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Indonesia's Mangrove and Tropical Peatland Research and related carbon accounting

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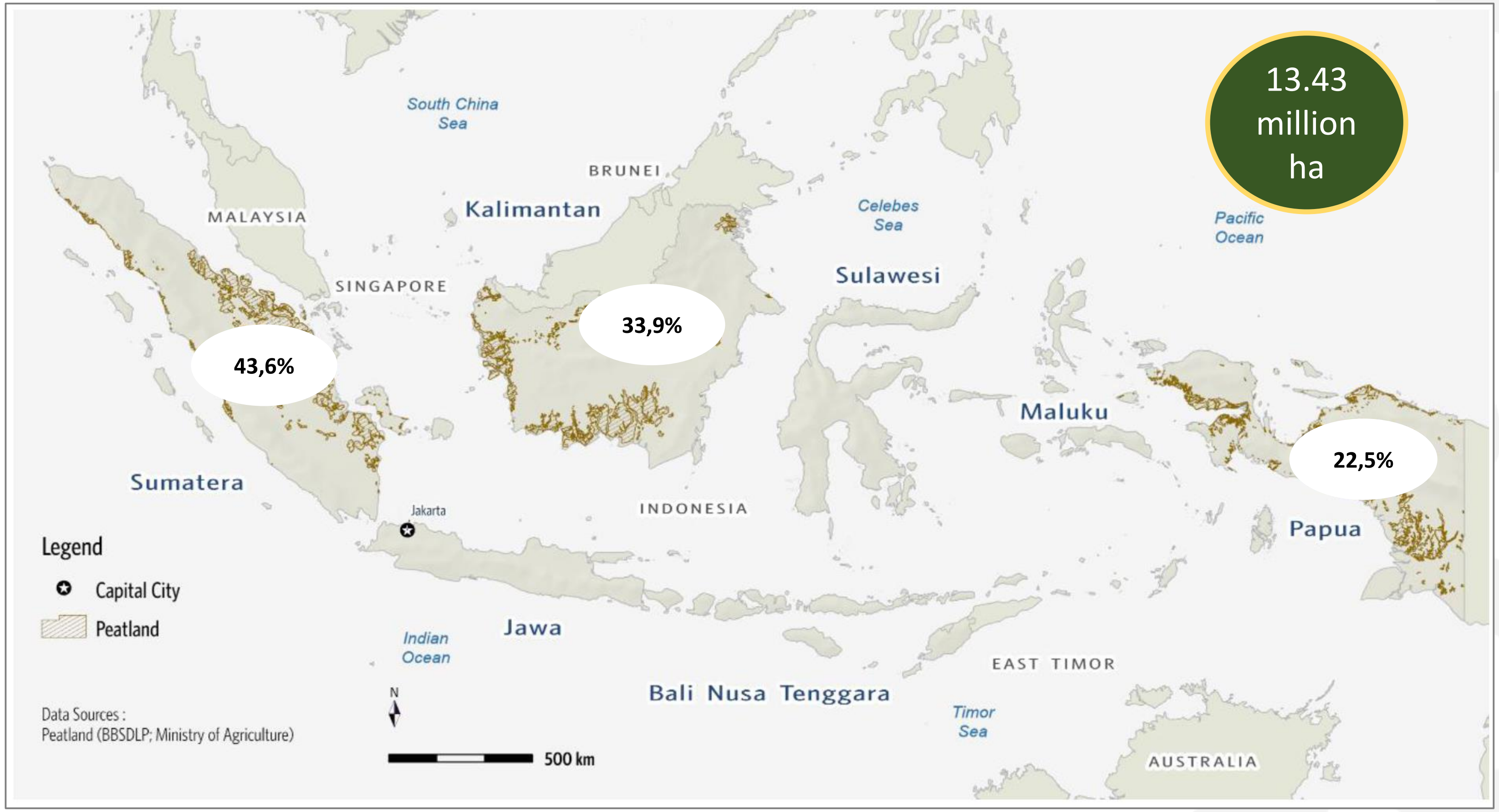
Why are mangroves and tropical peatlands?

- High carbon density and provide various important ecosystem services.
- Significant contributors to global GHG emissions due to their high rates of degradation and land use change.
- Potential for climate change mitigation and adaptation.
- Understanding the source and size of historical emissions is important for planning mitigation actions as well as assessing the potential impact of land management options on future emissions.
- A number of studies have been conducted in Indonesia to provide scientific information on emission factors and address a significant knowledge gap in the main parameters to improve the accuracy of emission estimation due to disturbances.

Mangroves in Indonesia

Ministry of Environment & Forestry (2021)

Peatlands in Indonesia



Source: Ministry of Agriculture (2019)

How research has contributed to the national emission reporting?

