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# Functions, goods and services of mangroves and their sustainable management.

Farid Dahdouh-Guebas

Université Libre de Bruxelles – ULB

**TROPIMUNDO.eu**  
ERASMUS MUNDUS JOINT MASTER DEGREE IN  
TROPICAL BIODIVERSITY AND ECOSYSTEMS



Ecologie des Systèmes et  
Gestion des Ressources

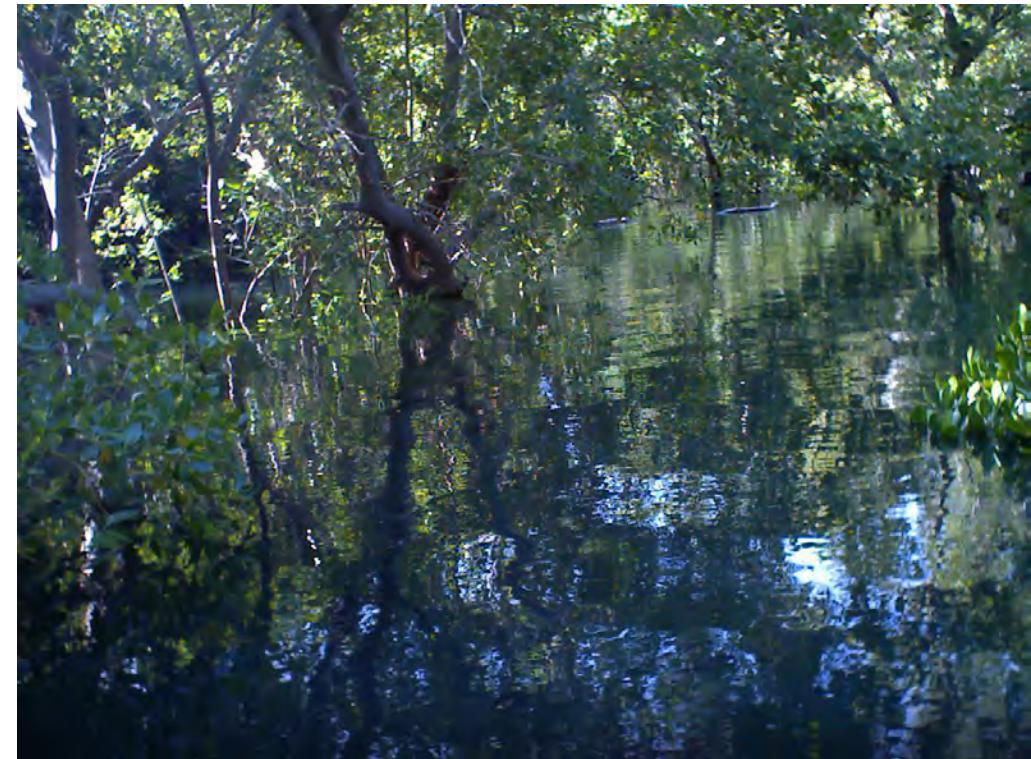


Systems Ecology and  
Resource Management

*Once upon a time...  
in an enchanting forest far far away...*



*Once upon a time...  
in an enchanting forest far far away...*

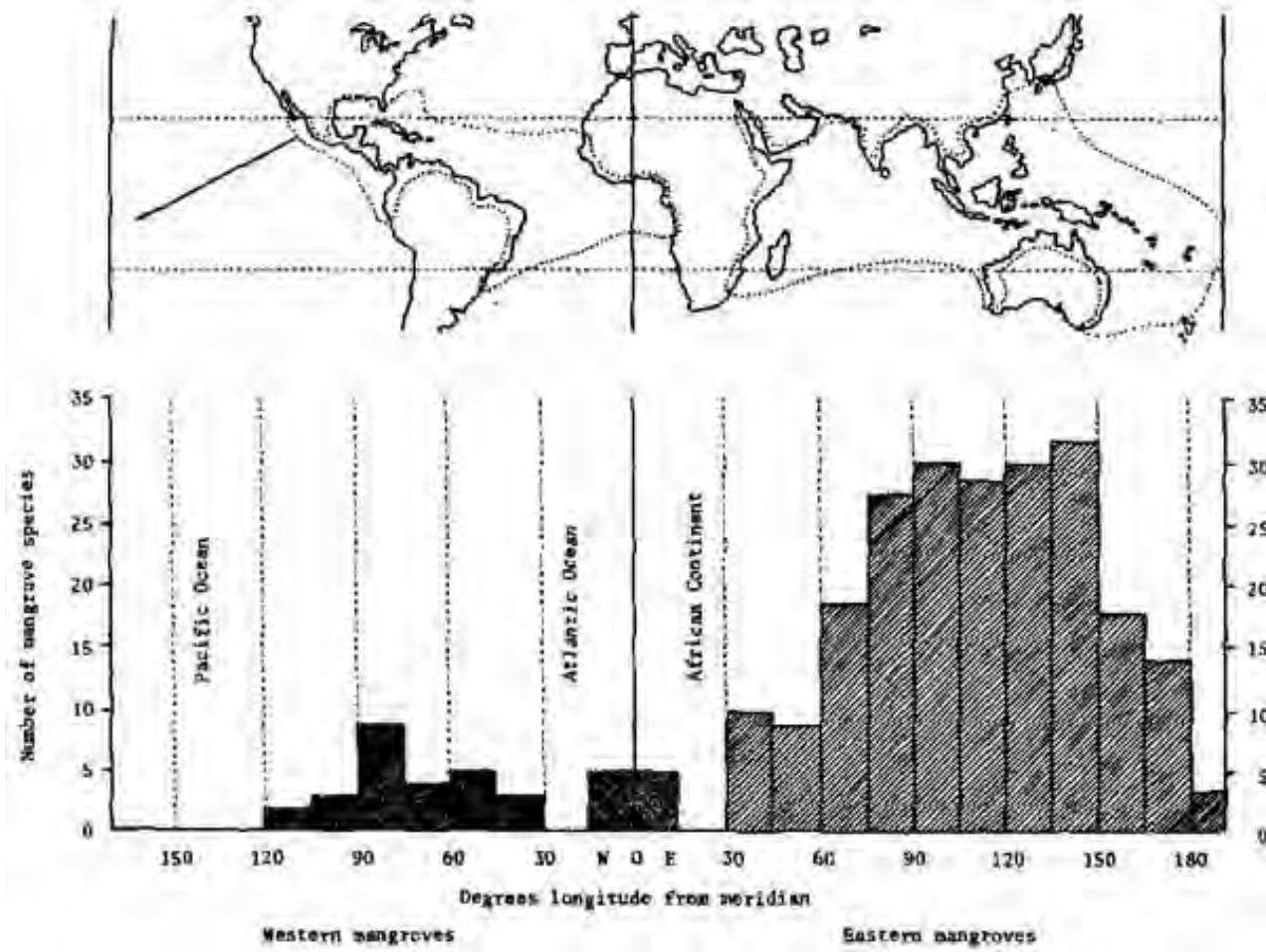


*Farid Dahdouh-Guebas*



*Er was eens...  
een betoverend zeewoud...  
in een land hier ver vandaan...*

*Er was eens...  
een betoverend zeewoud...  
in een land hier ver vandaan...*



**Botanic Garden  
Meise**



*Il était une fois...  
une forêt enchantée dans la mer...  
dans 126 pays autour du monde...*

# Il était une fois... Θεόφραστος (ca. °371 †287 BC)



# mangrove

# coastal protection

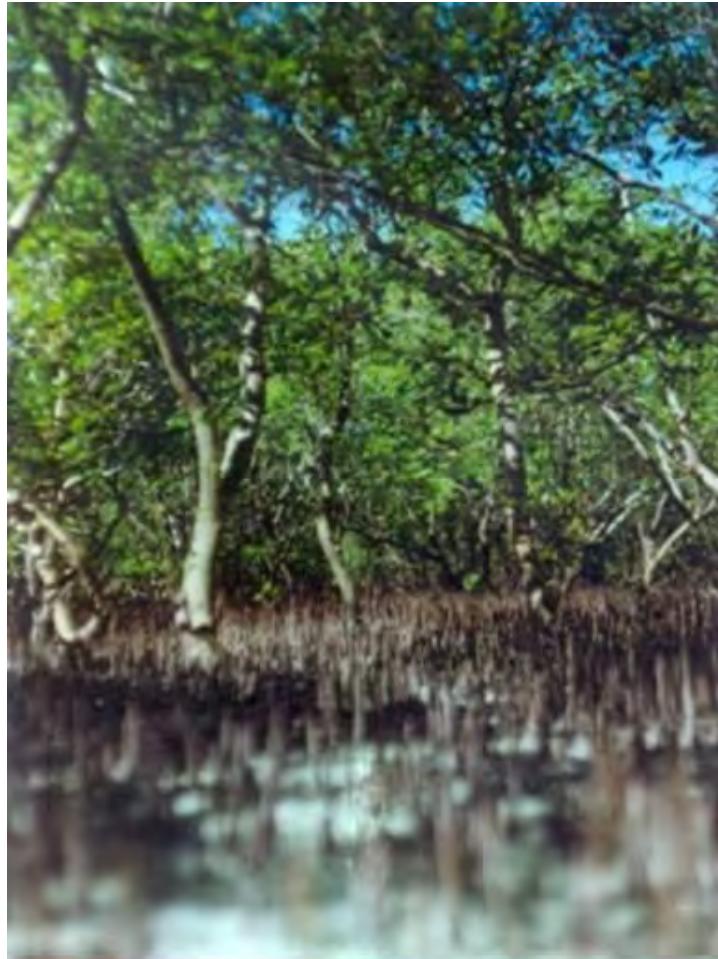
# salt tolerance

Archives of the Dutch East-India Company (Vereenigde Oost-indische Compagnie—VOC) and the Dutch West-India Company (West-Indische Compagnie—WIC), contains thousands of plans, maps, views, panoramas, scenes of everyday life, and many more descriptions that can be used as a source of information (e.g. Aldaeus, 1672). Historic expertise is needed to soundly interpret ancient descriptions, or scribbled notions in the margins of 17th century maps (Fig. 2). Sometimes sets of words such as 'till here reaches the sea water and all land is silty' (*tot dusverre komt het zeeewater en is alles brak en siltagtig land*), 'drowned land' (*verdroncken landt*) and 'bending rhizophorous belts' (*Deze tweede rhizophorengordel vormt bogten en inhammen en wordt door talrijke smalle straten doorsneden, die veelal de beddingen zijn van op het land ontspringende kreken*, Von Rosenberg, 1867) are unambiguous indications of the presence of a mangrove ecosystem. Probably the oldest known unambiguous references to mangroves going on for several paragraphs read amongst others: *In Persia in the Parmanian district, where the tide is felt, there are trees [Rhizophora mucronata]...[that] are all eaten away up to the middle by the sea and are held up by their roots, so that they look like a cuttle-fish* Theophrastus, 370–285 B.C.E.), as cited by A.M. Ellison (2008) in the preface of Aquatic Botany's Special Issue on Mangrove Ecology (Dahdouh-Guebas and Koedam, 2008). Other clues given by Theophrastus (370–285 B.C.) are: *In the island of Tylos, which is situated in the Arabian gulf, they say that on the east side there is such a number of trees when the tide goes out that they make a regular fence on the coastal protection function of mangroves* (Enquiry into Plants Book IV. VII. 7), and *As for the tall fruit-bearing trees found in tidal waters, one would perhaps not assign their feeding to the sea water, but say that it is possible that the roots draw potable water from the ground, and that the sea water surrounding the tree does it no more injury than the surface waters surrounding freshwater plants on the salt tolerance of mangroves* (De Causis Plantarum Book II. 5.2 1–9).

