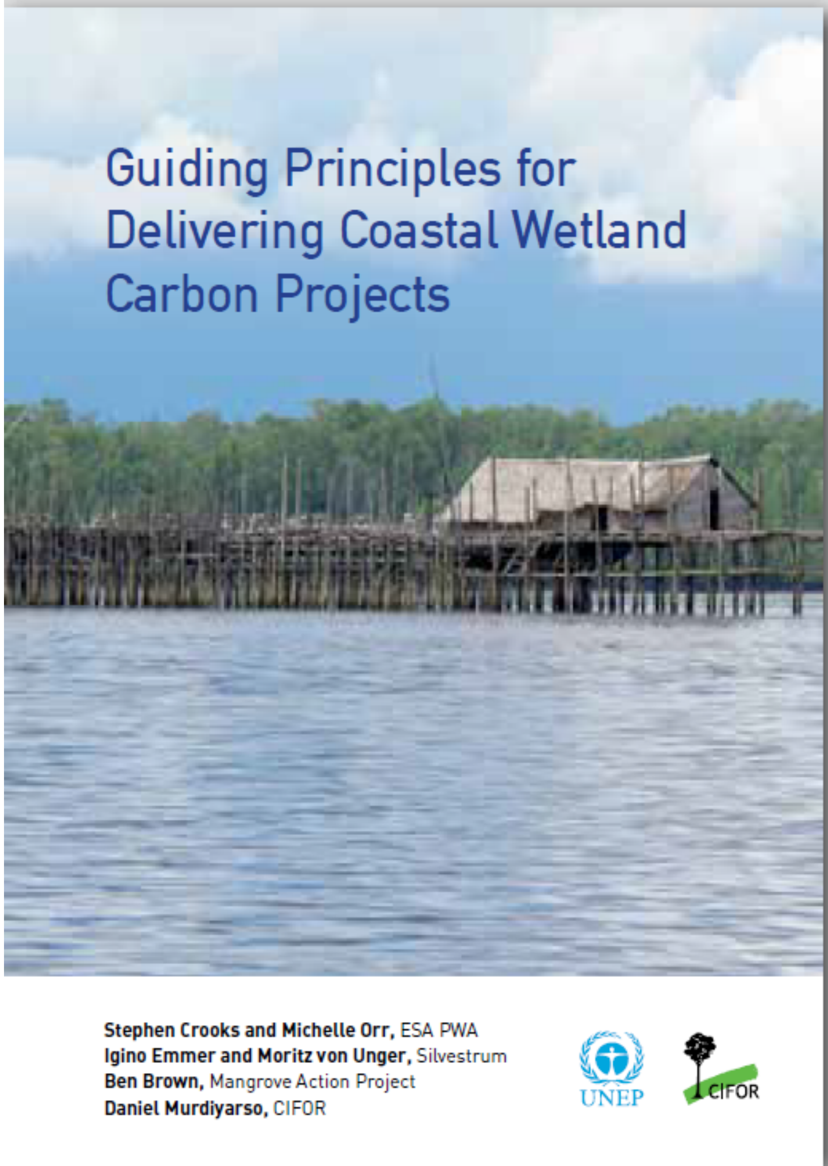
Developing the Learning Curve

1. Recognize value of wetland management
2. Establish examples of good practice
3. Achieve multi-use functional landscape
4. Adaptation to climate change
5. Incorporate GHG fluxes and storage

Blue Carbon Interventions:

Policy adjustment
Management actions
Carbon finance projects

Available at Silvestrum.com



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Blue Carbon Initiative

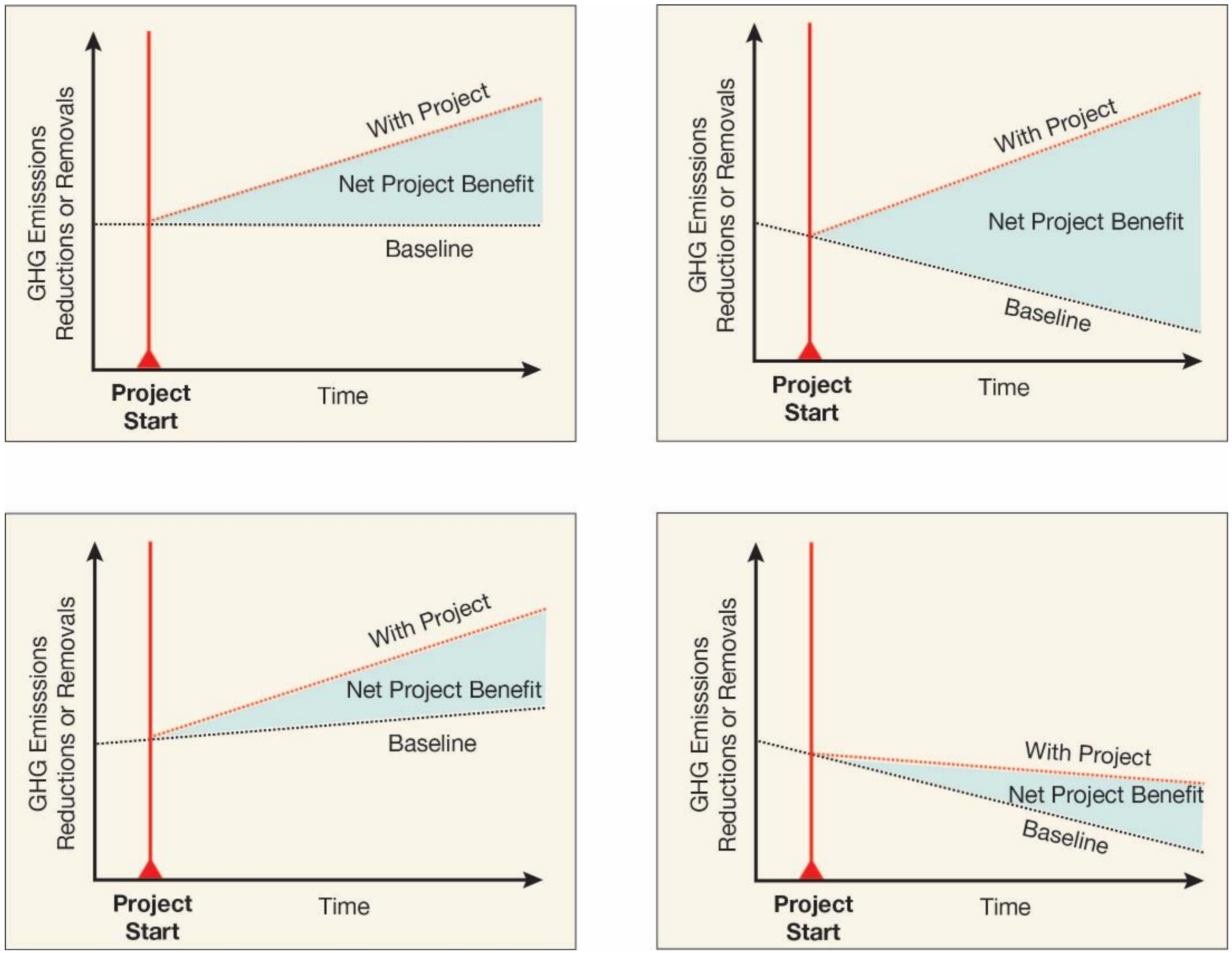
the BLUE CARBON initiative

- United Nations Framework Convention on Climate Change
  - Brief national climate change negotiators
  - Identify policy opportunities
  - Engage IPCC and SBSTA
  - Multi-national demonstration projects