Improvement of emission estimation

1st Indonesia FREL Wetland Emission Calculation

- Mangrove
  - AGB emission
- Peatland
  - AGB emission
  - SOC emission from peat decomposition

Uncertainty analysis

- **Propagation error from activity data and emission factor**

2nd Indonesia FREL Wetland Emission Calculation

- Mangrove
  - AGB, BGB, DOM emission
  - SOC emission from mangrove conversion
- Peatland
  - AGB, BGB, DoM emission
  - SOC emission from peat decomposition and peat fire

Uncertainty analysis

- **Adding sources of uncertainty (improved allometrics, increased samples, etc.)**
- **Applying uncertainty calculation (Montecarlo simulation)**

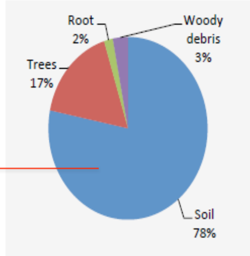
Some studies on Indonesia's mangroves

Mangrove carbon stocks

nature climate change | LETTERS
PUBLISHED ONLINE: 27 JULY 2015 | DOI: 10.1038/NCLIMATE2734

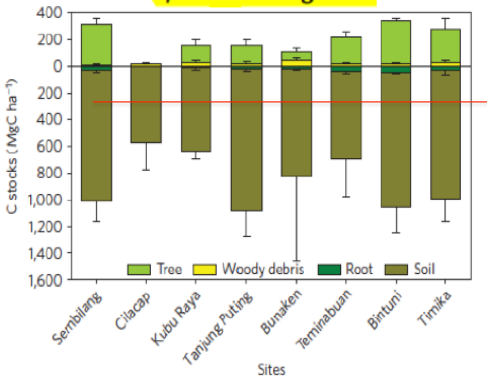
The potential of Indonesian mangrove forests for global climate change mitigation

Daniel Murdiyarso[1,2]*, Joko Purbopuspito[1,3], J. Boone Kauffman[4], Matthew W. Warren[5], Sigit D. Sasmito[1], Daniel C. Donato[6], Solichin Manuri[7], Haruni Krisnawati[8], Sartji Taberima[9] and Sofyan Kurnianto[1,4]



Mangrove C stocks across Indonesian archipelago

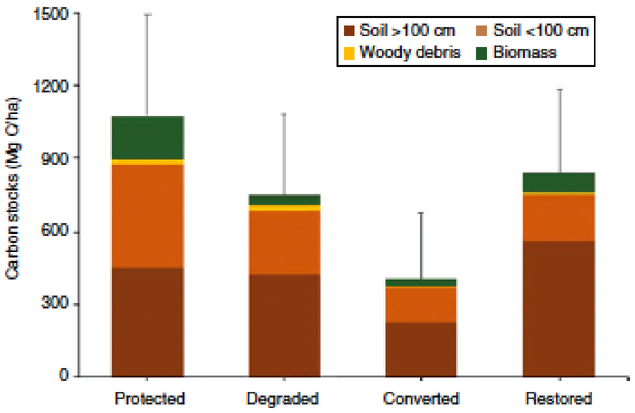
1,083 ± 378 MgC ha⁻¹.

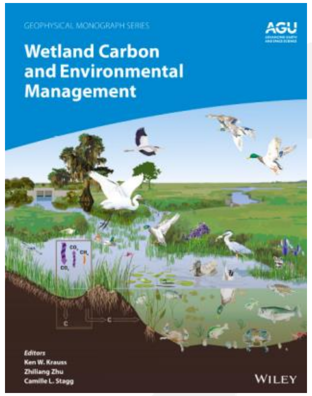


Indonesia mangroves:
High C-stocks - could meet a quarter of a 26% emission reduction target by 2020 by conserving mangroves from deforestation

Optimizing Carbon Stocks and Sedimentation in Indonesian Mangroves under Different Management Regimes

Daniel Murdiyarso[1,2], Virni B. Arifanti[3], Frida Sidik[4], Meriadec Sillanpää[5], and Sigit D. Sasmito[1,6]

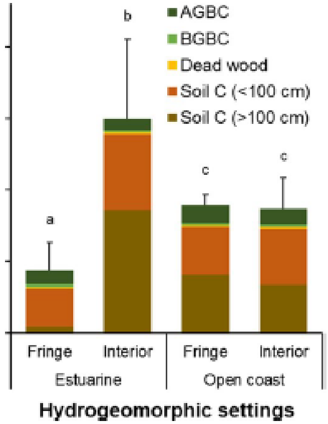


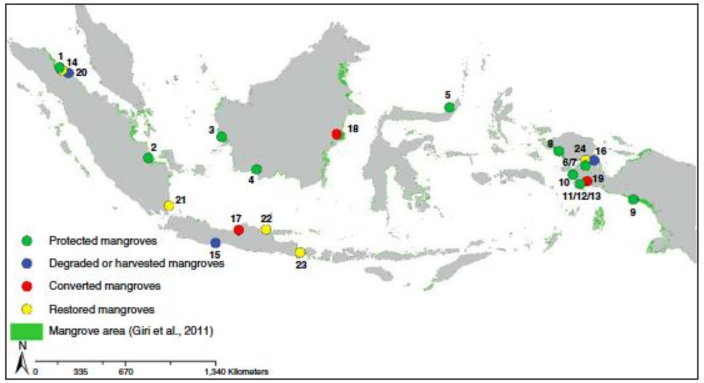


Received: 24 November 2019 | Revised: 20 February 2020 | Accepted: 20 February 2020
DOI: 10.1111/gcb.15056
PRIMARY RESEARCH ARTICLE
Global Change Biology WILEY

Mangrove blue carbon stocks and dynamics are controlled by hydrogeomorphic settings and land-use change

