The Science of Blue Carbon

Stephen Crooks Ph.D.

Environmental Science Associates

and

Blue Carbon Initiative

Blue Carbon:

What Scope for Mitigation Projects Currently?

June 8th, 2015 Paris.

Overview

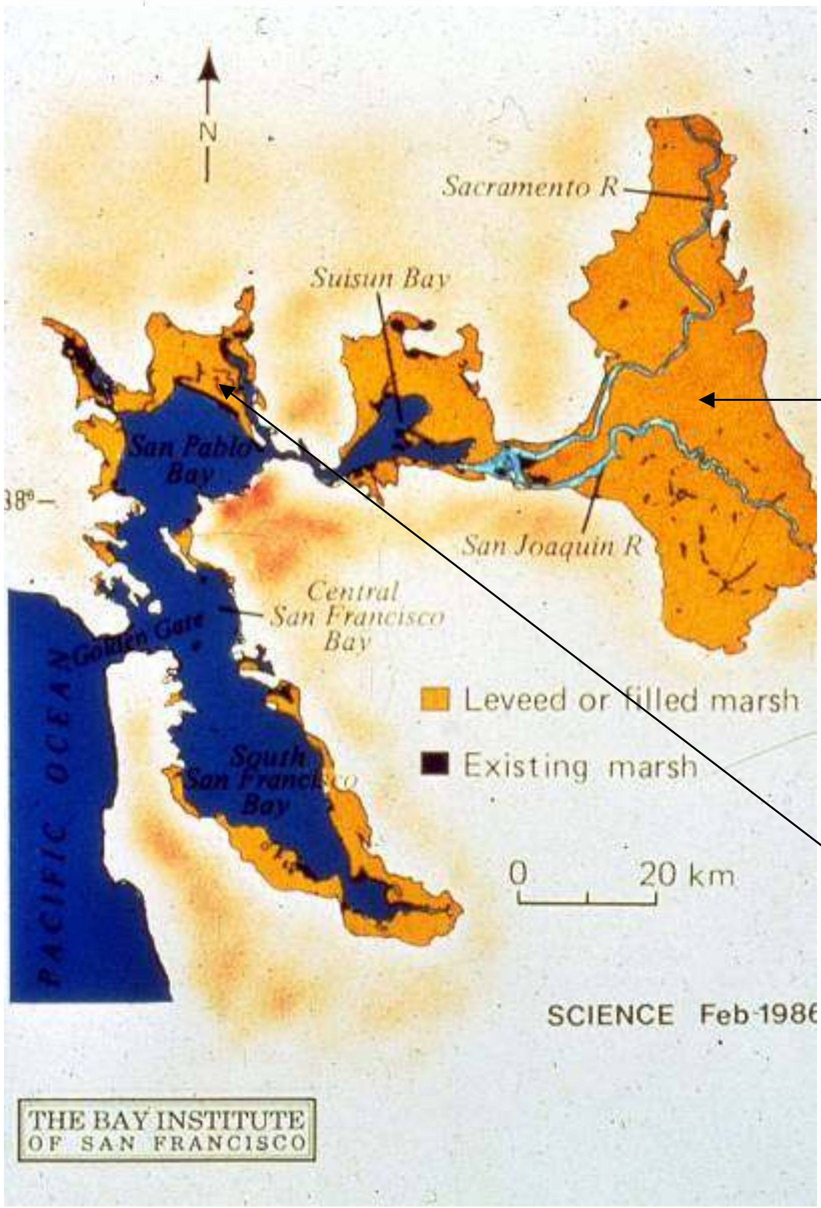
- Introduction to Blue Carbon Ecosystems
- Causes, Rates and Magnitude of Carbon Loss
- GHG Accounting and MRV
- Emerging Fields of Research and Demonstration

Section #1

INTRODUCTION TO BLUE CARBON ECOSYSTEMS

Coastal ecosystems: long-term carbon sequestration and storage

Tidal Marsh Ecosystems



San Francisco Bay

Wetlands lost
200,000 ha lost (95%)

Planned restoration
60,000 ha

Mangroves - Tremendous range in structural diversity

Seneboi River Delta, Papua, Indonesia

What are seagrasses?

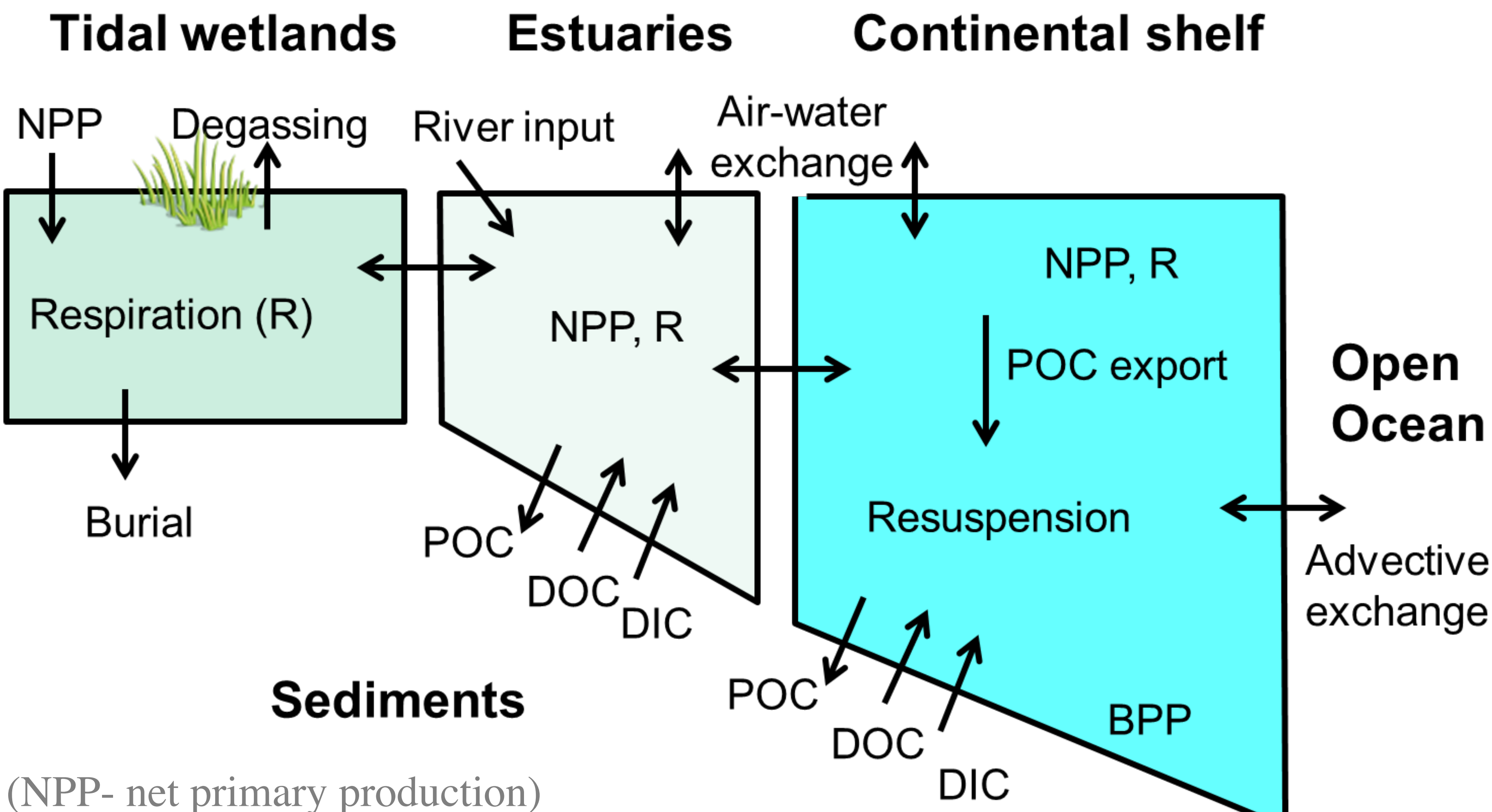
- Angiosperms (<u>flowering plants</u>) adapted to life in the sea (down to 60 m).
- About 60 species worldwide
- Present in all continents covering between 200,000 and 600,000 Km^2 globally.
- Clonal plants with extended life span (oldest living organism: seagrass clon , *Posidonia oceanica*, in the Mediterranean, Formentera Island, > 50,000 years old).
- Highly productive and develop massive belowground biomass (roots and rhizomes)