- National Governments
  - Establish programs and science research
  - Recognize wetlands in national accounting
  - Agency awareness, action, funding

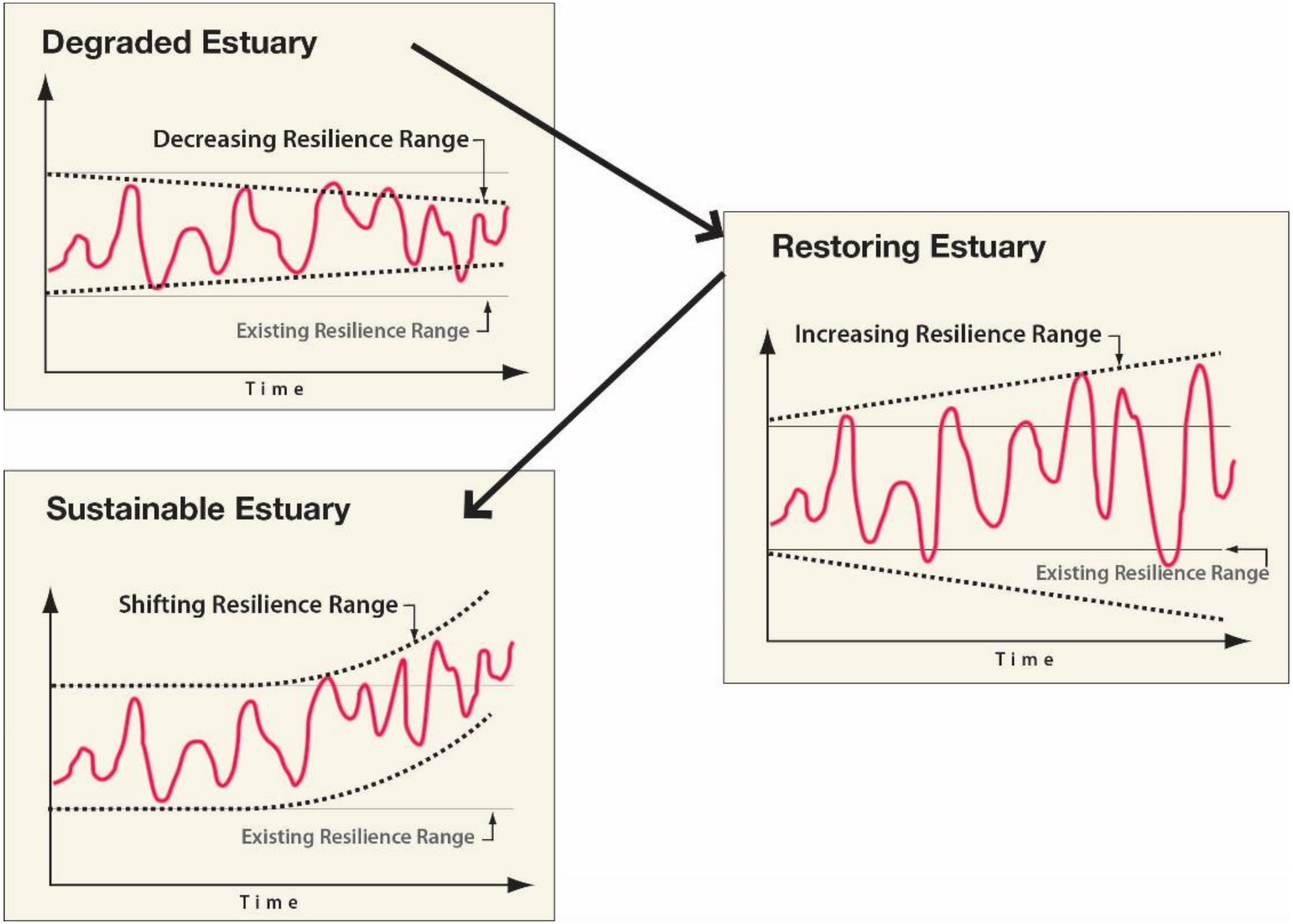
- Local Demonstration and Activities
  - Landscape level accounting
  - Establish carbon market opportunities
  - Look for synergistic conservation benefits
  - Demonstration projects and public awareness