Sigit D. Sasmito[1,2] | Mériadec Sillanpää[3,4] | Matthew A. Hayes[5] | Samsul Bachri[6] | Meli F. Saragi-Sasmito[2] | Frida Sidik[7] | Bayu B. Hanggara[2] | Wolfram Y. Mofu[8] | Victor I. Rumbiak[8] | Hendri[8] | Sartji Taberima[8] | Suhaemi[9] | Julius D. Nugroho[8] | Thomas F. Pattiasina[9] | Nuryani Widagti[7] | Barakalla[10] | Joeni S. Rahajoe[11] | Heru Hartantri[11] | Victor Nikijuluw[10] | Rina N. Jowey[8] | Charlie D. Heatubun[8,12,13] | Philine zu Ermgassen[14] | Thomas A. Worthington[15] | Jennifer Howard[16] | Catherine E. Lovelock[17] | Daniel A. Friess[3] | Lindsay B. Hutley[1] | Daniel Murdiyarso[2,18]





Mangrove carbon sequestration

JOURNAL OF THE INDIAN OCEAN REGION
https://doi.org/10.1080/19480881.2019.1605659

Routledge
Taylor & Francis Group

Check for updates

Carbon sequestration and fluxes of restored mangroves in abandoned aquaculture ponds

Frida Sidik[a,b], Maria Fernanda Adame[c] and Catherine E. Lovelock[b]

Tidal re-instatement facilitates natural regeneration

10 years – restoration

Components of carbon cycle have restored

	Natural ($Mg\ C\ ha^{-1}\ yr^{-1}$)	**Restored ($Mg\ C\ ha^{-1}\ yr^{-1}$)**
AB biomass + leaf litter	16.6	16.2
Soil	2.2	1.5

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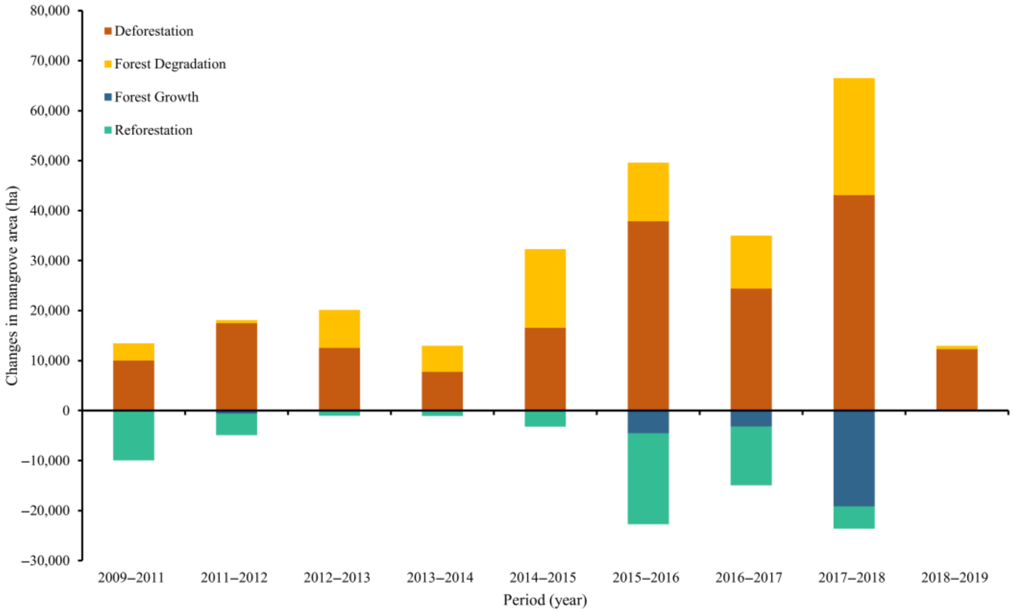
PAPER • OPEN ACCESS

Mangrove deforestation and CO_2 emissions in Indonesia

V B Arifanti[1], N Novita[2], Subarno[2] and A Tosiani[3]

Published under licence by IOP Publishing Ltd
IOP Conference Series: Earth and Environmental Science, Volume 874, International Conference of Indonesia Forestry Researchers VI 2021 - Stream 3: Enhancing Resilience Capacity of Disaster and Climate Change 7-8 September 2021, Jakarta, Indonesia



- Deforestation exceeds reforestation
- Mangrove gross deforestation rate in Indonesia is estimated at 18,209 ha yr^{-1} (Arifanti et al., 2021)
- Mangrove net emission rate is 28 Tg CO_2e r^{-1} (Arifanti et al., 2022)