Dahdouh-Guebas & Koedam (2008), *Aquatic Botany*

# اپنے عالم میں (ca. 980 †1037)

Avicennia = Avicenna = Abu Ali Sina



## Father of modern medicine

Father of the concept of momentum,  
founder of Avicennism and Avicennian logic,  
forerunner of psychoanalysis,  
pioneer of aromatherapy and neuropsychiatry,  
and important contributor to geology. (Ref. Encyclopedia Wikipedia)

### Famous Books

1. The Canon of Medicine "القانون"

2. The Book of Healing "الشفاء"

چھ سو برس تک یورپ میں طب کی تعلیم اہن سینا  
کی انہی کتابوں کے ترجموں سے دی جاتی رہی

: جنل، اش میں جڑی ہونے کے سات اور اصلی تینوں کا استعمال۔ Aromatherapy

: انسانی نیکیت (پاکھوس، ماغ) اور انسانی روپیے کے ہامی تحقیق کا معاشر۔ Neuropsychology

: طویلیات۔ اسی حرکت جسمی کی حرکت اس کی مقدار اس کی نیکیت اور رفتار کے مابین  
شرب کے طور پر معورہ یا مقتدر اور اگر... حرکت سے ماحصل ہوتے ہو جائندے تو اسی تحرک کے معاشر۔ Momentum

: تحلیل نئی ہو، ماقبلی مواد کا ایک طریقہ مانا جس میں ماغ کے شوری میرے  
عمل اور رہنمائی کی دریافت سے ہے جو خوف، تسلیمات و خیر و کوہاگر کی شوری  
کلیہ انسانی کوشش کی ہاتھی ہے۔ Psychoanalysis



( born c. 980 near Bukhara, contemporary Uzbekistan, died 1037 in Hamedan in modern Iran )

# Il était une fois... Frans Post (°1612 †1680)

- First mangrove painted unambiguously in 1637 on Itamaracá Island (BR)



Frans Hals

Original Articles

## Mangroves – Captured By The Keen Eye Of A 17th Century Landscape Painter

Nico Koedam, Farid Dahdouh-Guebas, Roberto Lima Barcellos & Tom Van der Stocken  
Pages 247-263 | Published online: 02 Dec 2016

Download citation <http://dx.doi.org/10.1080/03096564.2016.1246166>

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### Abstract

Artists and scientists alike came across unfamiliar landscapes and strikingly strange fauna and flora when they embarked for the 'colonies'. In the 17<sup>th</sup> and 18<sup>th</sup> centuries curiosity for the exotic developed into direct scientific observation, which is often still appreciated scientifically today, such as in biological taxonomy. Often observation, interpretation and reporting were geared towards functional aspects, a resourcerist view on the environment in the wake of the colonial enterprise. This entailed that focus could be biased towards aspects of mercantile, political or strategic interest. Landscape vision is no exception for the possible biases. The Dutch painter Frans Post during his 7 year stay in the New World (Brazil) in the 17<sup>th</sup> century was the first to depict mangroves as a very characteristic tropical vegetation, unfamiliar to Europeans, in spite of its limited interest in the context of colonial economy. He did this in the strong and developing tradition of Dutch landscape painting.

Koedam *et al.* (2017), *Dutch Crossings*

# Er was eens... Johannes Van Keulen

= (°1654 †1715)



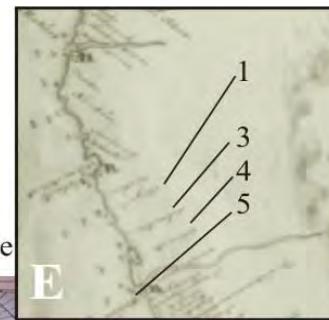
geographicus.com



*"end of the cinnamon land, which  
does not grow east of this ligne"*



1. Tangale
2. Rekkawa
3. Tilawadewe/Kahandare
4. Kallemette/Kaloemette
5. Walleuwe/Wallewe/Waluwe



# Er was eens... Frans Post (°1612 †1680)

MANGROVES — CAPTURED BY THE KEEN EYE OF A 17TH CENTURY LANDSCAPE PAINTER

3



FIGURE 1a Frans Post, *View of Itamaracá island in Brazil*, 1637, oil on canvas, 62 cm × 89 cm (Mauritshuis, The Hague, Accession Number 915).

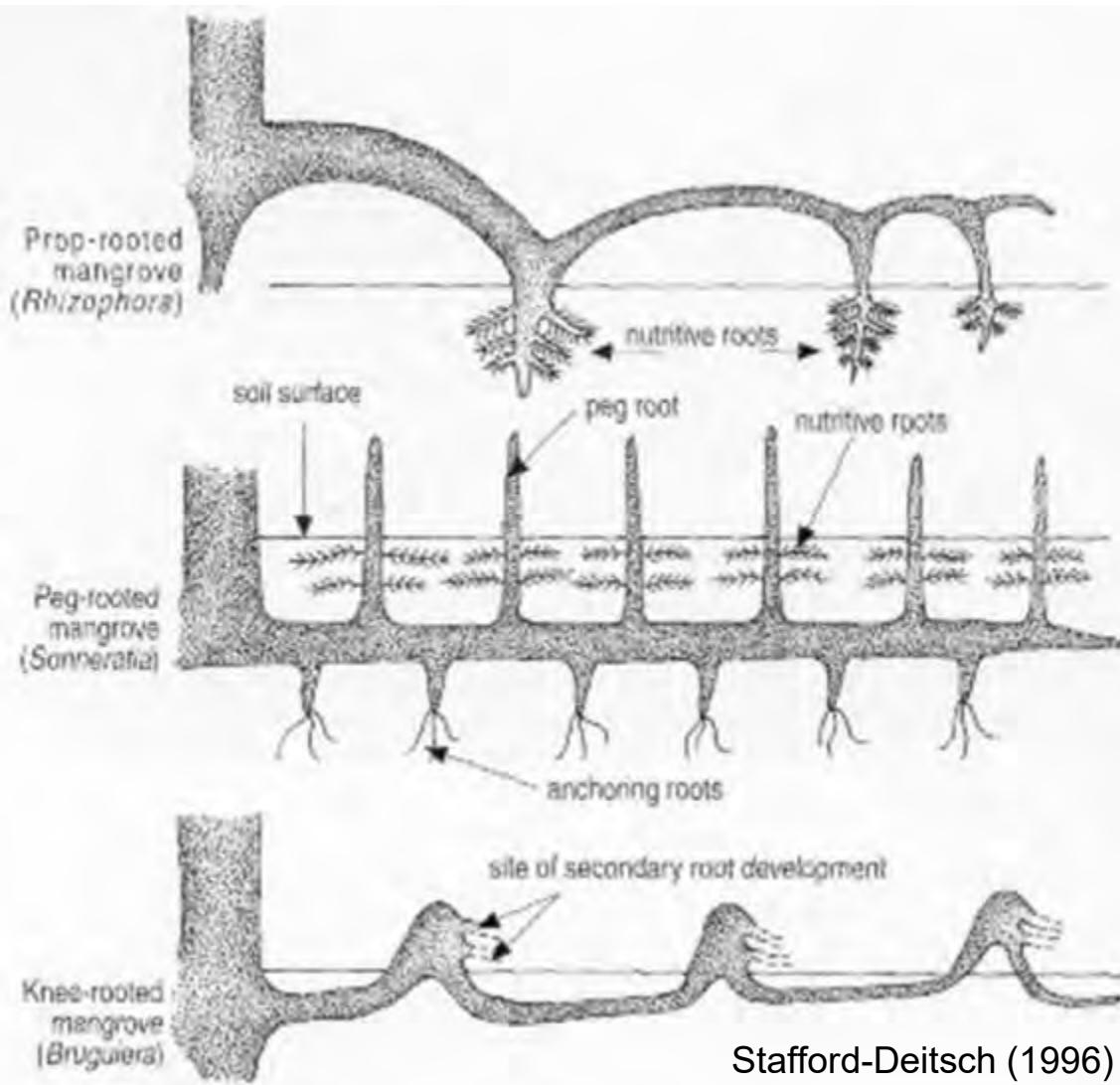
Aerial roots ←



FIGURE 1b Frans Post, detail from *View of Itamaracá island in Brazil*, 1637, showing *Avicennia* sp., with pneumatophores (breathing roots, pencil roots), oil on canvas (Mauritshuis, The Hague, Accession Number 915).