Global Distribution of **Blue Carbon Ecosystems**

Murray et al., 2011

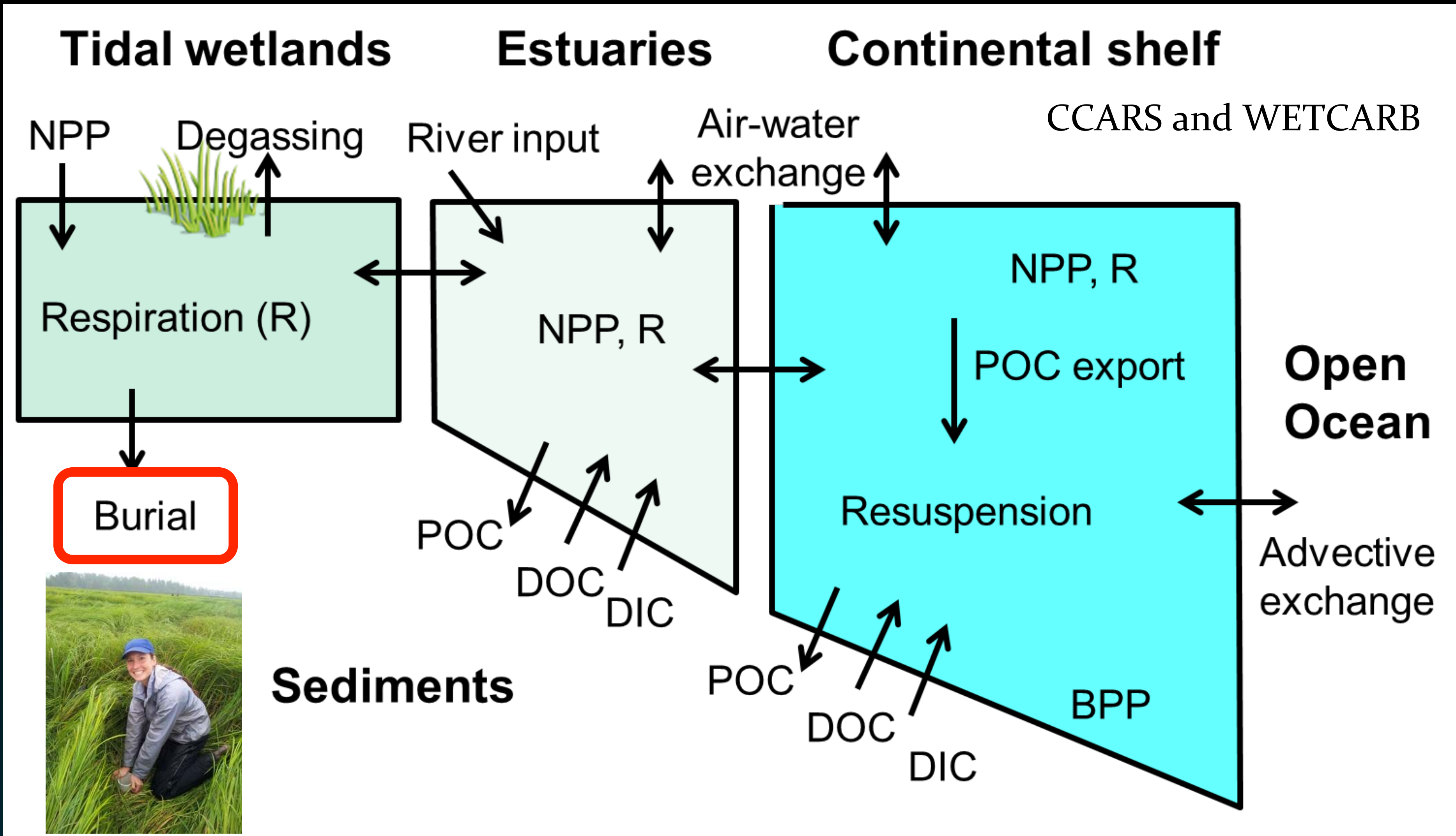

Wetlands Carbon Flows Feed Fish
(*floodplain fatties*)
igloo
Photo: Jeff Opperman. Research by Carson Jeffres

Land-ocean carbon accounting
Focus of science programs



(NPP- net primary production)
(P- particulate; D- dissolved; O- organic; I – inorganic)

Blue Carbon: Soil grows continuously, does not saturate



Long-term C burial in vegetated soils is 2 orders of magnitude higher in coastal marine than terrestrial ecosystems

