Sampling Protocol for C-Assessment in Mangrove System

Daniel Murdiyarso and Boone Kauffman

THINKING beyond the canopy

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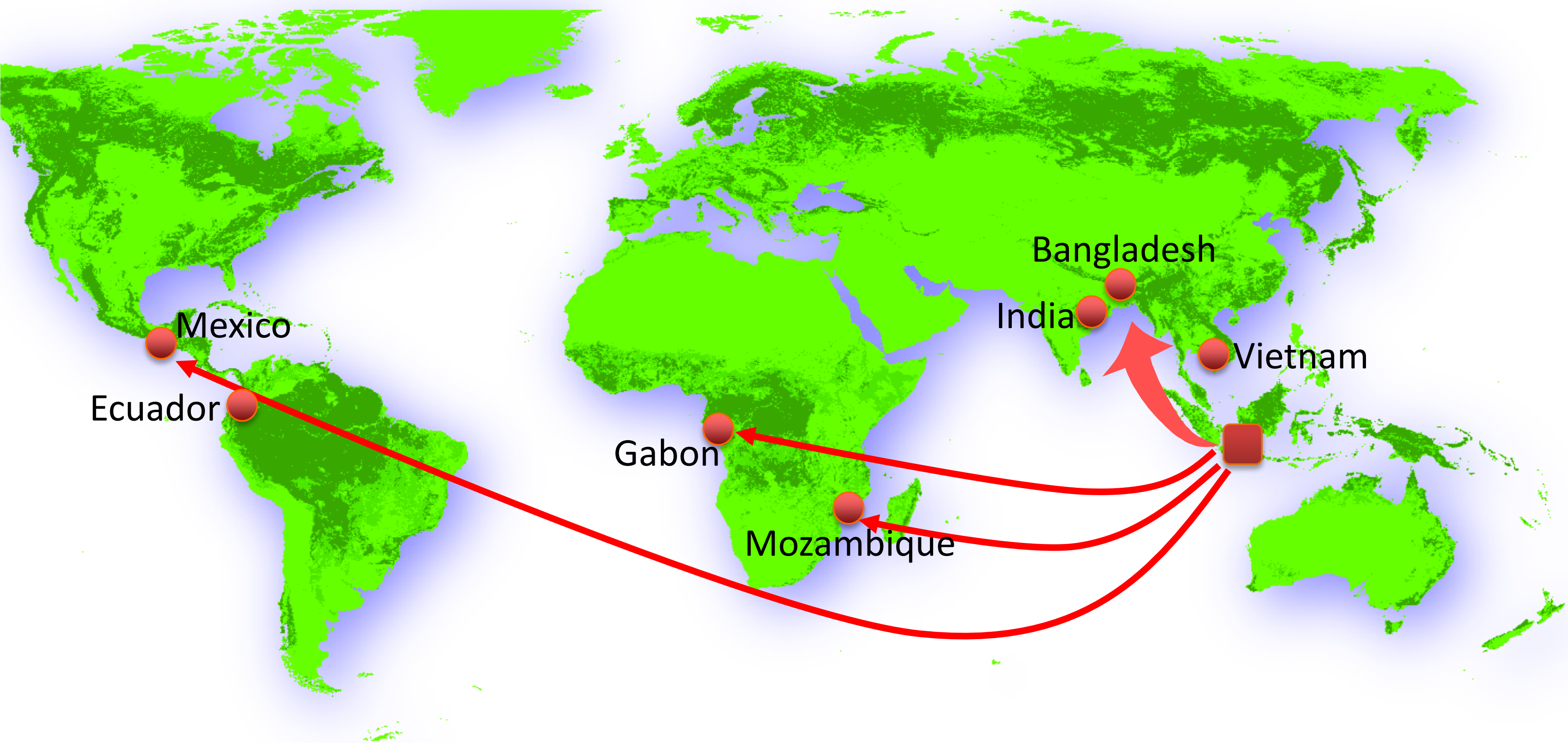
Outline

- Introduction
  - Establishing the network
  - Designing the sample plots
- The sampling protocol
  - Vegetation
  - Wood debris and litter
  - Soil
- Extrapolation: from plot to……
- IPCC Guidelines:
  - Emission factor
  - Activity data

TWINCAM: A global survey



info brief

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No. 41, July 2011 | www.cifor.cgiar.org

Addressing climate change adaptation and mitigation in tropical wetland ecosystems of Indonesia

Daniel Murdiyarso and J. Boone Kauffman

Key points

- While it is clear that tropical wetlands, especially peatlands and mangroves, are important in global carbon cycling, what we know about them is still rather patchy.
- Research addressing critical information needs and communicating such results on land use and carbon dynamics of tropical wetlands is greatly needed for sound policy decisions. It is important to study these ecosystems in Indonesia which has more tropical wetlands than anywhere else on Earth. Such science will be relevant to improving IPCC Guidelines on methodologies for greenhouse gas inventories.
- Standardised methods and protocols are needed for effective monitoring, reporting and verification of the land-use/land cover change-related emissions that arise from tropical wetlands.
- Low-laying coastal zones are prone to sea level rise and other oceanic-related climate change responses. Hence, mangroves are not only key to climate change mitigation but also play important roles in adapting to changing coastal conditions due to climate change.
- Conservation and reduction of degradation to tropical wetlands is not only a sound mitigation approach but is also an important adaptation strategy to climate change effects. Mitigation procedures that preserve ecosystem resistance and resilience to climate change are recommended as cost effective and ecologically sound adaptation strategies. Ecosystem-based or whole watershed approaches could provide the best options for communities to cope with changing climate conditions.

Why are tropical wetlands so important?

Tropical wetland ecosystems, including mangroves and peatlands provide a broad array of ecosystem services. These ecosystems are often highly productive and harbor a unique assemblage of aquatic and terrestrial biodiversity. Wetlands also play an important role in affecting the timing and delivery of water from terrestrial to aquatic ecosystems and provide a buffering function against the transmission of pollutants across this interface.

Mangroves are important sources of energy and nutrients to coral reefs, buffer coastal zones from tropical storms, and are extremely valuable as fish and wildlife nurseries. Among the least studied value of global significance ... their function as significant global carbon (C) pools. ... accumulation of carbon over several ... among the largest terrestrial ... About 42% of the ... in Asia,

with 21% in Africa, 15% in North and Central America, 12% in Australia and Oceania, and 11% in South America (Giri *et al.* 2010).

Despite covering only about 0.25% of the Earth's land surface, tropical peatlands contain around 3% of the global soil carbon stocks and at least 20% of global peat carbon (Page *et al.* 2004, Page and Banks 2007). Indonesia harbors more than 20 Mha peatlands (WI 2003, WI 2004, WI 2006), with carbon stocks estimated at approximately 55 Pg C (Jaenicke *et al.* 2008). During 2000–2005, the deforestation rate in Indonesian peatlands was estimated around 0.1 Mha per year (MoF 2007). The deforestation was largely related to establishment of unsustainable oil palm and pulp wood plantations resulting in C emissions estimated at an annual rate of 660 Gg C[1] (Koh *et al.* 2011). The most significant emissions (63%) came from the peat respiration (Hergoualc'h and Verchot 2011).