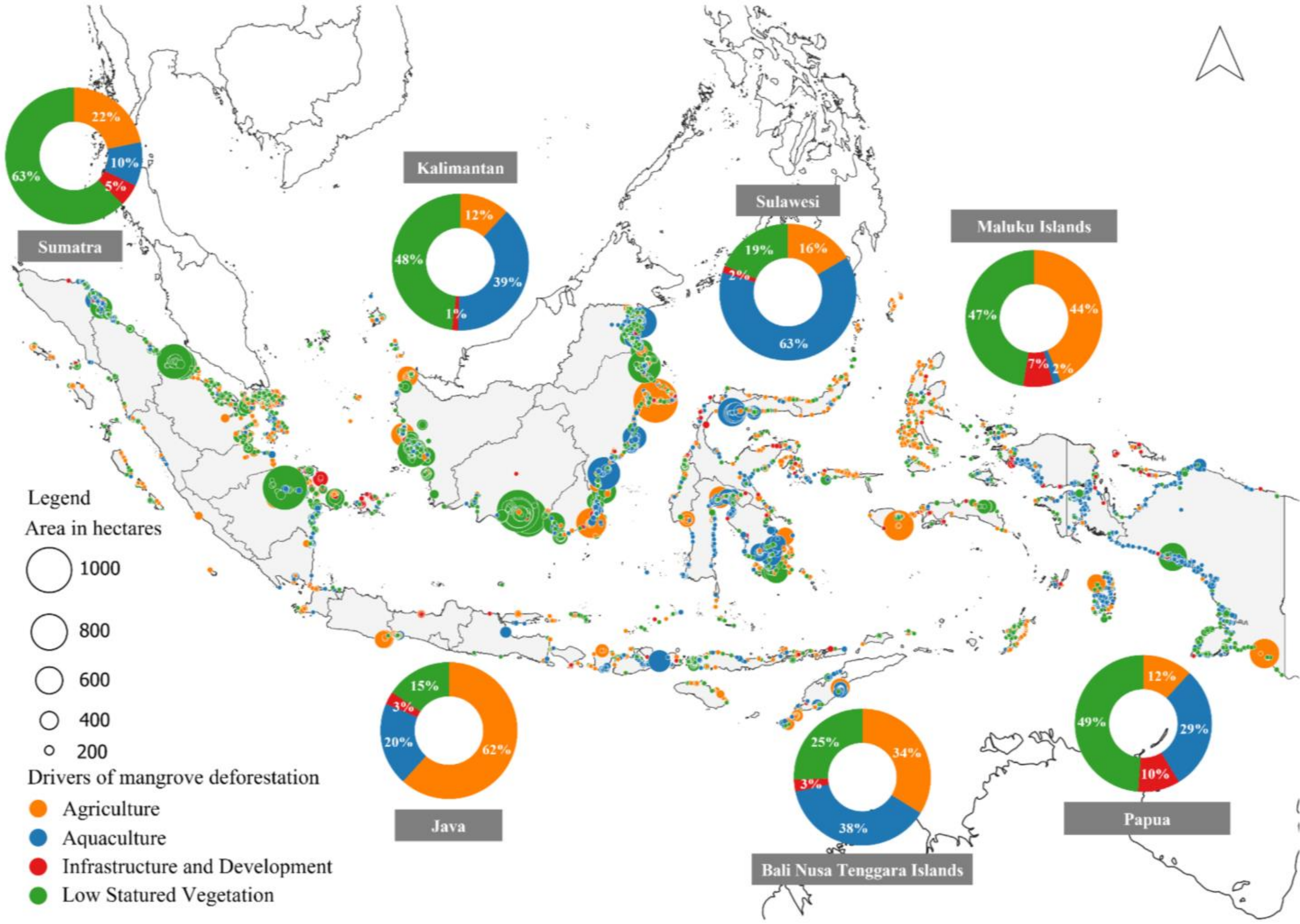
Global Change Biology

RESEARCH ARTICLE | Open Access

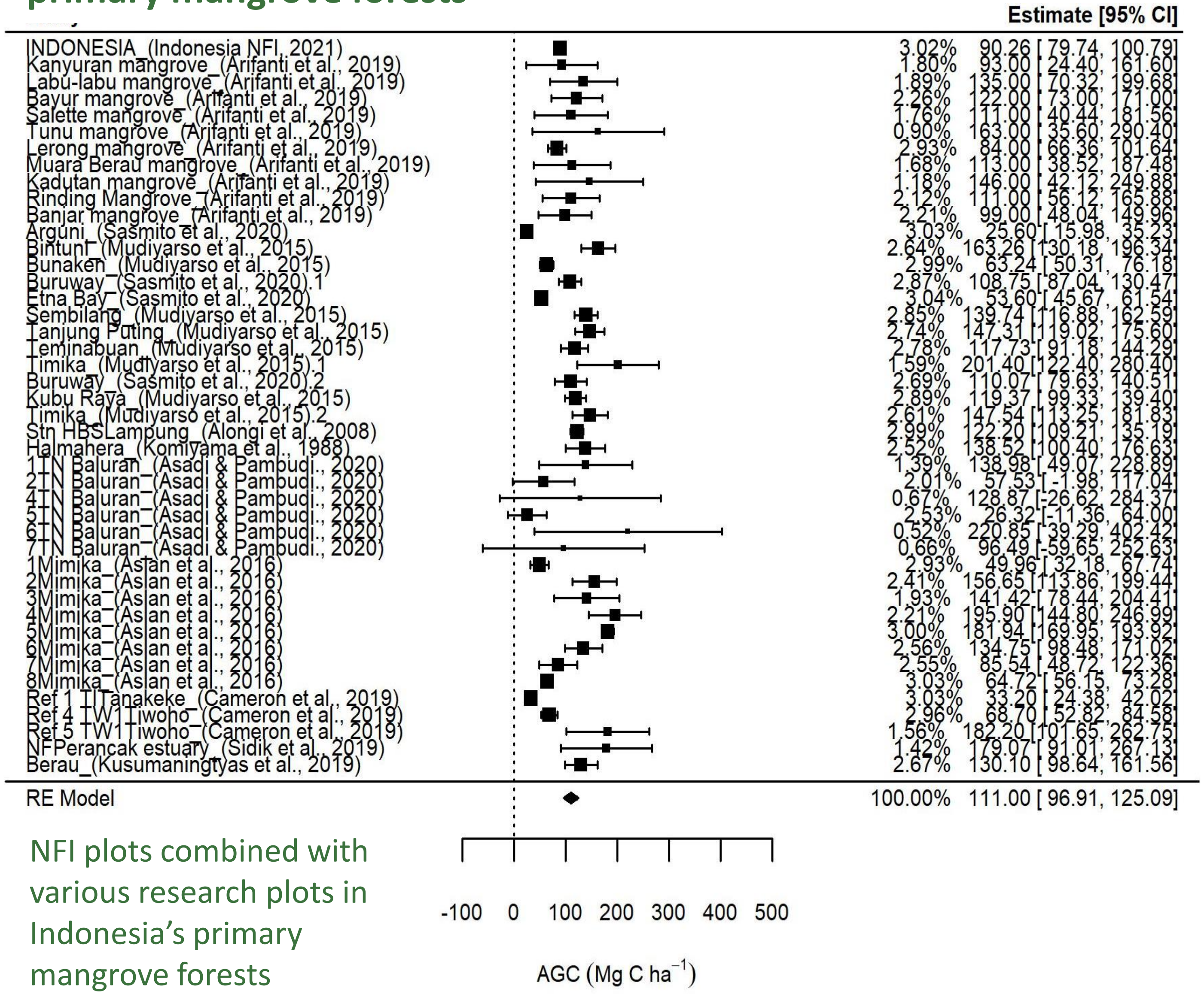
Contributions of mangrove conservation and restoration to climate change mitigation in Indonesia