Goal of Carbon Management

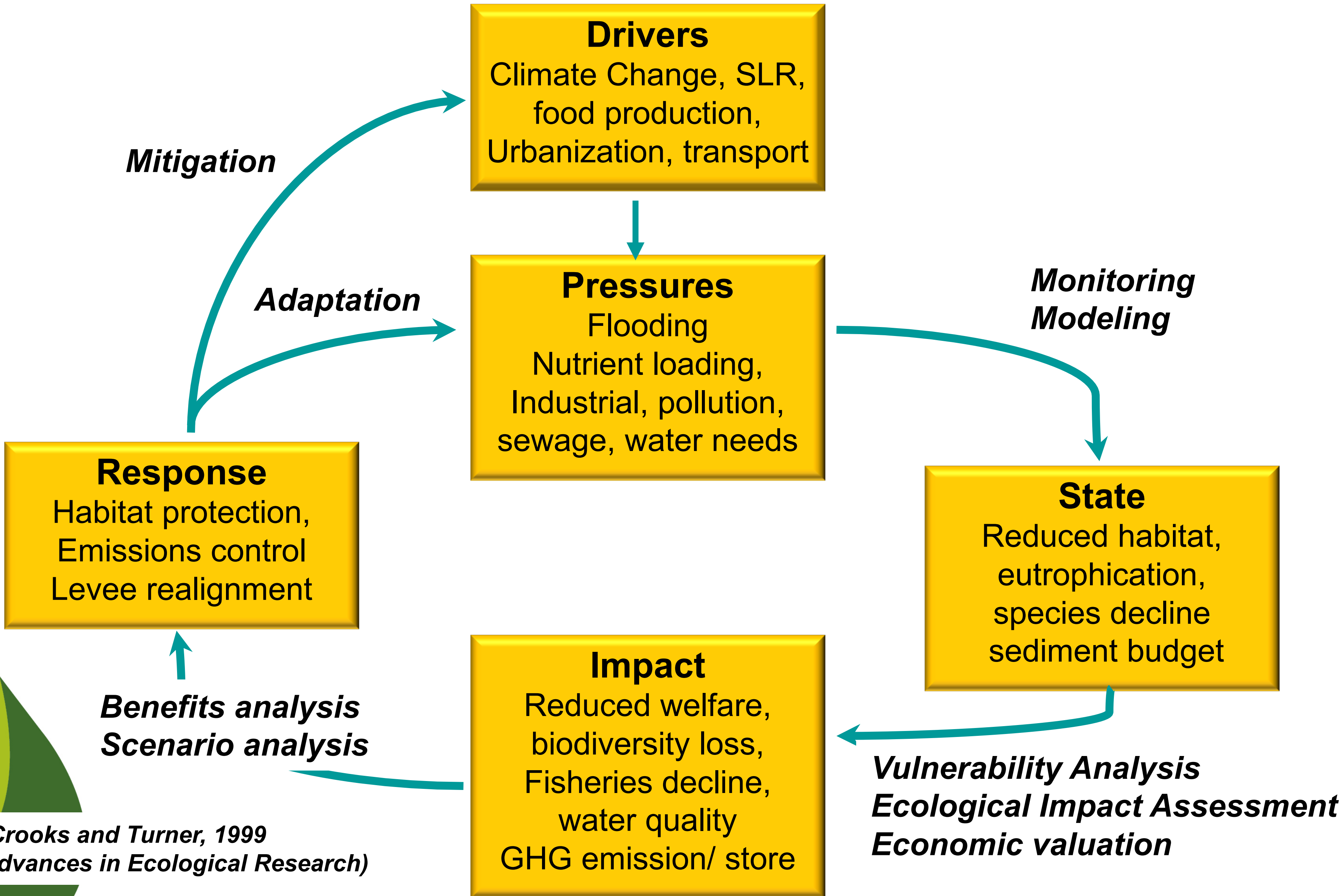


Source: Forest Trends

Goal of Ecosystem Management (Adaptation)



Sustainable Coastal Management



(Crooks and Turner, 1999 Advances in Ecological Research)

Coastal (blue carbon) ecosystems in focus for climate change mitigation

Forest

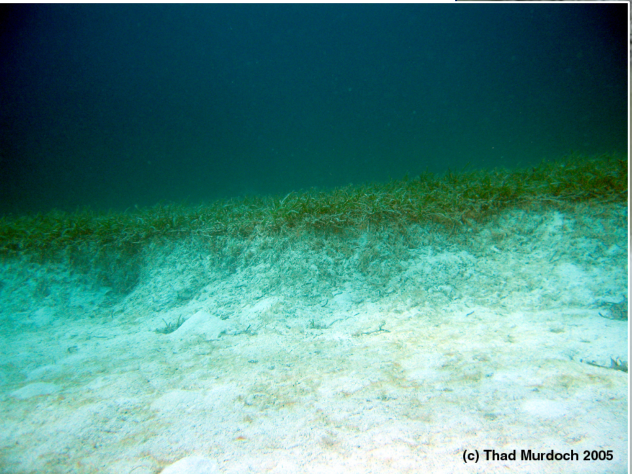
Peatland

Mangroves

Tidal Marshes

Seagrass

Coastal Ecosystems: Long-Term Carbon Sequestration and Storage



OPEN ACCESS Freely available online

PLOS | ONE

Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems

Linwood Pendleton[1¶], Daniel C. Donato[2*¶], Brian C. Murray[1], Stephen Crooks[3], W. Aaron Jenkins[1], Samantha Sifleet[4], Christopher Craft[5], James W. Fourqurean[6], J. Boone Kauffman[7], Núria Marbà[8], Patrick Megonigal[9], Emily Pidgeon[10], Dorothee Herr[11], David Gordon[1], Alexis Baldera[12]

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

	Inputs			Results	
Ecosystem	Global extent (Mha)	Current conversion rate (% yr^{-1})	Near-surface carbon susceptible (top meter sediment+biomass, Mg CO_2 ha^{-1})	Carbon emissions (Pg CO_2 yr^{-1})	Economic cost (Billion US$ yr^{-1})
Tidal Marsh	2.2–40 (5.1)	1.0–2.0 (1.5)	237–949 (593)	**0.02–0.24 (0.06)**	**0.64–9.7 (2.6)**
Mangroves	13.8–15.2 (14.5)	0.7–3.0 (1.9)	373–1492 (933)	**0.09–0.45 (0.24)**	**3.6–18.5 (9.8)**
Seagrass	17.7–60 (30)	0.4–2.6 (1.5)	131–522 (326)	**0.05–0.33 (0.15)**	**1.9–13.7 (6.1)**
Total	33.7–115.2 (48.9)			**0.15–1.02 (0.45)**	**6.1–41.9 (18.5)**