# Morphological adaptations: Aerial roots



- aerating component
- anchoring component
- absorbing component
- cable component

# Morphological adaptations: Aerial roots



lenticel

- aerating component



Photographs by  
Nico Koedam

# Physiological adaptations: (Na-)Sel

- salt balancing
- salt exclusion
- salt secretion
- salt accumulation



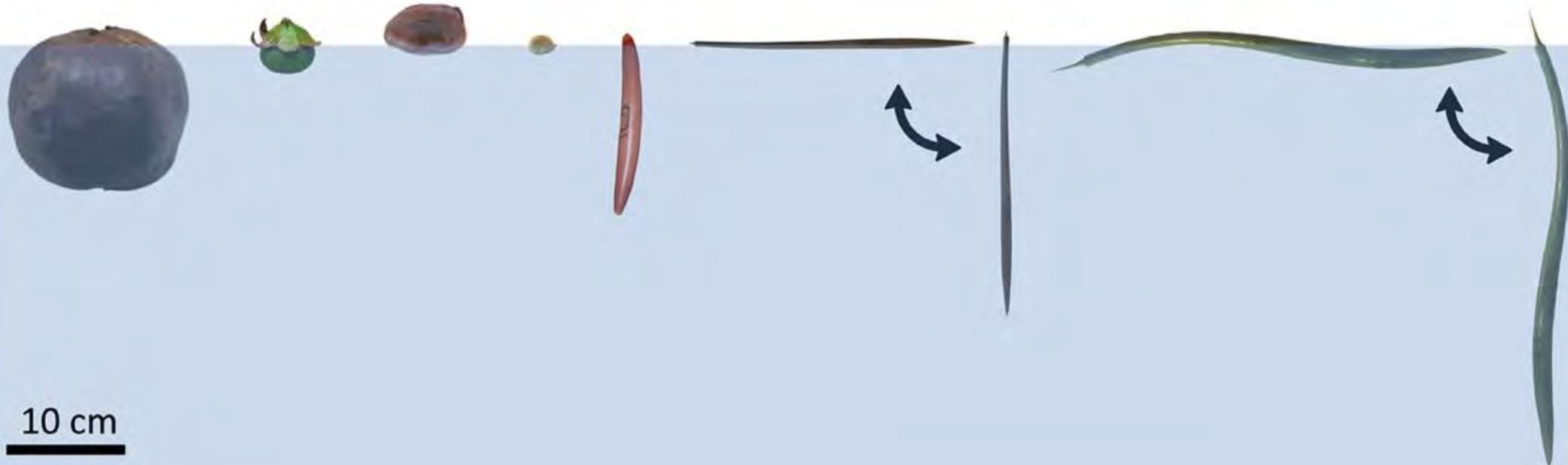
Nico Koedam



Duke (2006)

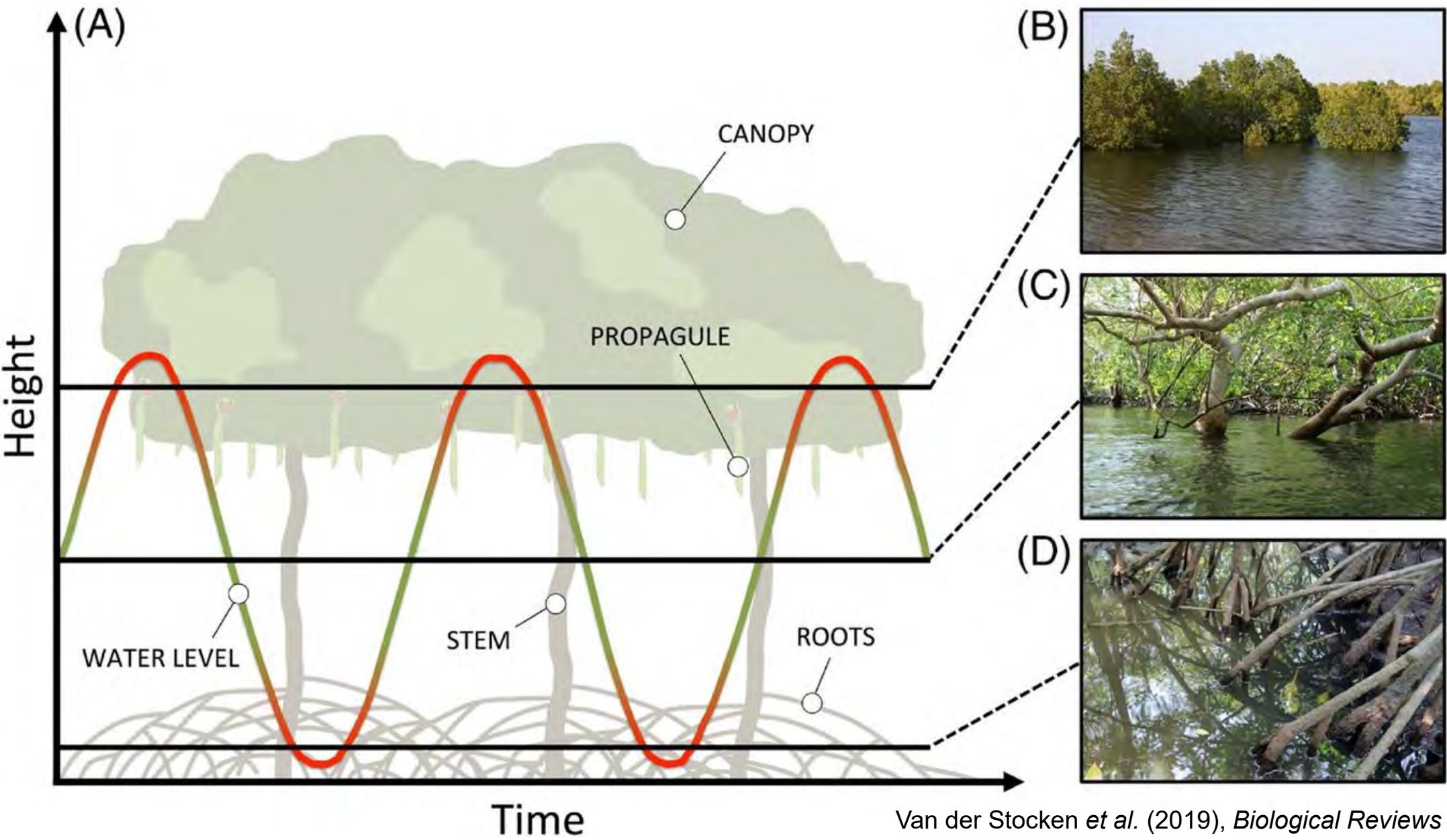


# Morphological adaptations: vivipary



10 cm

# Propagule dispersion (to 126 countries...)

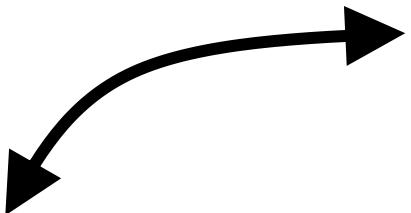


# Mangrove consensus definition

“‘mangroves’ are plants that grow in **tropical, subtropical and warm temperate latitudes** along the **intertidal land–sea interface**, in bays, estuaries, lagoons and backwaters. Most of them are **woody** trees and shrubs, but some are **non-woody** (e.g. *Nypa* palm) or **herbaceous** (e.g. *Acrostichum* and *Acanthus*). These plants **and their associated organisms** constitute the ‘**mangrove forest community**’ or ‘mangal’. The mangal and its associated abiotic factors constitute the ‘**mangrove ecosystem**’.”

# Mangrove fauna : mammals

RAINFORESTS



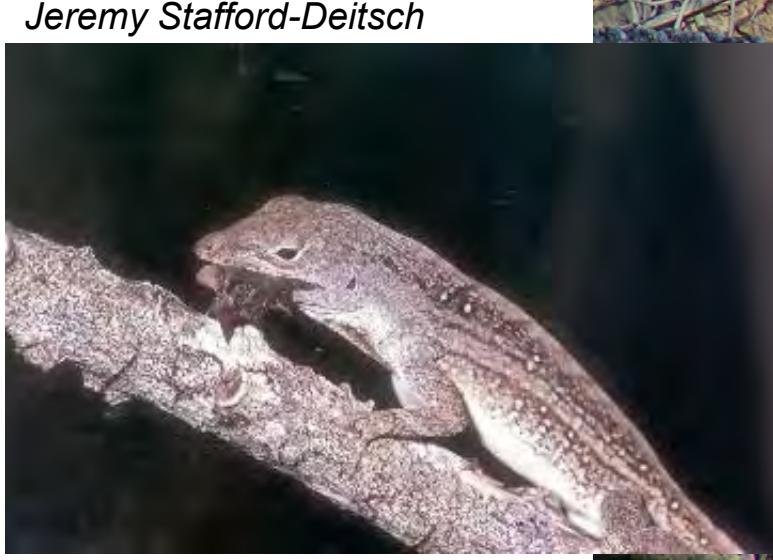
# Mangrove fauna : amphibians and reptiles