Virni Budi Arifanti, John Boone Kauffman, Subarno, Muhammad Ilman, Anna Tosiani, Nisa Novita

First published: 25 April 2022 | https://doi.org/10.1111/gcb.16216

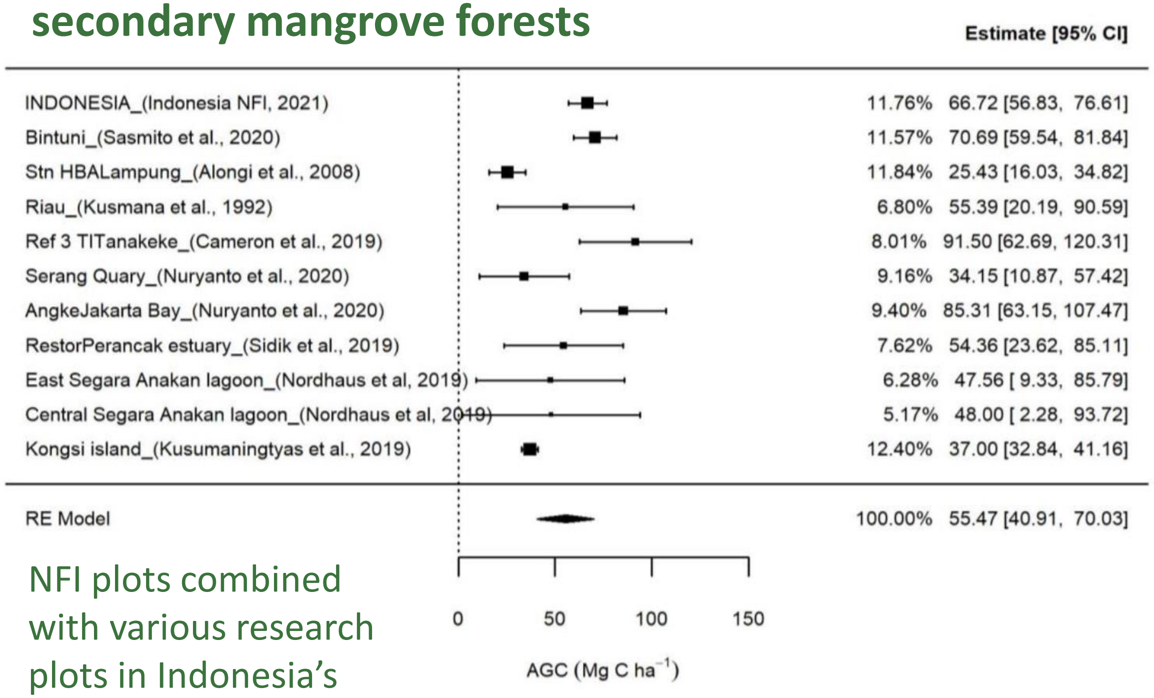


Studies on AGC in Indonesia's primary mangrove forests



NFI plots combined with various research plots in Indonesia's primary mangrove forests

