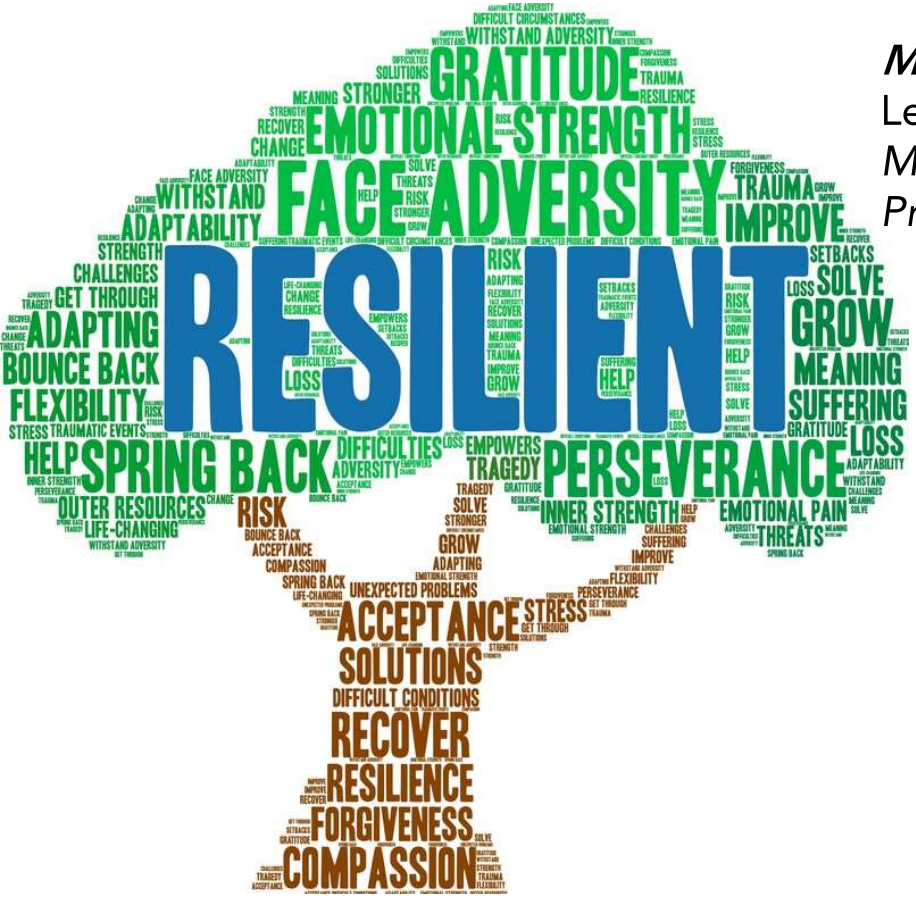
Ecosystem Co-Design
towards resilient coastal socio-ecological systems



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: world.of.mangroves

IUCN SSC Species Survival Commission Mangrove Specialist Group

What is Resilience?

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Ecosystem Co-Design & Coastal Resilience

What is Resilience?

-…the capacity to withstand, or to recover from, difficulties, stress or disturbance ("*toughness*")

-…the ability of a substance or object to bounce back into (previous) shape ("*elasticity*")

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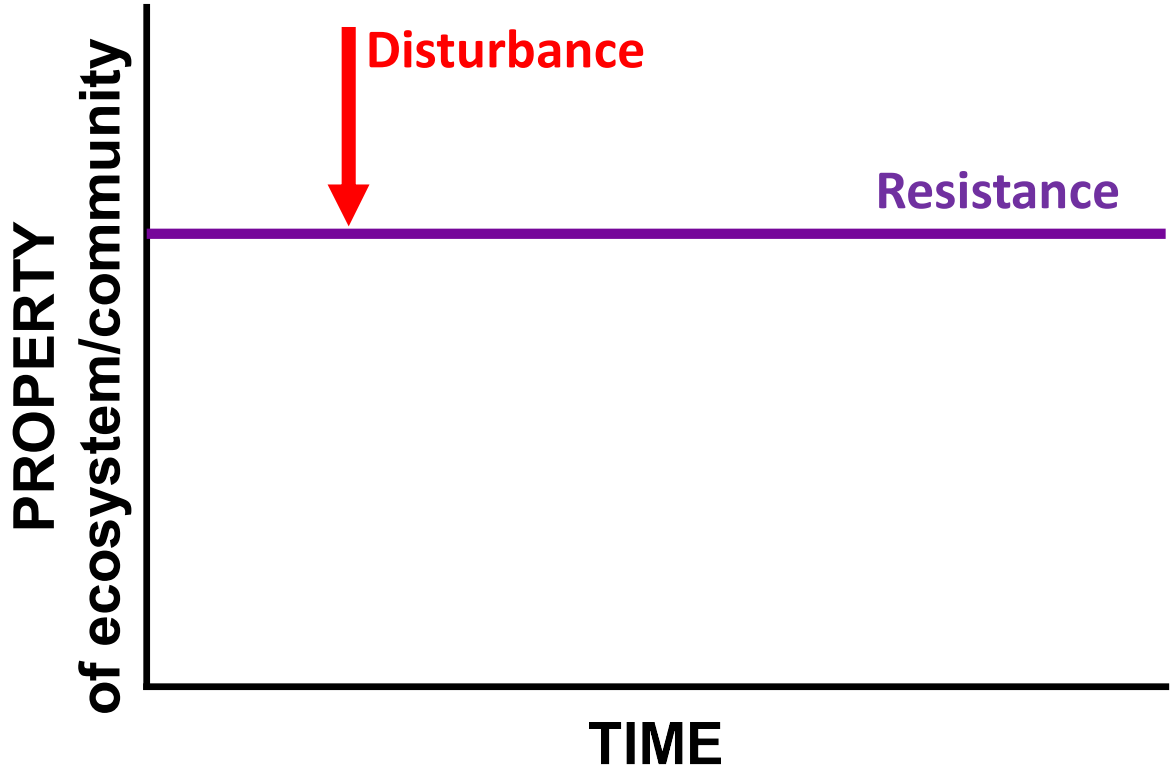
What is Resilience?

-…in Ecology:



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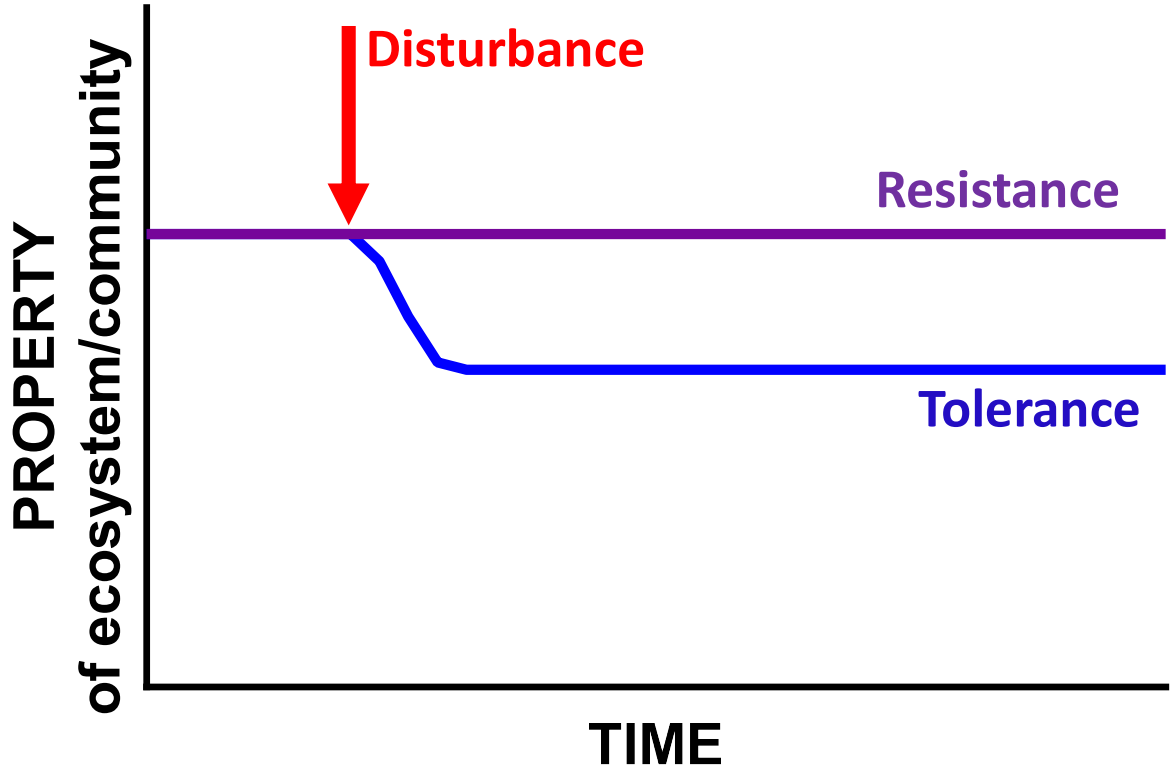
What is Resilience?

-…in Ecology:



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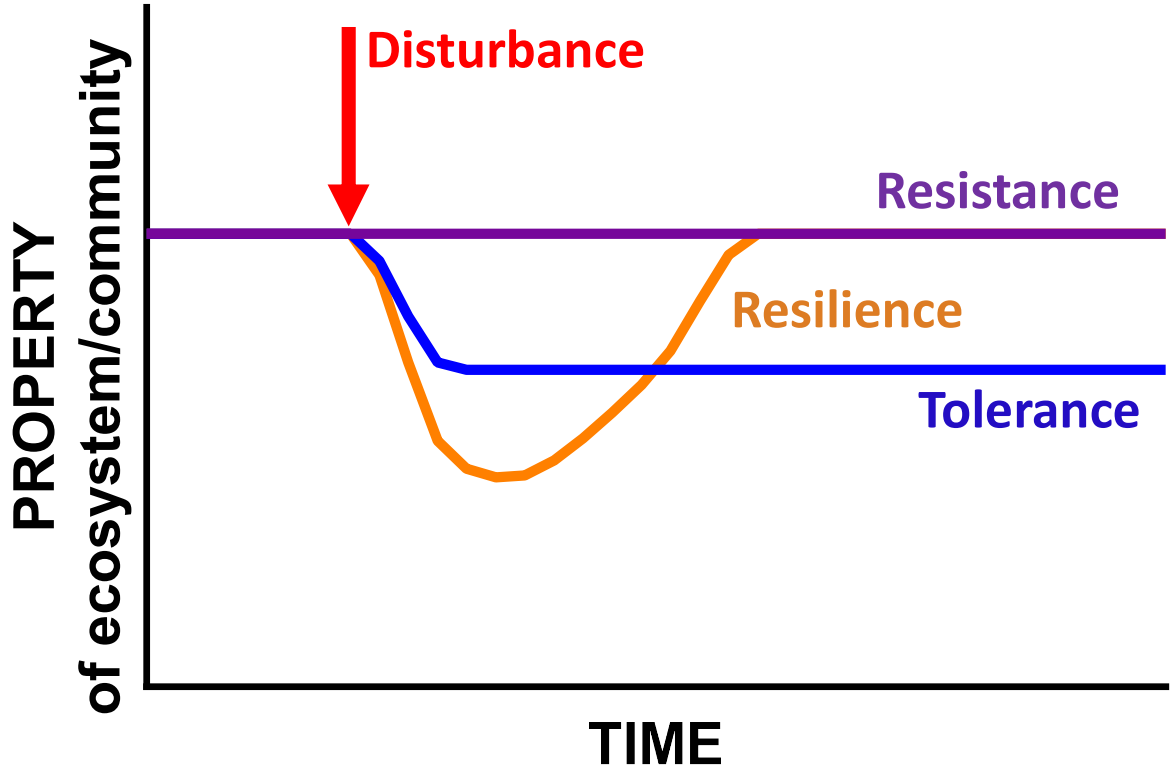
What is Resilience?

-…in Ecology:



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What is Resilience?

The ability of a system, community or society
to resist, absorb, accommodate, adapt to, transform, and/or recover from, hazards
in a timely and efficient manner,
including through the preservation and restoration of its essential basic structures
through risk management.

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Societal resilience is not a trait that people either have or don't have.
It involves behaviors, thoughts, and actions
that can be learned and developed in everyone.

→physical resilience, mental resilience, emotional resilience, and social resilience

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...*Coastal Resilience*...