*Jeremy Stafford-Deitsch*

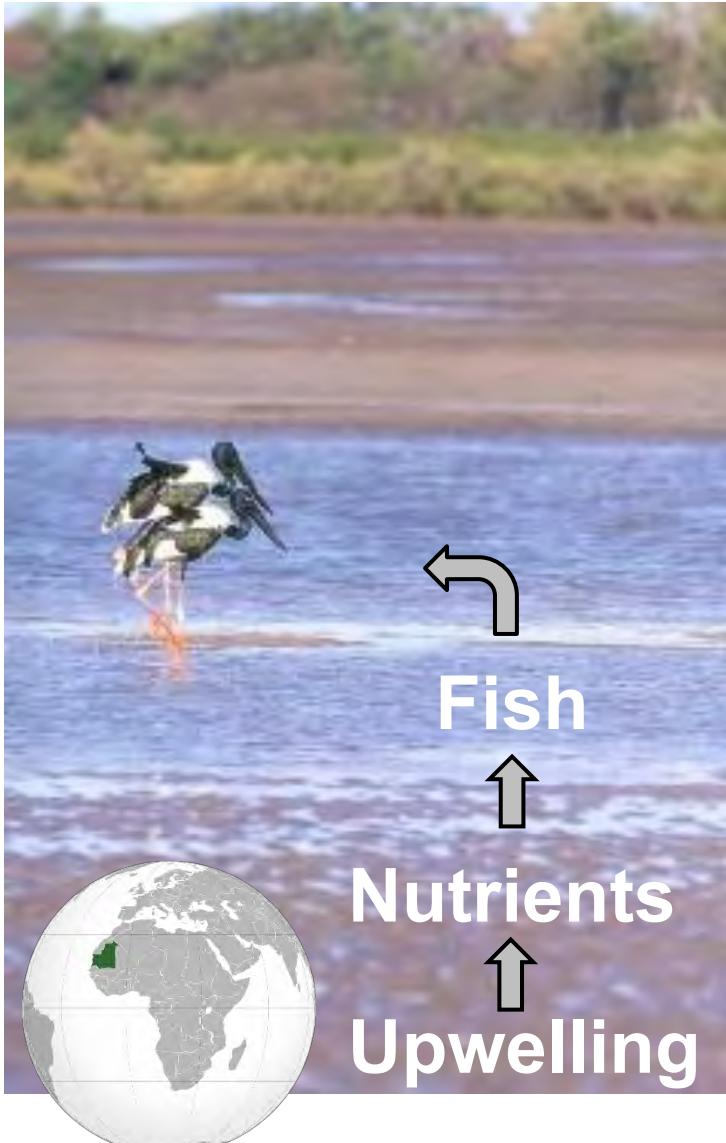


*Farid Dahdouh-Guebas*



# Mangrove fauna : birds

Photographs by Jeremy Stafford-Deitsch



# Il était une fois... Théodore Géricault (°1791 †1824)



Horace Vernet





**SEAGRASS BEDS**

**CORAL REEFS**

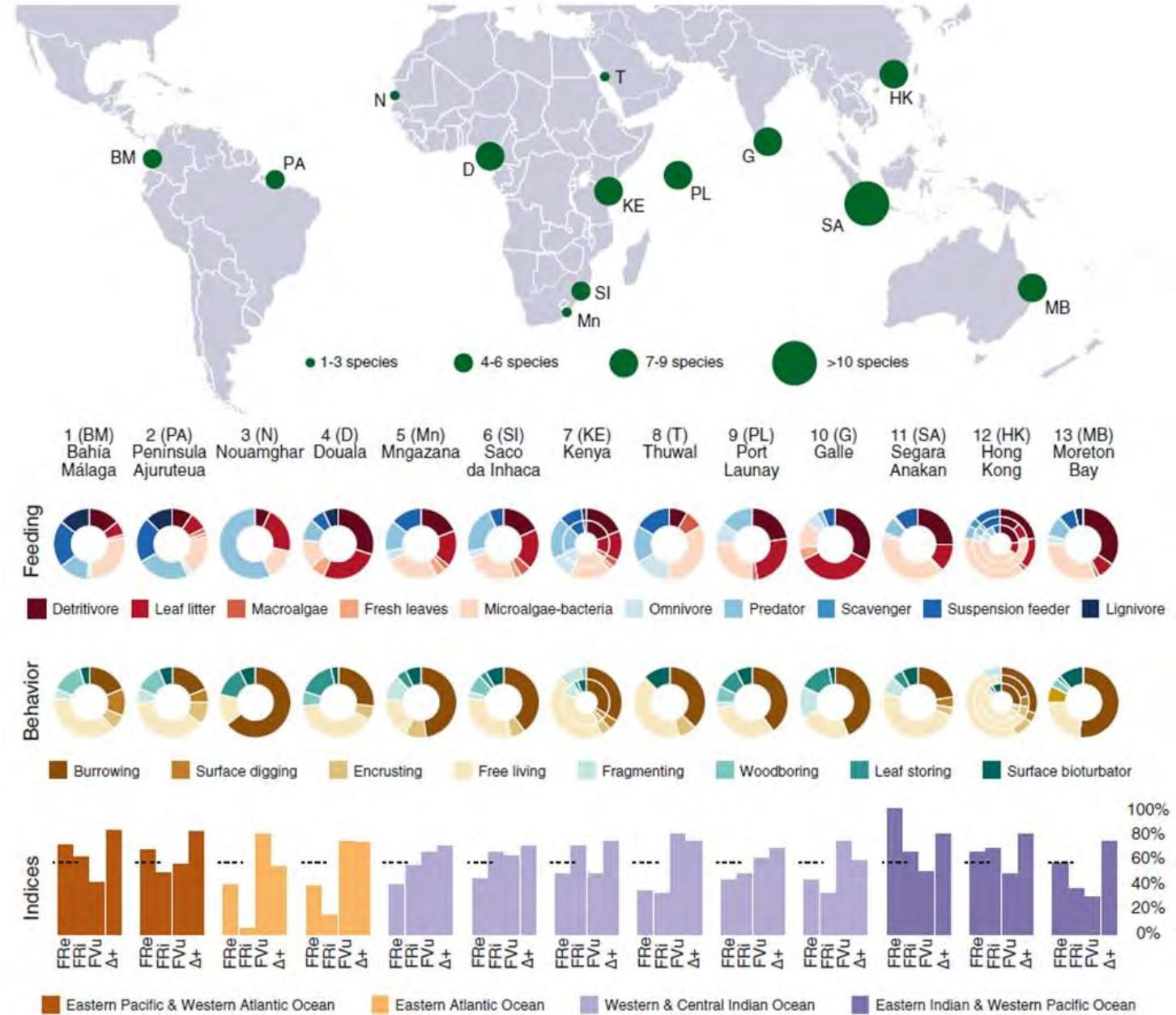
*Photographs by Matthew Potenski*

# Mangrove fauna : crustaceans



Photographs by Stefano Cannicci,  
Marco Vannini, Ricardo Innocenti,  
Jeremy Stafford-Deitsch and Farid  
Dahdouh-Guebas

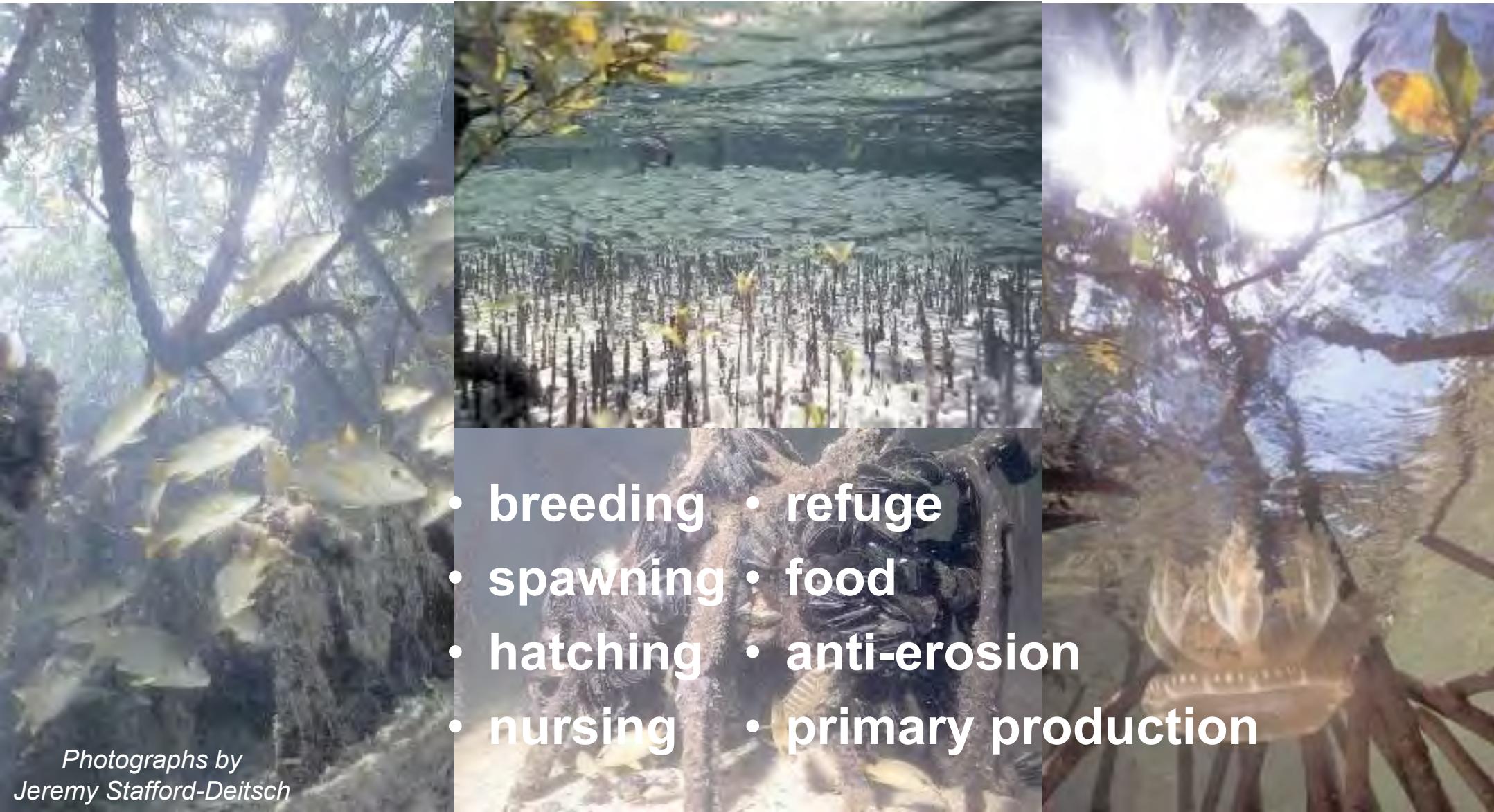
# Mangrove fauna : crustaceans & mollusks



Duke (2006)

Cannicci et al. (2021), PNAS - Proc. Nat. Acad. Sci. of the USA

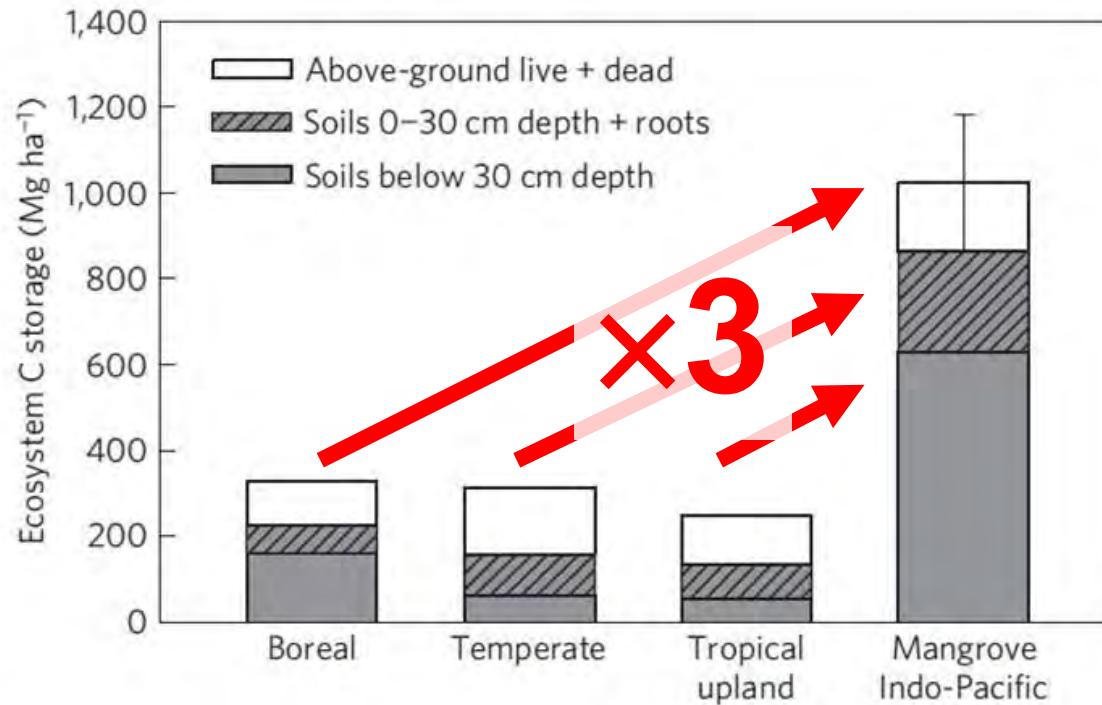
# Mangrove ecosystem processes & functions