Compare to national emissions from all sources

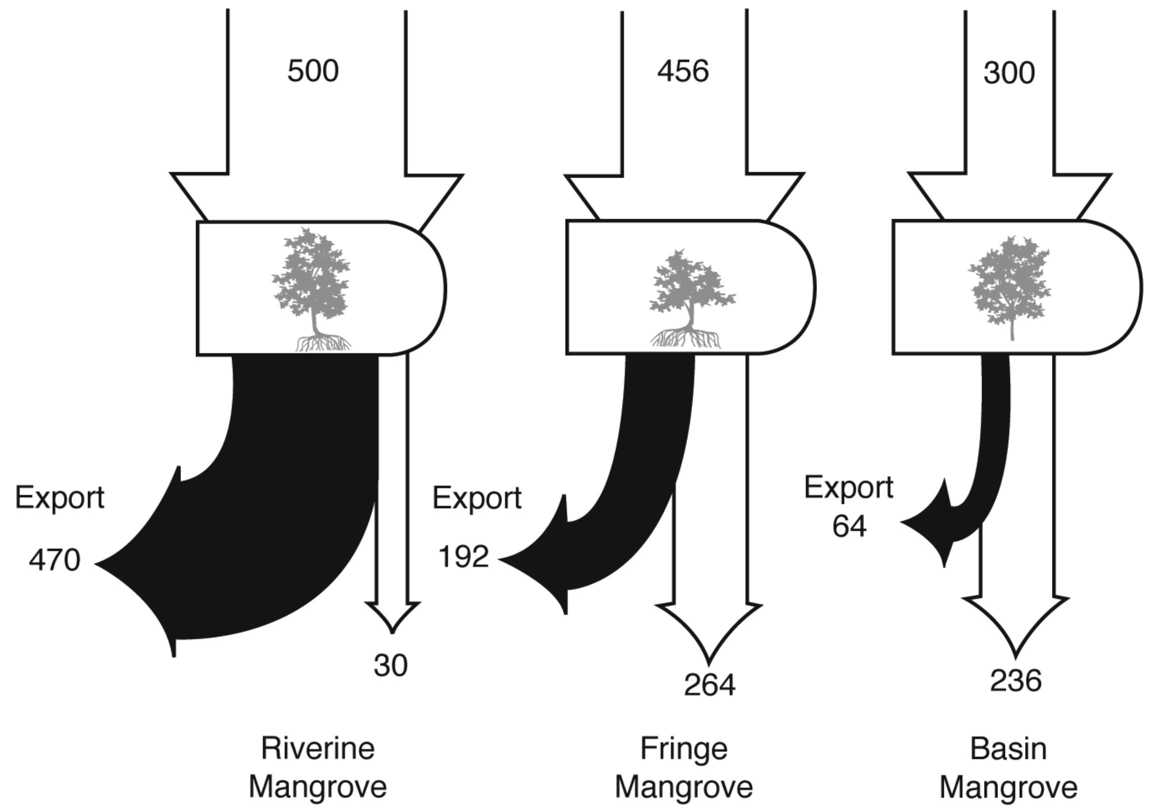
Poland

Japan

Carbon Flow and Storage

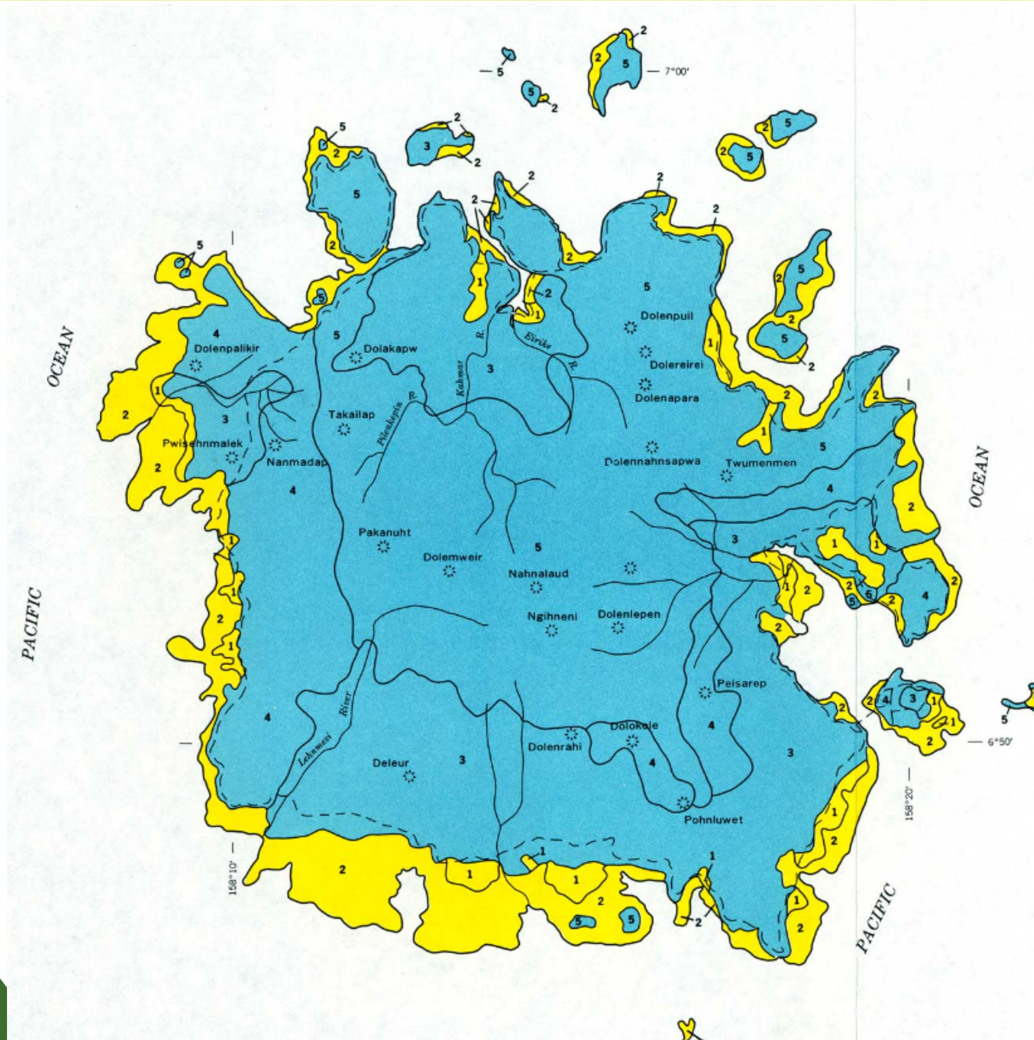
Management for soil carbon sequestration also provides carbon that builds and stabilizes coastal wetlands and supports fisheries.

We are not recognizing fate of exported but stored carbon in inventories.



Organic carbon inflows (litterfall), export to adjacent aquatic systems, and other pathways (decomposition and soil carbon storage). Width of each pathway is proportional to flow (g C m^{-2} yr^{-1}) (Twilley et al. 1986)

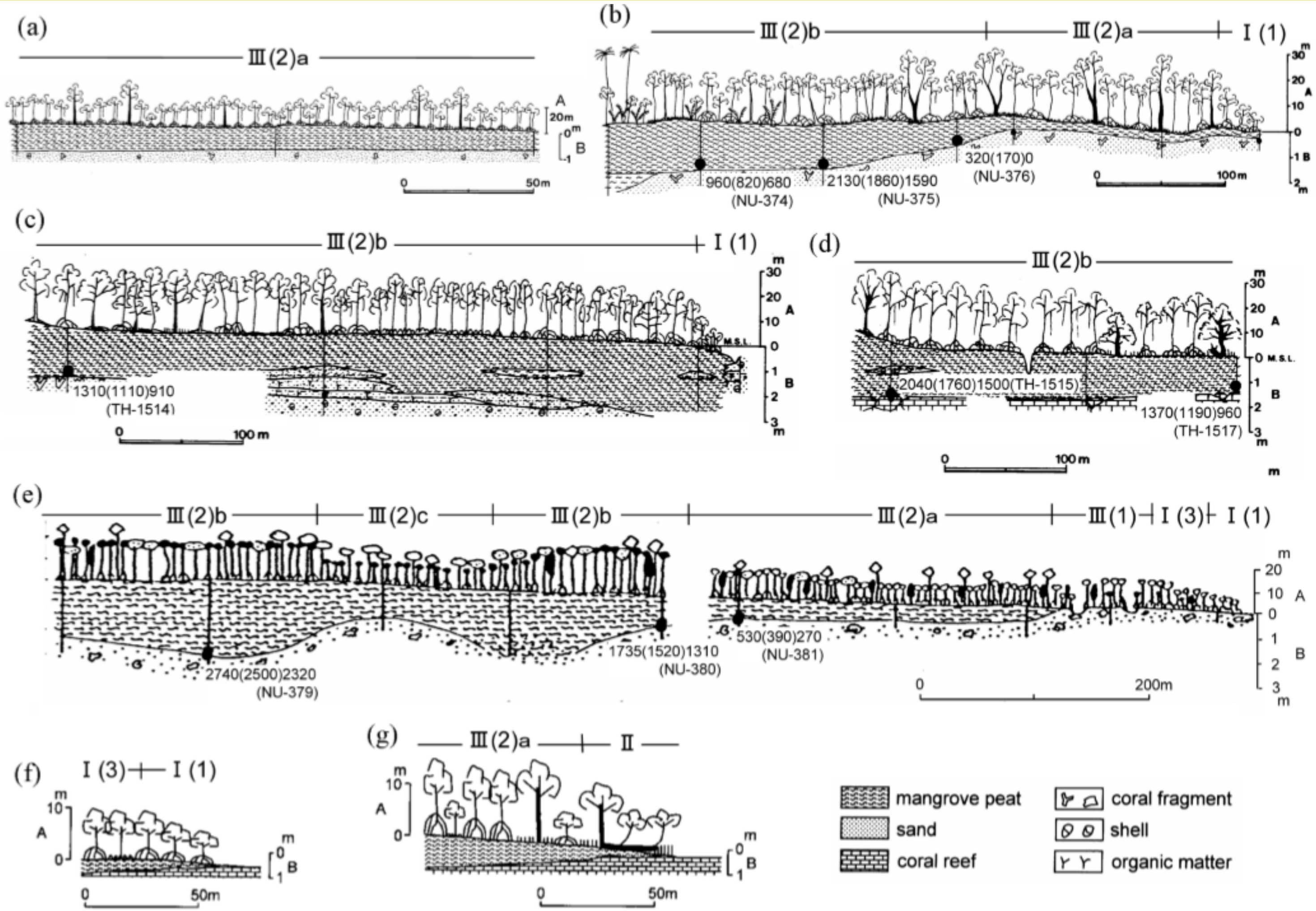
Pohnpei – Mangrove Carbon Project Assessment