1 1 Gg = 1 Gigagram = 1x 10^9 g

Bali, 11-15 April 2011

- Partnership with intl. community
- Capacity building
- Pilot
- Funding

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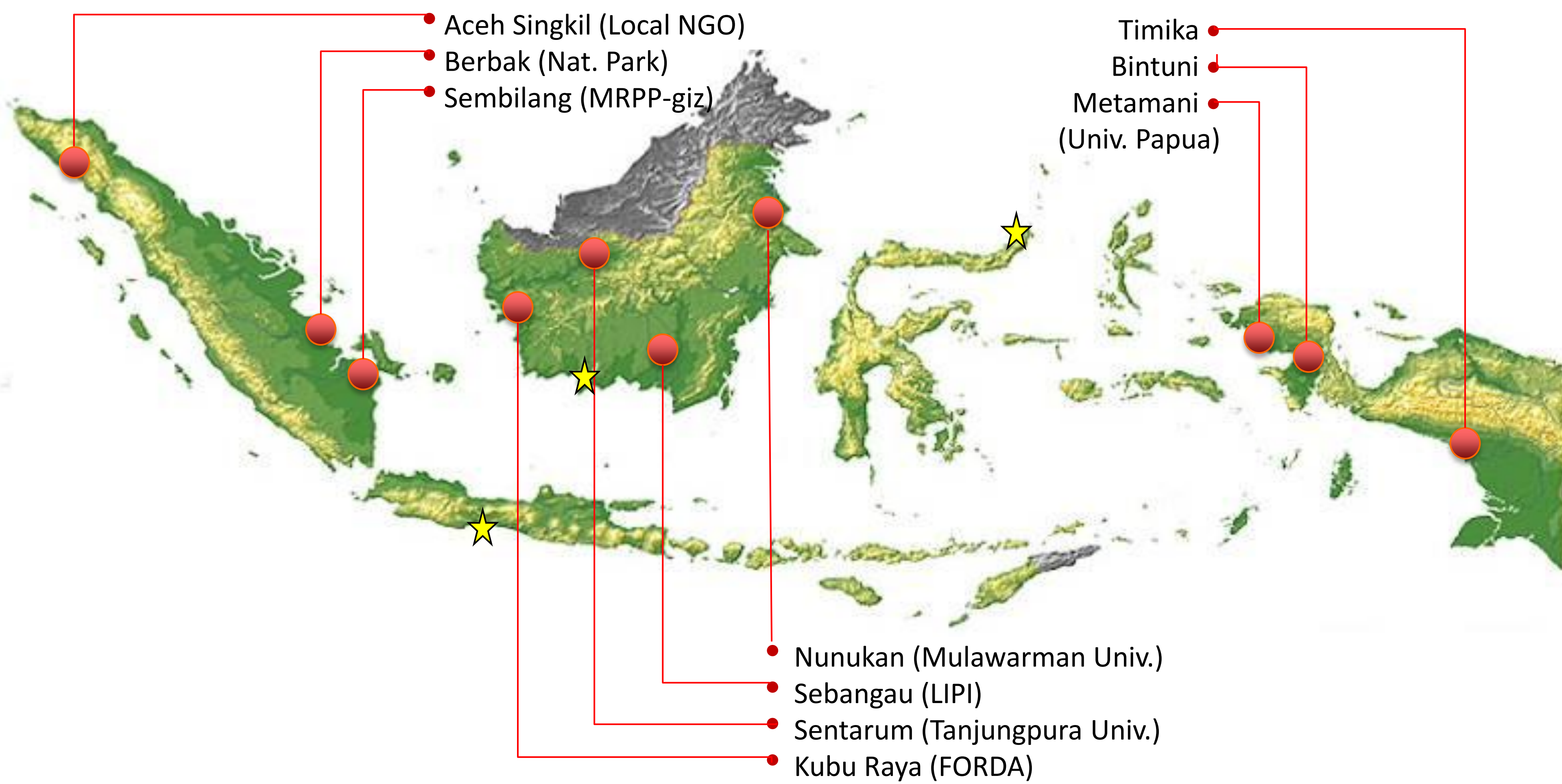
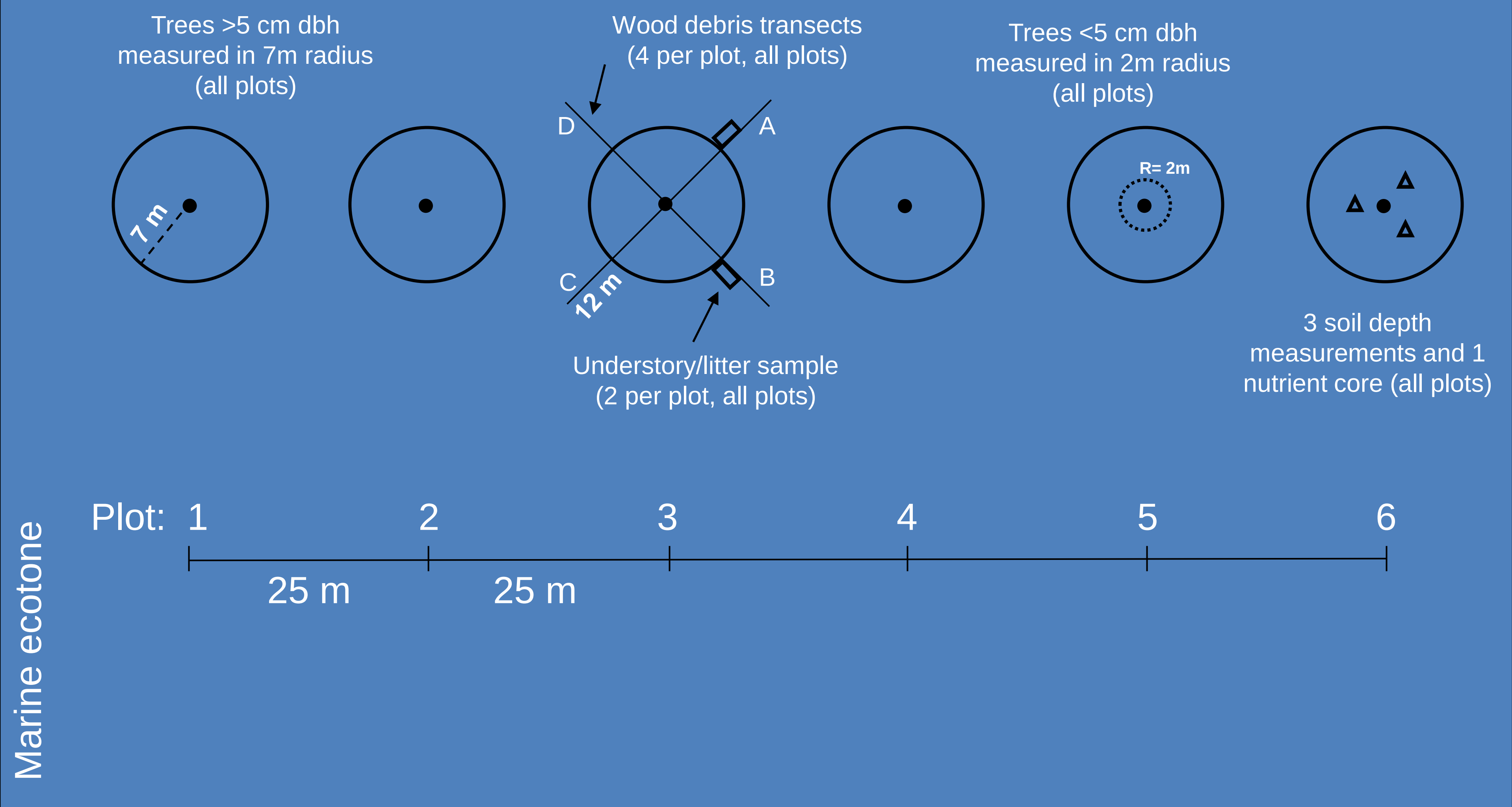
Mangroves