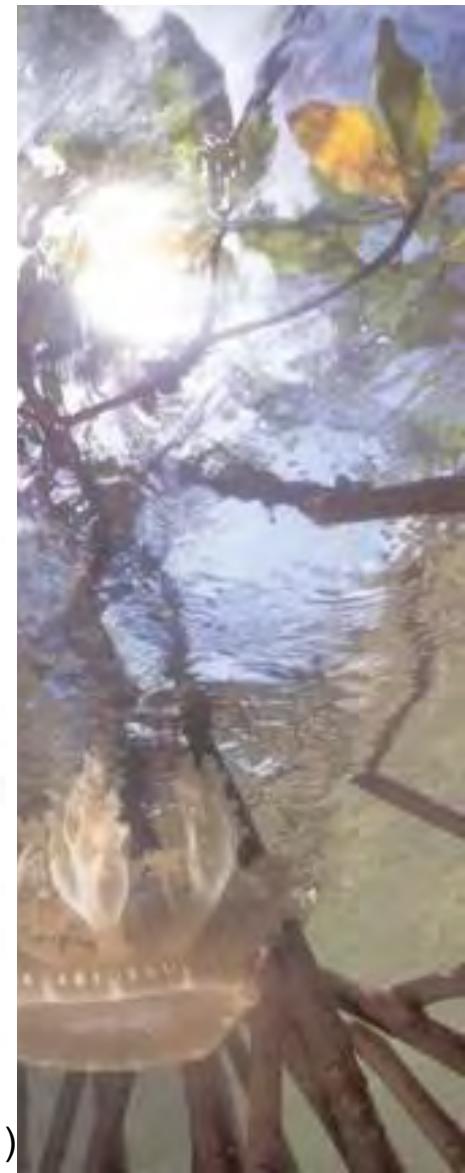
- breeding
- spawning
- hatching
- nursing
- refuge
- food
- anti-erosion
- primary production

Photographs by  
Jeremy Stafford-Deitsch

# Mangrove ecosystem processes & functions



**Figure 2 | Comparison of mangrove C storage (mean  $\pm$ 95% confidence interval) with that of major global forest domains.** Mean C storage by domain was derived from ref. 9, including default values for tree, litter, dead wood, root:shoot ratios, and soils, with the assumption that the top 30 cm of soil contains 50% of all C residing in soil<sup>9</sup>, except for boreal forests (25%). Domain means are presented for context; however some forest types within each contain substantially higher or lower C stores<sup>9,10</sup>. In general, the top 30 cm of soil C are considered the most vulnerable to land-use change<sup>9</sup>; however in suboxic peat/muck soils, drainage, excavation, and oxidation may influence deeper layers<sup>29</sup> Donato et al. (2011)



# Mangrove ecosystem processes & functions

## Essay

### How effective were mangroves as a defence against the recent tsunami?

Whether or not mangroves function as buffers against tsunamis is the subject of in-depth research, the importance of which has been neglected or underestimated before the recent killer tsunami struck. Our preliminary post-tsunami surveys of Sri Lankan mangrove sites with different degrees of degradation indicate that human activity exacerbated the damage inflicted on the coastal zone by the tsunami.

F. Dahdouh-Guebas<sup>1\*</sup>,  
L.P. Jayatissa<sup>3\*</sup>, D. Di Nitto<sup>1</sup>,  
J.O. Bosire<sup>4</sup>, D. Lo Seen<sup>5</sup> and  
N. Koedam<sup>2</sup> (\* = equal contribution)

their large above-ground aerial root systems and standing crop. Like many habitats, mangrove forests have been degraded and destroyed by humans, and their

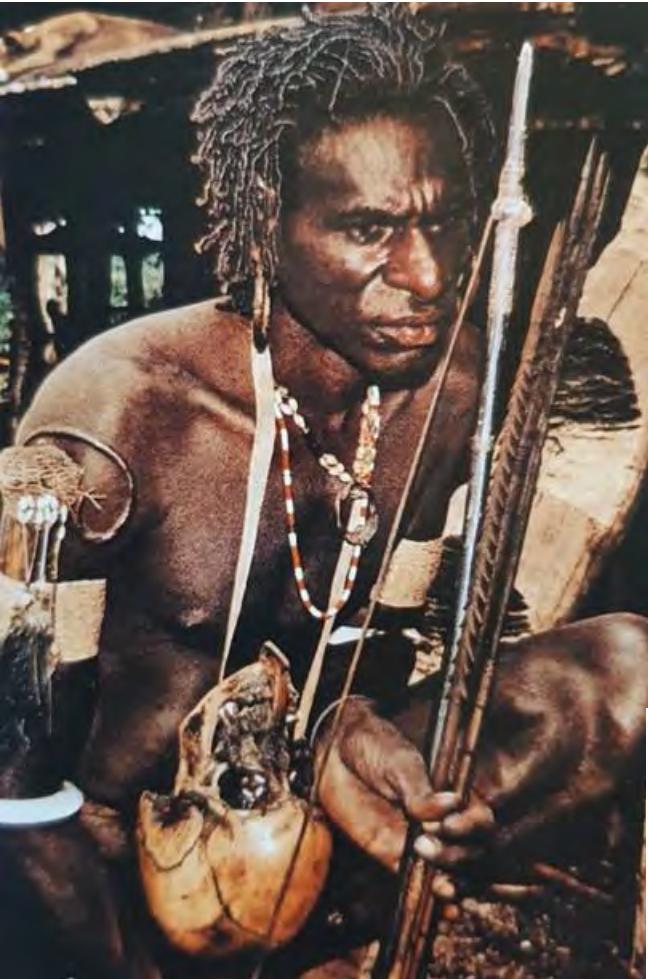


# Mangrove ethnobiology



# Asmat spirituality

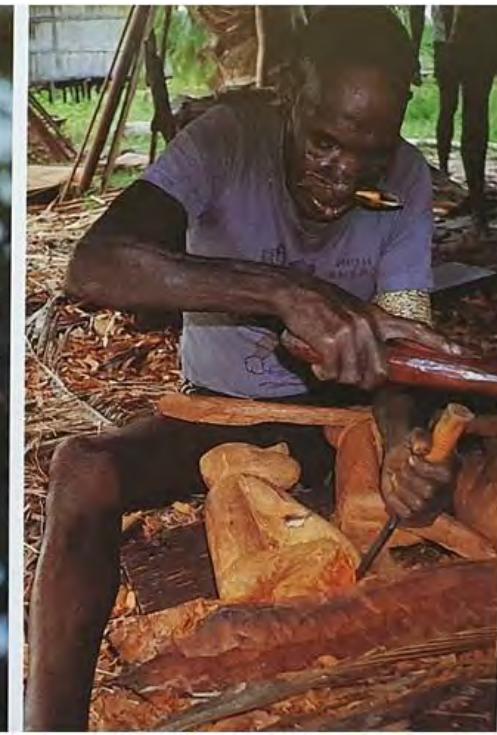
*Fumeripitsj, the Creator, was sitting amidst the swampy jungle. Feeling lonely he carved **human-like figurines** out of a mangrove root. Pleased with his work, but still lonely, **he cut down a mangrove tree and made a drum**. While drumming the figurines came to life and began to dance. They were the first Asmat people (Mastaller, 1997).*