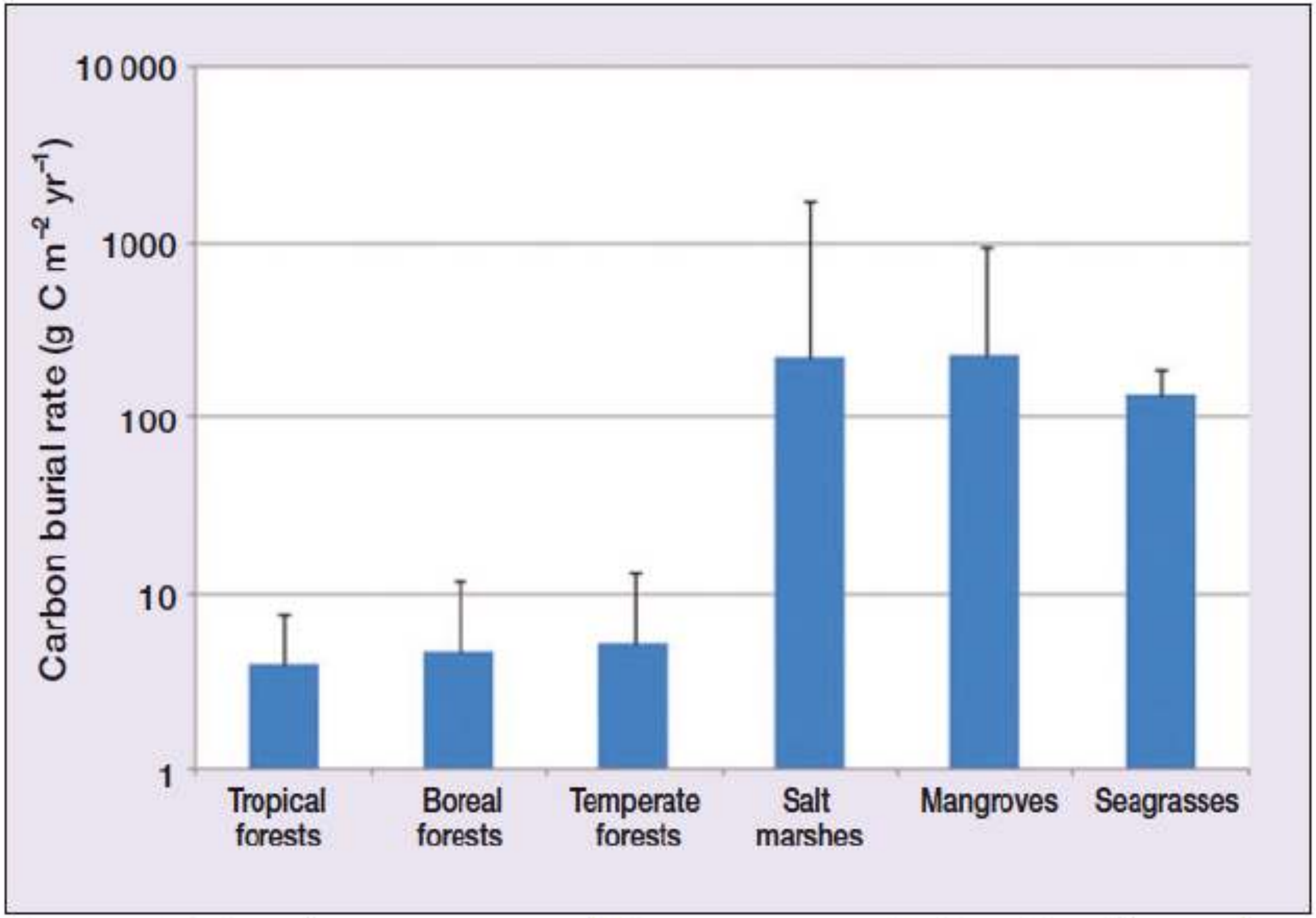


Figure 5. Mean long-term rates of C sequestration (g C m^{-2} yr^{-1}) in soils in terrestrial forests and sediments in vegetated coastal ecosystems. Error bars indicate maximum rates of accumulation. Note the logarithmic scale of the y axis. Data sources are included in Tables 1 and 2.

Vegetated coastal communities are responsible of the 46.9 % of the total carbon burial in the ocean

McLeod et al (2011)

Estimates of total C Burial in Ocean

111 Tg y^{-1} (407 tCO_2e y^{-1}) represents 46% of Ocean C sequestration

Component		Area 10^{12} m^2	$g\ C\ m^{-2}\ y^{-1}$	$Tg\ y^{-1}$	N
Vegetated habitats					
	Mangroves	0.2	139.0	23.6	27
	Salt Marsh	0.4	151.0	60.4	96
	Seagrass	0.3	83.0	27.4	5
Total vegetated habitats				111.4	
Depositional areas					
	Estuaries	1.8	45.0	81.0	24
	Shelf	26.6	17.0	45.2	15
Total coastal burial				237.6	
	% vegetated habitats			46.9	
Deep sea burial				6.0	
Total oceanic burial				243.6	
	% vegetated habitats			45.7	

Duarte et al., 2005

Causes, Rates and Consequences of Blue Carbon Ecosystem Loss

Photo by Cath Lovelock

Currently coastal wetlands are being lost at around 1% per year.