Studies on AGC in Indonesia's secondary mangrove forests

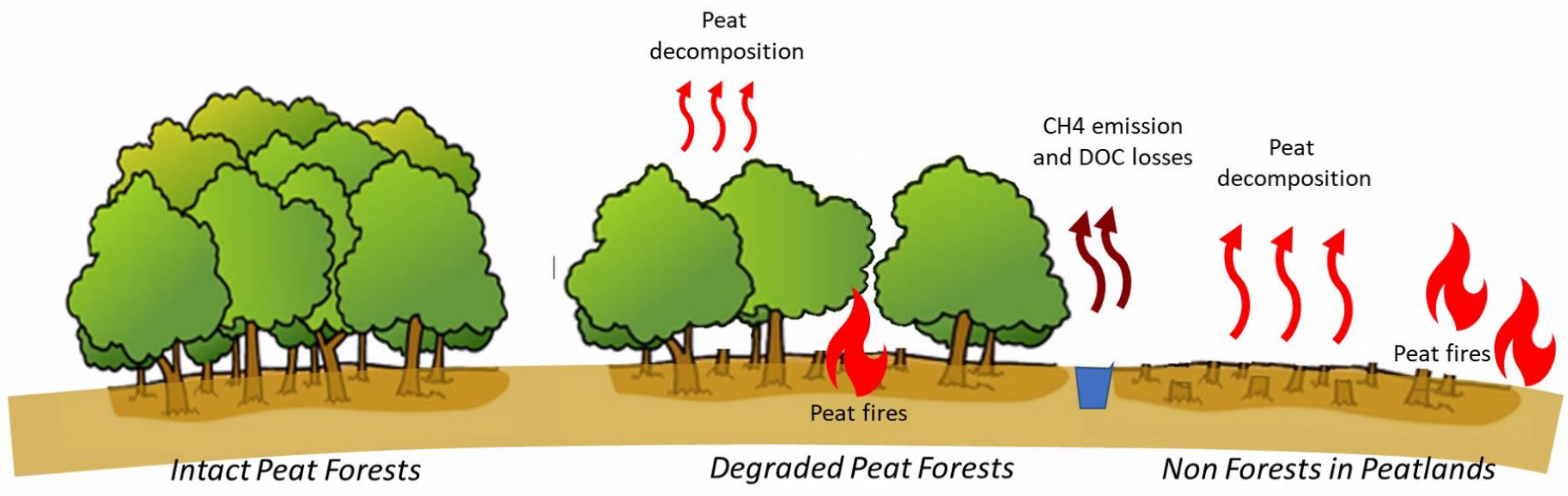


NFI plots combined with various research plots in Indonesia's secondary mangrove forests

Studies in Indonesia's tropical peatlands

Scope

- **Carbon Stocks**
- **Emissions from Organic Soils on Degraded Peatlands**
  - Peat Decomposition
  - Peat Fires



Improving emission estimates from tropical peatland fires

Accounting for all carbon pools

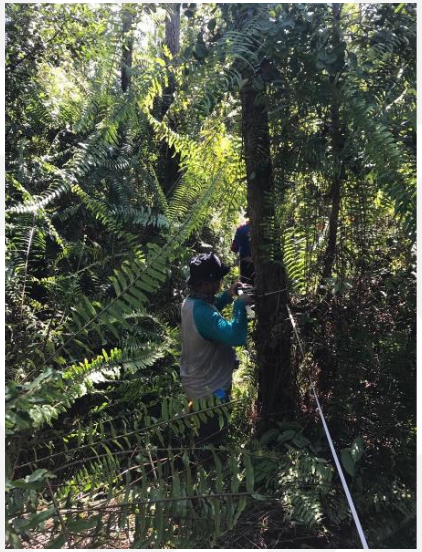
Live aboveground biomass
(trees, shrubs, grasses)

Dead organic matter
(litter, coarse woody debris)

Peat (depth, bulk density, C content)