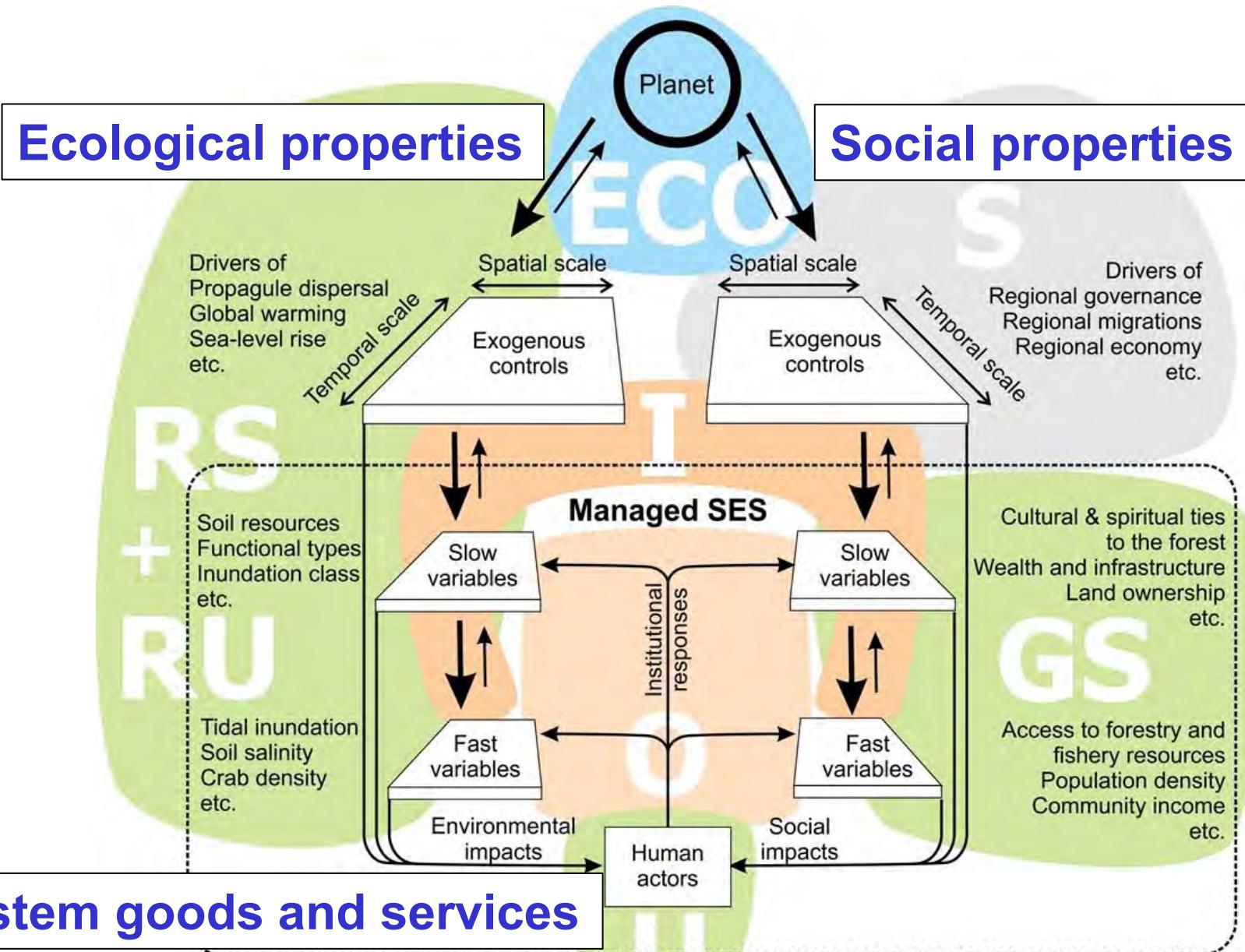
Anne Deknock



Michael Mastaller



# The mangrove social-ecological system





# Living from mangroves



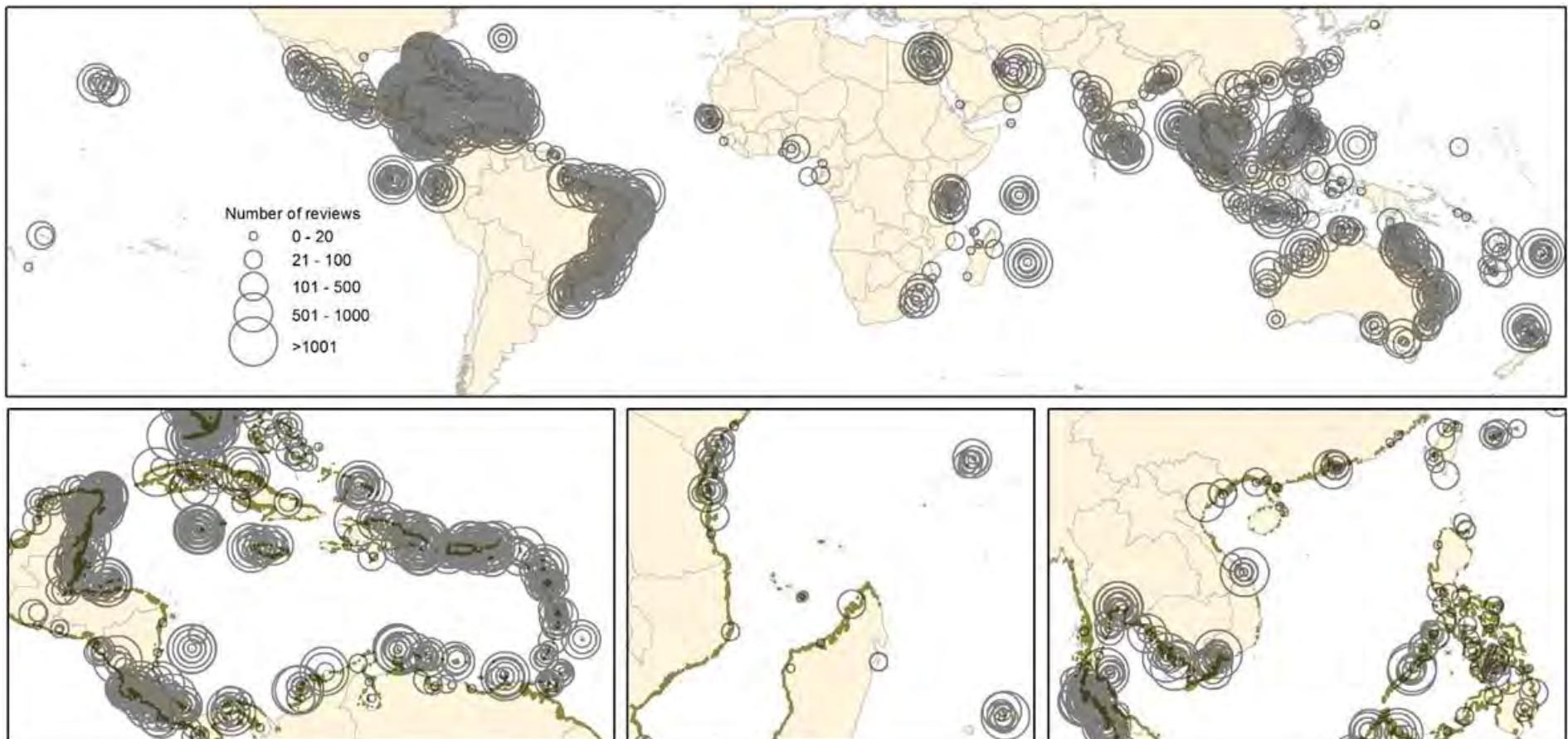
Mexico	Senegal The Gambia	Cameroon	Tanzania	Kenya	India	Sri Lanka	Vietnam
fuelwood construction others medicine	fuel wood construction food medicine dye fish traps tourism	fuelwood construction charcoal others	fuelwood construction others	construction fuelwood furniture medicine dye others	fuelwood construction dye/tannin fodder boat repair fish poison	fuelwood medicine tannins fisheries food/drink (juice, ice cream and jam)	fertilizer fuelwood animals
tea	tea			insecticide		brushpile	fertilizer

Sources : Dahdouh-Guebas *et al.* (2000), *Economic Botany*  
Hernandez-Cornejo *et al.* (2005), *Ecology & Society*  
Dahdouh-Gueas *et al.* (2006), *Environmental Conservation*  
Jayatissa *et al.* (2006), *Environment, Development & Sustainability*  
Satyanarayana *et al.* (2013), *Ambio*  
Gallup *et al.* (2020), *Ocean and Coastal Management*

# Visiting mangroves

- Tourists enjoy visiting mangrove forests in what has become a **multi-billion-dollar industry**, with over 37,000 TripAdvisor reviews mentioning mangroves across nearly 4,000 mangrove attractions world-wide

Spalding & Parrett (2019)



# Mangrove ecosystem disservices



François Leguat (1708)

# Mangrove ecosystem disservices



François Leguat (1708)



Mark Catesby (1743)

# Mangrove ecosystem disservices

- Descriptions of mangroves as a source of *putrid exhalations* indicative of *death to come* have been around since at least the 19<sup>th</sup> century (Darwin, 1839; Friess, 2016)
- “Mangroves are **not pretty to look at,...**” (IUCN)
- “**Ugly, smelly, overlooked**” (CIFOR)
- “Seen as **unproductive and smelly**” (WWF)
- “*Mangroves don't inspire awe and wonder...In many parts of the world, they've long been frowned upon as dirty, mosquito-infested tangles of roots that stand in the way of an ocean view*” (conservation.org)

# Iconic species and services

frontiers  
in Marine Science

published: 19 November 2020  
doi: 10.3389/fmars.2020.603651



## Public Perceptions of Mangrove Forests Matter for Their Conservation

Farid Dahdouh-Guebas<sup>1,2,3\*</sup>, Gordon N. Ajonina<sup>2,4,5</sup>, A. Aldrie Amir<sup>3,6</sup>, Dominic A. Andradi-Brown<sup>3,7</sup>, Irfan Aziz<sup>3,8</sup>, Thorsten Balke<sup>3,9</sup>, Edward B. Barbier<sup>2,10</sup>, Stefano Cannicci<sup>3,11,12</sup>, Simon M. Cragg<sup>3,13</sup>, Marilia Cunha-Lignon<sup>3,14</sup>, David J. Curnick<sup>3,15</sup>, Carlos M. Duarte<sup>16</sup>, Norman C. Duke<sup>3,17</sup>, Charlie Endor<sup>3,15</sup>, Sara Fratini<sup>3,12</sup>, Ilka C. Feller<sup>3,18</sup>, François Fromard<sup>3,19</sup>, Jean Hugé<sup>1,2,20</sup>, Mark Huxham<sup>3,21</sup>, James G. Kairo<sup>3,22</sup>, Tadashi Kajita<sup>3,23</sup>, Kandasamy Kathiresan<sup>3,24</sup>, Nico Koedam<sup>2,3</sup>, Shing Yip Lee<sup>3,25</sup>, Hsing-Juh Lin<sup>3,26</sup>, Jock R. Mackenzie<sup>27</sup>, Mwita M. Mangora<sup>3,28,29</sup>, Cyril Marchand<sup>3,30</sup>, Tarik Meziane<sup>3,31</sup>, Todd E. Minchinton<sup>3,32</sup>, Nathalie Pettorelli<sup>3,15</sup>, Jaime Polania<sup>3,33</sup>, Gianluca Polgar<sup>3,34</sup>, Meenakshi Poti<sup>1,2,20</sup>, Jurgenne Primavera<sup>3,35</sup>, Alfredo Quarto<sup>3,36</sup>, Stefanie M. Rog<sup>37</sup>, Behara Satyanarayana<sup>1,3,38</sup>, Yara Schaeffer-Novelli<sup>3,39</sup>, Mark Spalding<sup>3,40,41</sup>, Tom Van der Stocken<sup>2</sup>, Dominic Wodehouse<sup>3,36</sup>, Jean W. H. Yong<sup>3,42</sup>, Martin Zimmer<sup>3,43,44</sup> and Daniel A. Friess<sup>3,45</sup>