- Indonesia has ca. 3 million ha or 23% world's mangrove area
- There are more mangroves in Indonesia than any continents

Research network in Indonesia



Sampling plot and sub plots



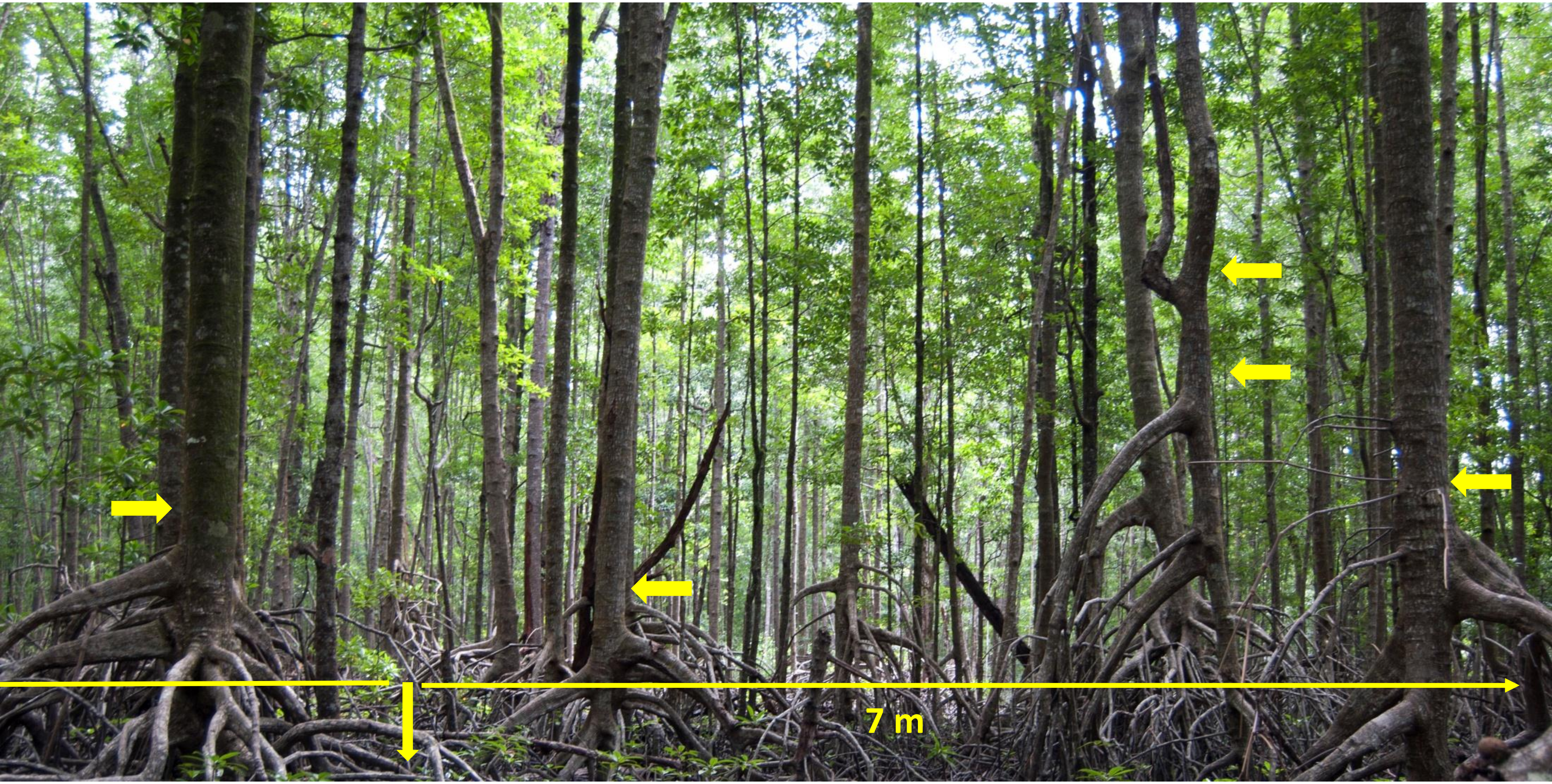
Sonneratia sp.

Rhizophora sp.

Avicennia sp.

Bruguiera sp.

Stem diameter for allometric equation



Allometric equations

Species	Equation	R^2; N	Reference	Location	D_{max}
Rhizophora apiculata	$B = 0.1709D^{2.516}$	0.98; N=20	Putz and Chan 1986	Malaysia	30
Rhizophora apiculata (wood mass)*	$B_{wood} = 0.0695D^{2.644} * \rho$	0.89; N=191	modified from Cole et al. 1999 and Kauffman and Cole 2010	Micronesia	60
Rhizophora apiculata, stylosa (leaf mass)	$B_{leaf} = 0.0139D^{2.1072}$	0.86; N=23	Clough and Scott 1989	Australia	23
Rhizophora apiculata/stylosa (Stilt roots)	$B_{stiltroots} = 0.0068D^{3.1353}$	0.97; N=23	Clough and Scott 1989	Australia	23

Allometric equations

	N	D_{max}	Max H		R^2
General Equation	84	42		$B = 0.0509 * \rho * (D)^2 * ht$	
Bruguiera gymnorrhiza	325	132.0	34	$0.0464 * (D^2H)^{0.94275} * \rho$	0.96
Sonneratia alba	345	323.0	42	$0.0825 * (D^2H)^{0.89966} * \rho$	0.95
Rhizophora apiculata	193	60.0	35	$0.0444 * (D^2H)^{0.96842} * \rho$	0.96
Rhizophora mucronata	73	39.5	21	$0.0311 * (D^2H)^{1.00741} * \rho$	0.95
Rhizophora spp.	265	60.0	35	$0.0375 * (D^2H)^{0.98626} * \rho$	0.95
Lumnitzera littorea	20	70.6	19	$0.0214 * (D^2H)^{1.05655} * \rho$	0.93
Xylocarpus granatum	115	128.5	31	$0.0830 * (D^2H)^{0.89806} * \rho$	0.95

