Mangroves

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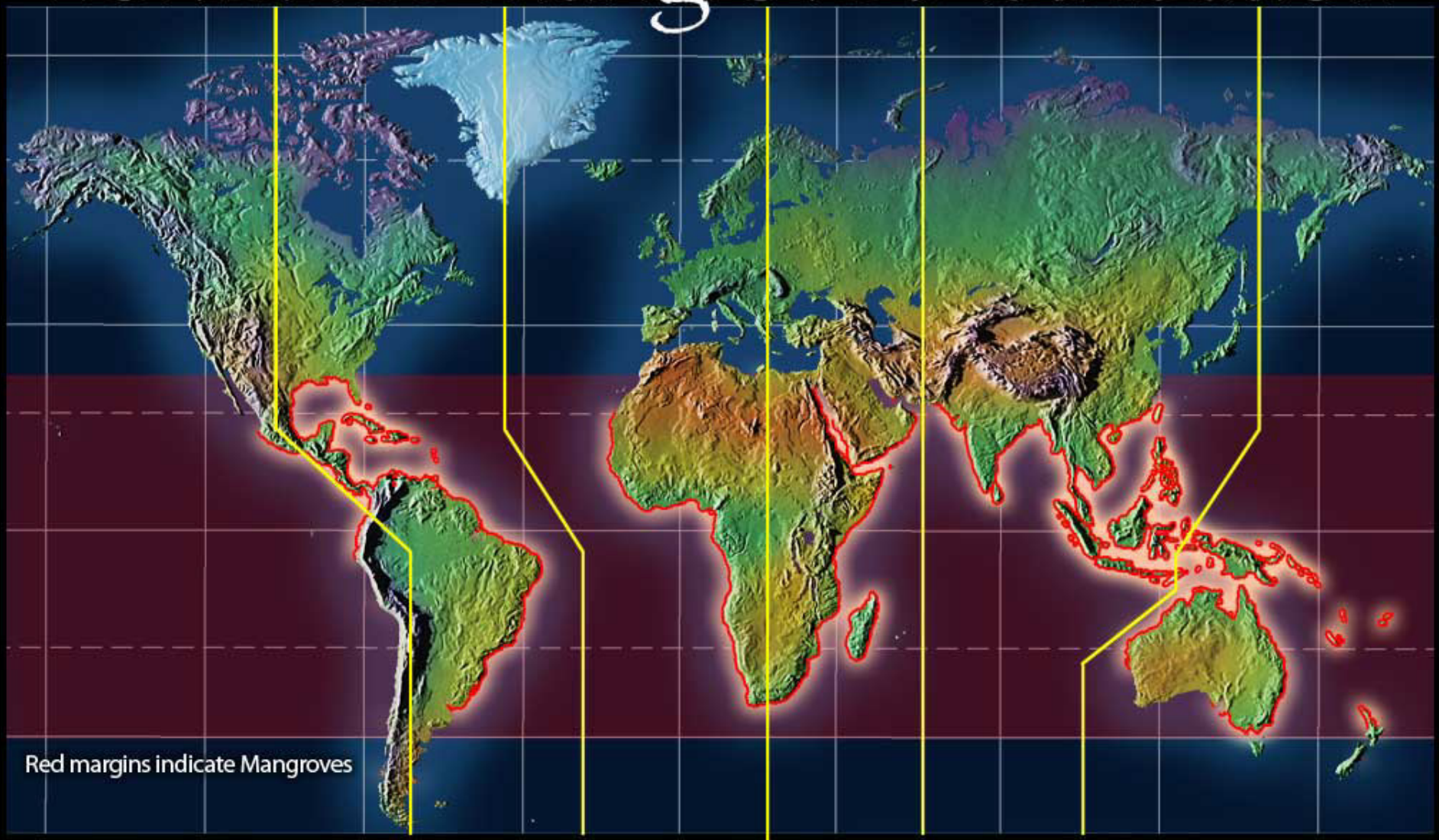
Mangroves