<u>Partners</u>
State of Pohnpei,
Pohnpei Conservation Society,
Micronesia Conservation Trust,
USFWS, USFS, USGS.

<u>Questions</u>
Is there a threat to mangroves?
Can carbon financing reduce that threat?

Pohnpei: Mangrove Community and Soil Profiles



Fujimoto et al. 2015 The Relationship among community type, peat layer thickness, below ground carbon storage and habitat age of mangrove forest in Pohnpei Island, Micronesia. Open Journal of Forestry. 5:48-56

Small-scale cumulative losses, but long term?

Pohnpei mangrove area: 5000 ha

Total C stock: 15-20 $MMtCO_2$
(biomass + top 1m soil)

Small scale losses: 20 $MktCO_2$ / yr

FSM energy sector emissions:
152 $MktCO_2$ / yr (2000 report)

But what of external forces that might drive rapid change?

Response to Sea Level Rise?

Science needs to support blue carbon projects

- Mapping of wetland extent and conversion
- Thresholds for mangrove building with sea level rise
- Observational and modeled relationships between productivity and C seq.
- (have for marshes not mangroves)
- Predictors of mangrove stress
- Projections of coastal response to climate change: 100 year timeframe
- Fate of carbon laterally transported from wetlands, including through erosion
- Capacity to monitor and model CH_4 spatially and temporally

Stressed mangroves? Collier County, Florida

UNDERSTANDING STRATEGIC COASTAL BLUE CARBON OPPORTUNITIES IN THE SEAS OF EAST ASIA

4 Mha of mangroves, upto 3 Mha of seagrass, tidal marsh <60,000 ha

13,700 $MMTCO_2$ in biomass and surface soils (top 1 m)

Ongoing wetland conversion.

3.4 Mha of converted marshes and mangroves.

Available at Silvestrum.com, PEMSEA.org

PEMSEA · CONSERVATION INTERNATIONAL · The Nature Conservancy · silvestrum CLIMATE ASSOCIATES · the BLUE CARBON initiative

UNDERSTANDING STRATEGIC COASTAL BLUE CARBON OPPORTUNITIES IN THE SEAS OF EAST ASIA

<u>Opportunities</u>

Track status and trends of coastal wetlands

Report in national GHG inventories

Include in Nationally Determined Contributions

Set the stage for expanded bilateral and regional cooperation, development and expansion of emissions trading schemes, sharing of research, technology and capacity building.

Available at Silvestrum.com, PEMSEA.org

Bringing Coastal Wetlands into the U.S. Inventory of GHG Emissions & Sinks

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Smithsonian Environmental Research Center
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Restore America's Estuaries

Photo: Jacqueline Rose

Restore America's Estuaries
Webinar Series
June, 1, 2017

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silvestrum CLIMATE ASSOCIATES

U.S. Coastal Wetland Carbon Working Group

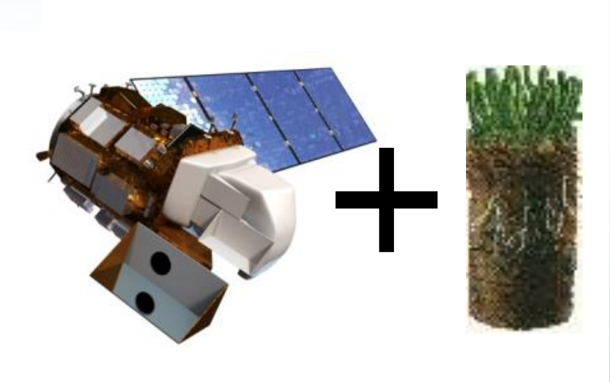
U.S. National Oceanic and Atmospheric Administration (Coastal Management, Habitat Conservation, International), U.S. Environmental Protection Agency (Climate Change, Wetlands), U.S. Geological Survey, U.S Forestry Service, Environmental Science Associates, Florida International University, Smithsonian Environmental Research Center, Restore America's Estuaries, Colorado State University, Pennsylvania State University, Texas A & M.

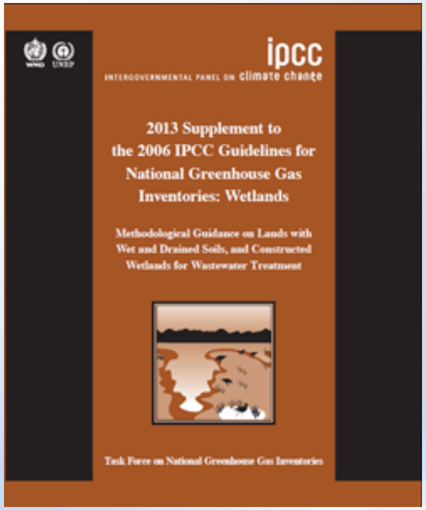
"Blue" Carbon Monitoring System

Linking soil and satellite data to reduce uncertainty in coastal wetland carbon burial: a policy-relevant, cross-disciplinary, national-scale approach

Lisamarie Windham-Myers (18 Science PIs; October 2014-17)