-...snippets from UNOC3, Nice:

...anticipating rather than only reacting
...response beyond shock
...not "cope with" but "transform"

...build cities protected by ecosystems
...NbS need to be tailored with traditional knowledge:
→community-led resilience
→always involve all relevant stakeholders

...no one-fits-all solution(s)

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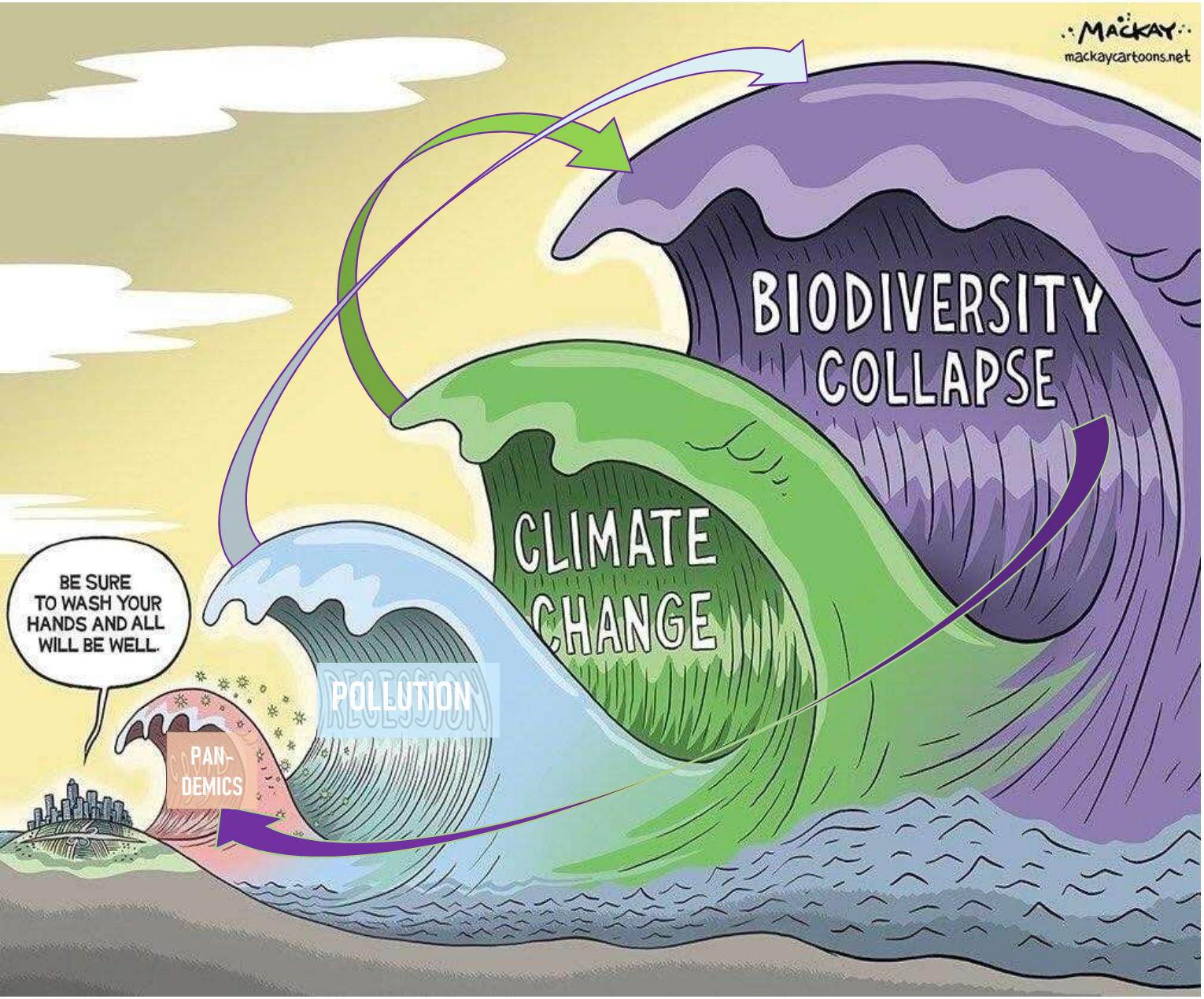
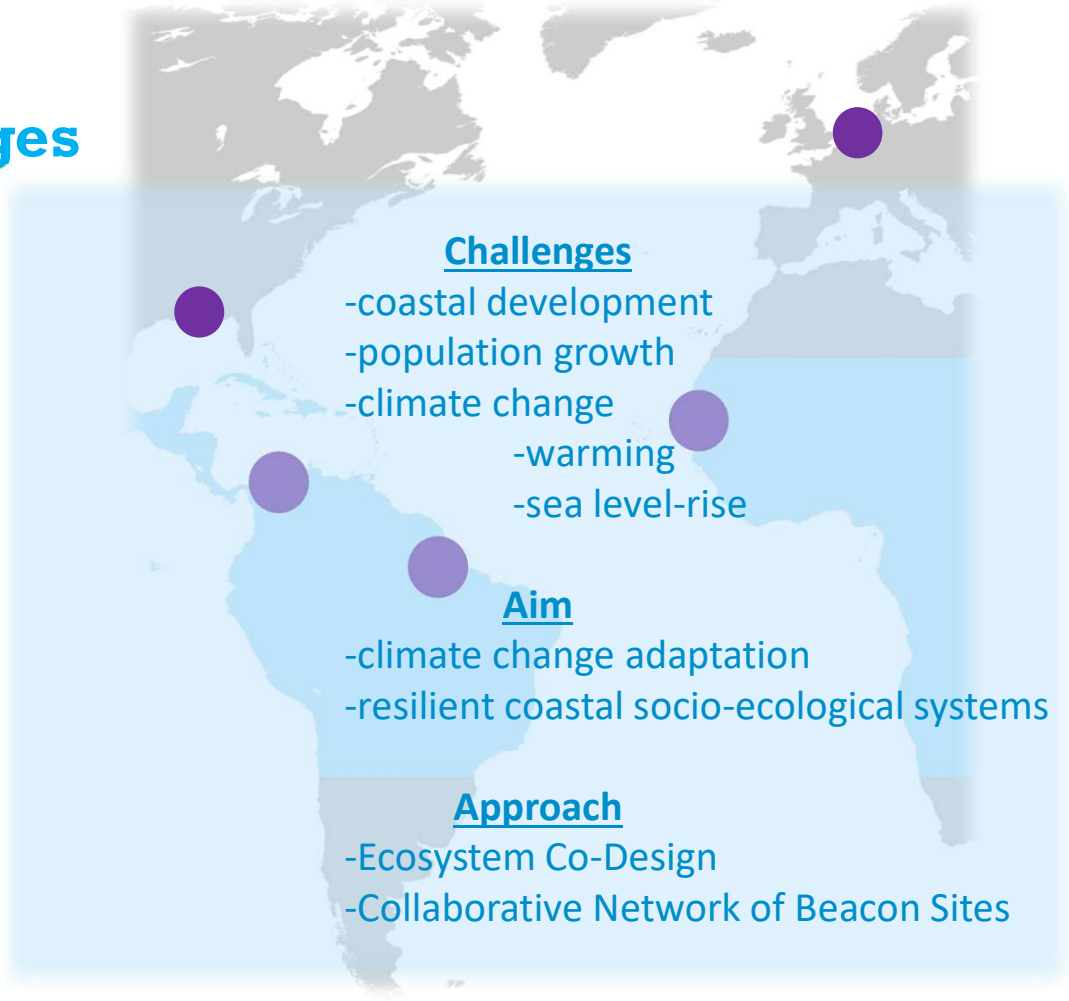

MACKAY
mackaycartoons.net
BIODIVERSITY COLLAPSE
CLIMATE CHANGE
POLLUTION
RECESSION
PAN-DEMICS
BE SURE TO WASH YOUR HANDS AND ALL WILL BE WELL.

Common *versus* specific challenges



Challenges

-coastal development
-population growth
-climate change
-warming
-sea level-rise

Aim

-climate change adaptation
-resilient coastal socio-ecological systems

Approach

-Ecosystem Co-Design
-Collaborative Network of Beacon Sites

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Nature-based Solutions

Nature-based Solutions leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future.

Nature-based Solutions address societal challenges through actions to protect, sustainably manage, and restore natural and modified ecosystems, benefiting people and nature at the same time.

They target major challenges like climate change, disaster risk reduction, food and water security, biodiversity loss and human health, and are critical to sustainable development.

The benefits of Nature-based Solutions for biodiversity and human well-being flow from healthy ecosystems

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https://www.iucn.org/our-work/nature-based-solutions

green-grey hybrid Solutions

- sponge-streets → wetlands
- integrated aquaculture
- floating mangrove stands
- …

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(courtesy of N. Moosdorf)

A. Mondal & S. M. Jesmin
(courtesy of *Global Nature Fund*)

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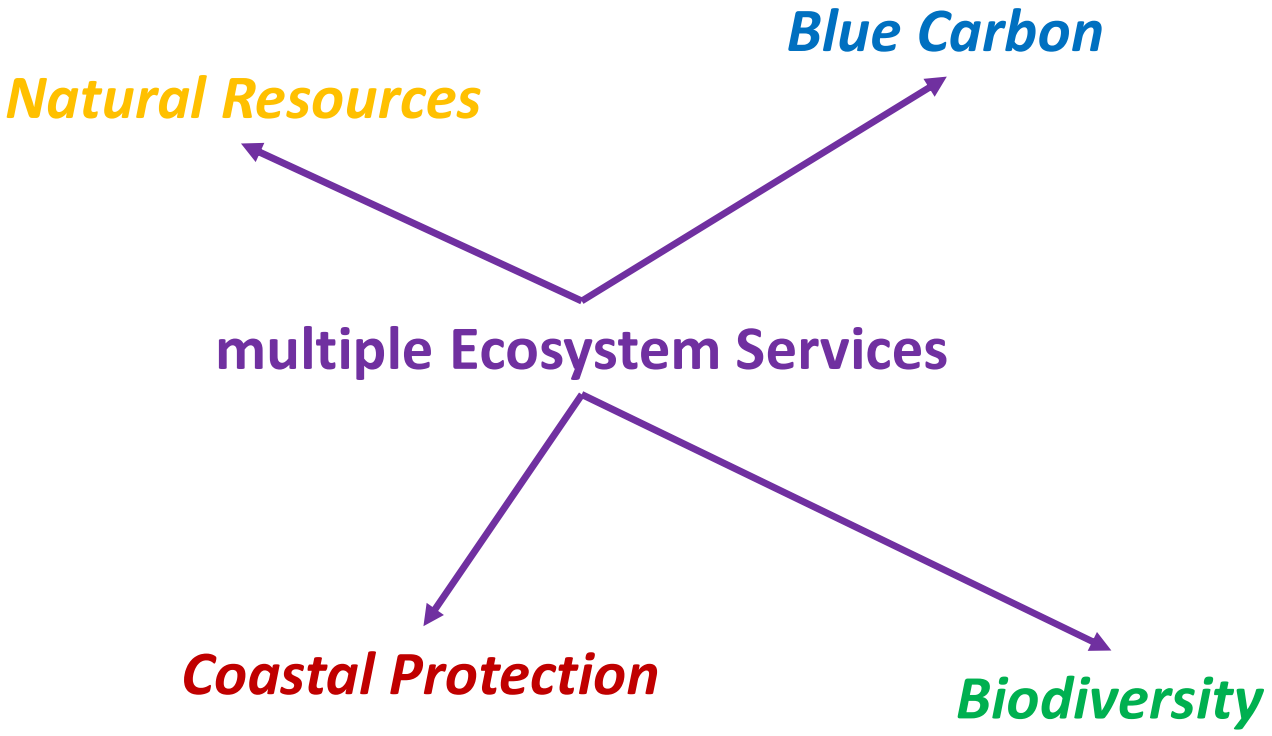
Nature-based Solutions: Ecosystem Services



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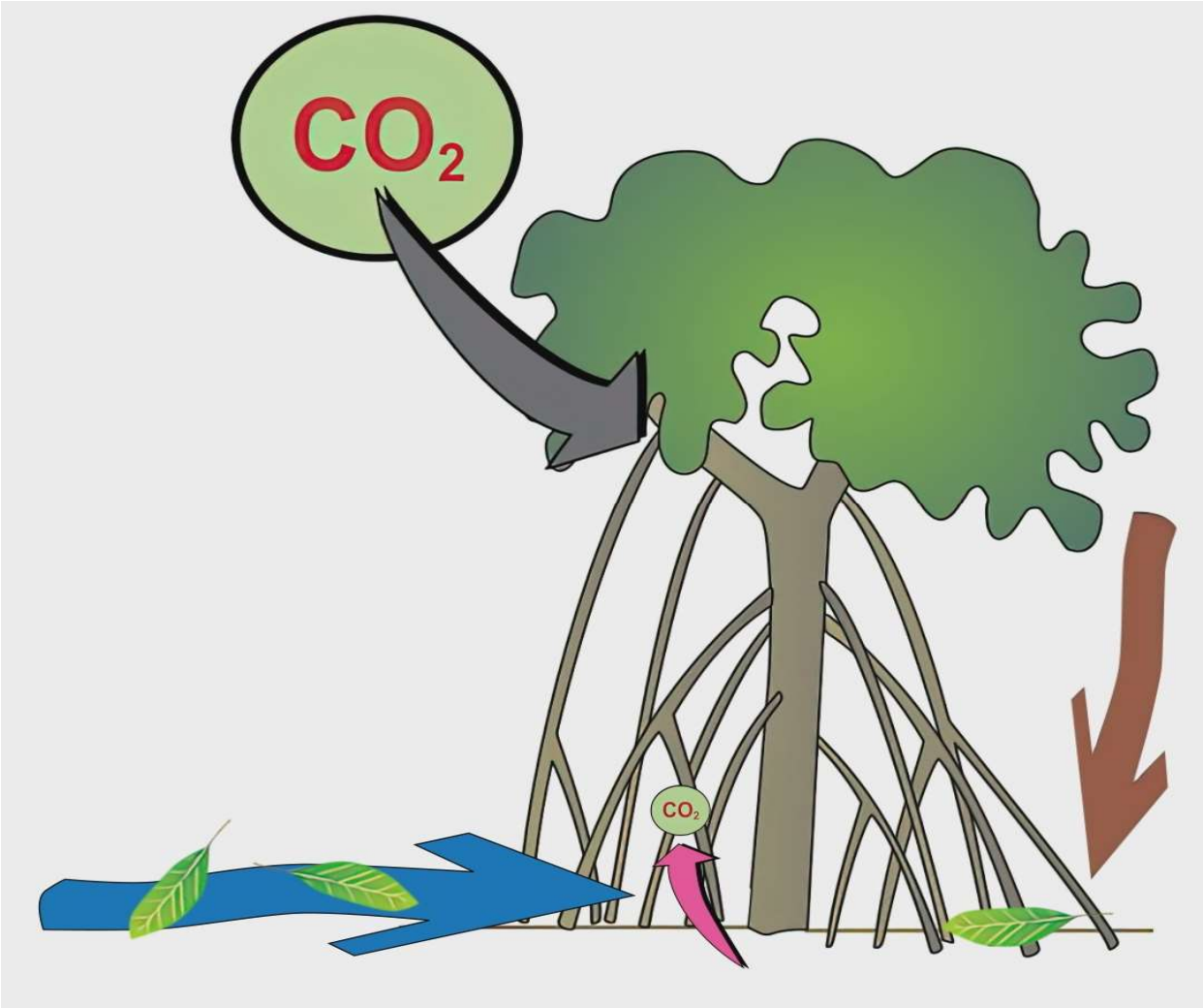
***Nature-based Solutions*: Climate Change-Mitigation**