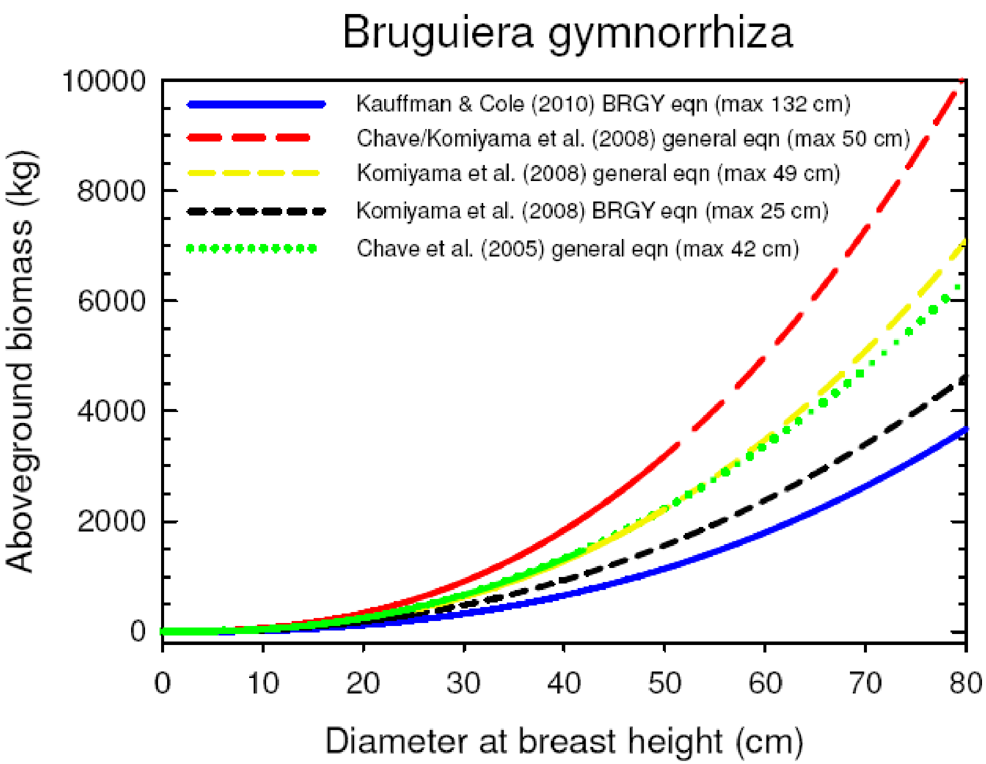
B = biomass (kg), ht = height (m), D = diameter at breast height (cm), ρ = wood density (g cm^{-3}), D_{MAX}= maximum diameter of sampled trees (cm). Additional equations can be found in Komiyama et al. (2008), and Smith and Whelan 2006.

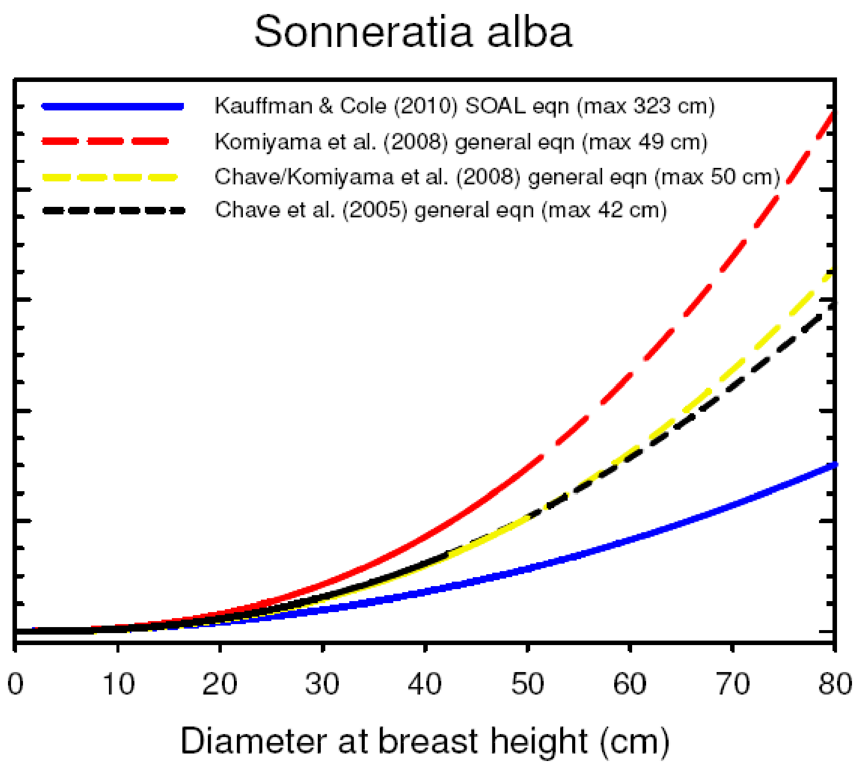



Wood density

Species	Wood density, ρ ($g\ cm^{-3}$)
Rhizophora apiculata	1.050
Rhizophora mangle	0.830
Sonneratia alba	0.0780
Avicennia germinans	0.661
Laguncularia racemosa	0.600
Avicennia officinalis	0.670
Bruguiera gymnorrhiza	0.860
Ceriops decandra	0.960
Excoecaria agallocha	0.450
Heritiera fomes	1.074
Sonneratia apetala	0.559
Xylocarpus granatum	0.700
Xylocarpus mekongensis	0.725
Site average of above values	0.752

Comparisons:
by species and diameter classes





Kauffman and Cole (2010)

Standing dead trees

Taper equation for estimating the top-diameter of a broken-topped dead tree:

$$d_{top} = d_{base} - \left[100 * ht * \left(\frac{(d_{base} - dbh)}{130} \right) \right]$$

d_{top} = estimated diameter at top of tree (cm)
d_{base} = the measured basal diameter (cm)
ht = tree height (m)
d.b.h = tree d.b.h. (cm)

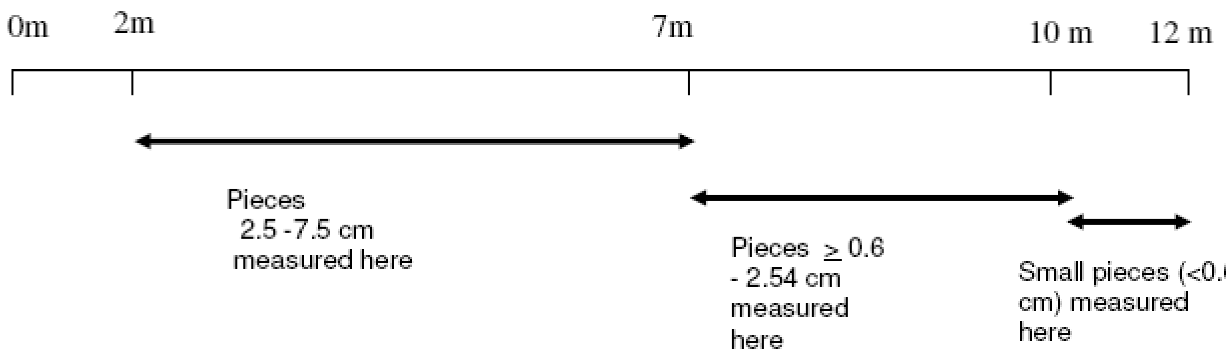
Then volume is determined by assuming the tree is a truncated cone:

$$\text{Volume } (cm^3) = \left(\frac{\pi * (100*ht)}{12} \right) * (d^2_{base} + d^2_{top} + (d_{base} * d_{top}))$$

ht = tree height (m)
d_{base} = the basal diameter (cm)
d_{top} = the diameter at the top (cm) estimated from the taper equation (if taper equation results in negative number, use 0 for d_{top}).