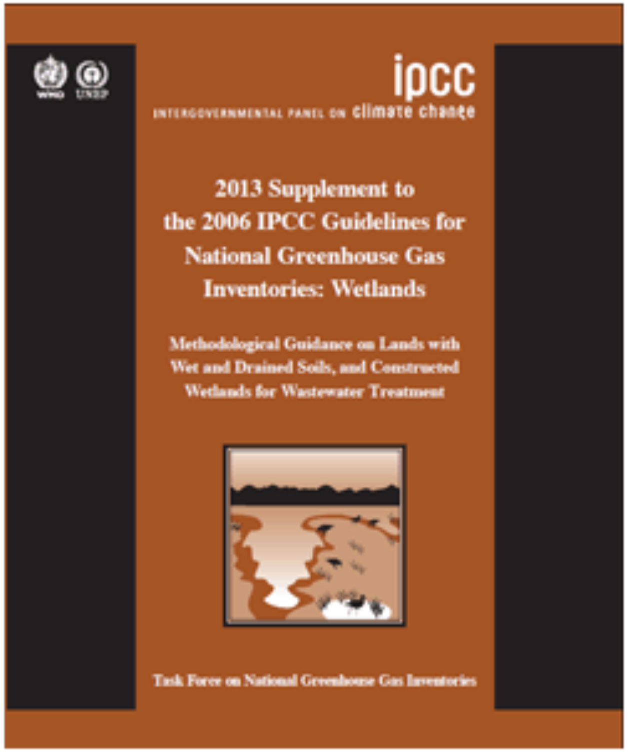
Federal		Non Federal	
USGS	Brian Bergamaschi	U. South Carolina	Jim Morris
	Kristin Byrd	U. Maryland/NOAA	Ariana Sutton-Grier
	Judith Drexler	U. San Francisco	John Callaway
	Kevin Kroeger	Florida Intl. U.	Tiffany Troxler
	John Takekawa	Texas A&M U.	Rusty Feagin
	Isa Woo	Independent	Stephen Crooks
Postdoc: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





2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

1. Introduction
2. Cross cutting guidance on organic soils
3. Rewetting and restoration of organic soils
4. **<u>Coastal wetlands</u>**
5. Other freshwater wetlands
6. Constructed wetlands
7. Good practice and implications for reporting

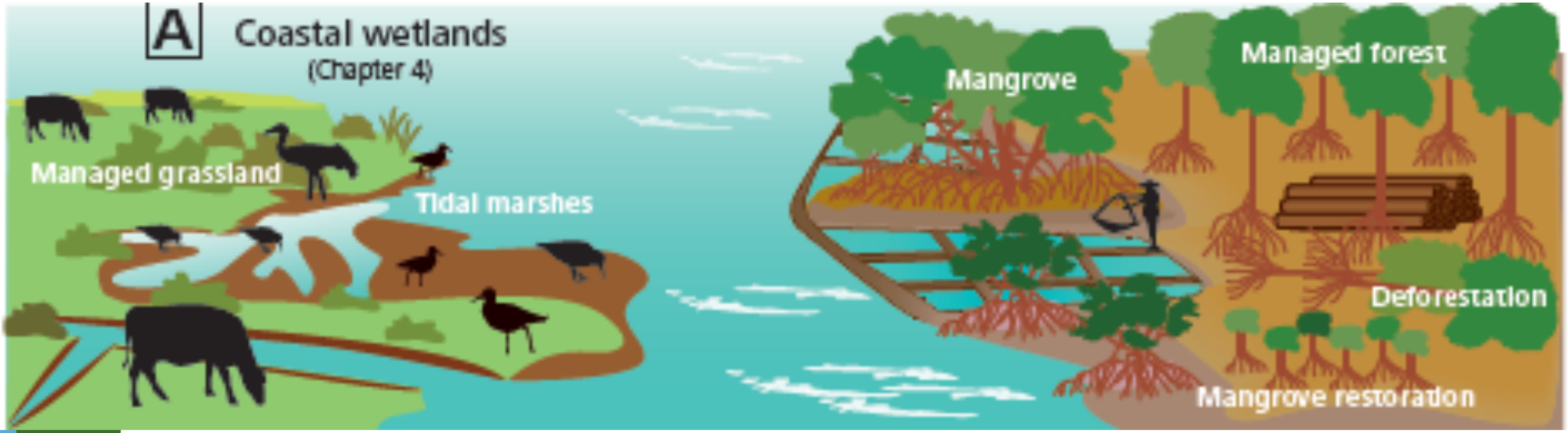


Adopted by IPCC Oct 2013, Published Feb 2014

- http://www.ipcc-nggip.iges.or.jp/

Chapter 4: Coastal Wetlands of the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*

- Updated default data for estimation of C stock changes in mangrove living biomass and dead wood pools
- New generic methodological guidance and data on:
  - CO_2 emissions and removals on coastal wetlands on organic and mineral soils for specific management activities
  - N_2O emissions during aquaculture use
  - CH_4 emissions from rewetted soils and creation of mangroves and tidal marshes



Guidance to Estimate CO_2, CH_4 and N_2O Fluxes from Management Activities in Coastal Wetlands – Consistent with 2006 GLs but also captures E/R that fall outside of land base

Activity	Coastal Vegetation Types Affected*	Sub-Activity	New/Updated Guidance or Data Provided in Coastal Wetlands Chapter of the Wetlands Supplement
Activities Relevant to CO_2 Emissions and Removals			
Forest Management	M	Planting, thinning, harvest, wood removal, fuelwood removal and charcoal production. Including conversion to or from Forest Land	Updates to 2006 GLs default data for estimation of C stock changes in biomass , dead organic matter and soil C pools
Extraction	M, TM, SGM	Excavation to construct port, harbor or marina; filling or dredging to raise elevation of land	New guidance , data and EFs provided for estimation of CO_2 emissions and removals from biomass, dead organic matter and organic/mineral soils
	M, TM	Construction of aquaculture facilities	
	M, TM	Construction of salt production facilities	
Drainage	M, TM	Agriculture, forestry, mosquito control	
Rewetting, revegetation and creation	M, TM	Conversion from drained to saturated soils by restoring hydrology and vegetation	
Revegetation	SGM	Reestablishment of vegetation on undrained soils	
Activities Relevant to non-CO_2 Emissions			
Aquaculture (use)	M, TM, SGM	N_2O emissions from aquaculture use	New methodological guidance and EFs for estimating N_2O emissions from aquaculture use
Rewetting, revegetation, and creation	M, TM, SGM	CH_4 emissions from rewetting, revegetation and creation of wetlands	New methodological guidance and EFs for estimating CH_4 emissions from rewetting, revegetation and creation of M, TM, SGM

*M=Mangroves, TM= Tidal Marsh, SGM=Sea Grass Meadows

United States: Emissions of Interest

- Emissions and removals of CO_2 and CH_4 on intact and restoring vegetated wetlands (all coastal wetlands considered managed).
- Drainage and excavation activities
- Conversion of vegetated wetlands to open water
- Forestry activities on wetland soils
- CH_4 emissions from impounded waters
- Aquaculture

Methodology

- Define Coastal Land Area based upon extent of tides and US Land Representation.
- Quantify land use within Coastal Land Area
- Quantify land use change 1990-2015 on mineral and organic soils
- Ascribe a CO_2 and CH_4 emissions factor for land use & land use change from published literature.
- Calculate annual emissions and removals:
  - Coastal Vegetated Wetlands Remaining Coastal Vegetated Wetlands
  - Coastal Vegetated Wetlands converted to Coastal Wetlands Open Water
  - Lands Converted to Coastal Wetlands.

Methodological Tiers Applied

Tier 3: **Higher order methods**

Detailed modeling and/or inventory measurement systems

Data at a greater resolution

→ *Anticipated 2018 inclusion of BCMS analysis on biomass and soils stocks and stock change.*

Tier 2: **A more accurate approach**

Based on Tier 1 with country or region-specific values for the general defaults, greater stratification

More disaggregated activity data

→ Mapping of land use change and distribution of organic soils, country-specific data on reference soil carbon stock and stock change.