Upstream disruptions

Salt Ponds

Aquaculture

Rice/Agriculture

Road development /hydrological disruptions

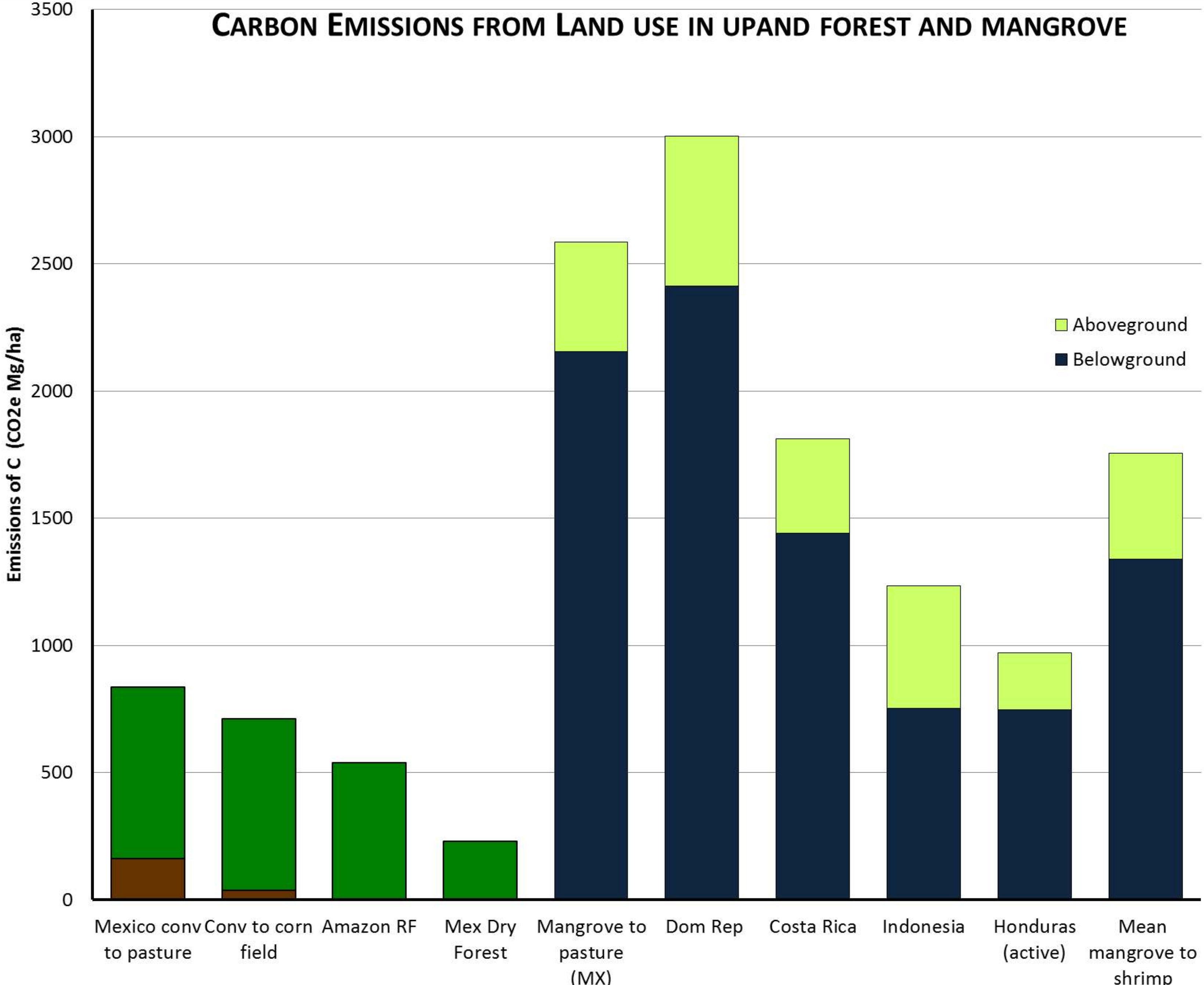
Coastal development

Management Practices in Coastal Wetlands

- Coastal wetlands that have been modified by anthropogenic activities are often reduced in area.

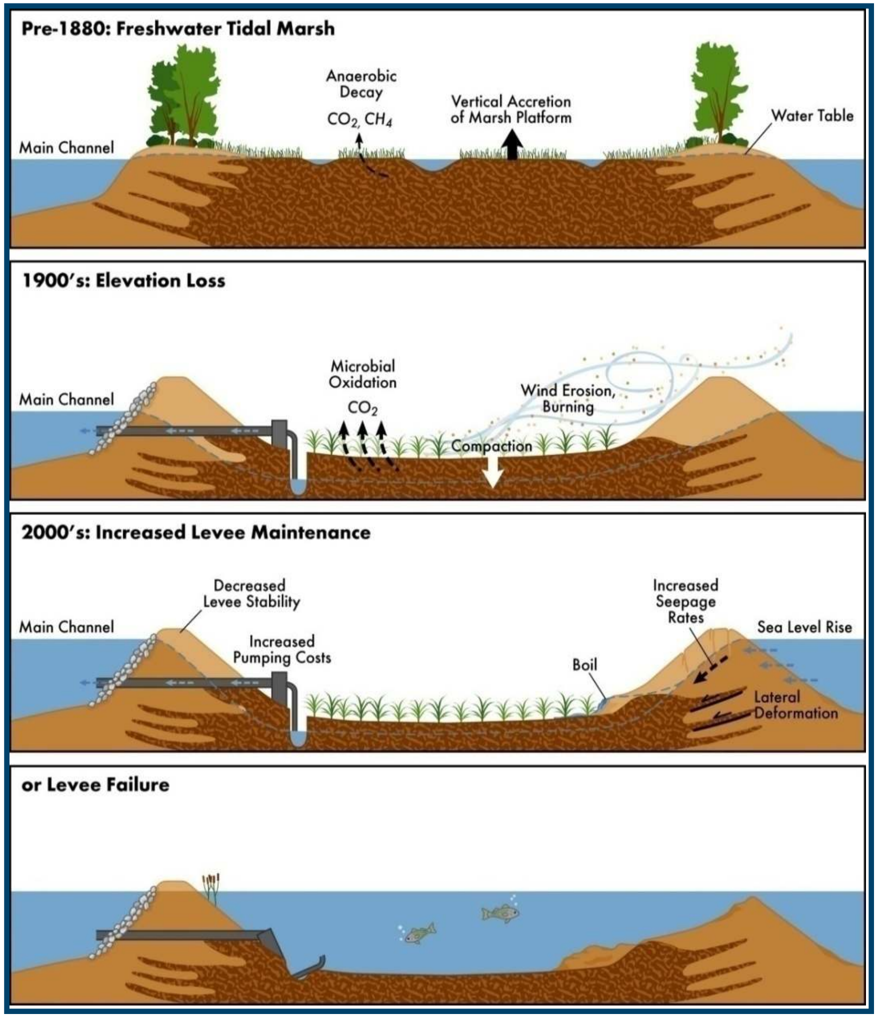
- Globally about 35% of the area of mangroves has disappeared since 1980, with a current global areal rate of loss of between 0.7 and 3% yr^{-1} (Pendelton et al., 2012). Tidal marshes and seagrasses continue to be lost at rates that are poorly quantified.

- The management activities that have led to the majority of mangrove loss include forestry activities (26%) and aquaculture, comprising the construction (and extraction of soil) for shrimp ponds (38%) and fish farms (14%) (Vaiela et al., 2009).