Wood debris

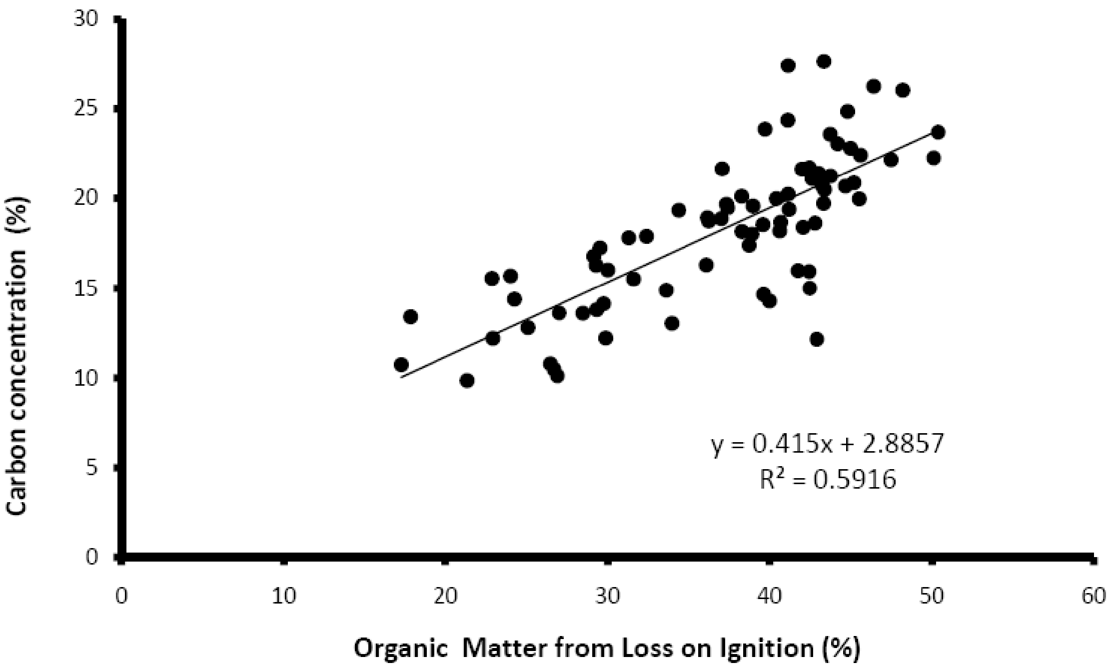
Fine	: < 0.6 cm (count along 10-12 m)
Small	: 0.6 - 2.5 cm (count along 7-10 m)
Medium	: 2.5 - 7.5 cm (count along 2-7 m)
Large	: >7.5 cm (measure, sound and rotten)