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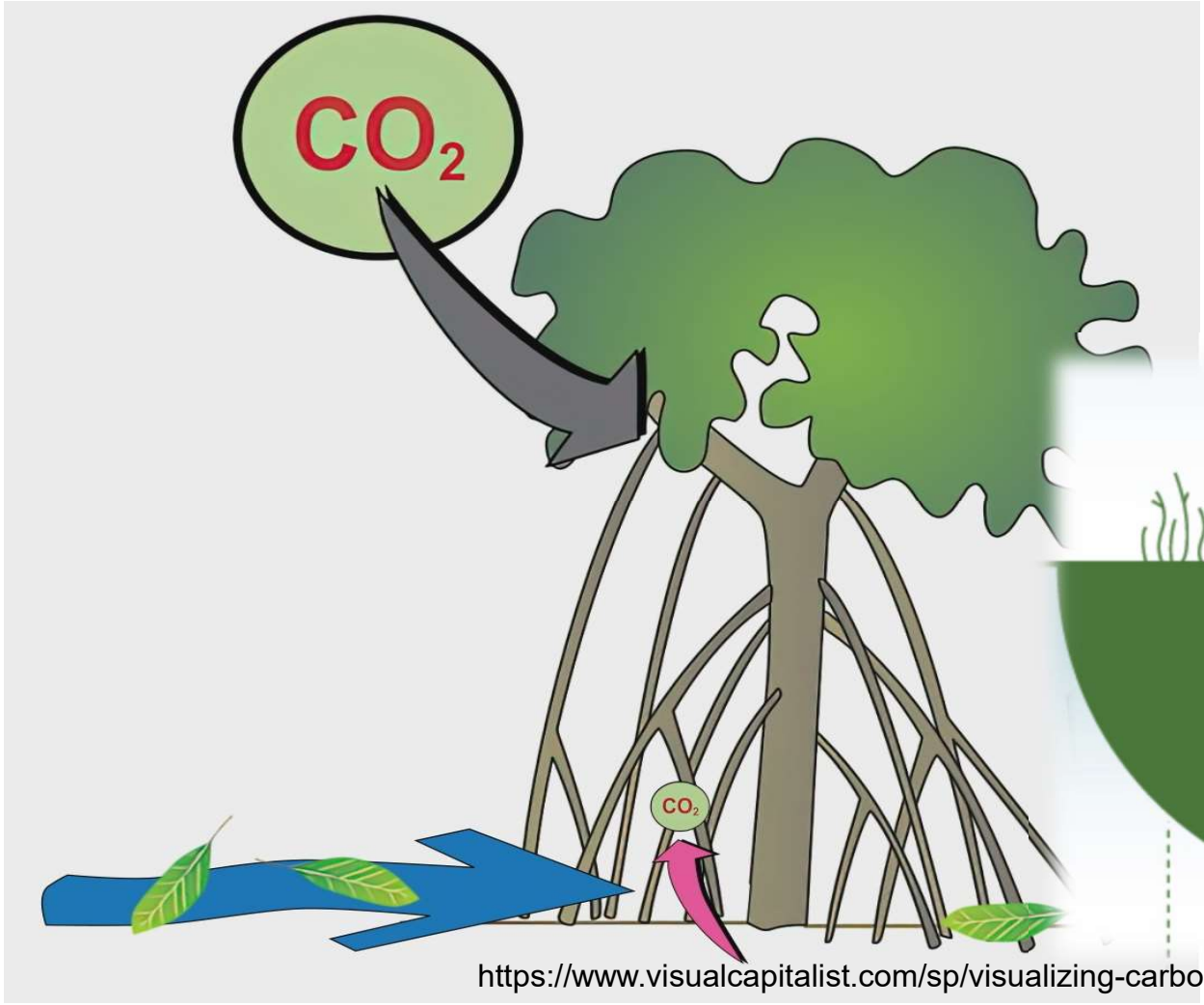

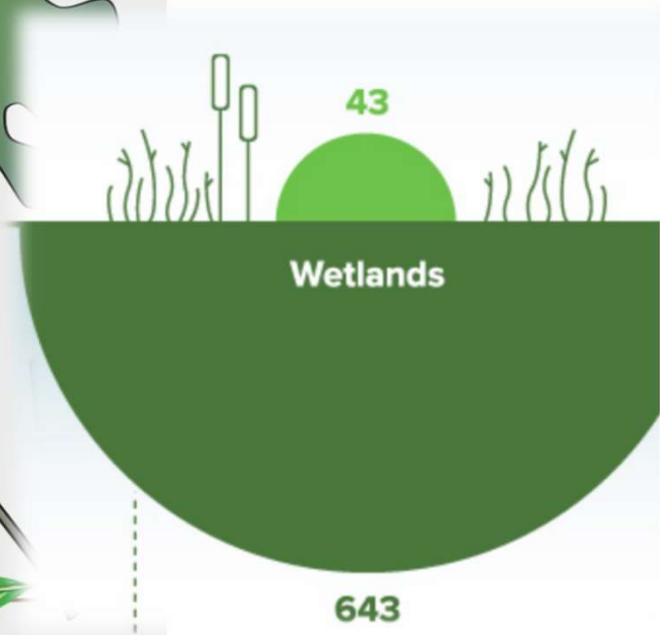

https://www.visualcapitalist.com/sp/visualizing-carbon-storage-in-earths-ecosystems/

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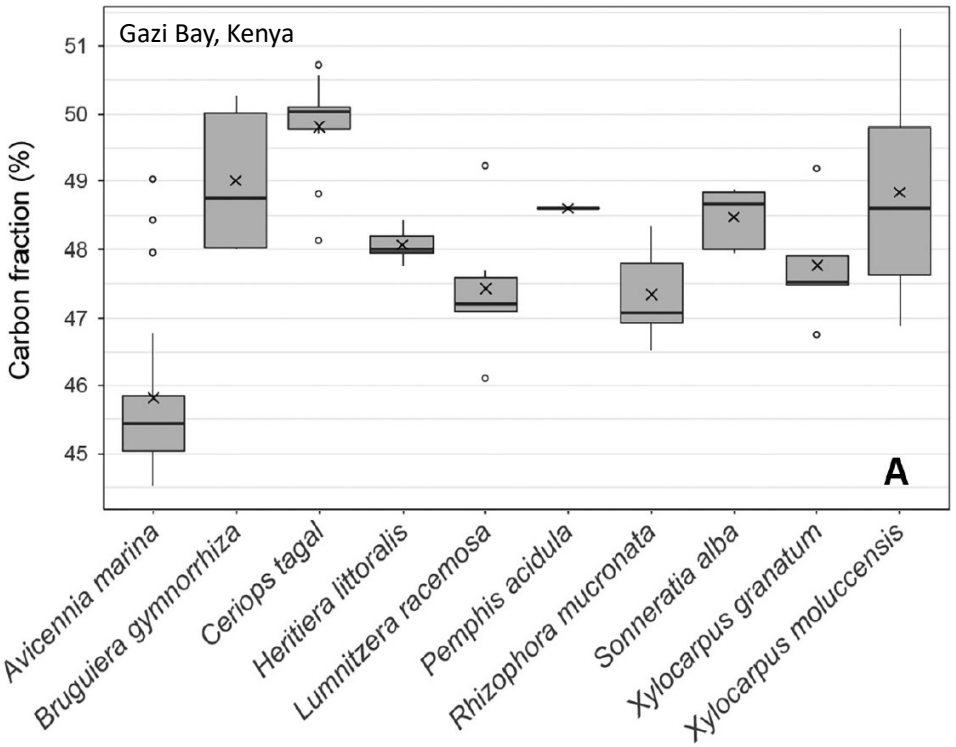
Nature-based Solutions: Species-specificity

Aboveground biomass

Segara Anakan, Indonesia

Mangrove species	Biomass (ton/ha)		Percent carbon			Carbon (ton/ha)		
	Min	Max	Min	Max	Average	Min	Max	Average
Bruguiera gymnorhiza (L.) Lam.	1.5	39.2	51.13	55.55	53.34	0.36	10.23	5.30
Rhizophora apiculata Blume	2.4	56.52	51.3	53.98	52.64	0.58	14.34	7.46
Rhizophora stylosa Griffith	1.66	78.11	50.35	52.32	51.335	0.39	19.21	9.80
Ceriops tagal (Perr.) C.B.Rob.	5.78	11.52	50.12	52.29	51.205	1.38	2.83	2.10
Rhizophora mucronata Lam.	0.75	20.2	50.09	51.86	50.975	0.18	4.92	2.55
Bruguiera parviflora (Roxb.) Wight & Arn. ex Griff.	0.08	1.37	50.02	51.01	50.515	0.02	0.33	0.17
Ceriops decandra (Griff.) Ding Hou	1.89	12.68	49.04	51.22	50.13	0.44	3.05	1.74
Bruguiera sexangula (Lour.) Poir.	1.62	21.48	49.05	50.42	49.735	0.37	5.09	2.73
Xylocarpus granatum J.Koenig	0.47	6.8	47.59	51.59	49.59	0.10	1.61	0.86
Xylocarpus moluccensis (Lam.) M.Roem.	10.6	11.25	47.23	50.15	48.69	2.35	2.65	2.50
Sonneratia caseolaris (L.) Engl.	0.6	18.28	45.02	52.12	48.57	0.13	4.48	2.30
Avicennia marina (Forssk.) Vierh.	1.09	88.28	45.41	50.23	47.82	0.23	20.84	10.54
Sonneratia alba Sm.	1.63	130.39	44.99	50.55	47.77	0.34	30.98	15.66
Aegiceras corniculatum (L.) Blanco	0.6	123.08	44.85	50.67	47.76	0.13	29.31	14.72
Aegiceras floridum Roem. & Schult.	0.64	1.23	44.92	50.55	47.735	0.13	0.29	0.21
Avicennia officinalis L.	0.65	17.73	45.32	49.05	47.185	0.14	4.09	2.11
Avicennia alba Blume	1.99	44.5	43.62	50.09	46.855	0.41	10.48	5.44
Heritiera littoralis Dryand. ex Aiton	0.1	3.18	43.59	49.87	46.73	0.02	0.74	0.38
Nypa fruticans Wurmb	0.78	100.81	41.45	43.5	42.475	0.15	20.61	10.38
Total	34.83	786.61				7.85	186.09	



-stand age

Alongi & Zimmer. 2024. *Mar Ecol Progr Ser*

-stand characteristics, e.g., tree density and size

-species composition

Ahmed & Kamruzzaman. 2021. *Biom Bioen*
Hilmi et al. 2024. *Biodiversitas*

-species

Gillerot et al. 2018. *Ecosphere*
Hilmi et al. 2024. *Biodiversitas*
BUT SEE: Alongi & Zimmer. 2024. *Mar Ecol Progr Ser*

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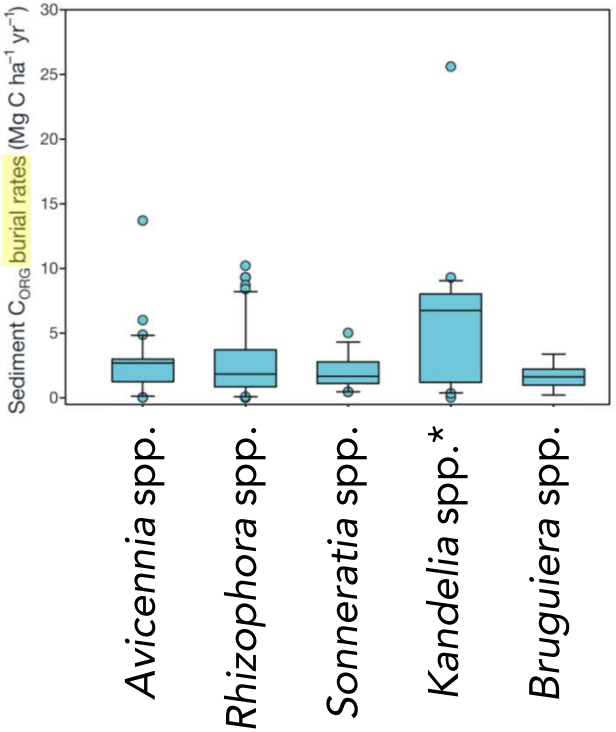
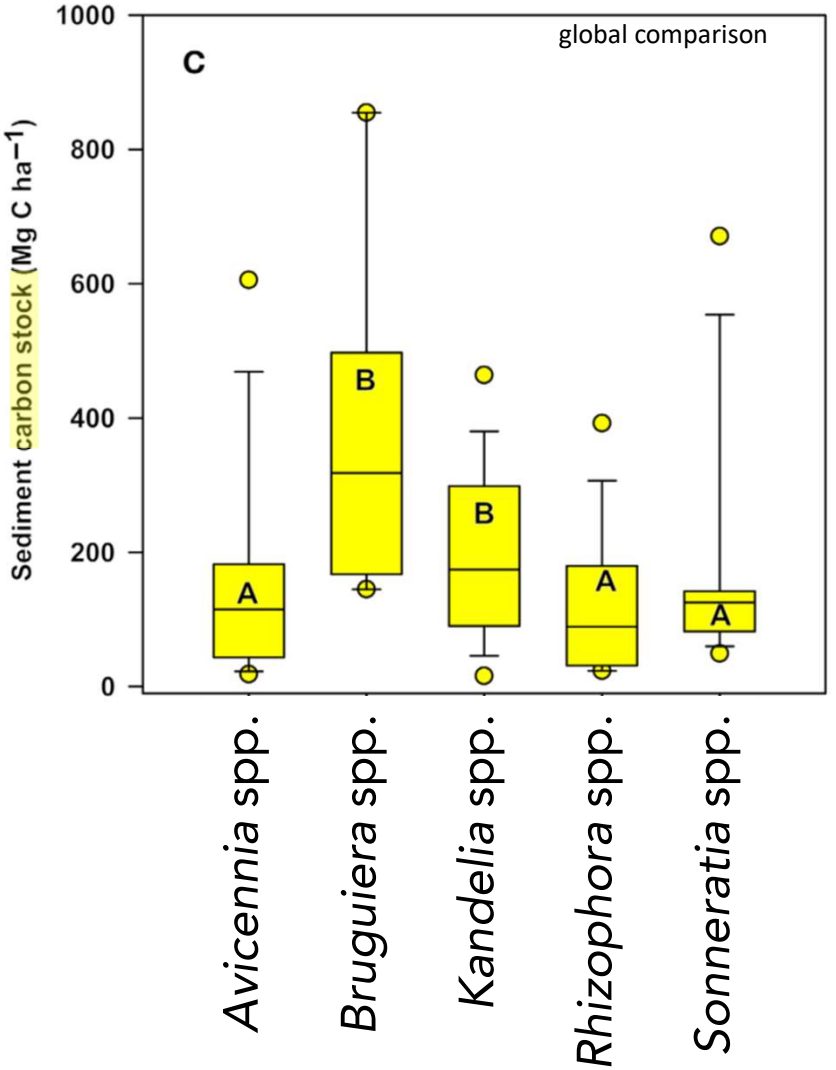
Nature-based Solutions: Species-specificity