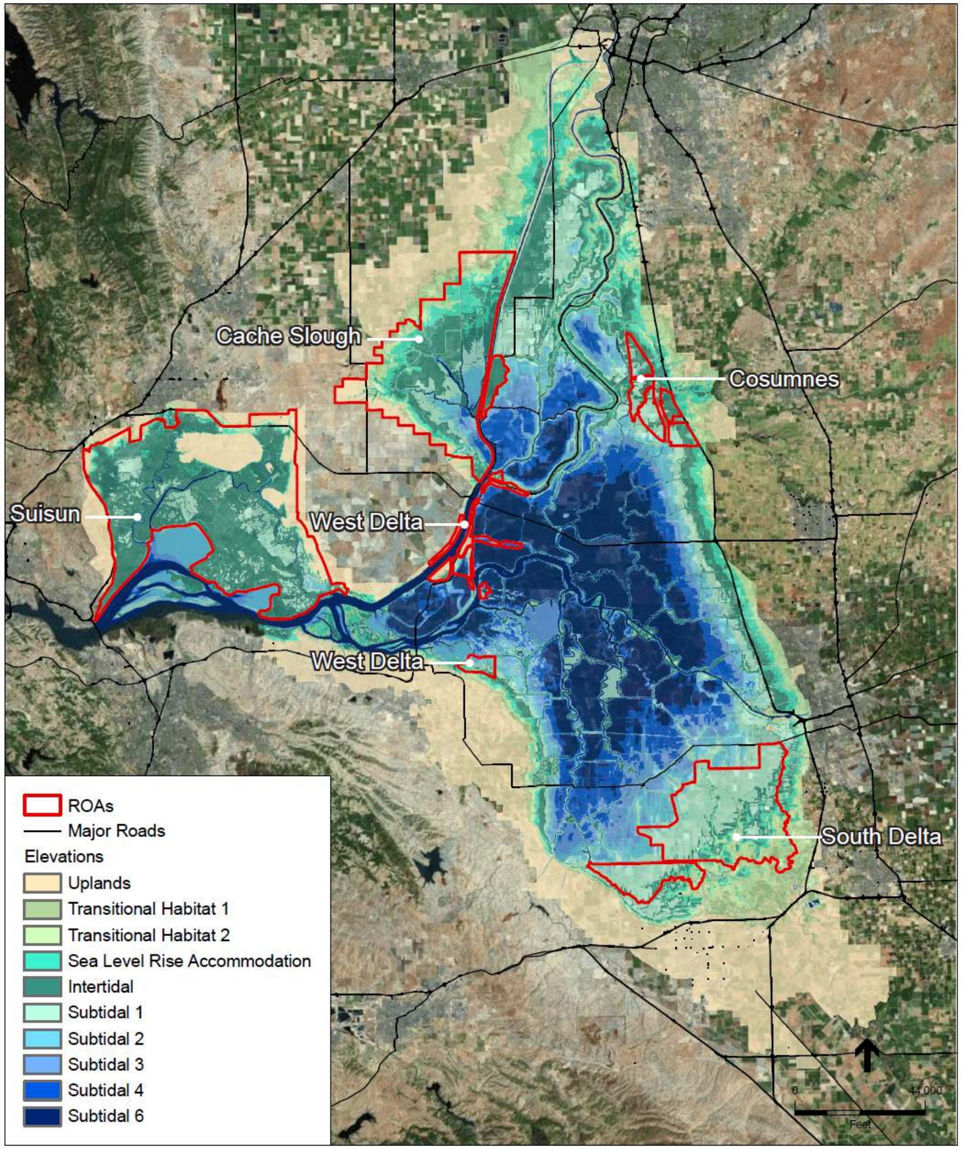


Kauffman et al (In prep);
(See also Bhomia et al 2015, Kauffman et al. 2014, 2015)

Carbon Emissions from Drained Tidal Marshes



Sacramento – San Joaquin Delta



SOURCE:
DWR 2007 LiDAR; ESA-PWA 2012

Bay Delta Science Conference.
Figure 1
Elevations and ROAs of Delta-Suisun Marsh Planning Area

ESA PWA

Emissions from One Drained Wetland: Sacramento-San Joaquin Delta

Area under agriculture	**180,000 ha**
Rate of subsidence	2.5 cm / yr

3 million tCO_2/ yr
released from Delta

1 $GtCO_2$ release in c.150 years
4000 years of carbon emitted
Equiv. carbon held in 25% of
California's forests

Accommodation space: 3 billion m^3

OPEN ACCESS Freely available online

PLOS ONE

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

Linwood Pendleton[1,9], Daniel C. Donato[2*,9], 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

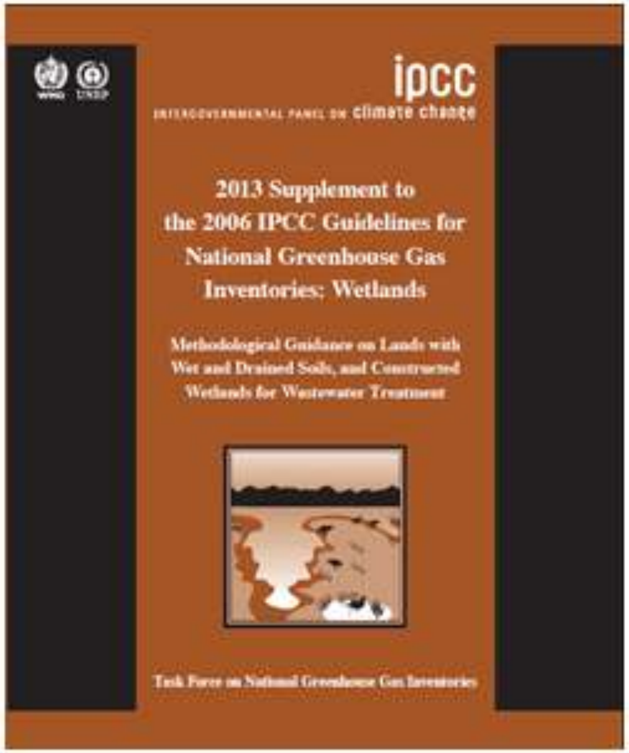
Poland

Japan

GHG Accounting and MRV

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. Coastal wetlands
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/

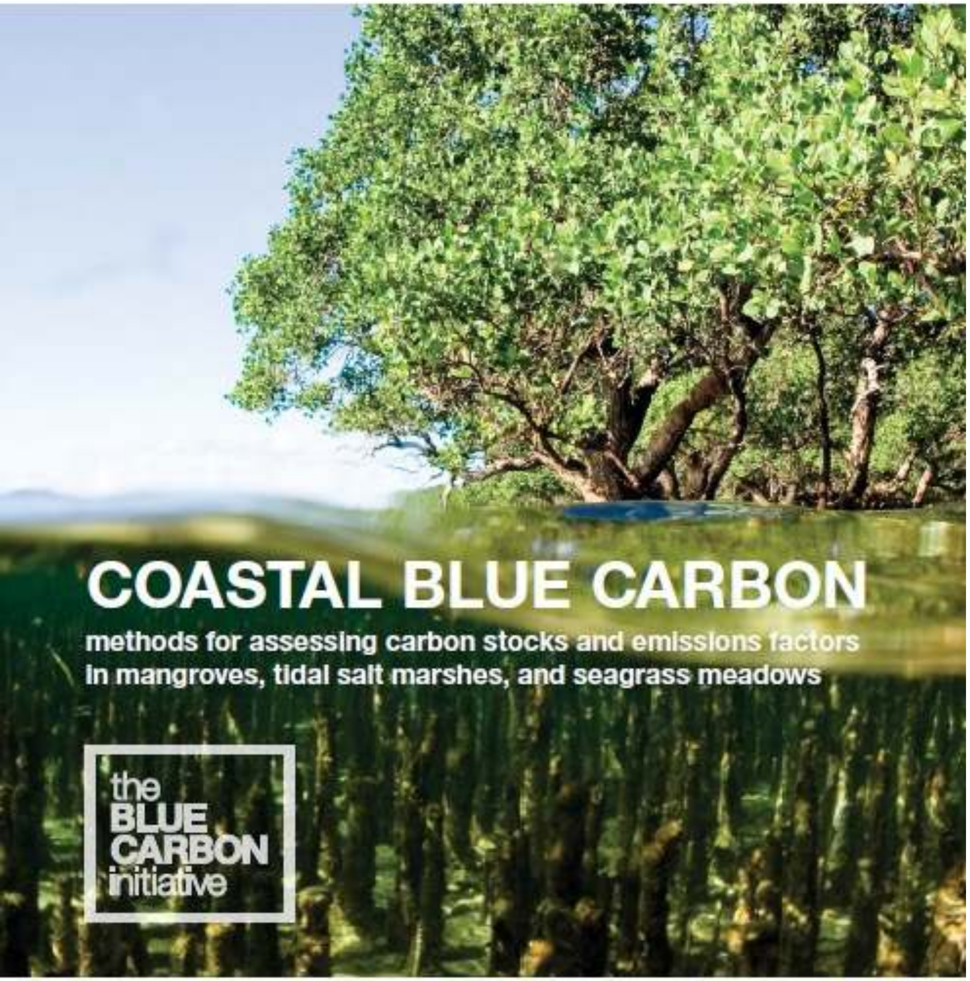
Chapter 4: Coastal Wetlands

This chapter updates guidance contained in the *2006 IPCC Guidelines* to:

- Provide default data for estimation of C stock changes in mangroves living biomass and dead wood pools for coastal wetlands at Tier 1

This chapter gives new:

- **Guidance for CO_2 emissions and removals** from organic and mineral soils for the management activities of extraction (including construction of aquaculture and salt production), drainage and rewetting and revegetation
- **Default data** for the estimation of anthropogenic CO_2 emissions and removals for soil in mangrove, tidal marsh and seagrass meadows.
- **Guidance for N_2O** emissions during aquaculture use.
- **Guidance for CH_4** emissions for rewetting and revegetation of mangroves and tidal marshes.