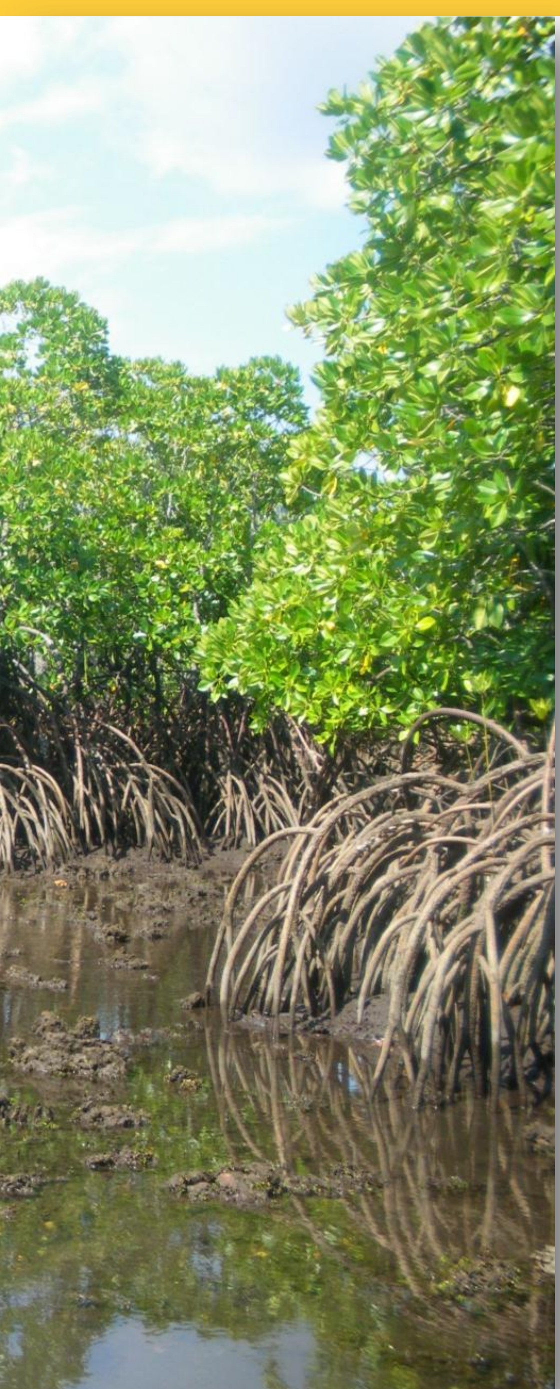
Soil depth and sampling

Intervals: 0-15 cm, 15-30 cm, 30-50 cm, 50-100 cm, 100-300 cm

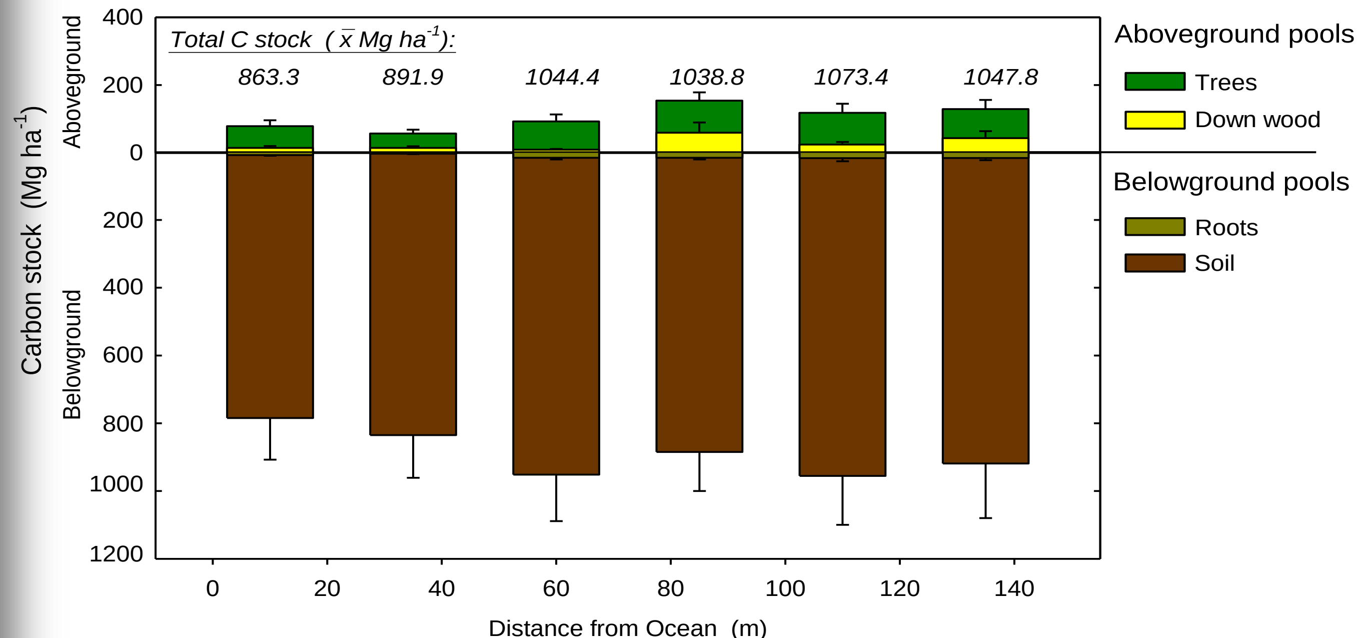
Soil sample analysis



Kauffman et al. (2011)

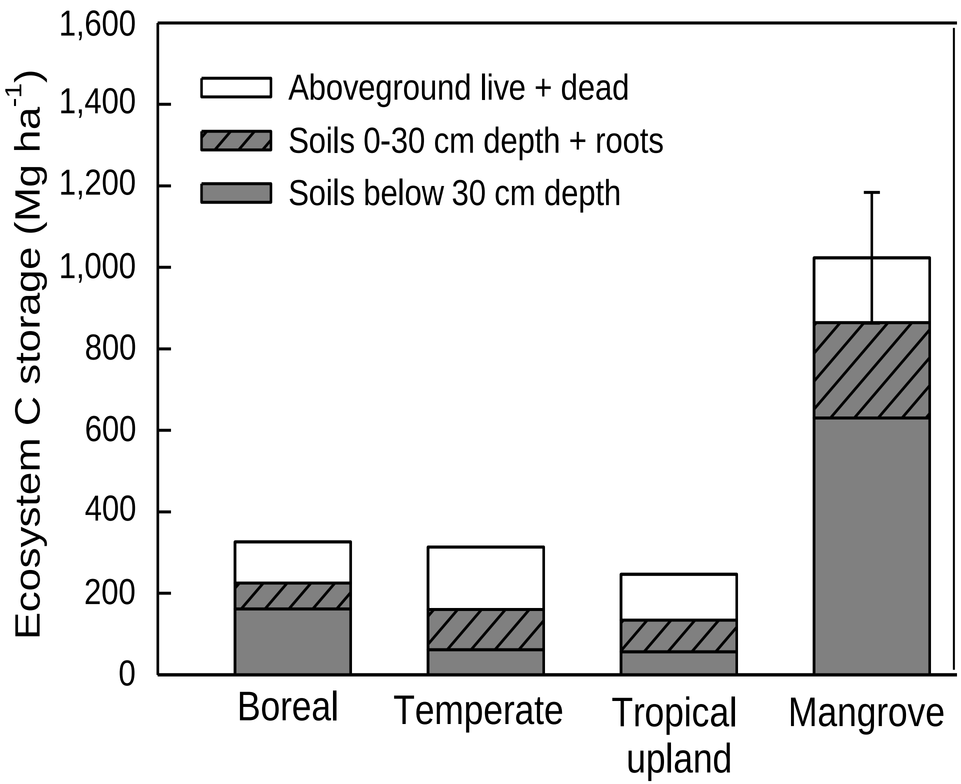


C-stocks in mangroves



Murdiyarso et al. (2010)

Large belowground pools



Donato et al., (2011)

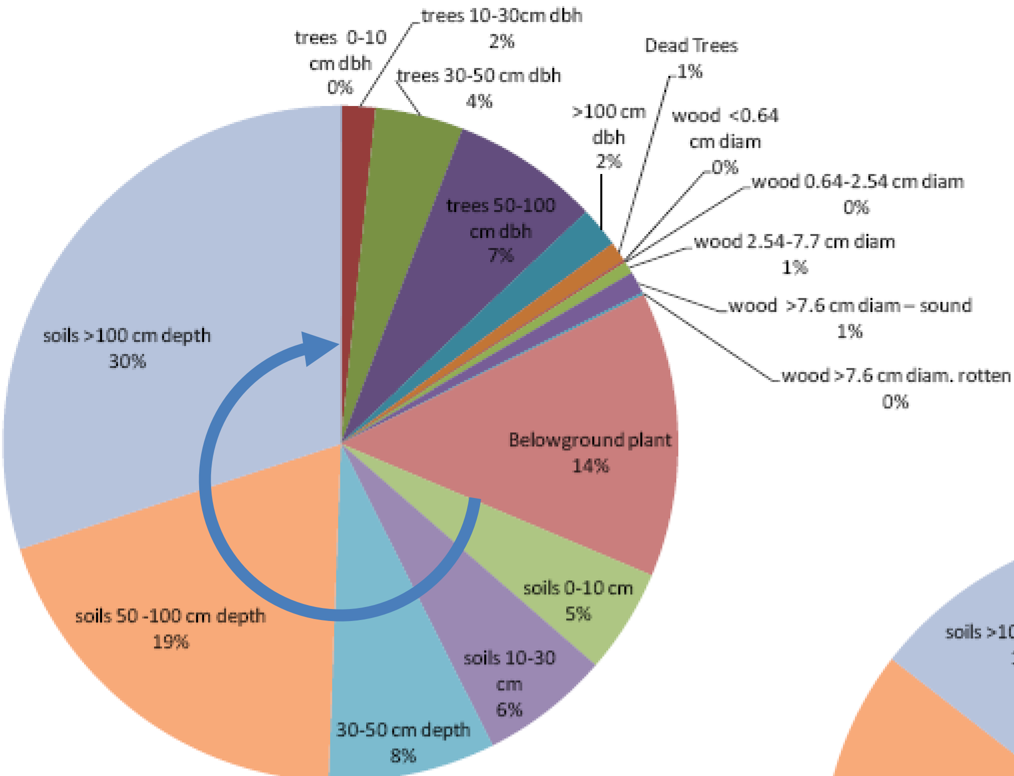
Extrapolation

Component	Plot	Stand	Ecosystem C-pools	Nat/Sub national
Vegetation	Allometric ($Mg\ plot^{-1}$)	Allometric ($Mg\ ha^{-1}$)		
Wood debris	$QMD = \sqrt{(\sum d_i^2)/n}$	$SG \times (\pi^2(N_i \times QMD_i^2) + \pi^2(d_1^2+d_2^2..dn^2/8L)$ ($Mg\ ha^{-1}$)	Σ = TCS (V+WD+S) ($Mg\ ha^{-1}$)	TCS x area (Mg)
Soil	BD x depth x %C ($Mg\ plot^{-1}$)	Averaged plot ($Mg\ ha^{-1}$)		