Sediment



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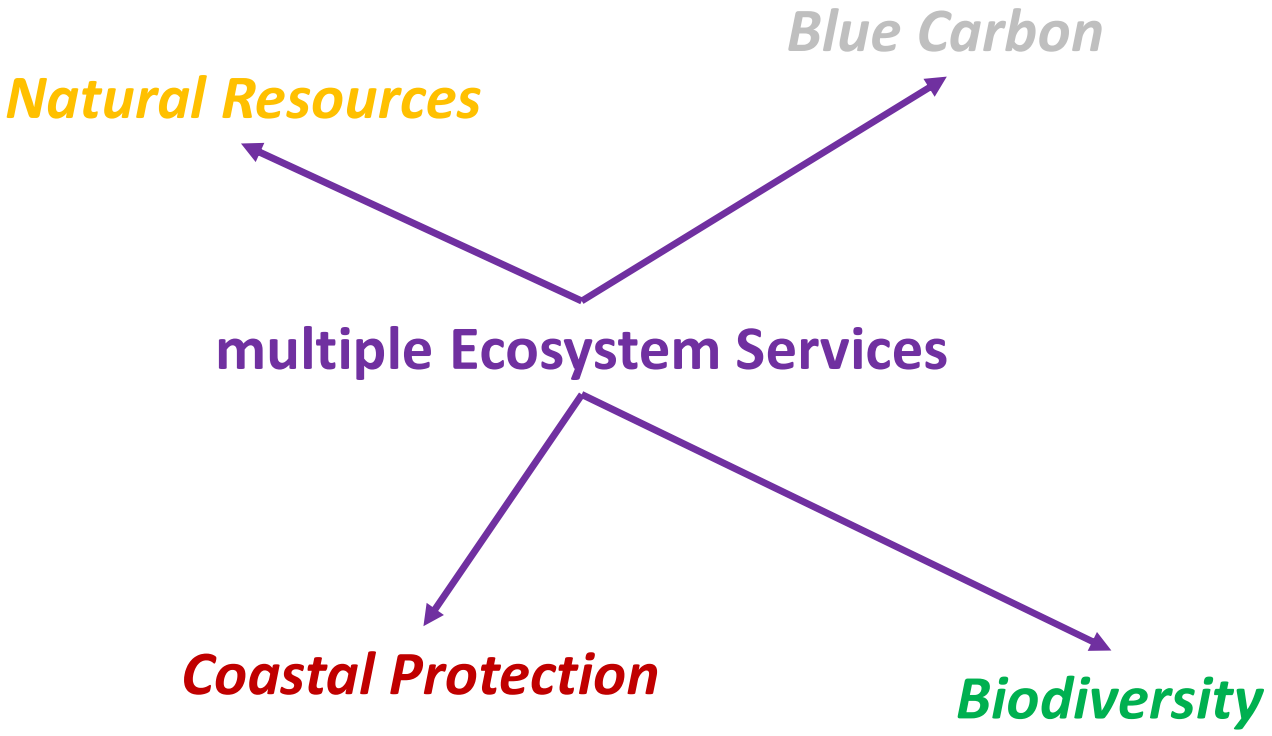
Alongi & Zimmer. 2024. *Mar Ecol Progr Ser*

Nature-based Solutions: Ecosystem Services



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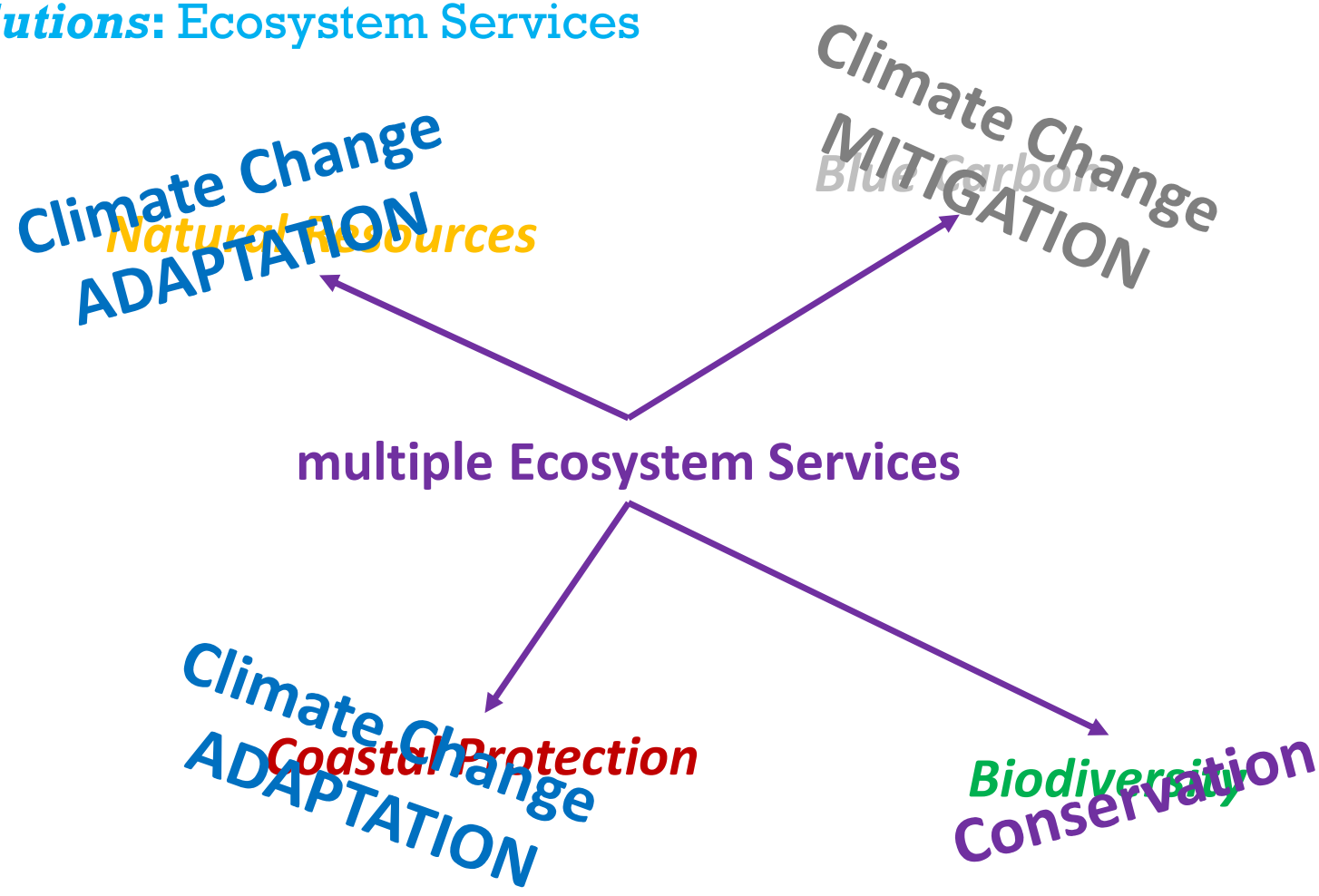
Nature-based Solutions: Ecosystem Services



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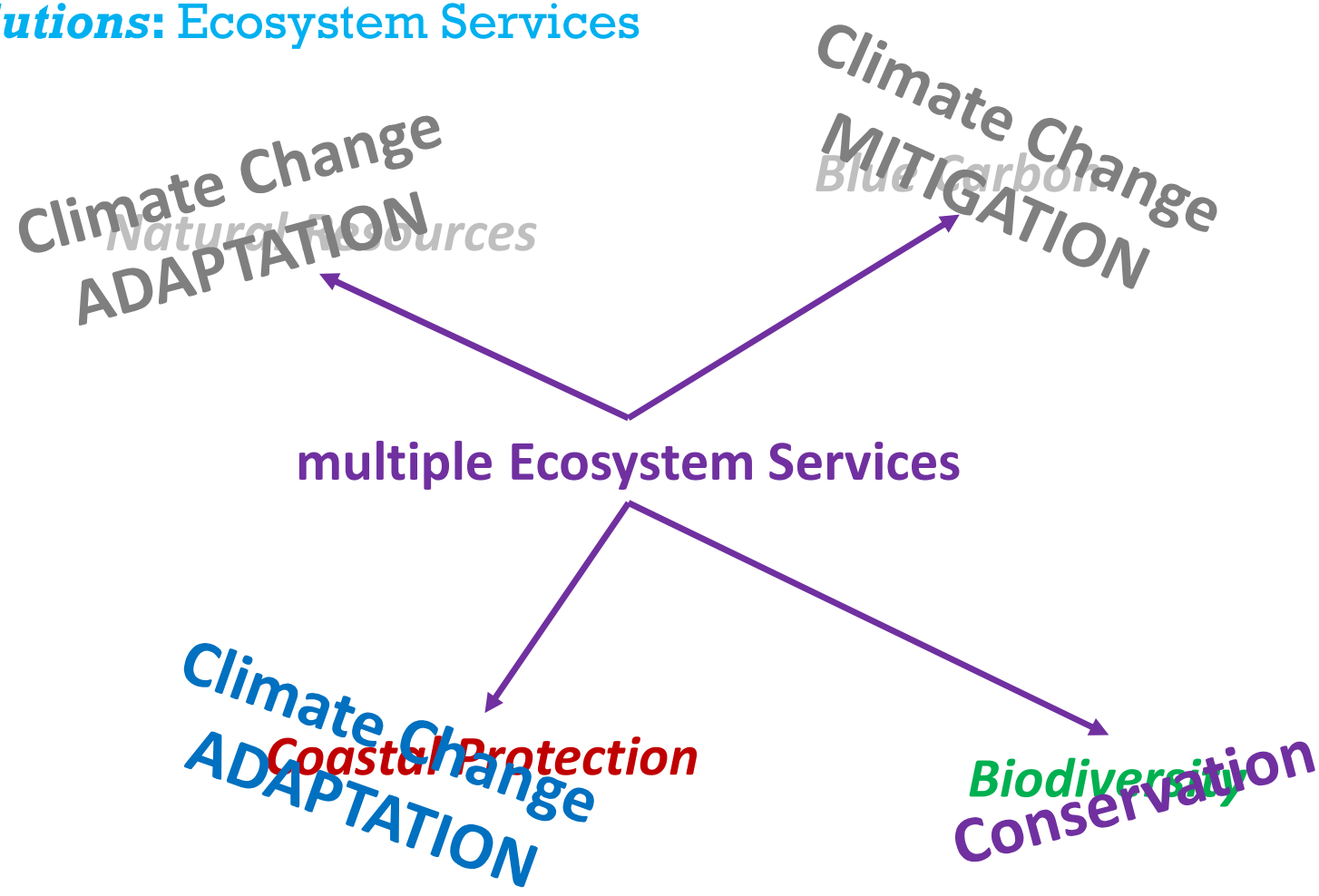

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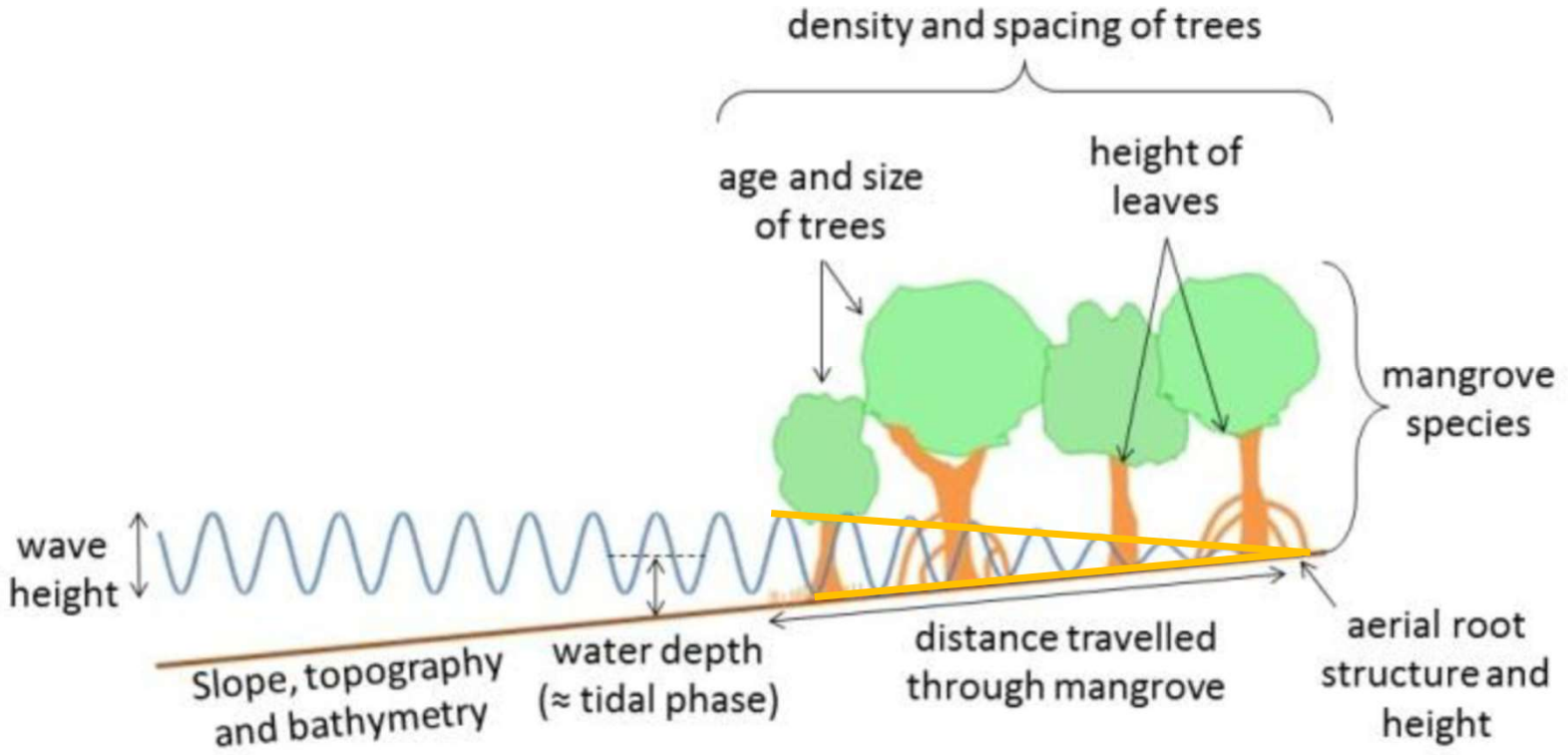