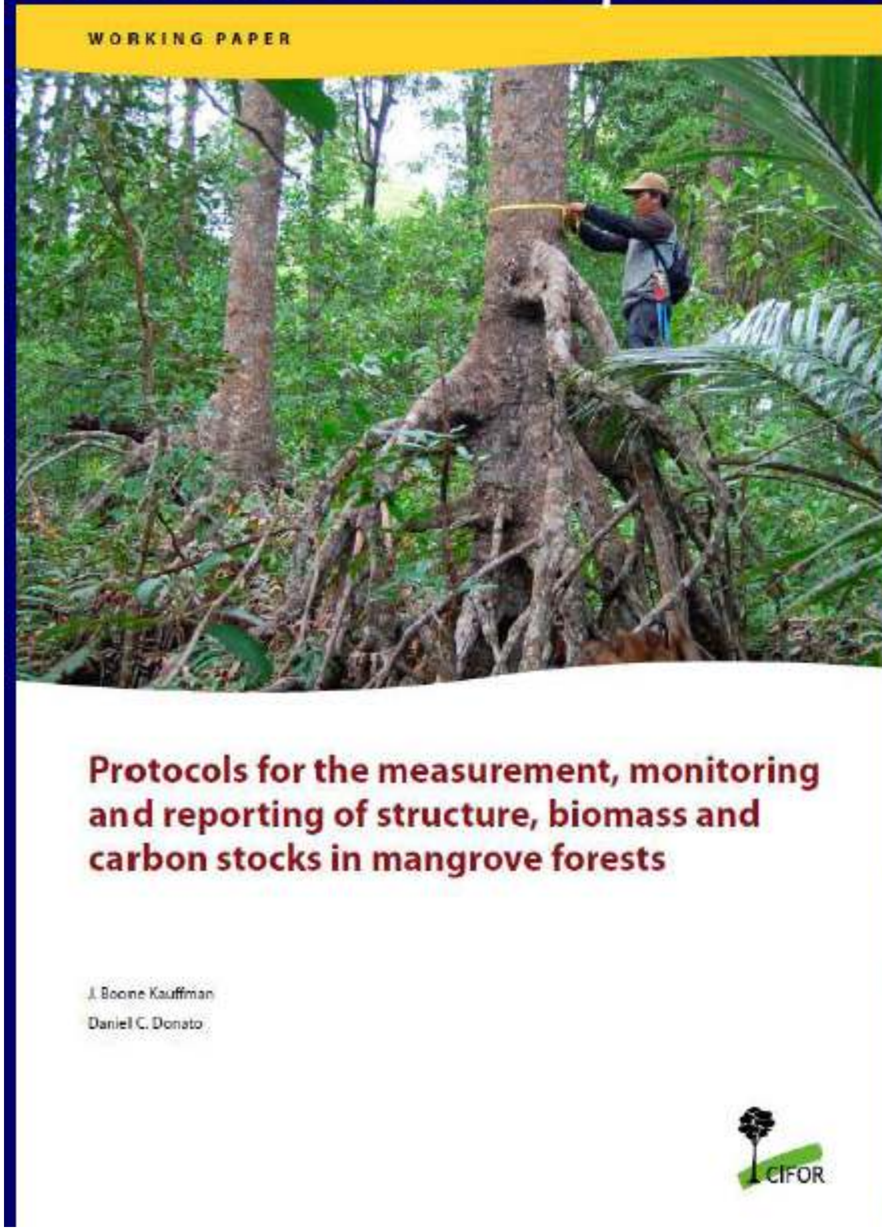
CONSERVATION INTERNATIONAL IUCN

BlueCarbonInitiative.org

Contents

- Why measure C stocks?
- Field Campaign Planning
- Sampling Soils
- Sampling Vegetation
- Estimating Emissions
- Remote Sensing and Mapping
- Data Management