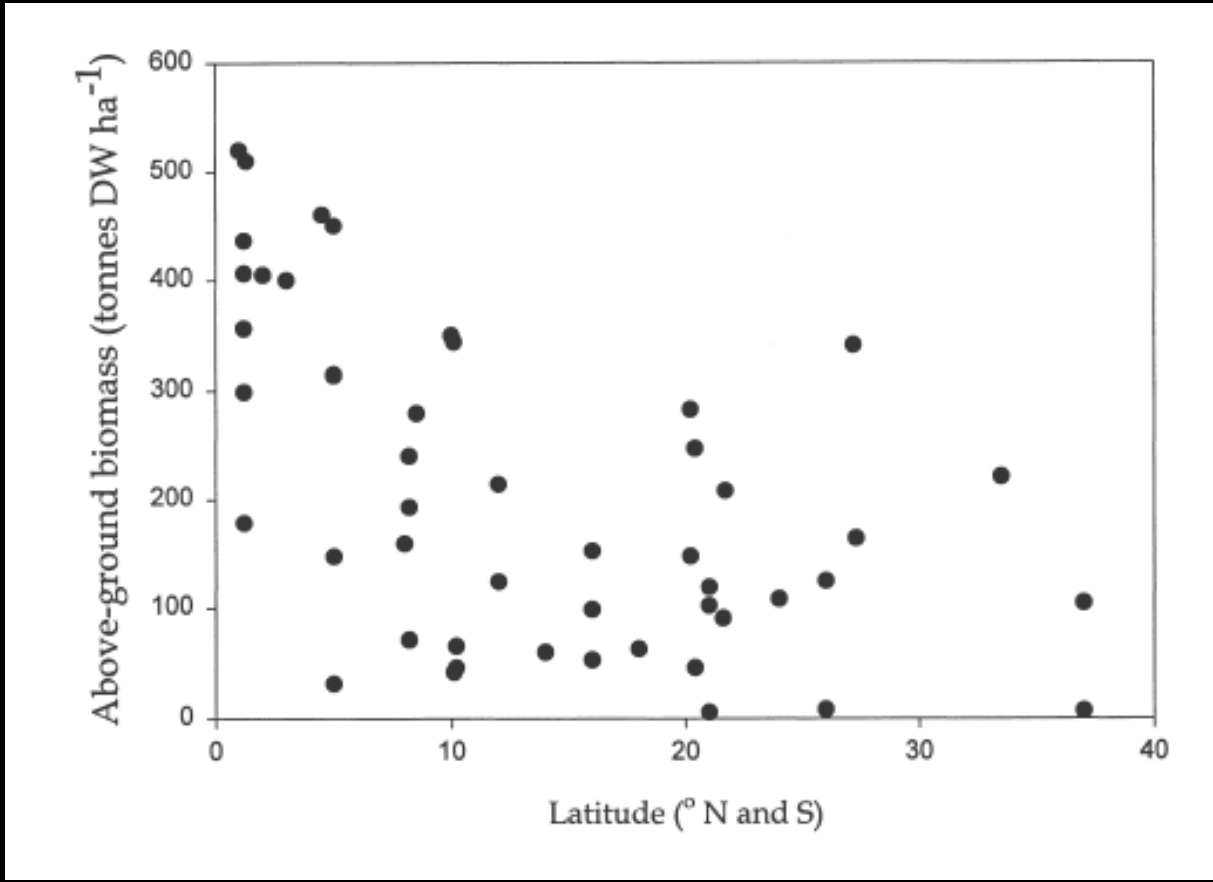
- *Overview of ecosystem*
- *Global distribution of ecosystem*
- *Basics of carbon storage and sequestration*
- *How much, where in the system, sources of variance?*
- *Relevant carbon cycle details - what is the fate of carbon in degraded or impacted systems?*
- *State of knowledge of carbon sequestration and storage in these systems?*