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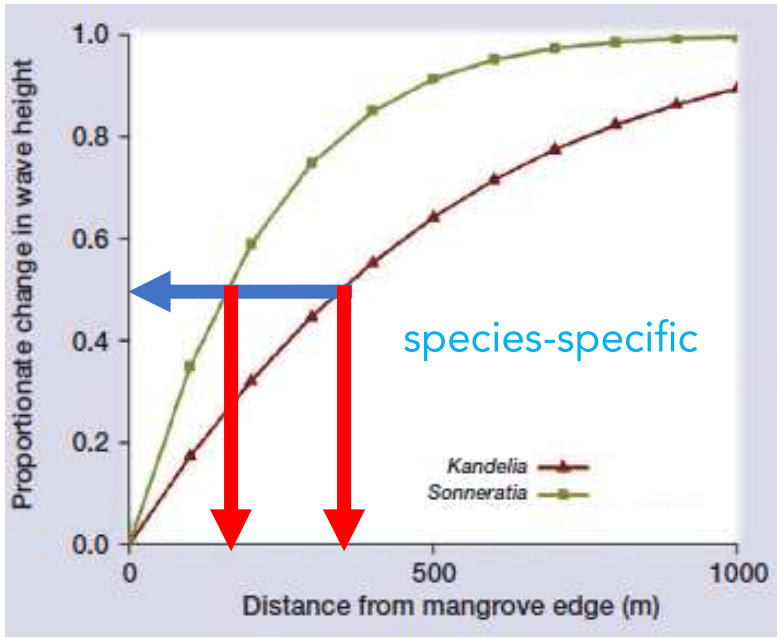
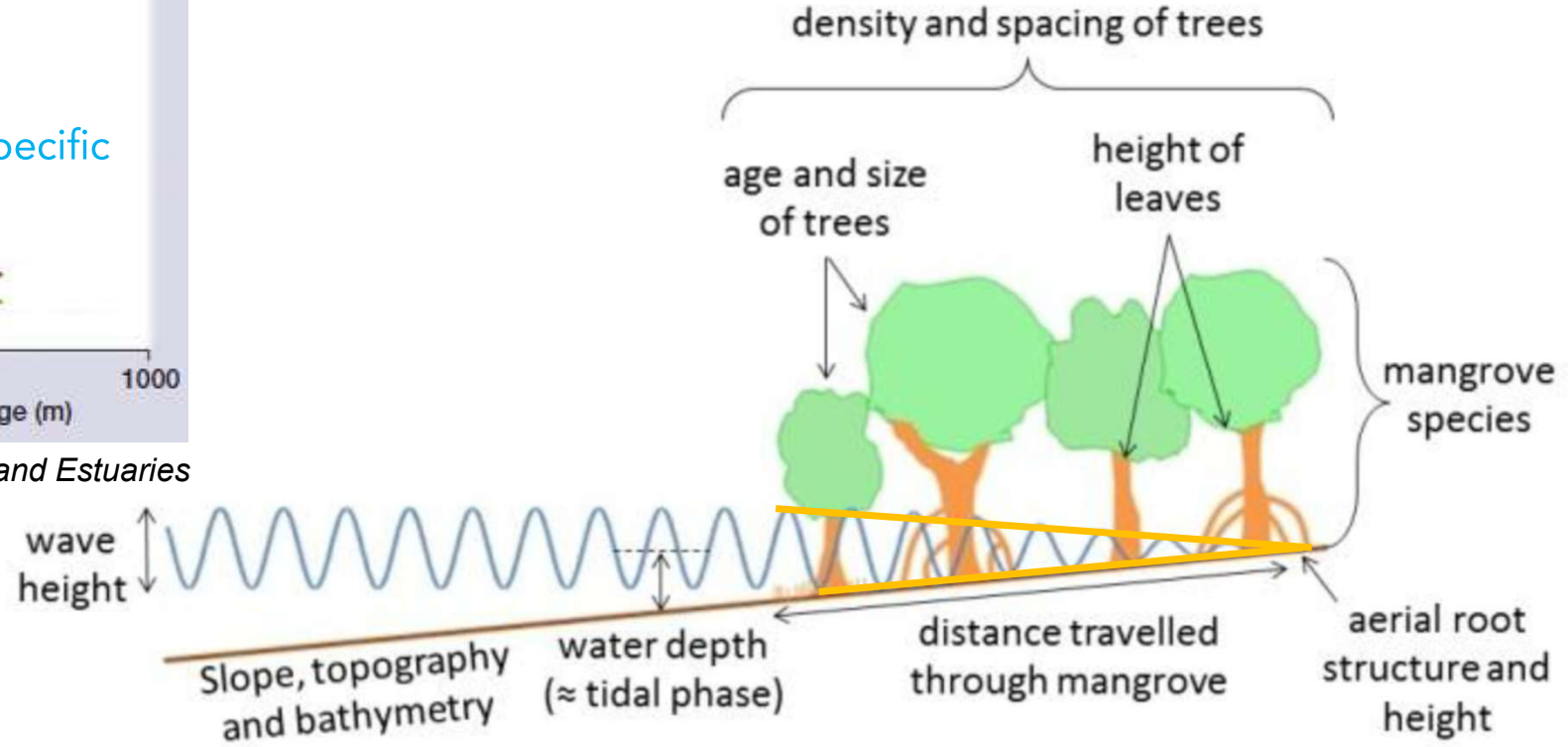
McIvor et al. 2012. *National Coastal Protection Series*: Report 1

Nature-based Solutions: Ecosystem Services



Little. 2000. *The Biology of Soft Shores and Estuaries*



McIvor et al. 2012. *National Coastal Protection Series*: Report 1

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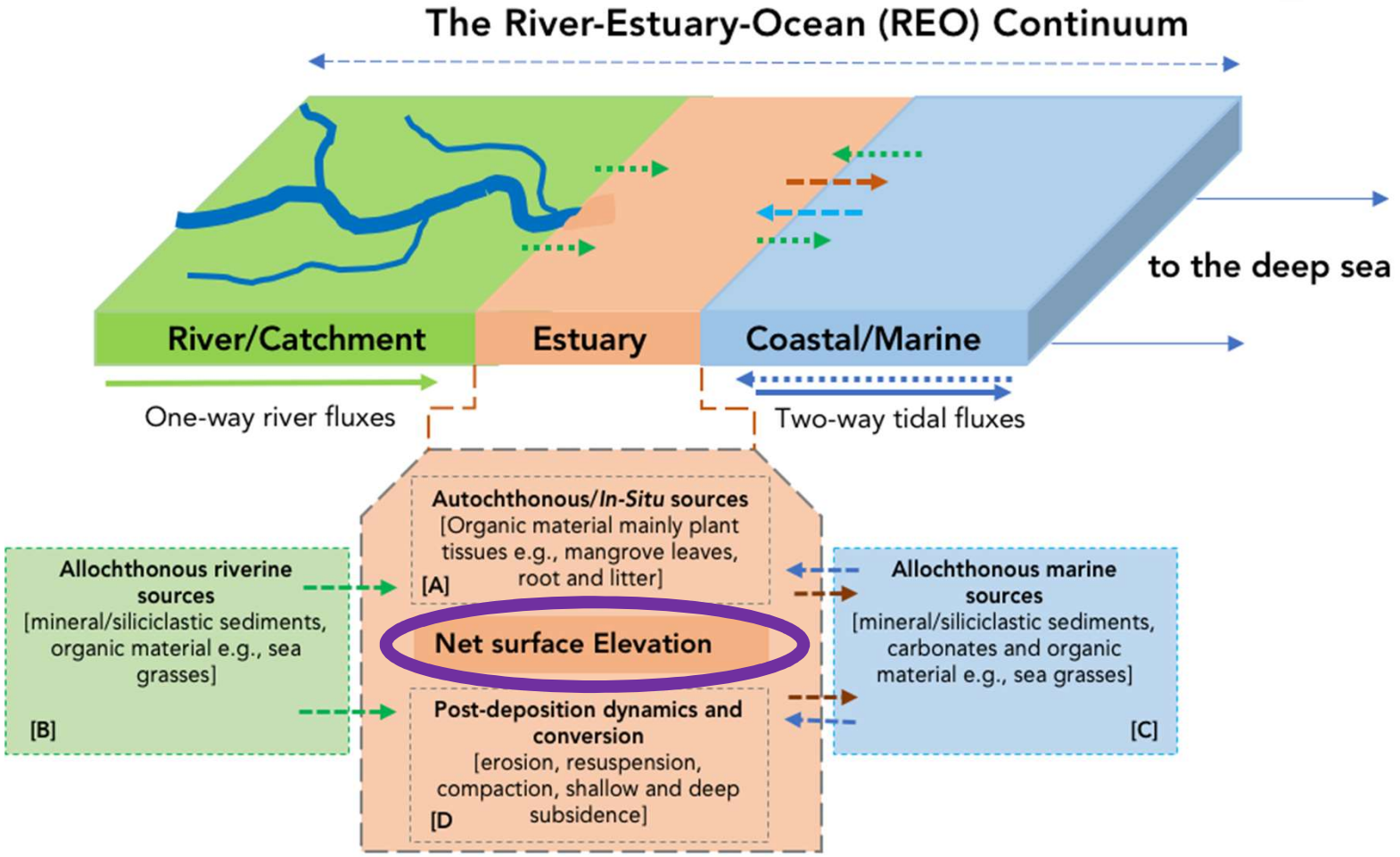
***Nature-based Solutions*: Ecosystem Services**



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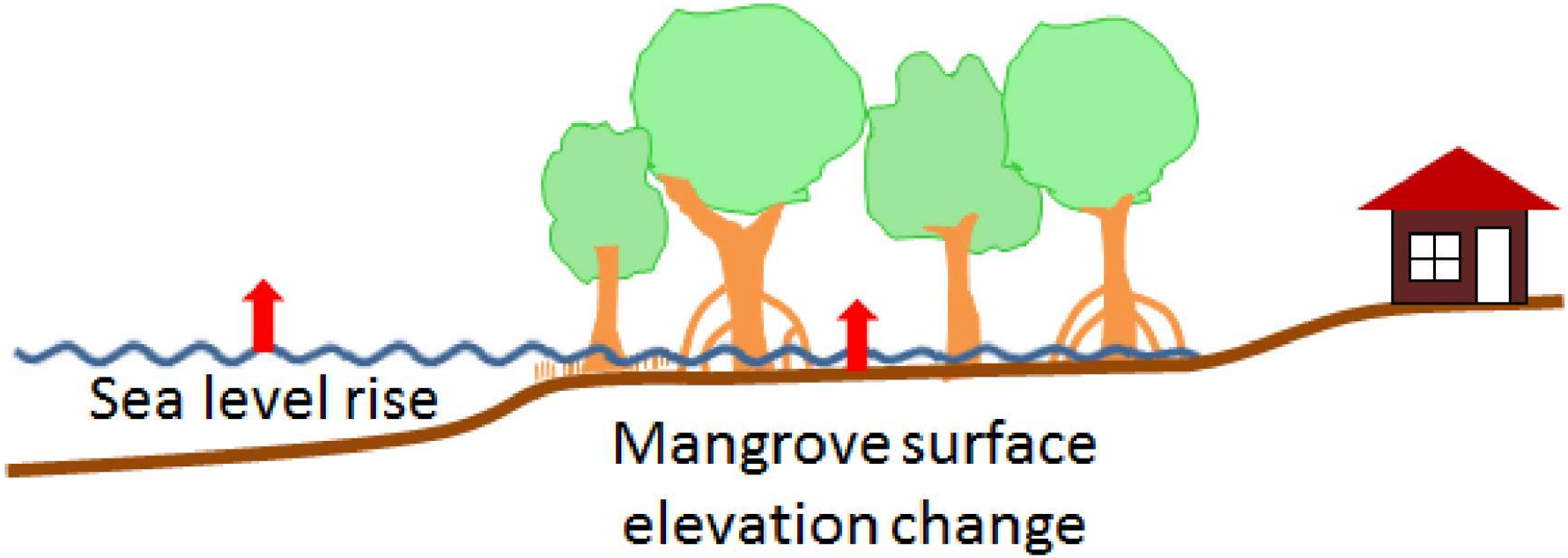
Kimeli A, Zimmer M. in press. Springer

***Nature-based Solutions*: Climate Change-Adaptation**



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McIvor et al. 2013. *National Coastal Protection Series*: Report 3