Tier 1: **Simple first order approach**

Default values of the parameters from the IPCC guidelines

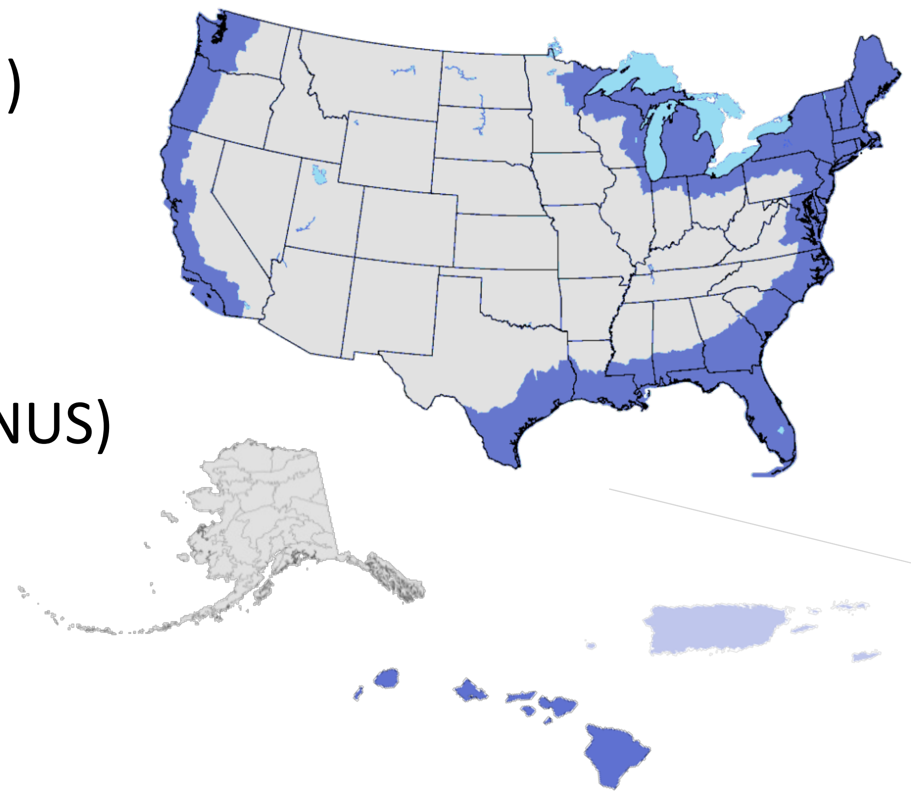
Spatially coarse default data based on globally available data

→ Depth of soil impacted by drainage, conversion to open water. CH_4 emissions by wetland type. N_2O emissions from aquaculture.

C-CAP Regional Land Cover and Change

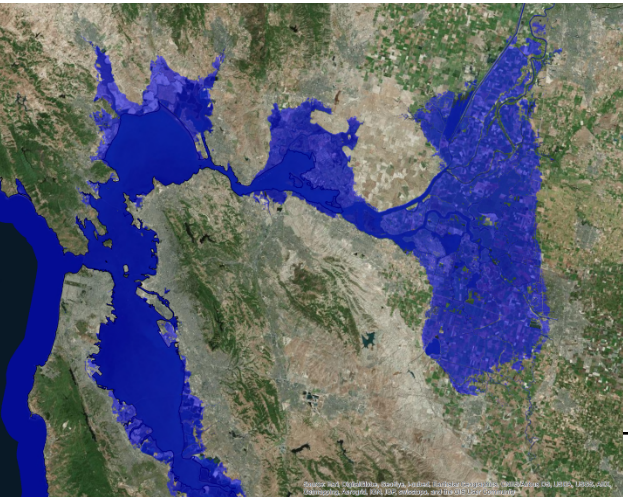
coast.noaa.gov/digitalcoast/data/ccapregional

- National Coastal Land Cover Monitoring Program
  - Updated every five years since 1996
- Based on Landsat imagery (30m)
  - Regional to county scale in scope
- Consistent, Accurate Products
  - FGDC National Geospatial Data Asset
- 25% of the contiguous U.S. (CONUS)
  - Coastal expression of the NLCD
- Additional Coastal Detail
  - Focus on wetland categories
  - More dates / longer time series