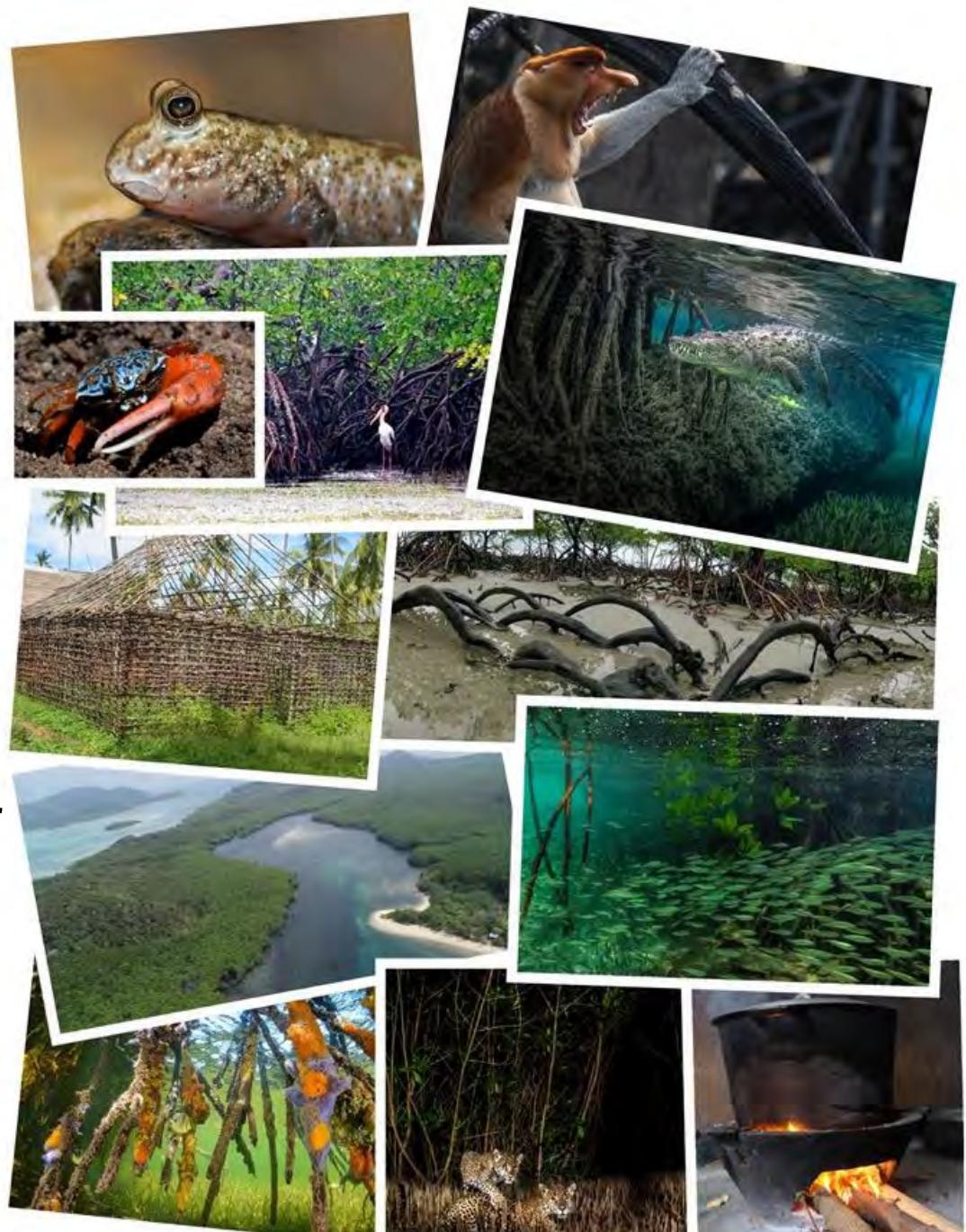
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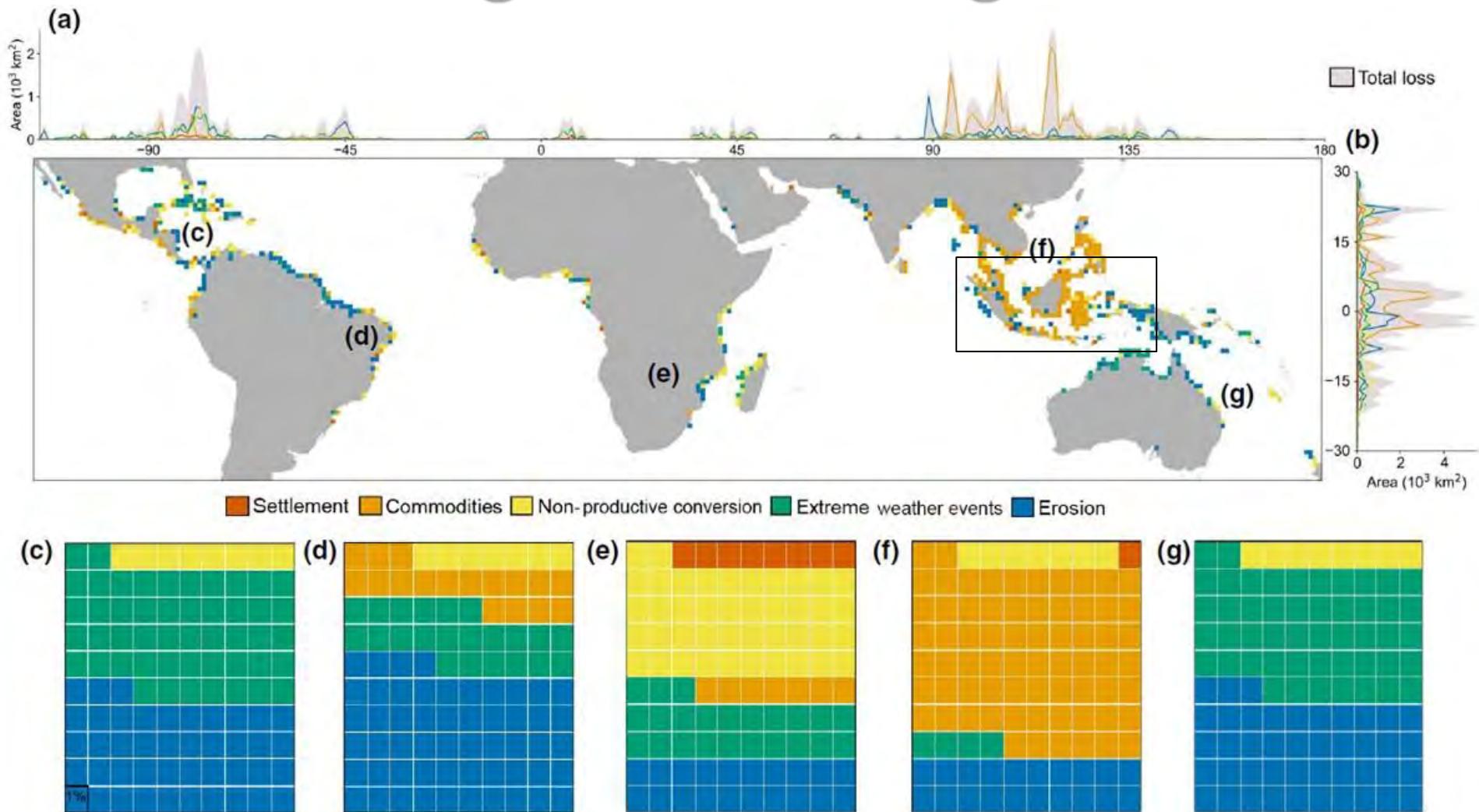
José M. Rilascos,  
University of Antioquia, Colombia

Reviewed by:  
Syed Alirul Hussain,

What is written, said, shown, and shared through all sorts of oral, written and visual media in papers, on radio & TV or online eventually affects biological conservation discourses and attitudes



# Mangroves endangered



**FIGURE 1** Global distribution of mangrove loss and its drivers. (a) The longitudinal distribution of total mangrove loss and the relative contribution of its primary drivers. Different colors represent unique drivers of mangrove loss. (b) The latitudinal distribution of total mangrove loss and the relative contribution of its primary drivers. (c-g) Global distribution of mangrove loss and associated drivers from 2000 to 2016 at  $1^\circ \times 1^\circ$  resolution, with the relative contribution (percentage) of primary drivers per continent: (c) North America, (d) South America, (e) Africa, (f) Asia, (g) Australia together with Oceania.

# Mangroves endangered

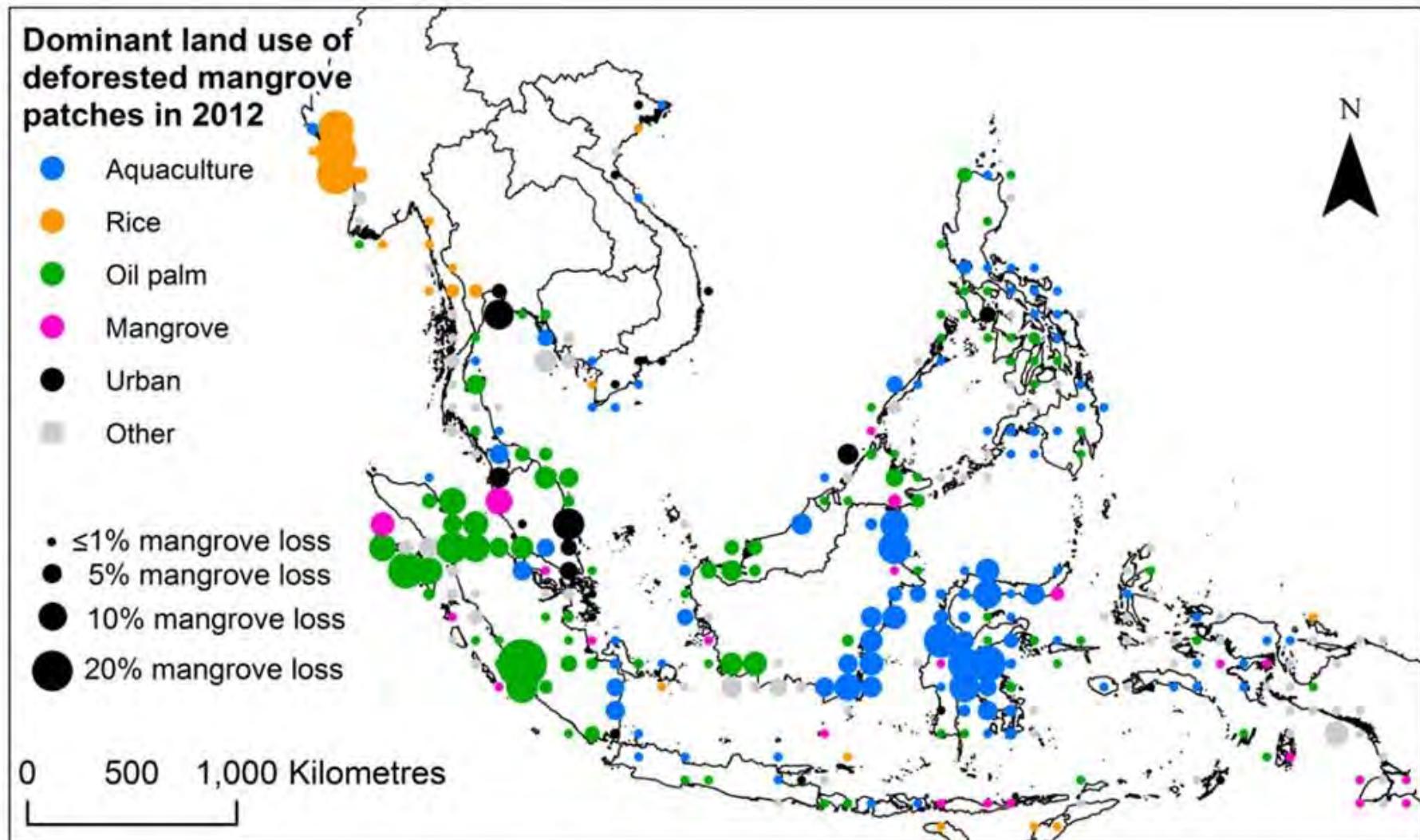


Fig. 2. Percentage mangrove deforestation between 2000 and 2012, and dominant land uses of deforested areas in 2012. Land uses are summarized as the converted land use with the greatest area within each 1 decimal degree grid square. Circles are located in the center of each grid square, and circle size represents the percentage of the mangrove area in 2000 that has been lost.