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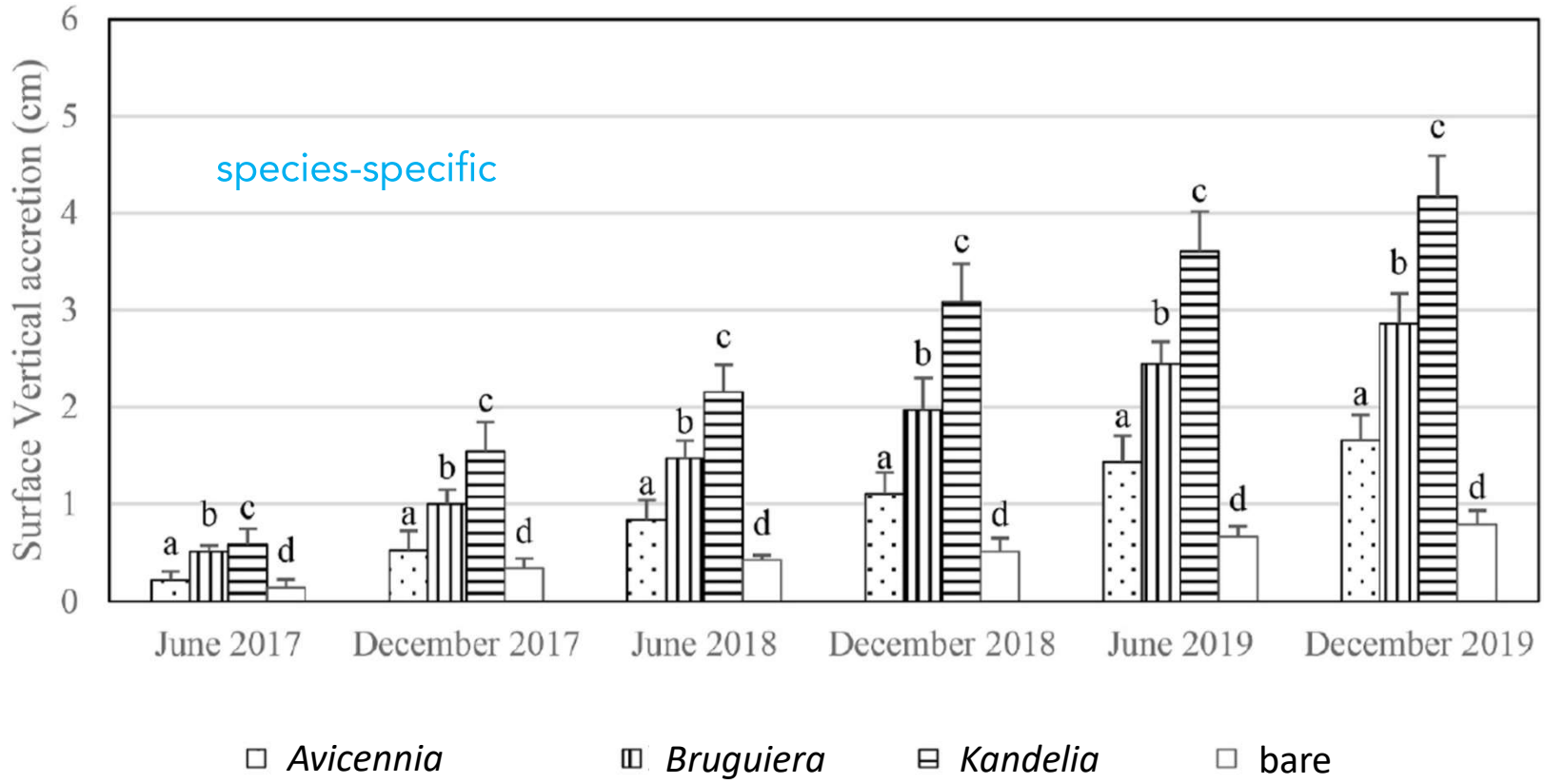

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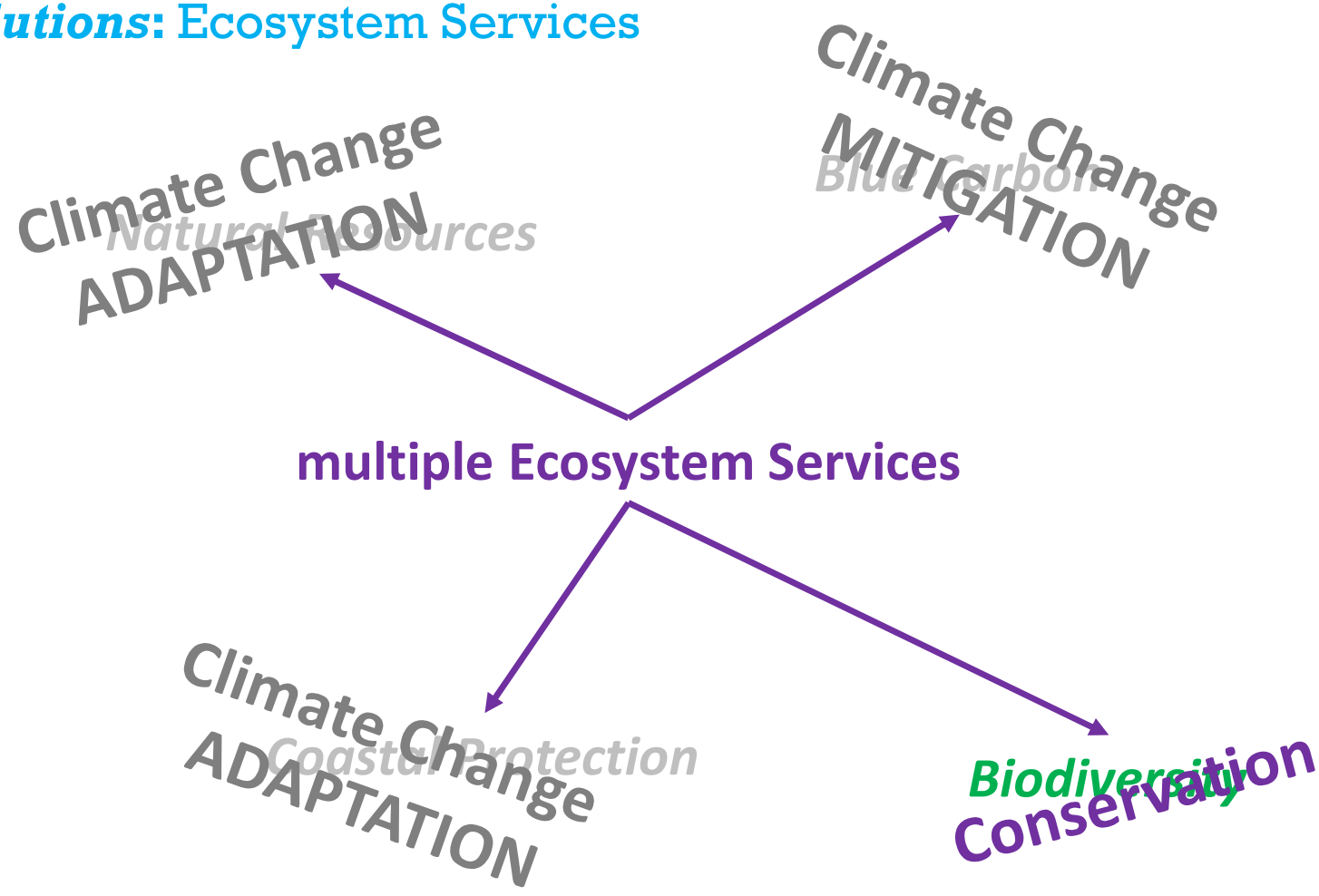
Du et al. 2021. *Est Coast Shelf Sci*

Nature-based Solutions: Ecosystem Services



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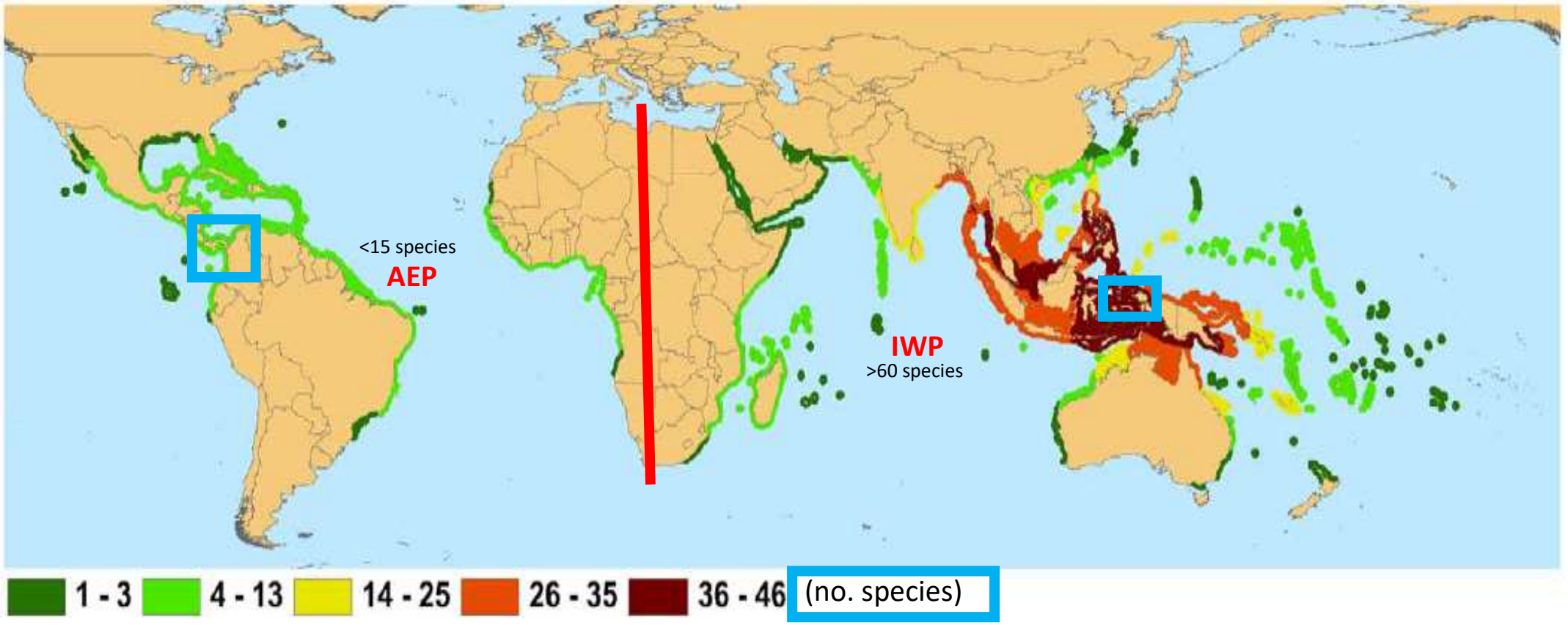

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Polidoro *et al.* 2010. *PLoS one*

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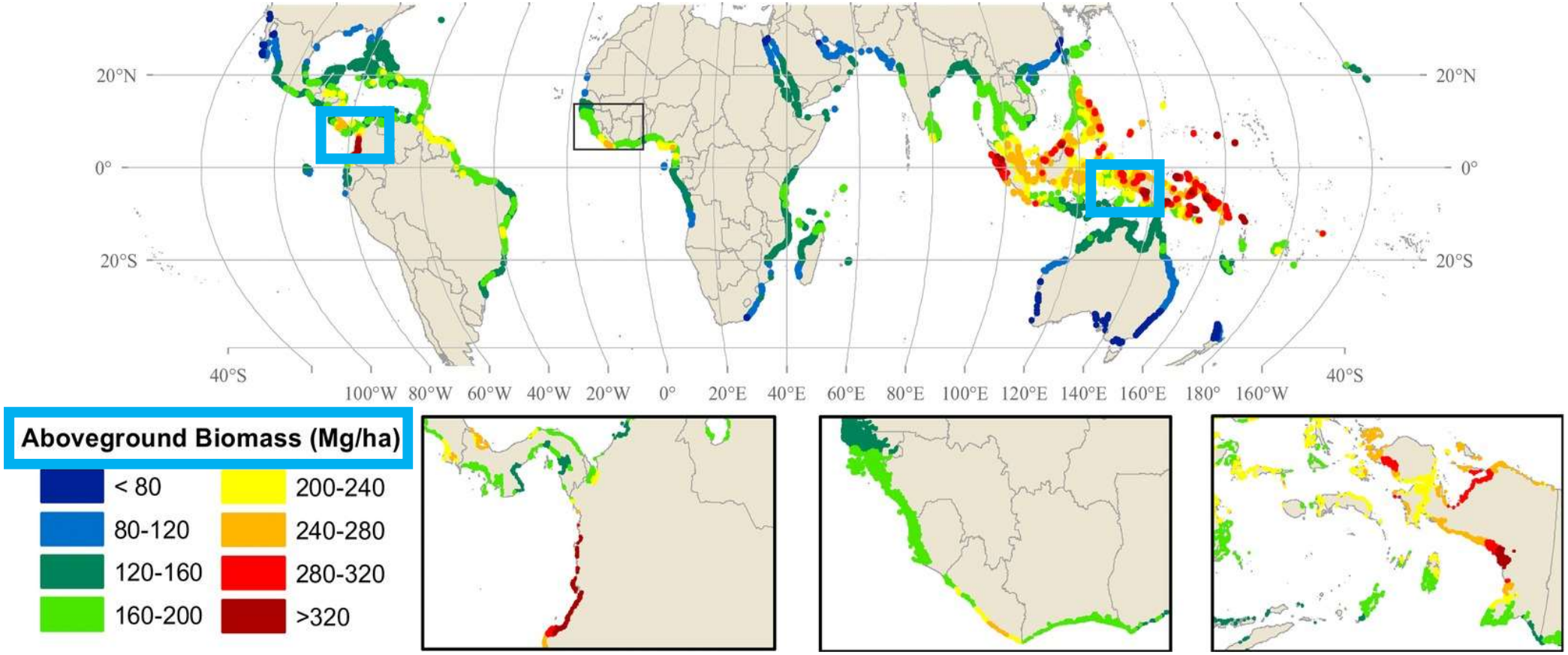