- By species
- By biome

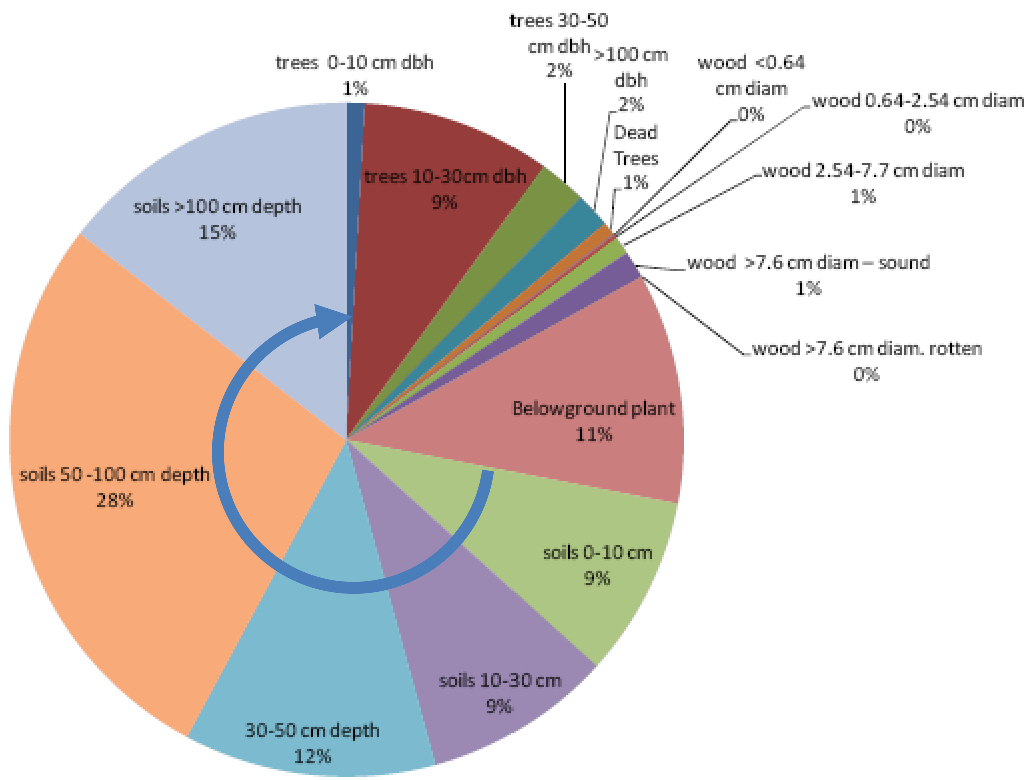
ΔC = emission factor
($Mg\ y^{-1}$)

Ecosystem C-pools



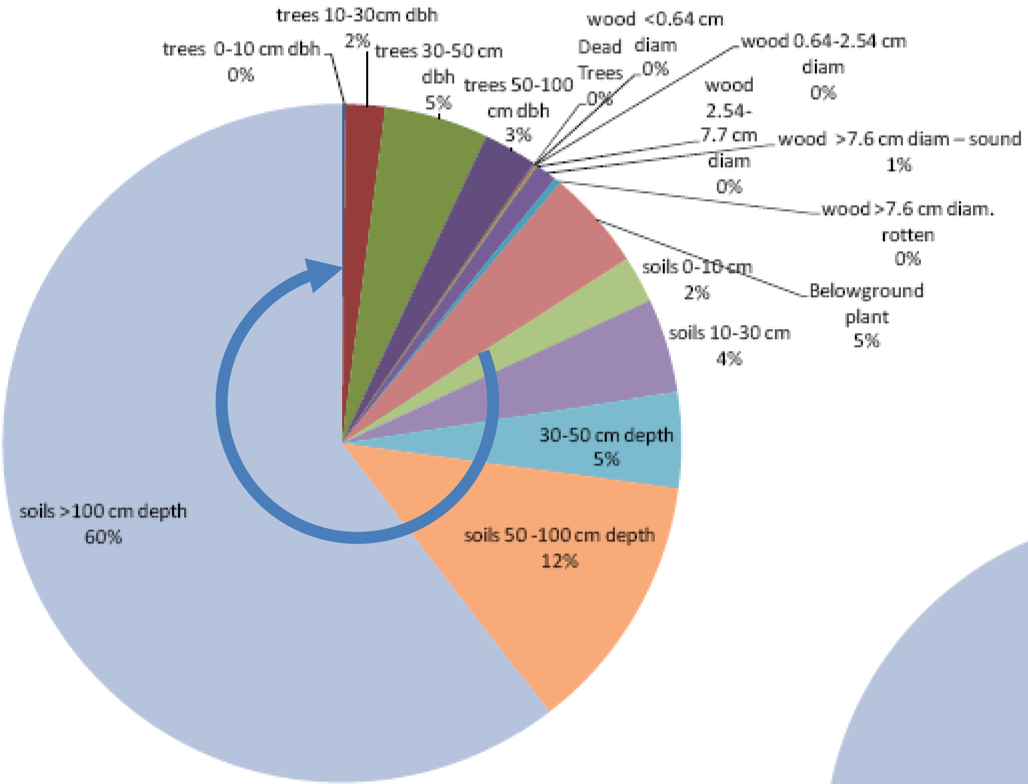
Coastal Fringe Yap FSM
1066 Mg/ha
(68%)

Coastal Fringe, Republic of Palau
723 Mg/ha
(73%)



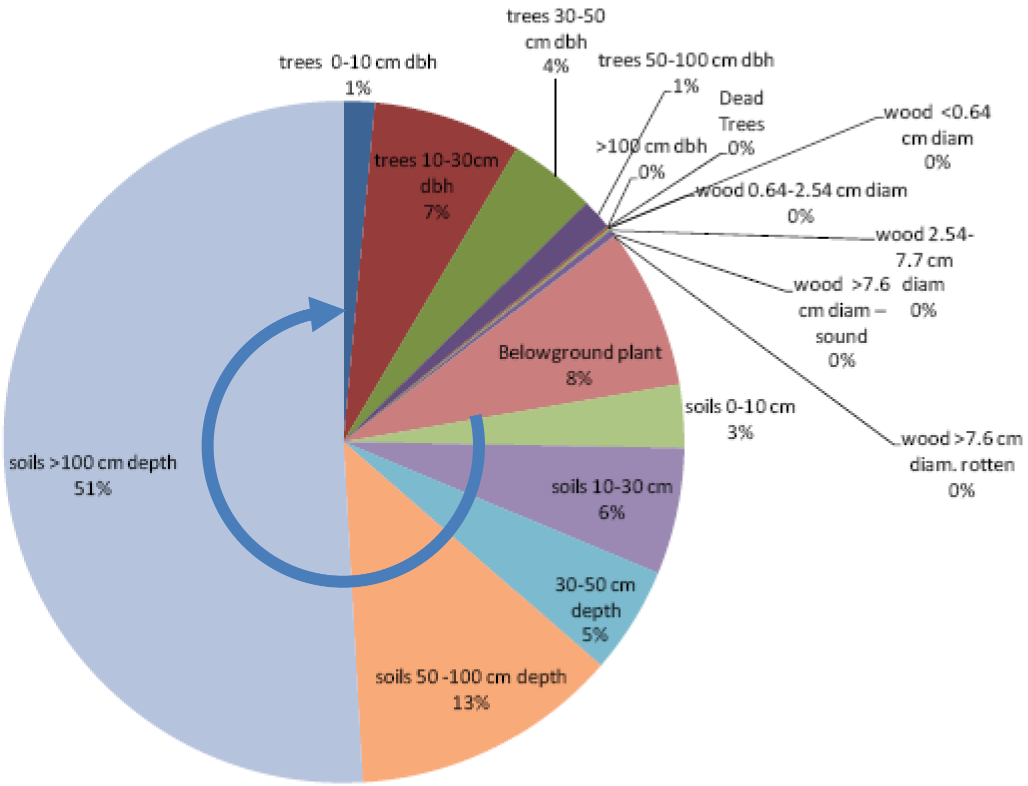
Kauffman and Donato (2011)