Mean (Higher) High Water Spring Surface Result

Tide data
Lidar surface
C-CAP land cover

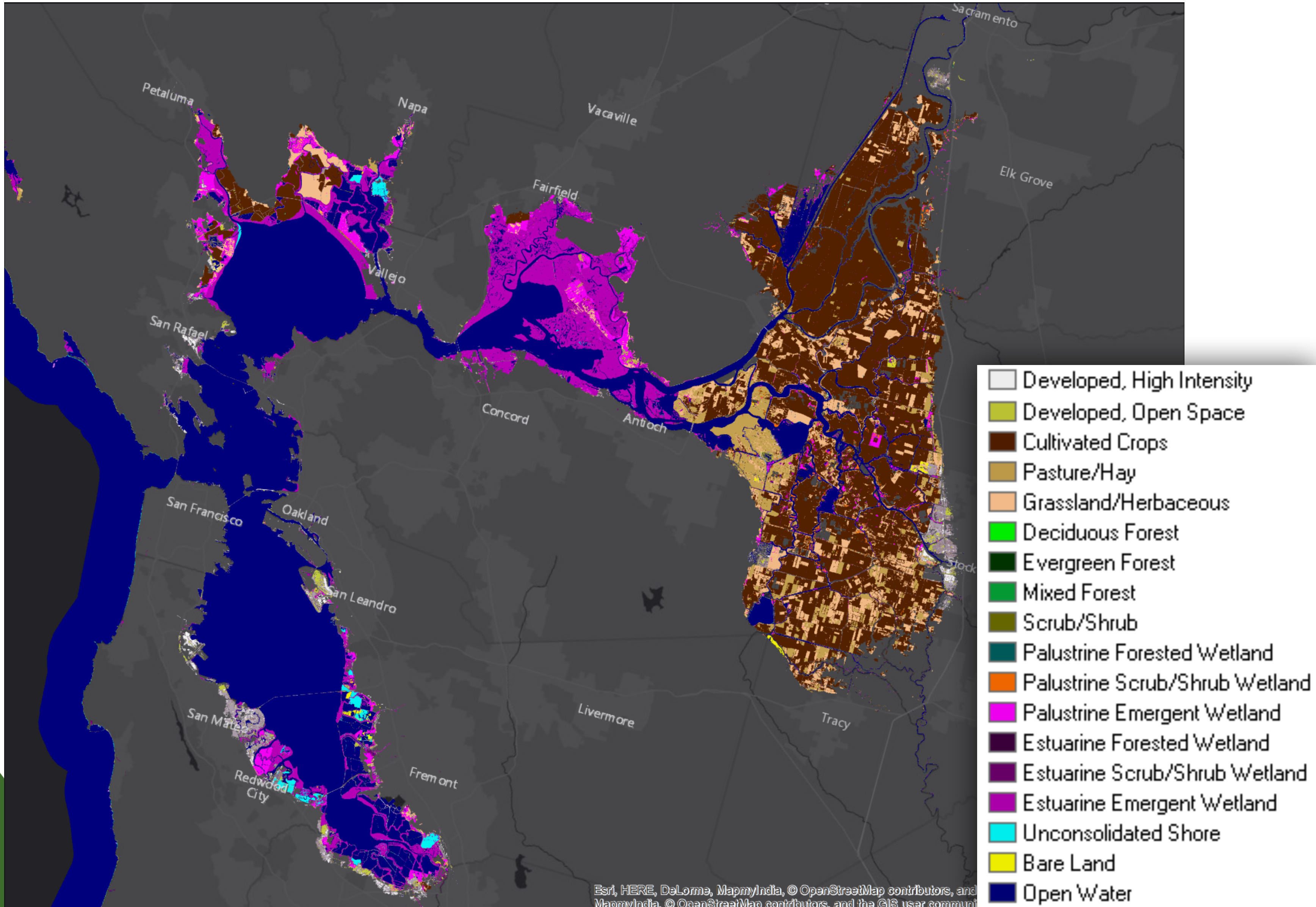


San Francisco Bay – San Joaquin River, CA

New Orleans – Mississippi River, LA

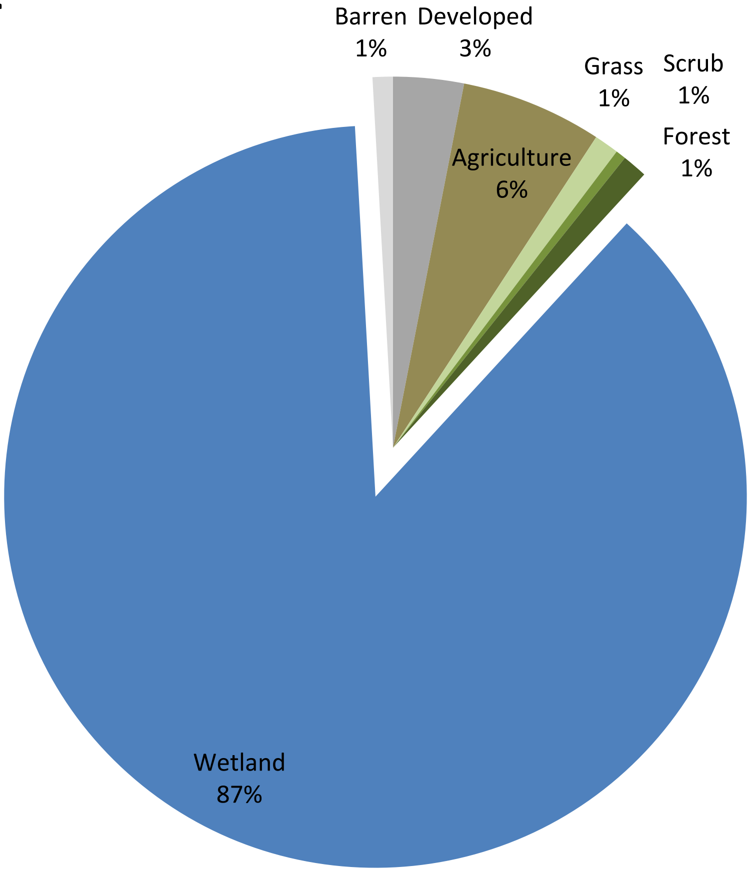
Chesapeake Bay – Blackwater National Wildlife Refuge, MD

San Francisco Estuary, CA



Land Cover Distribution 2010

- Total tidal area identified is 89,900 square miles
- Vast majority (78%) is open water
- If water is ignored:
  - 87% (17,745 sqmi) is wetland
  - 6% (1,249 sqmi) is agriculture
  - 3% (624 sqmi) is development
  - 1% (221 sqmi) is upland forest
  - 1% (218 sqmi) is grassland
  - < 1% (179 sqmi) bare land
  - < 1% (90 sqmi) upland scrub/shrub



Summary of soil stocks, emissions and removals

- Marshes and mangroves hold in top one meter of soil **3,190 MMTCO_2**
- Marshes and mangroves sequester **net** about **8 MMTCO_2e/yr.**
- Drainage emits **0.7 – 1.9 MMTCO_2e/yr**.
- Drained former wetland organic soils continue to emit **5 MMTCO_2e/yr**.
- Methane emissions from tidally disconnected are estimated to be **1-3 MMTCO_2eq/yr.** (Not yet included in inventory)
- Wetlands conversion to open water releases **1-7 MMTCO_2e/yr.**
- Aquaculture emits **0.15 MMTCO_2e/yr** of N_2O
- Current restoration accounts for only **0.02 MMTCO_2e/yr** of new carbon sequestration

Future Research Needs

- **Inventory Support**:
  - Fate of eroded wetland carbon
  - Impact of forestry on wetland soils
  - Methane emissions from impounded wetlands
  - Methane emissions across the salinity gradient and approaches for mapping
  - GHG fluxes in coastal palustrine (non tidal) wetlands
- At the **largest scale**, improving our understanding of coastal wetlands in the U.S. national inventory is limited by the fact that terrestrial, wetland and aquatic science are largely isolated from one another. The observations, budgets and models developed for these systems normally use the adjacent system as a boundary condition, and do not address how carbon is moved from one system to the next. Deliberately integrating across the discipline- and agency-specific silos of land, wetland and sea will advance the US national inventory in the long run.

Broader Implications within U.S. and Abroad

- The U.S. has demonstrated that it is possible to include tidal marshes and mangroves in national GHG inventories using freely available datasets of human activity with either country-specific emissions factors or IPCC default values

- Protecting wetlands are important in reducing emissions.

- For some countries, excavation and drainage will a more significant component of the inventory.

- The *Wetland Supplement* does not provide specific guidance on erosion, one of the largest emission from coastal wetlands.

Challenges

- Complexity of integrating wall-to–wall spatial analysis with dominantly survey and plot-based databases of the National Resource Inventory (NRI) and Forest Inventory Analysis (FIA)
- Assigning methane emissions across salinity gradient
- Interpolating and extrapolating emissions estimates based upon 4 land cover data epochs.
- Limited data for emissions: seagrasses extent and change in extent; palustrine wetland C fluxes, impacts of forestry activities on coastal wetland soil C, CH_4 emissions from impounded waters and magnitude and fate of eroded carbon.

Planned and Potential Improvements

Planned

- Inclusion of emergent marsh biomass
- Refined dataset on soil carbon stocks
- Further integration with NRI and FIA datasets

Potential

- Inclusion of seagrass meadows
- Improved C and CH_4 fluxes from palustrine wetlands
- Improved quantification of fluxes from impounded water
- Impacts of forestry activities on wetland soils
- Inclusion of terrestrial wetlands above the Coastal Land Area.

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