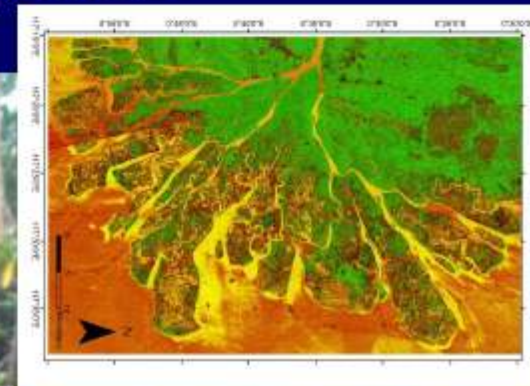
Accurate MRV is possible for mangroves


WORKING PAPER

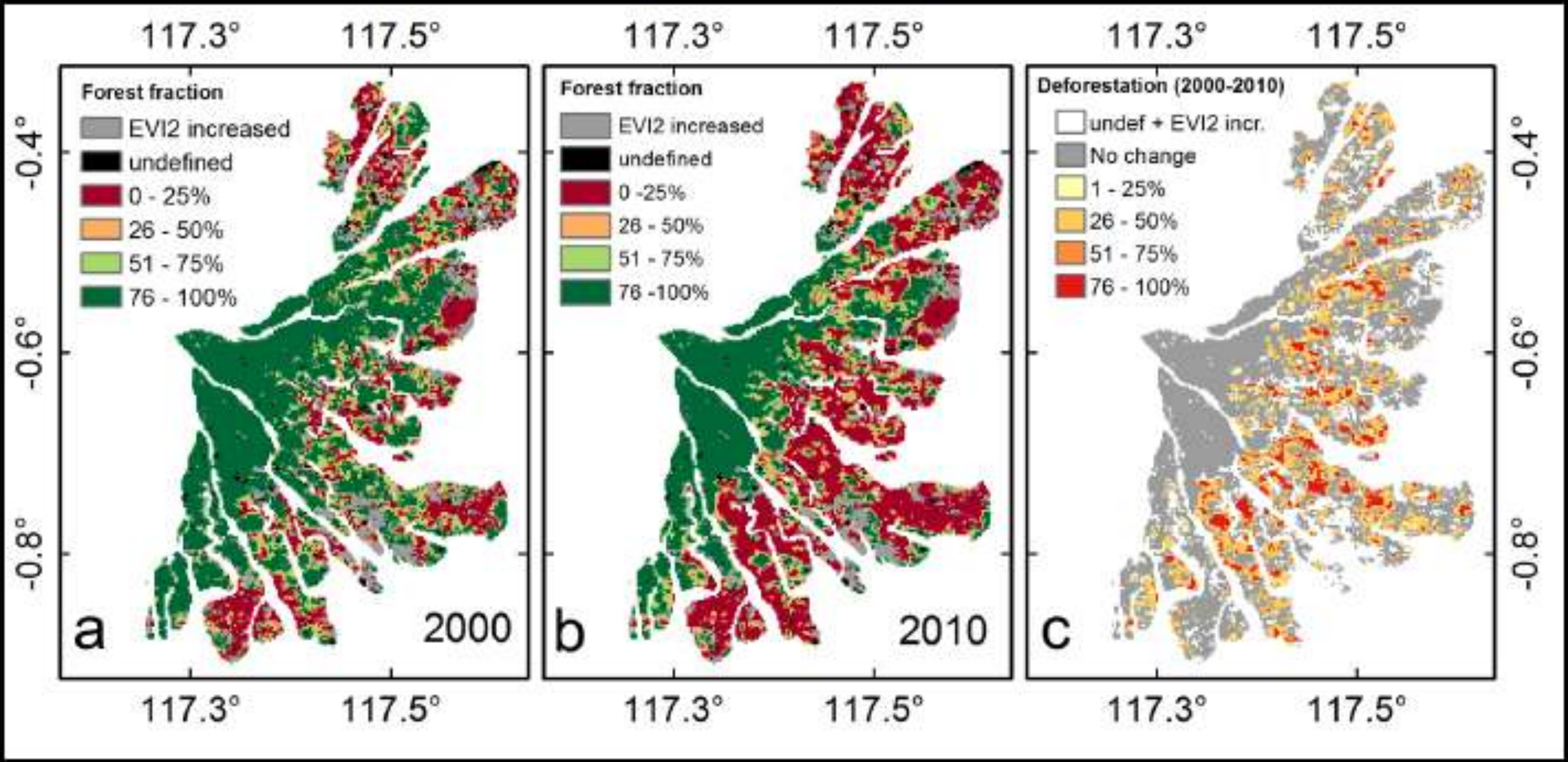
Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests

J. Boone Kauffman
Daniel C. Donato

CIFOR



Land cover change of the Mahakam delta, East Kalimantan, Indonesian from 2000 to 2010 (bottom). The figure shows the forest cover fraction in 2000 (a) and 2010 (b), and absolute change in forest cover fraction between 2000 and 2010



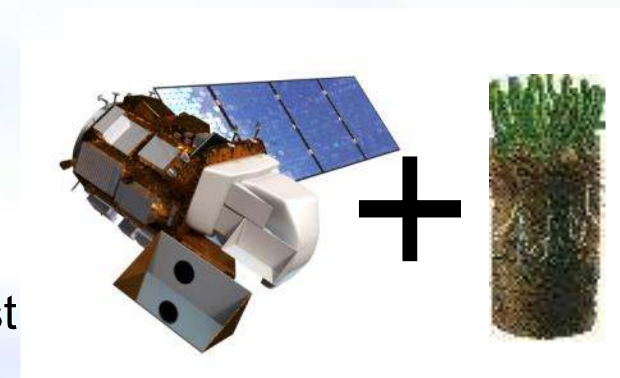
- Accurate monitoring of activity data is possible with remote sensing
- C stocks, emissions, and sequestration is possible with combinations of field and remote sensing – examples Indonesia, Dominican Republic, Yap FSM

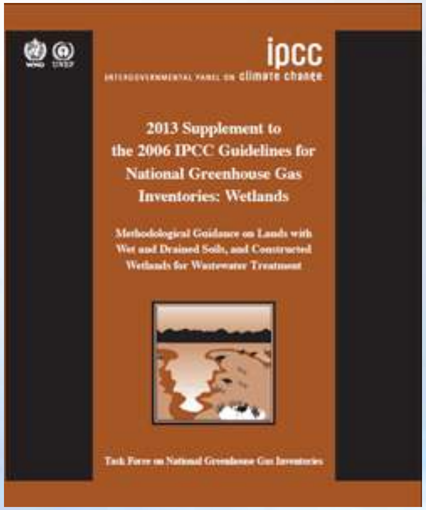
"Blue" Carbon Monitoring System

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)

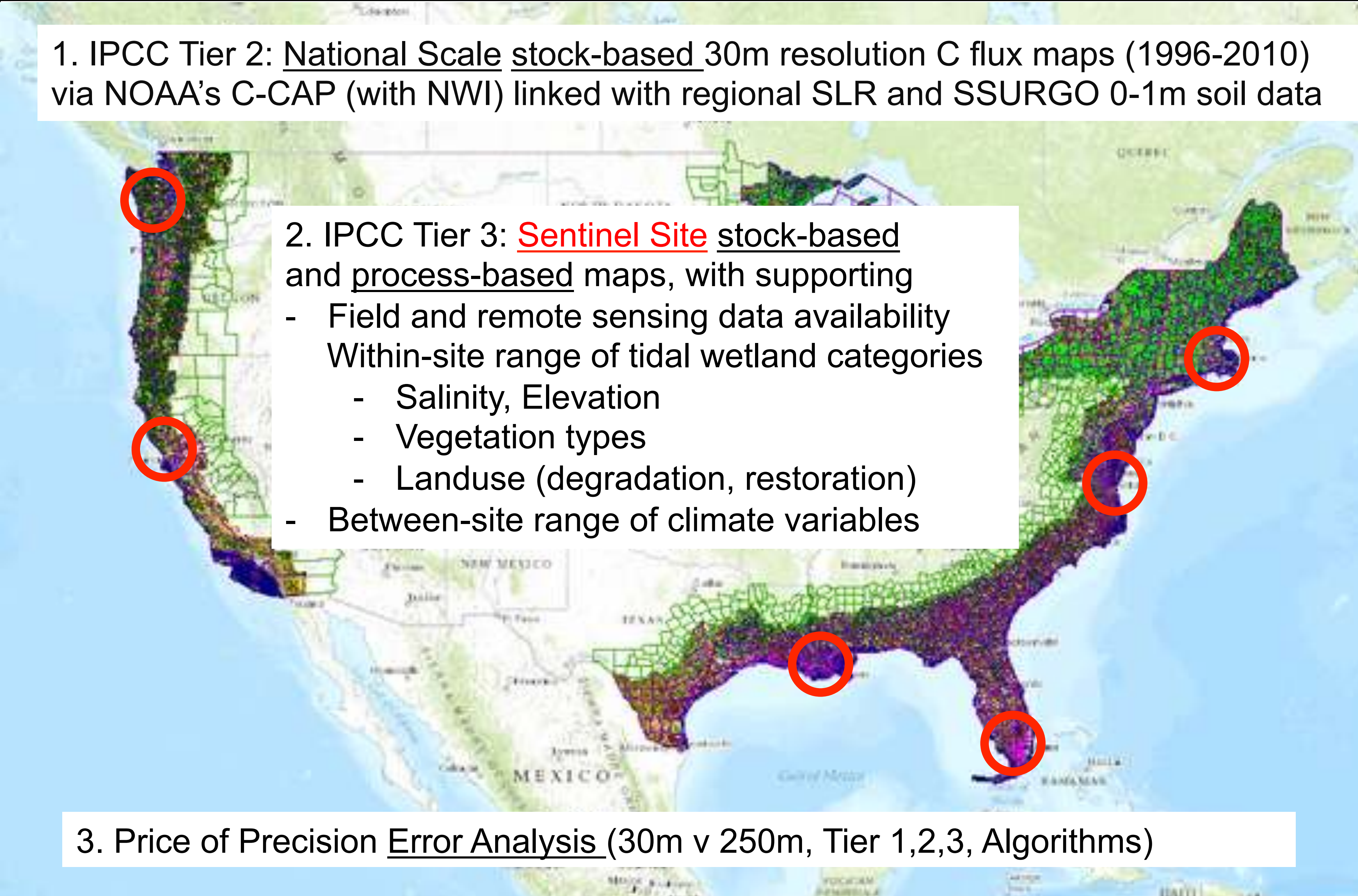
Federal		Non Federal	
USGS	Brian Bergamaschi	U. South Carolina	Jim Morris
	Kristin Byrd	U. Maryland/NOAA	Ariana Sutton-Grier
	Judith Drexler	U. San Francisco	John Callaway
	Kevin Kroeger	Florida Intl. U.	Tiffany Troxler
	John Takekawa	Texas A&M U.	Rusty Feagin
	Isa Woo	Independent	Stephen Crooks
Postdoc: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