Ecosystem C-pools



Kalimantan, Indonesia Riverine
1259 Mg/ha
(83%)

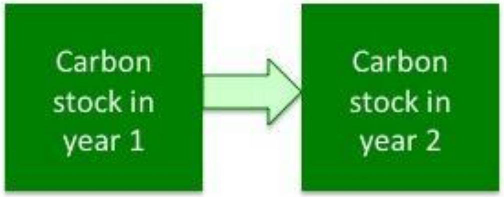
Sundarbans, Bangladesh
566 Mg/ha
(78%)



Kauffman and Donato (2011)

IPCC Guidelines - 2006

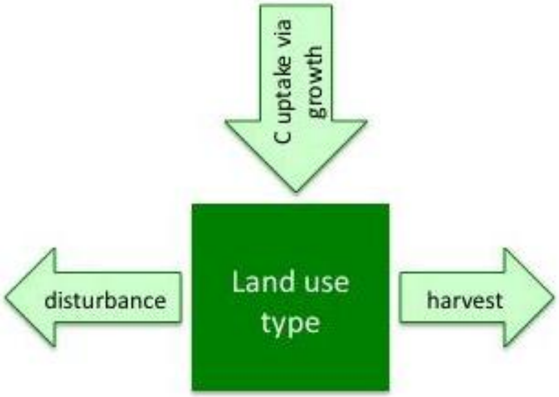
Stock-change approach



$$\Delta C = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

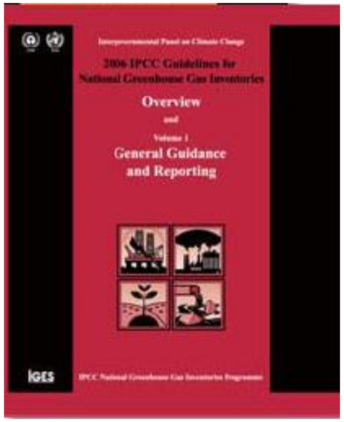
Where:
ΔC = annual carbon stock change in pool (t C/yr)
ΔC_{t1} = carbon stock in pool at time t_1 (t C)
ΔC_{t2} = carbon stock in pool at time t_2 (t C)

Flux-change approach



$$\Delta C = \Delta C_{gain} - \Delta C_{loss}$$

Where:
ΔC = annual carbon stock change in pool (t C/yr)
ΔC_{gain} = annual gain in carbon (t C/ yr)
ΔC_{loss} = annual loss in carbon (t C/ yr)



Source: IPCC (2006)

IPCC Guidelines - 2006

TABLE 7.1 SECTIONS ADDRESSING MAJOR GREENHOUSE GAS EMISSIONS FROM MANAGED WETLANDS		
Land-use category/GHG	**Peatlands**	**Flooded Land**
Wetlands Remaining Wetlands		
CO_2	Section 7.2.1.1	No Guidance [1]
CH_4	No Guidance [2]	Appendix 3
N_2O	Section 7.2.1.2	No Guidance [3]
Lands Converted to Wetlands		
CO_2	Section 7.2.2.1	Section 7.3.2.1 and Appendix 2
CH_4	No Guidance [2]	Appendix 3
N_2O	Section 7.2.2.2	No Guidance [3]

NOTES:

[1] CO_2 emissions from *Flooded land Remaining Flooded land* are covered by carbon stock change estimates of land uses and land-use change (e.g., soils) upstream of the Flooded Land.

[2] Methane emission from peatlands is negligible after drainage during conversion and peat extraction.

[3] N_2O emissions from Flooded Land are included in the estimates of indirect N_2O from agricultural or other run-off, and waste water.

Side Event – Don't miss it….!

Photo by Daniel Murdiyarso

Friday
10 June 2011
18.15 – 19.45
RAIL room,
Ministry of Transport

Programme
Chair:
Daniel Murdiyarso, CIFOR

1. Stocks and fluxes of carbon associated with land use change in Southeast Asian tropical peatlands: A review
Louis Verchot, CIFOR
2. Targeting tropical wetlands for climate adaptation and mitigation
Matthew Warren, US Department of Agriculture's Forest Service
3. Development of IPCC guidance on wetlands
Simon Eggleston, IPCC Task Force on National Greenhouse Gas Inventories
4. Challenges of climate change adaptation in Sundarban mangrove forest of Bangladesh
S.M. Munjurul Hannan Khan, Government of Bangladesh

Discussion

Refreshments will be served.

Tropical wetlands initiative for climate change adaptation and mitigation

Recent studies demonstrate that carbon stocks in peatlands and mangroves of Southeast Asia are almost five times higher than carbon stocks in upland tropical and temperate forests. However, methodologies are lacking for countries to assess and communicate their greenhouse gas inventories. Even IPCC guidelines are not readily applicable to such ecosystems in the tropics, which could very well benefit from REDD+. Emissions factors associated with land use change and activity data in these ecosystems need to be revisited so that peatlands and mangroves are included in mitigation schemes.

Climate change is already affecting these wetlands and the people whose livelihoods depend on them, through rising sea levels, increasing soil salinity, changing temperature and rainfall patterns, increasing number and severity of cyclones, and increasingly frequent extreme weather events. These stressors require adaptation strategies. Bundling adaptation and mitigation strategies would enhance the benefits to communities that have relatively low capacity to adapt and yet most vulnerable to and hard hit by climate change.

This side event will present a conceptual framework, what we know to date and lessons learnt to enhance the roles of wetlands in climate change adaptation and mitigation.

For more information, contact Daniel Murdiyarso at d.murdiyarso@cgiar.org.

CIFOR USAID Australian Government AusAID

Bonn, SB-34 Side event

- SBSTA-32 to revise the IPCC 2006 for Annex 1 reporting guidelines for GHG emissions and removals
- Invited IPCC to hold an Expert Meeting to "*explore the need to clarify methodological issues related to...wetlands…*
- Synergizing adaptation strategies and measures
- ➢ Tropical wetlands should be in the agenda

Thank you

Two recent publications

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