Pyrogenic carbon

Measuring trees in secondary peat swamp forest

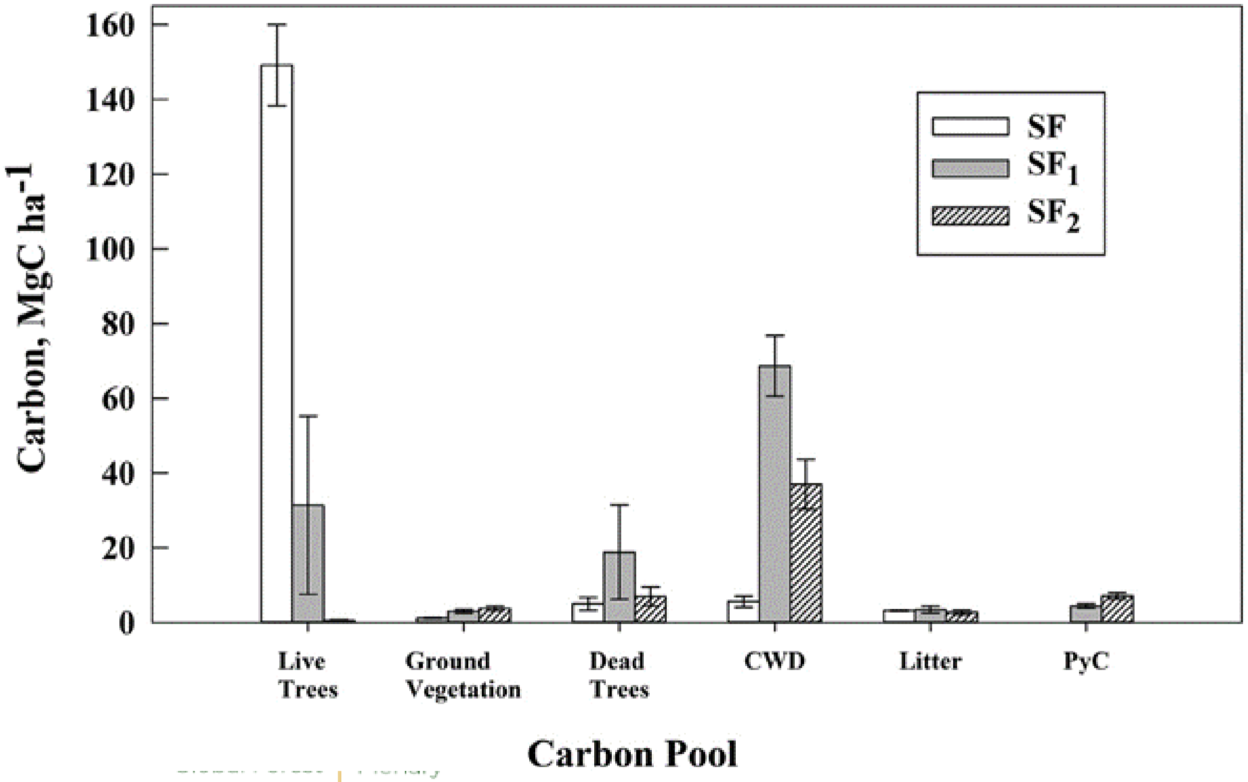


Measuring peat depth

Assessing PyC

Impact of fire frequency on AGC

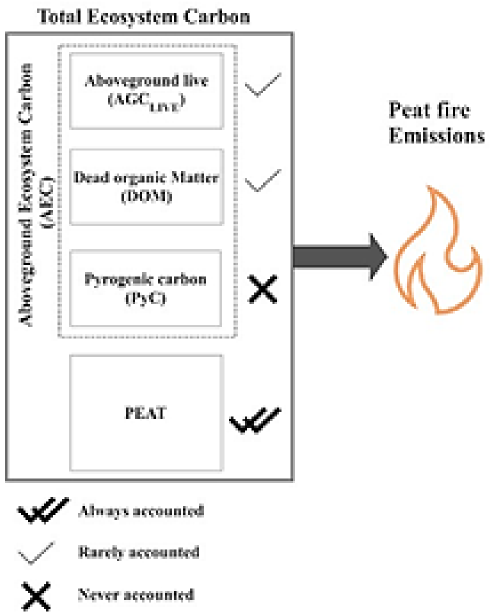
A comprehensive assessment of the above-ground and peat carbon pools as they are affected by recurring fires

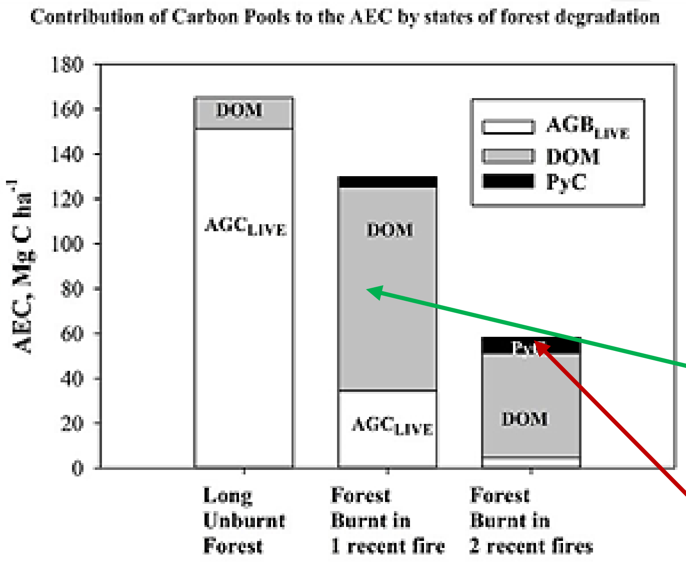


- There has been aa high uncertainty in the estimates of peat fire emissions, especially where peat swamp forest are burnt in more than one fire.
- Our study shows that after one recent fire about 90 Mg C ha^{-1} remains aboveground as the deadwood carbon pool.
- Following a 2nd consecutive fire, about a half of the deadwood is retained, mainly as CWD, or converted to pyrogenic carbon.

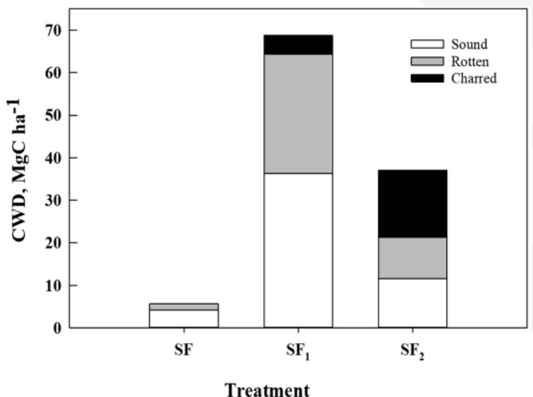
Source: Volkova, Krisnawati, Adinugroho et al. (2021)

Improved knowledge on peat fires emissions estimates





Carbon pool	Treatment		
	SF	SF_1	SF_2
AGC_{LIVE}	92 (150.4)	26 (34.4)	8 (4.5)
Live trees	91	24	1
Ground cover	1	2	7
Deadwood	6 (10.7)	68 (87.6)	75 (44.1)
Dead trees	3	15	12
CWD	3	53	63
Litter	2 (3.2)	3 (3.4)	5 (2.8)
PyC	0	3 (4.5)	12 (7.1)
AGC_{TOTAL}	100 (164.3)	100 (129.9)	100 (58.5)



- Contribution of deadwood to peatfire emissions is not properly accounted.
- Deadwood accounts for 50–60% of aboveground carbon in recently burnt peat forests
- PyC accounts for 12% of aboveground carbon in repeatedly burnt peat forests

Source: Volkova, Krisnawati, Adinugroho et al. (2021)