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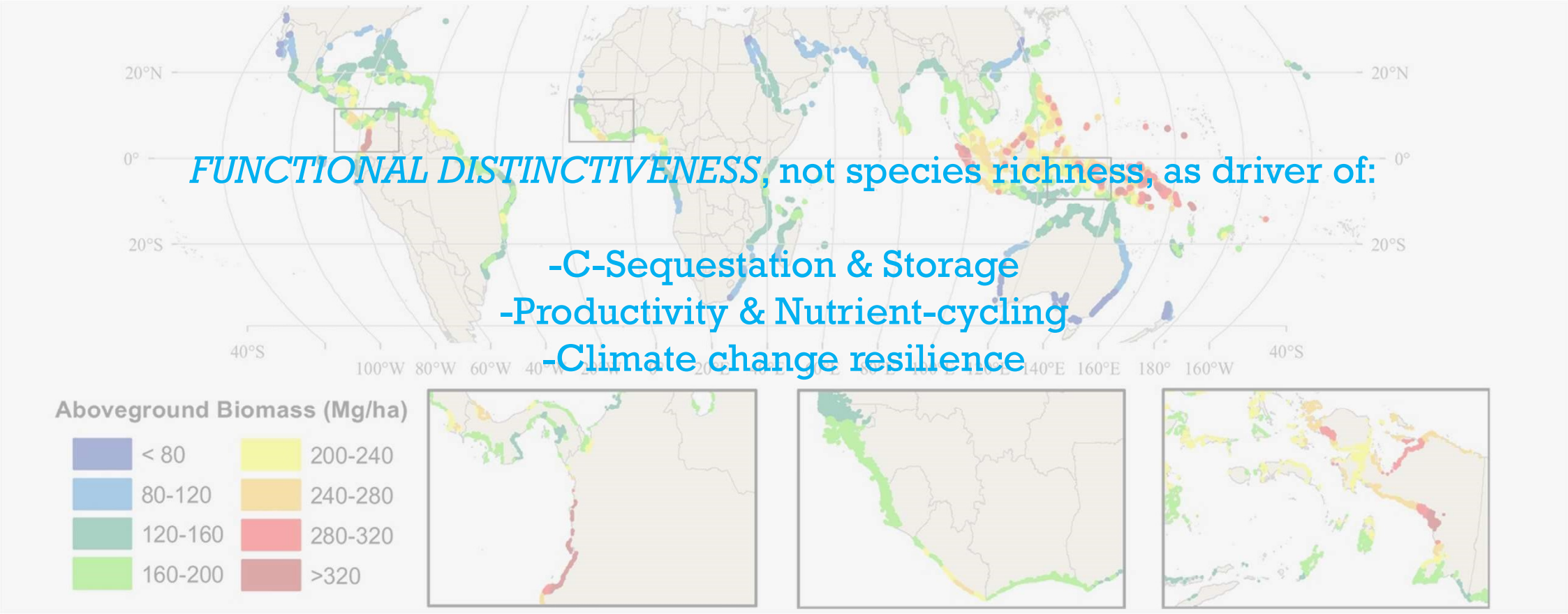
Hutchison *et al.* 2013. *Cons Lett*

Nature-based Solutions: Ecosystem Services



FUNCTIONAL DISTINCTIVENESS, not species richness, as driver of:

-C-Sequestation & Storage
-Productivity & Nutrient-cycling
-Climate change resilience

Quadros et al. 2021. *Biol Bull;* Rahman et al. 2021. *Nat Comm*
Rahman et al. 2024. *Global Change Biol*
Rahman et al. 2025. *in rev.*

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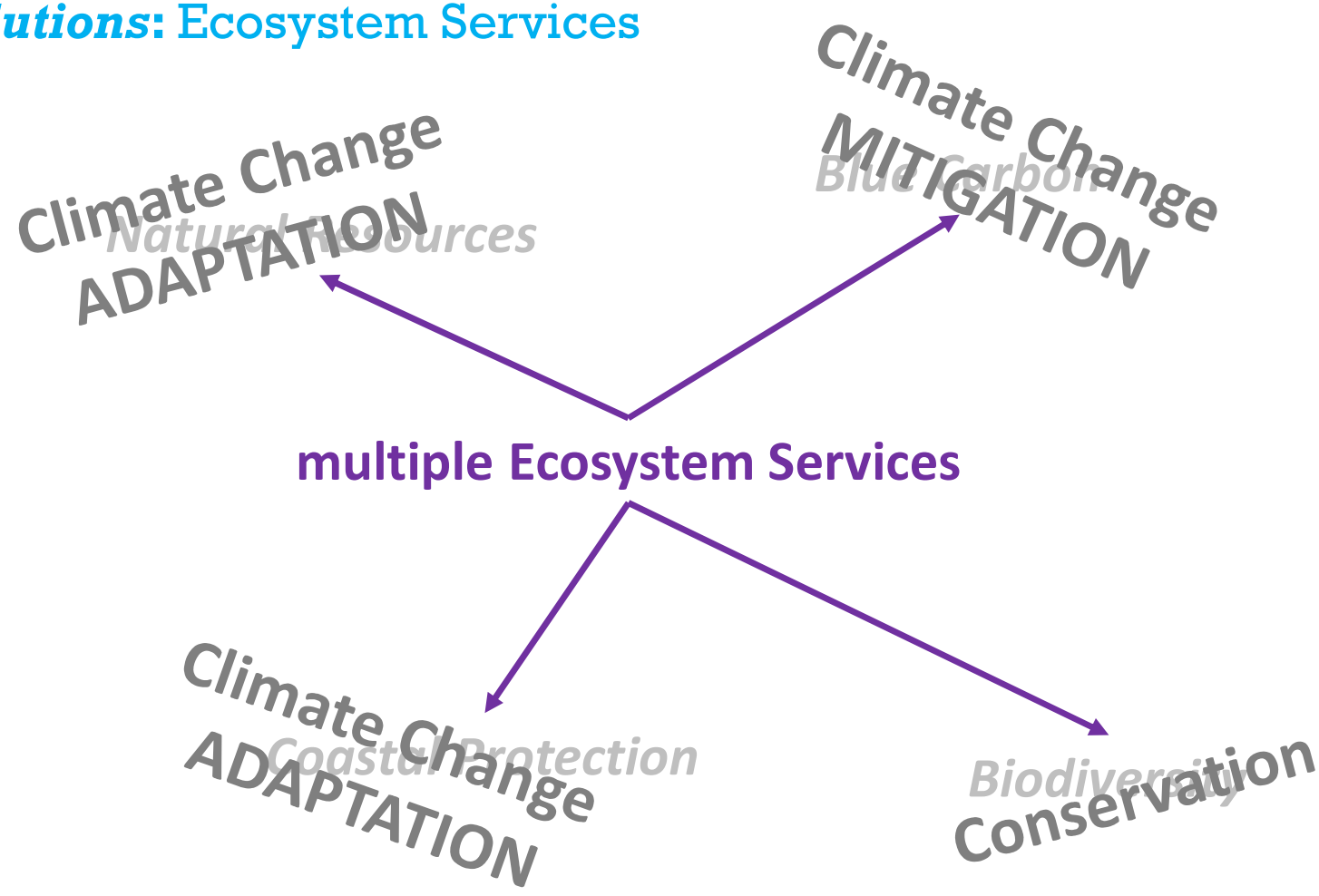
Nature-based Solutions: Ecosystem Services



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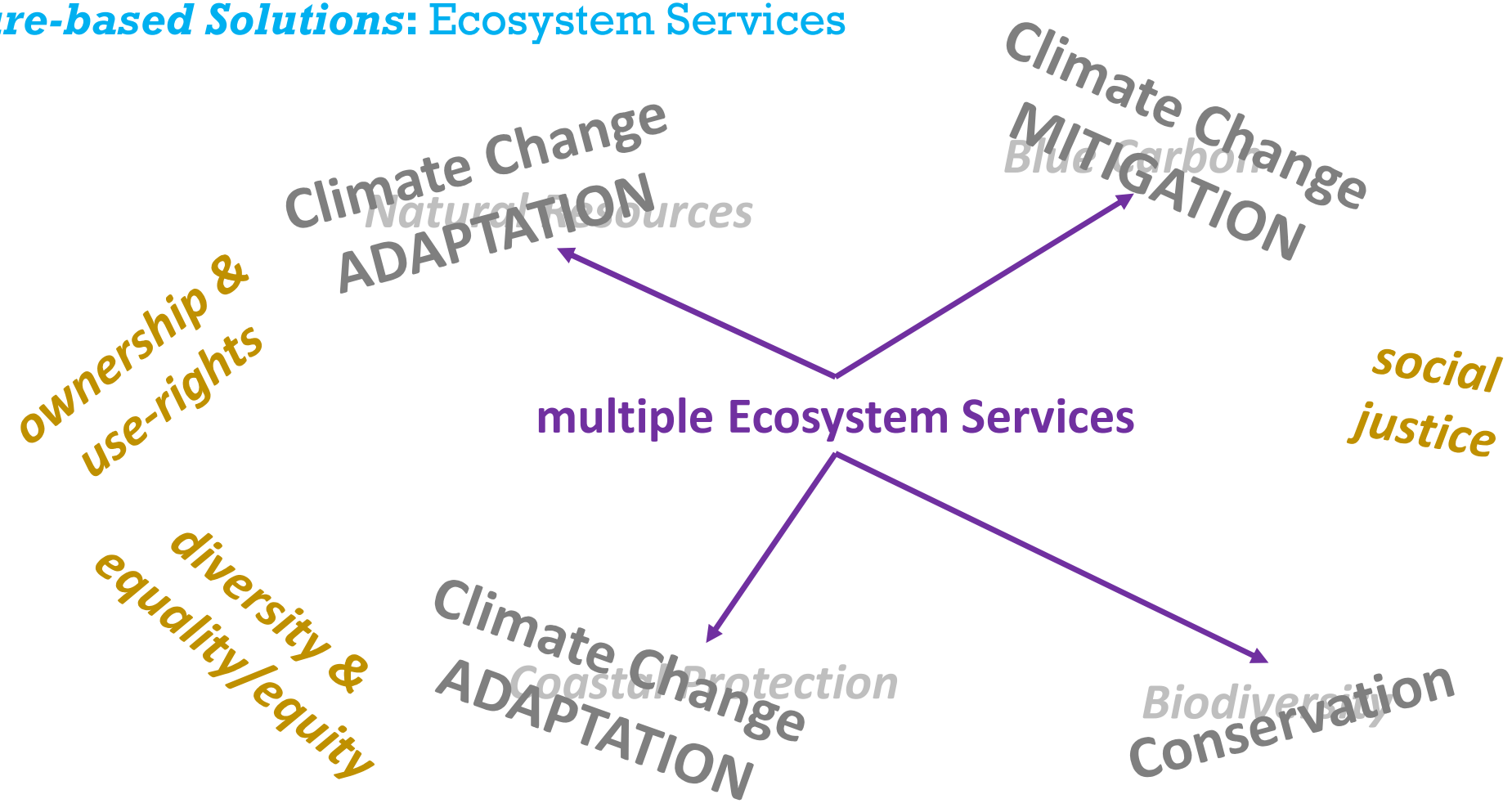

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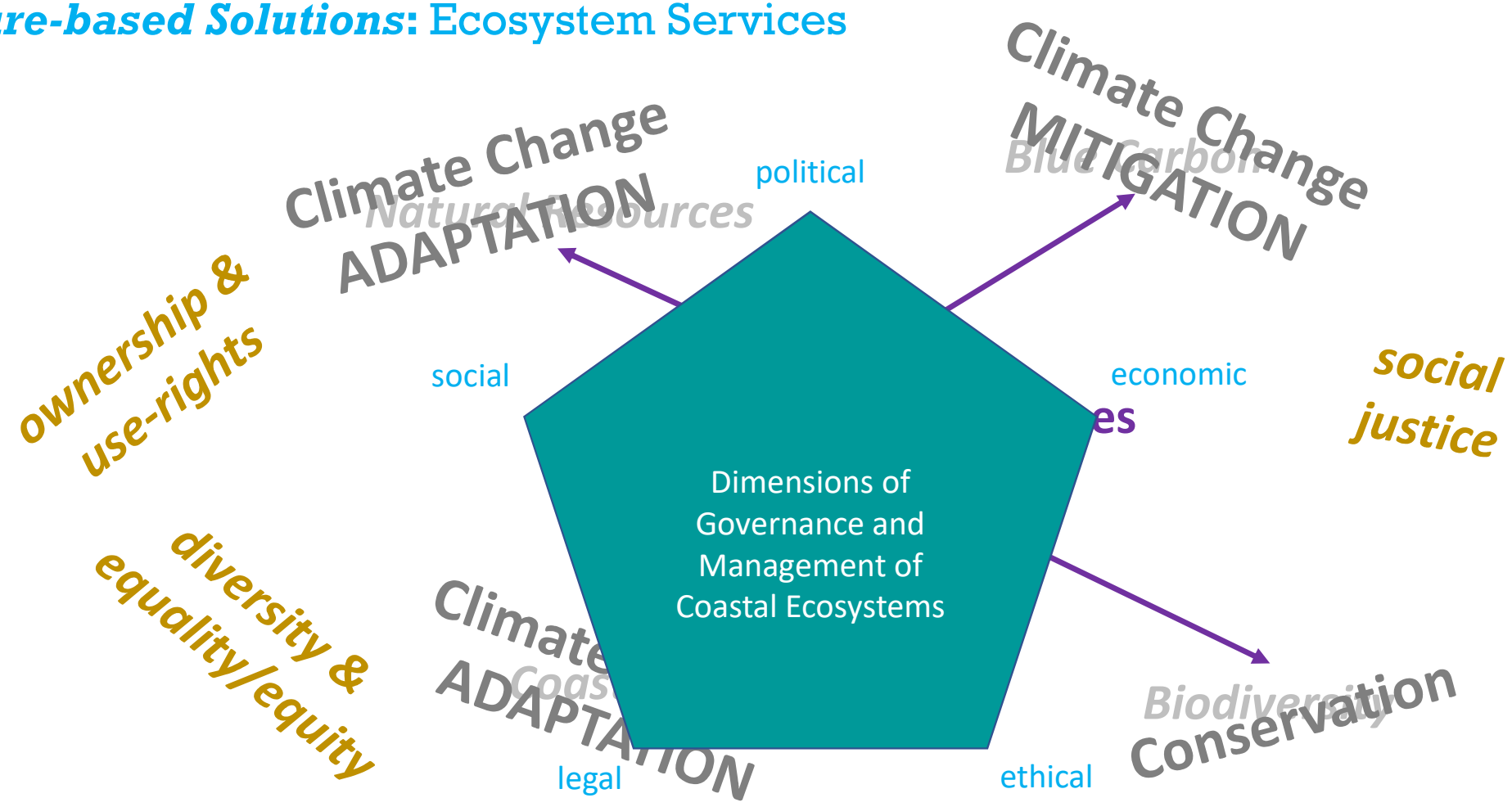
Nature-based Solutions: Ecosystem Services