Worldwide Mangrove Distribution



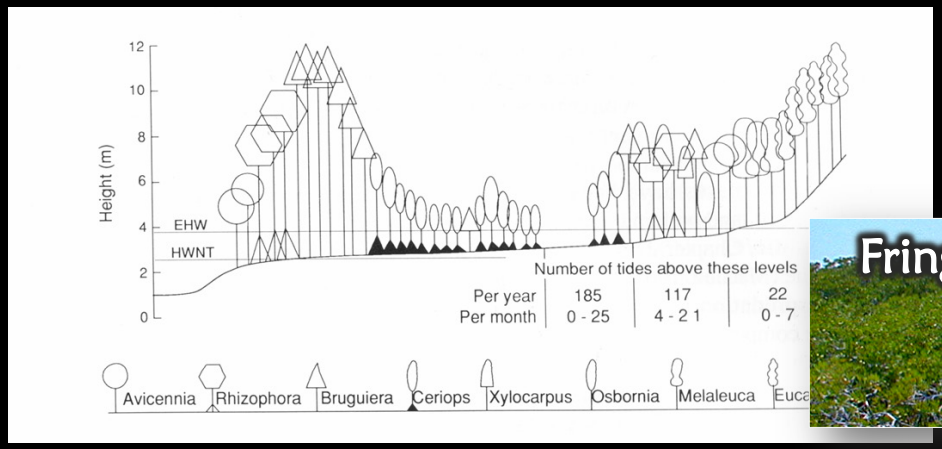
Adapted from Duke 1992

Variation in biomass with latitude



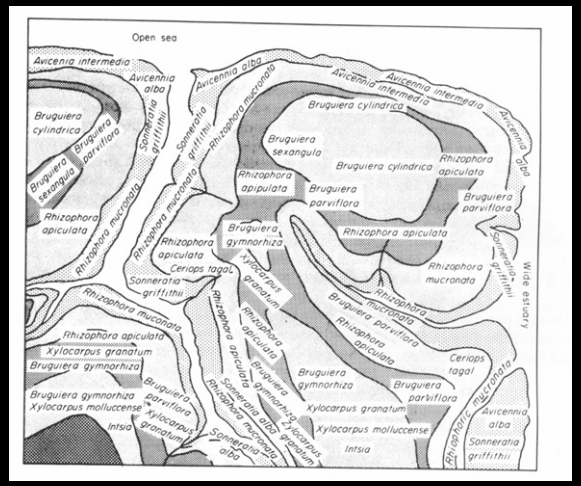
Heterogeneous communities:

1. Strong gradients in tree height and productivity

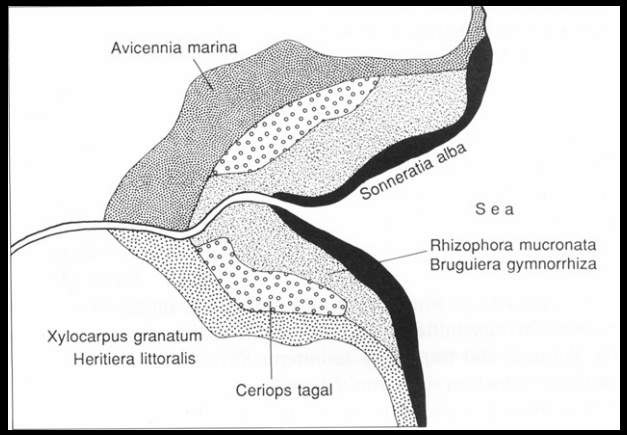


Macnae 1969

2. Species zonation

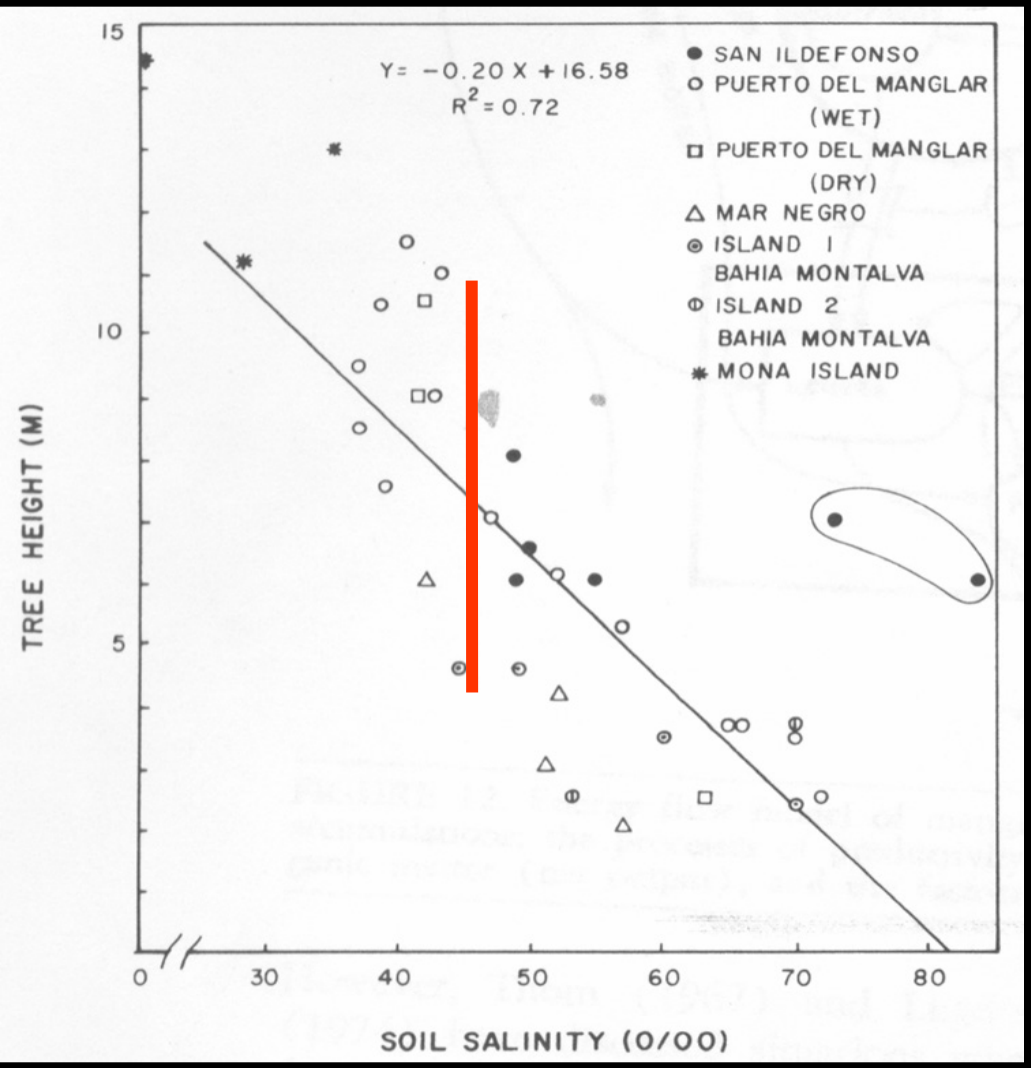


Watson 1928



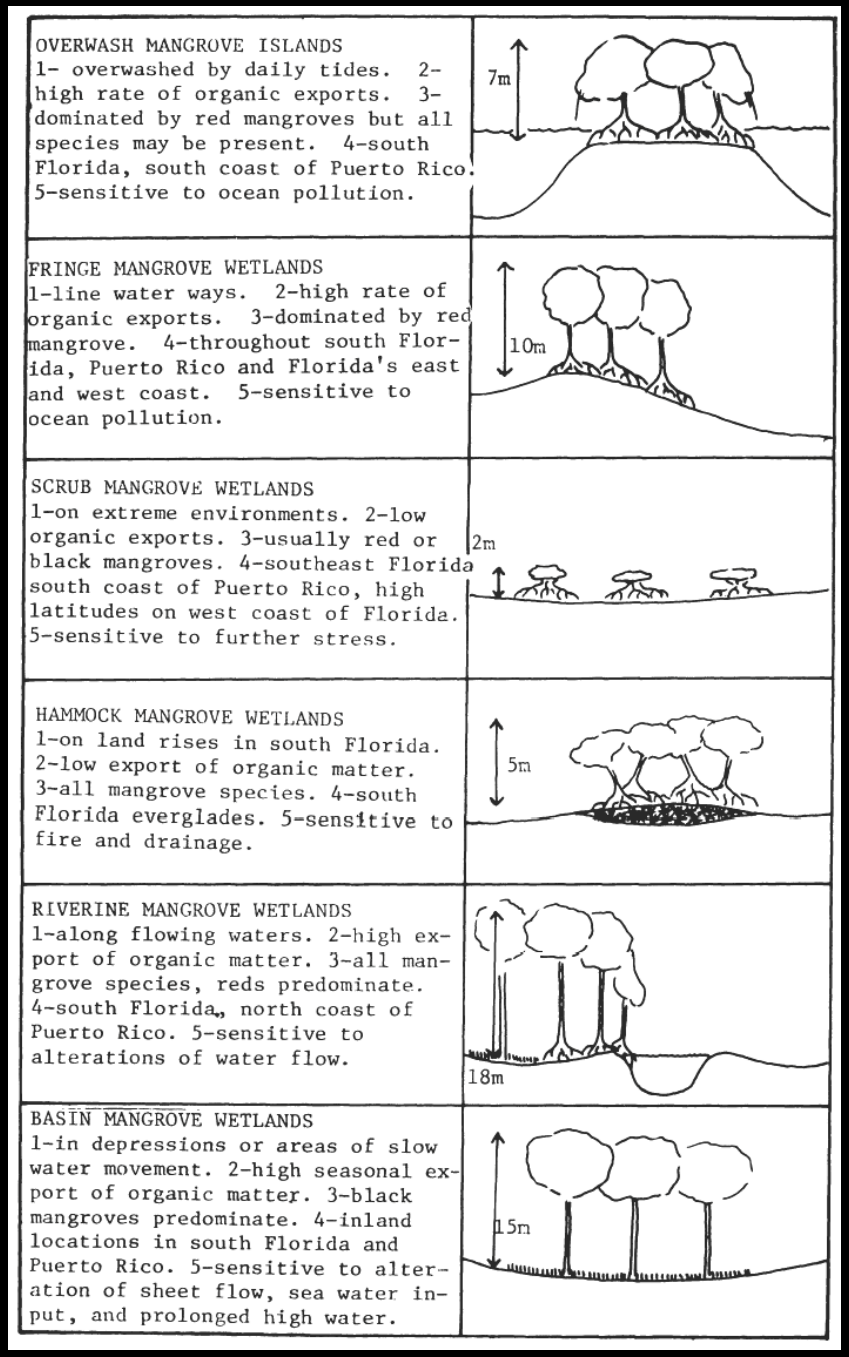
Grewe 1941

Salinity, nutrient