New Combustion Factors for Peat swamp forests

Current assumption: complete combustion of peat (CF = 1) is an oversimplification

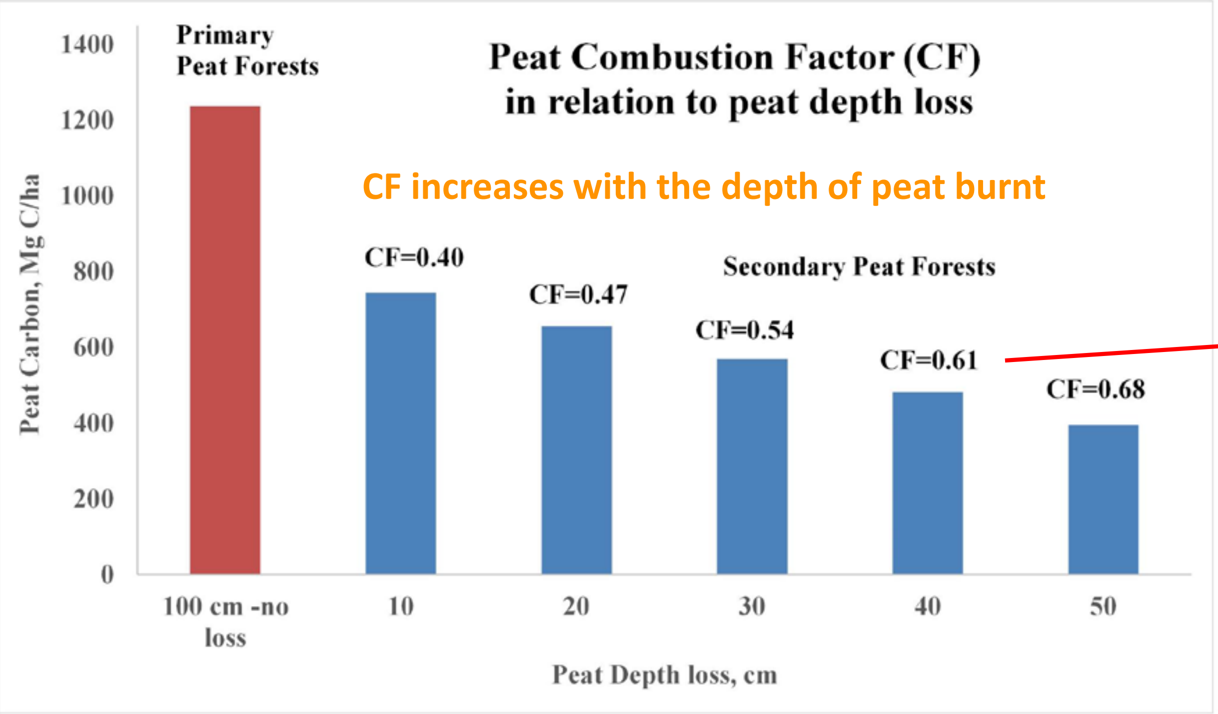


Table 5
Combustion factors for aboveground and peat biomass.

Combustion factor	This study	IPCC default
CF_{AGC}[a]	0.564	0.50
$CF_{PEAT-10cm}$	0.399	1.0
$CF_{PEAT-20cm}$	0.469	1.0
$CF_{PEAT-30cm}$	0.540	1.0
$CF_{PEAT-40cm}$	0.610	1.0
$CF_{PEAT-50cm}$	0.681	1.0

Table 6
Estimated CO_2 emissions (Mg CO_2-e) from 1 ha of peat burnt down to 10 cm and 30 cm depth using the IPCC default and study derived CF_{PEAT}.

Peat depth burnt	Estimated CO_2 emissions using the IPCC default CF	Estimated CO_2 emissions using study derived CF_{PEAT}	Emission reduction per hector of peat burnt
10 cm	262	104	2.51
30 cm	1275	688	1.85

Source: Krisnawati et al. (2021)

Parameter to estimate peat fire emission

Parameter	Mean (SE)	Unit	Source
Cf (combustion factor)	0.54 (0.05)	-	Krisnawati et al. 2021;
Gef CO_2 (CO_2 emission factor)	1670.13 (34.03)	g kg^{-1} CO	Stockwell *et al.*2016; Stockwell *et al.*2015; Stockwell *et al.* 2014; Christian *et al.* (2003); Huijnen *et al.*2016; Setyawaty *et al.*2017; Wooster *et al.*2018; Nara *et al.*2017
Gef CH_4 (CH_4 emission factor)	177,87 (24,36)	g kg^{-1} CO_{2eq}	Stockwell *et al.*2016; Stockwell *et al.*2015; Stockwell *et al.* 2014; Christian *et al.* (2003); Huijnen *et al.*2016; Setyawaty *et al.*2017; Wooster *et al.*2018; Nara *et al.*2017
BD (bulk density)	0.16 (0.015)	g cm^{-3}	Konecny et al. 2016; Warren *et al.* 2012, Agus *et al.* 2011; Lampela *et al.*2014; Kononen *et al.* 2015; Shimada *et al.*2001
Db (Burn depth)	31.88 (4.68)	cm	Stockwell *et al.*2016; Ballhorn *et al.*2009; Konecny *et al.* 2016; Usup *et al.*2004; Page *et al.*2002; Saharjo 2007; Simpson *et al.*2016; Saharjo and Munoz 2005

Thank you.

Haruni Krisnawati