# Mangroves endangered

## A World Without Mangroves?

AT A MEETING OF WORLD MANGROVE EXPERTS HELD LAST YEAR IN Australia, it was unanimously agreed that we face the prospect of a world deprived of the services offered by mangrove ecosystems, perhaps within the next 100 years.

Mangrove forests once covered more than 200,000 km<sup>2</sup> of sheltered tropical and subtropical coastlines (1). They are disappearing worldwide by 1 to 2% per year, a rate greater than or equal to declines in adjacent coral reefs or tropical rainforests (2–5). Losses are occur-

tional diversity, particularly in species-poor systems like mangroves, which have low redundancy *per se* (8). Therefore, any further decline in mangrove area is likely to be followed by accelerated functional losses. Mangroves are already critically endangered or approaching extinction in 26 out of the 120 countries having mangroves (2, 9).

Deforestation of mangrove forests, which have extraordinarily high rates of primary productivity (3), reduces their dual capacity to be both an atmospheric CO<sub>2</sub> sink (10) and an essential source of oceanic carbon. The support that mangrove ecosystems provide for terrestrial as well as marine food webs would be lost, adversely affecting, for example, fisheries (11). The decline further imperils mangrove-dependent fauna with their complex habitat linkages, as well as physical benefits like the buffering of seagrass beds and coral reefs against the impacts of river-borne siltation, or protection of coastal communities from sea-level rise, storm surges, and tsunamis (12, 13). Human communities living in or near mangroves would lose access to sources of essential food, fibers, timber, chemicals, and medicines (14).

We are greatly concerned that the full implications of mangrove loss for humankind are not fully appreciated. Growing pressures of urban and industrial developments along coastlines, combined with climate change and sea-level rise, urge the need to conserve, protect, and restore tidal wetlands (11, 13). Effective governance structures, socioeconomic risk policies, and education strategies (15) are needed now to enable societies around the world to reverse the trend of mangrove loss and ensure that future generations enjoy the ecosystem services provided by such valuable natural ecosystems.

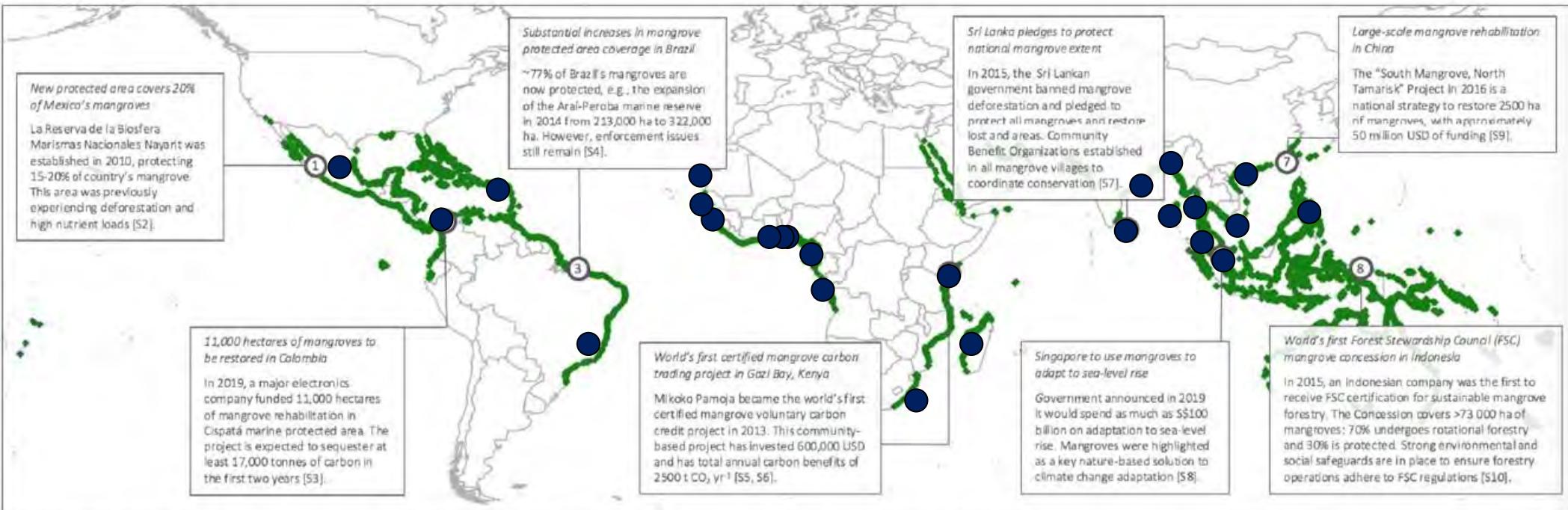
N. C. DUKE,<sup>1\*</sup> J.-O. MEYNECKE,<sup>2</sup> S. DITTMANN,<sup>3</sup> A. M. ELLISON,<sup>4</sup> K. ANGER,<sup>5</sup> U. BERGER,<sup>6</sup> S. CANNICCI,<sup>7</sup> K. DIELE,<sup>8</sup> K. C. EWEL,<sup>9</sup> C. D. FIELD,<sup>10</sup> N. KOEDAM,<sup>11</sup> S. Y. LEE,<sup>2</sup> C. MARCHAND,<sup>12</sup> I. NORDHAUS,<sup>8</sup> F. DAHDOUH-GUEBAS<sup>13</sup>



Emerging from the embrace of a mangrove tree-lined channel in northern Brazil, these pescadores, like coastal fishers worldwide, know that healthy mangroves mean good fishing and a secure livelihood.

# Mangroves give cause for conservation optimism, for now

Friess et al. (2020), *Current Biology*



**Figure S1. Global examples of recent mangrove conservation success stories. For map of global mangrove extent, see [S1].**



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# II était une fois... قباس فرج (ca. °1972 †20??)



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Ecologie des Systèmes et  
Gestion des Ressources



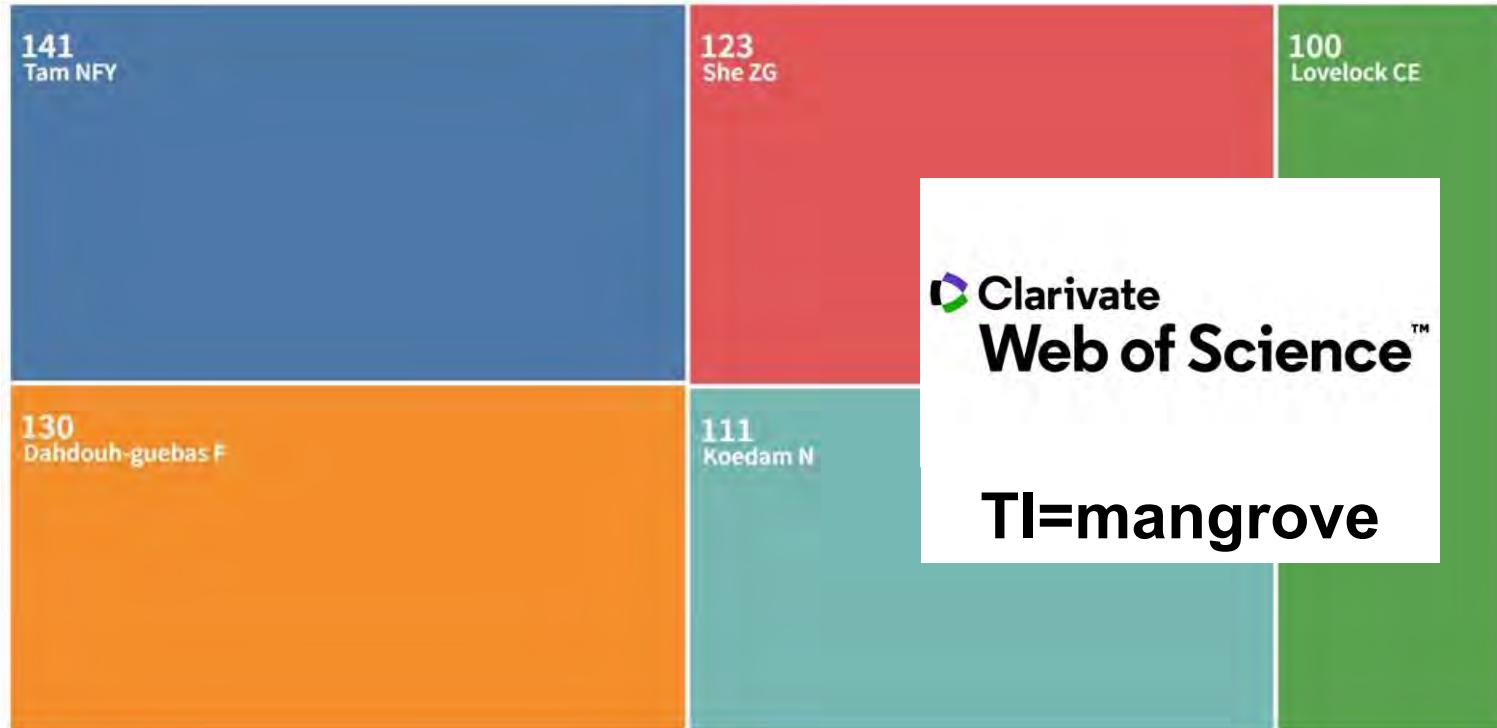
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Systems Ecology and  
Resource Management



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Contact:

Prof. Dr. Farid DAHDOUH-GUEBAS  
c/o Université Libre de Bruxelles - ULB  
Fac. Sciences, Dépt. Biologie des Organismes

Av. F.D. Roosevelt 50, CPI 264/1  
B-1050 Brussels, BELGIUM

E-mail : [Farid.Dahdouh-Guebas@ulb.be](mailto:Farid.Dahdouh-Guebas@ulb.be)

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