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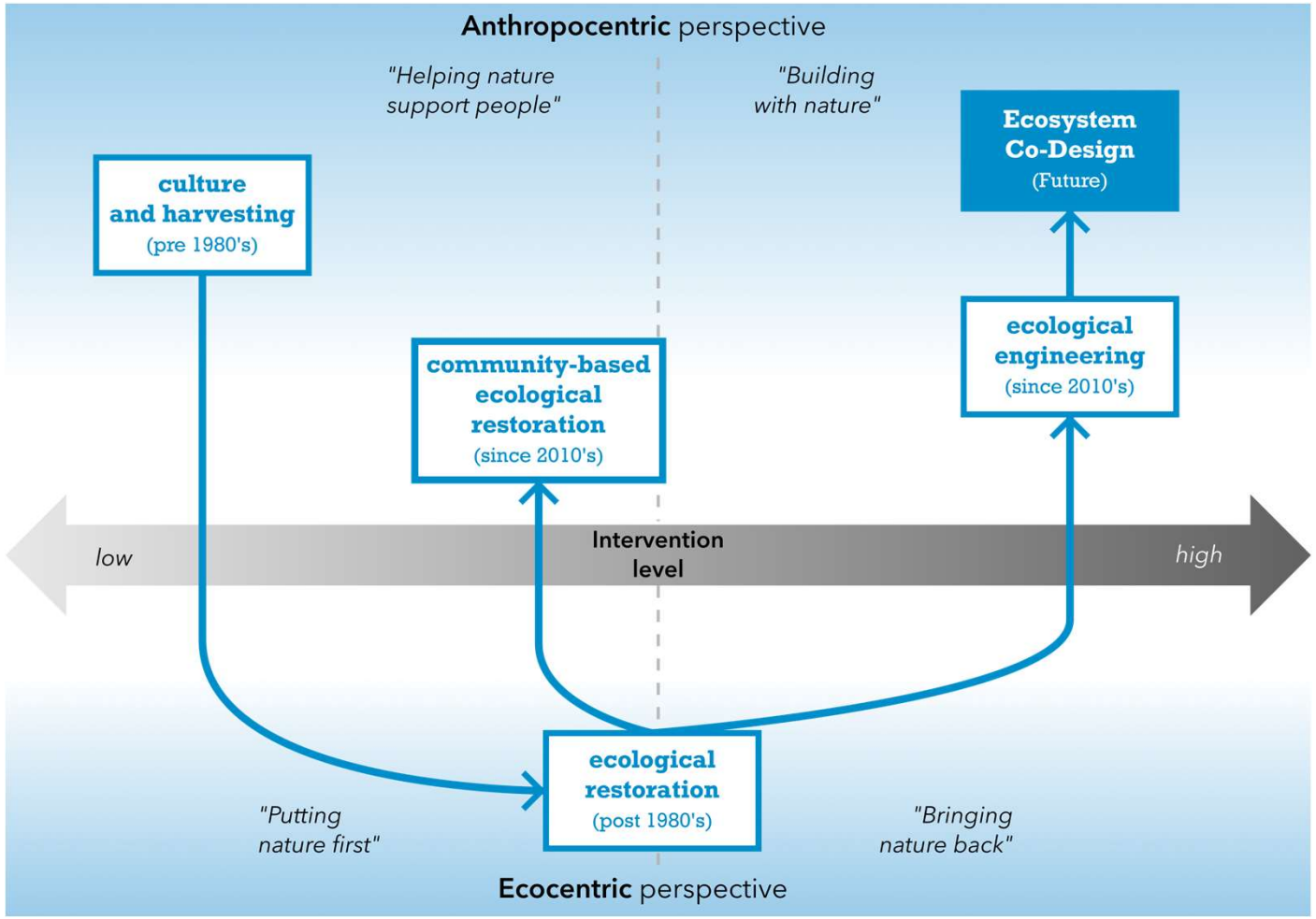
Nature-based Solutions: **Ecosystem Co-Design**



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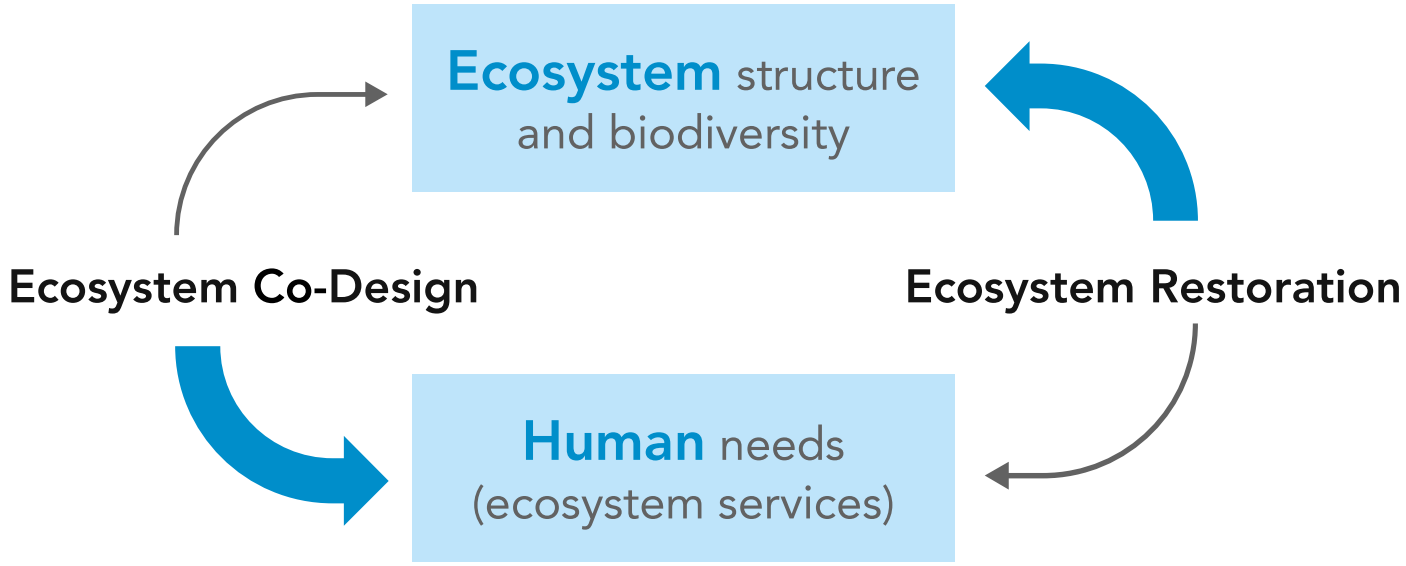
Modified after Ellison et al. 2020. *Front Mar Sci*

Ecosystem Co-Design

towards resilient coastal socio-ecological systems



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Ecosystem Co-Design & Coastal Resilience

Modified after Zimmer 2018. In: Makowski C, Finkl CW (eds). *Threats to Mangrove Forests: Hazards, Vulnerability and Management*

Collaborative Hubs

"we are not alone"

European Commission

ALL-ATLANTIC OCEAN RESEARCH ALLIANCE
Connecting | Acting | Cooperating

- cores of trans- and interdisciplinary research under local lead
- long-term innovation hubs in real-life environments
- collaborative iterative feedback processes

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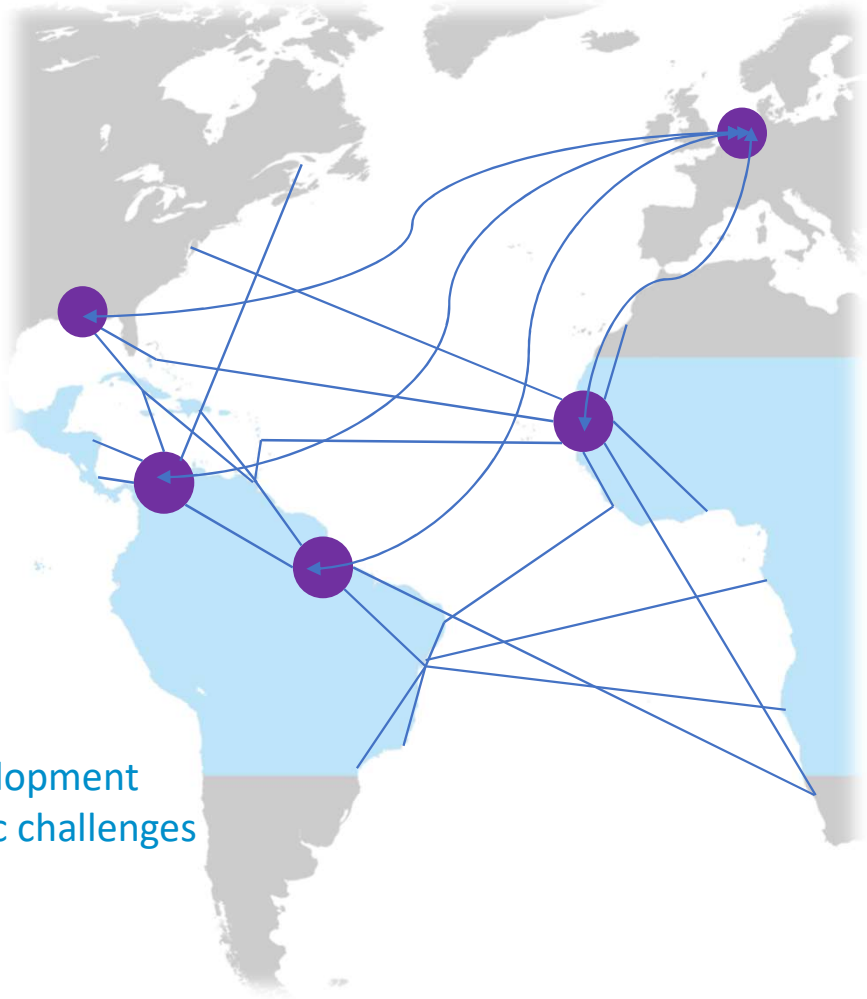
Collaborative Hubs

& living labs



- collaborative **network of networks**
  → **ECOP exchange** – training and mutual capacity development
- common and specific solutions to common and specific challenges
  → ***Ecosystem Co-Design*** **– pilot sites**

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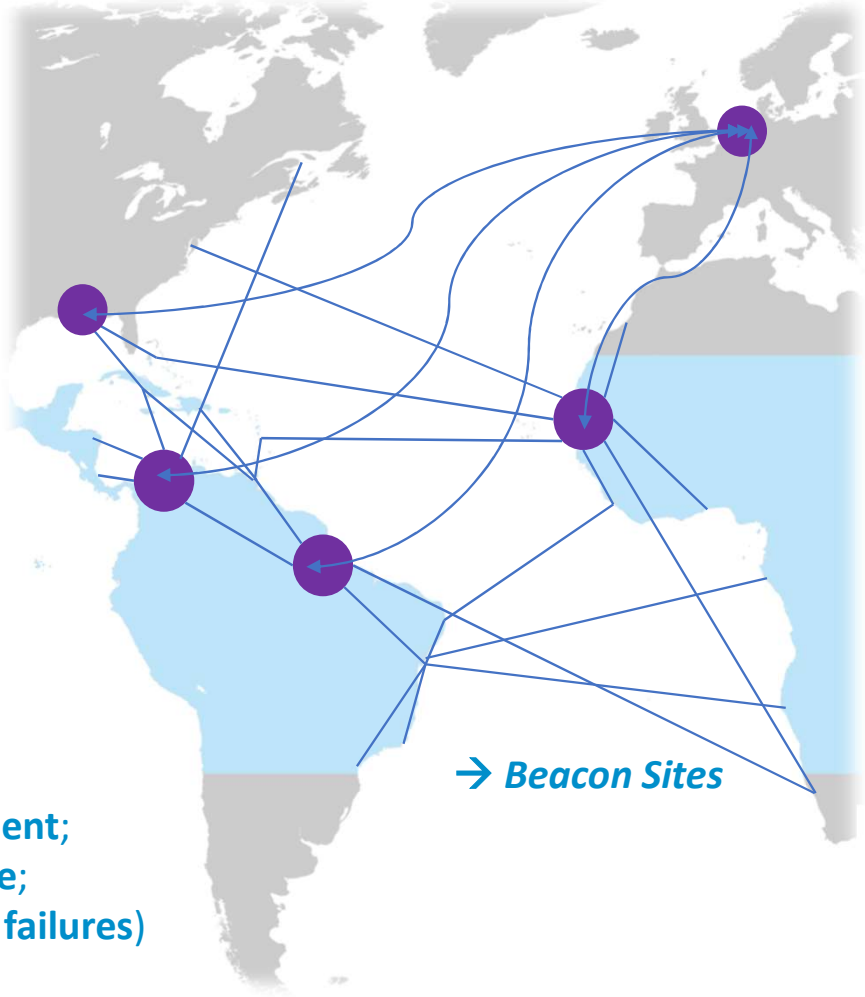
Collaborative Hubs

& living labs



→ ***Beacon Sites***

- collaborative network of networks
  → ***Ecosystem Co-Design***
- **across the Atlantic Ocean** – mutual **capacity development**;
  exchange of **resources & infrastructure**;
  exchange of experiences (**successes & failures**)

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Thank you!

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(courtesy of N. Moosdorf)

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