“Blue” CMS – Product Goals

1. IPCC Tier 2: National Scale stock-based 30m resolution C flux maps (1996-2010) via NOAA’s C-CAP (with NWI) linked with regional SLR and SSURGO 0-1m soil data

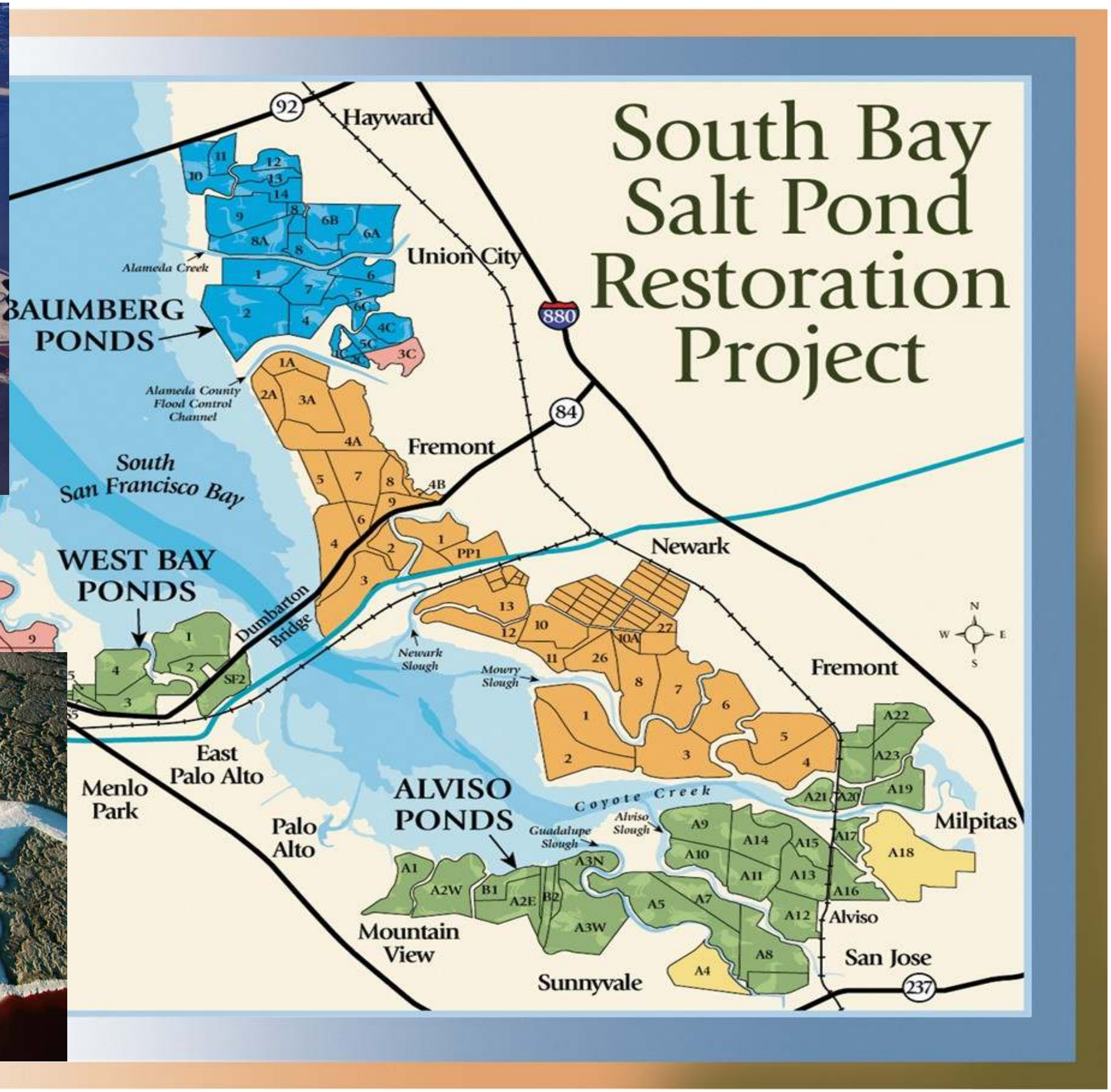


2. IPCC Tier 3: Sentinel Site stock-based and process-based maps, with supporting

- Field and remote sensing data availability
  Within-site range of tidal wetland categories
  - Salinity, Elevation
  - Vegetation types
  - Landuse (degradation, restoration)
- Between-site range of climate variables

3. Price of Precision Error Analysis (30m v 250m, Tier 1,2,3, Algorithms)

Restoration is an Established Practice



Advancing Research and Demonstration

Quantifying flux

Mapping and accounting

Technology development

Ocean acidification buffering

Green- Grey Infrastructure

Holistic management plans (Community & Policy relevant)

Conclusions

•Coastal blue carbon ecosystems are a significant component of the global carbon cycle.

•Human activities are releasing long terms stores of carbon back to the atmosphere (plus decline of other eco services)

•There are important linkages between climate mitigation and adaptation through blue carbon management.

•Conservation intact wetlands most effective carbon strategy

•Restoration halts ongoing emissions and recovers some, slowly.

Blue Carbon: The Game Plan

- 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