availability, inundation



Cintron et al. 1978

Mangrove Classifications



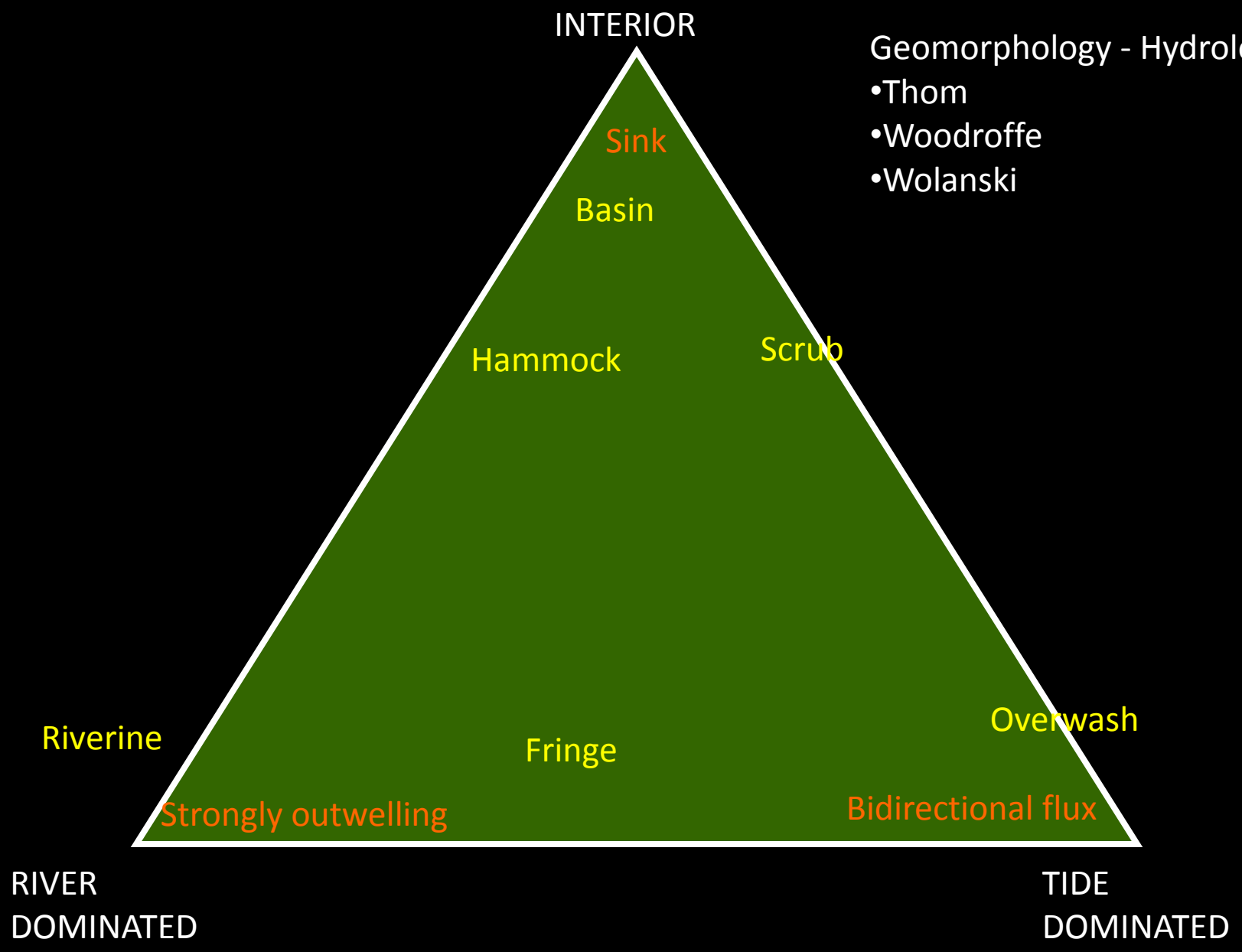
Seaward position:

- Fringe
  - ❖riverine,
  - ❖oceanic,
  - ❖overwash

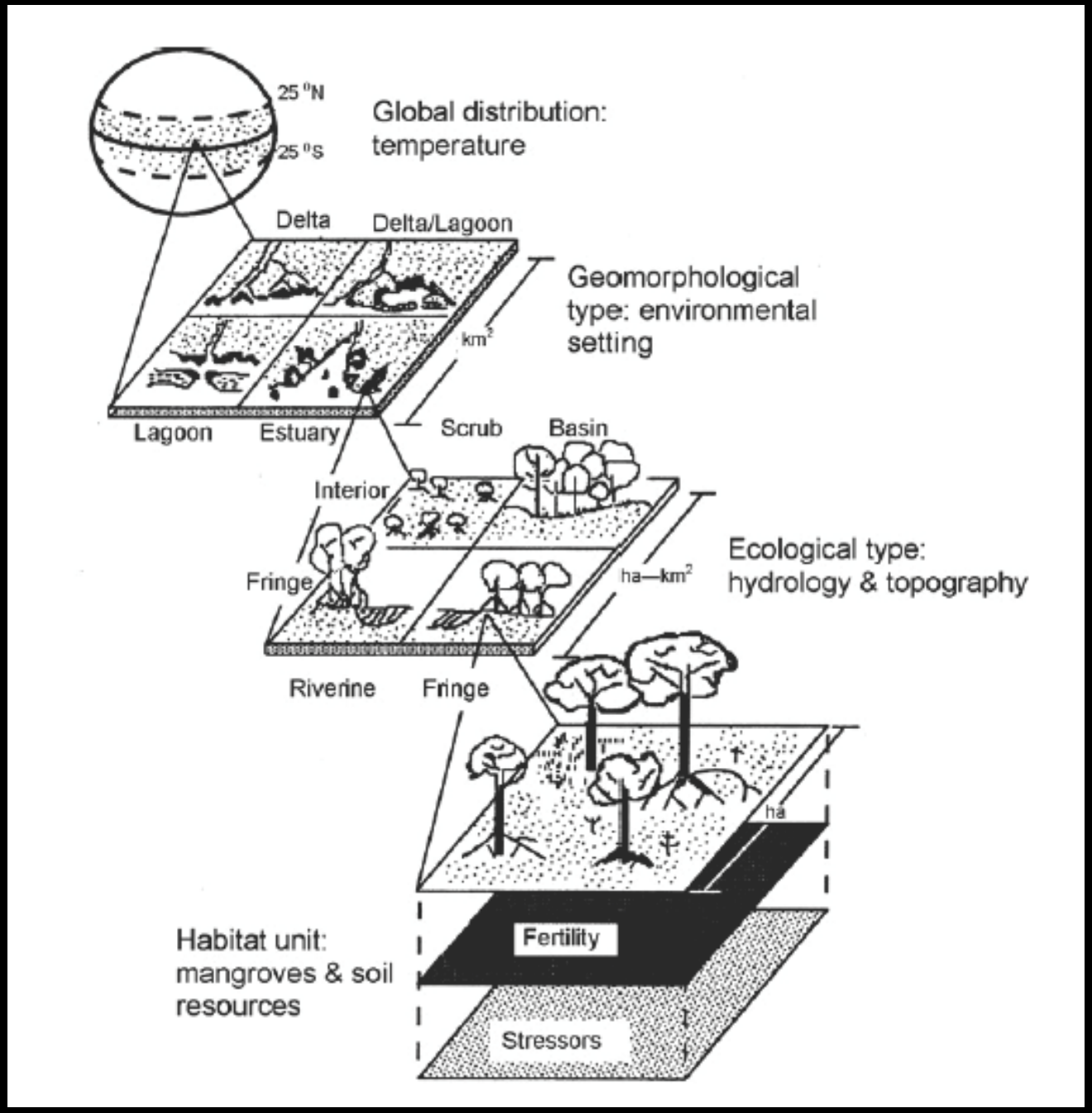
- Landward positions:
- Scrub
- Basin

Lugo and Snedaker 1974

Mangrove environments and exchange with land and sea:

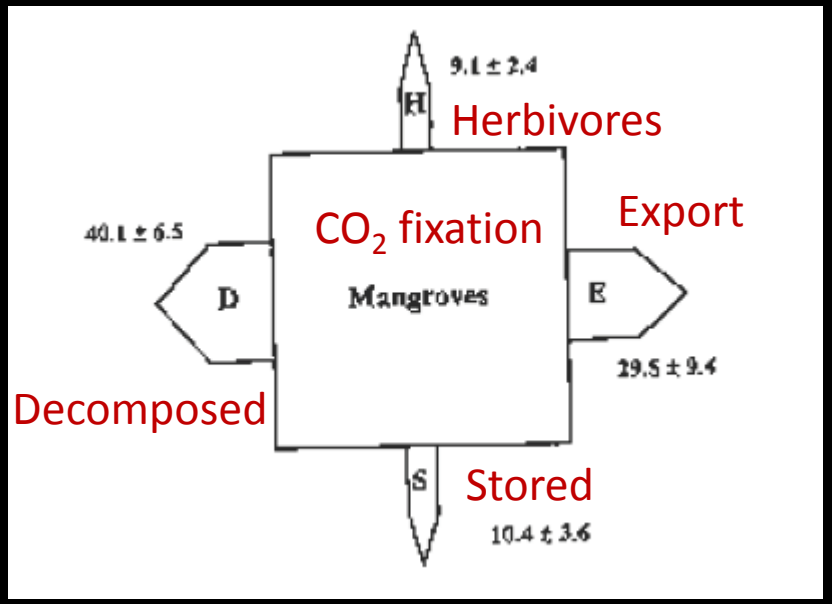


Geomorphology - Hydrology
- Thom
- Woodroffe
- Wolanski



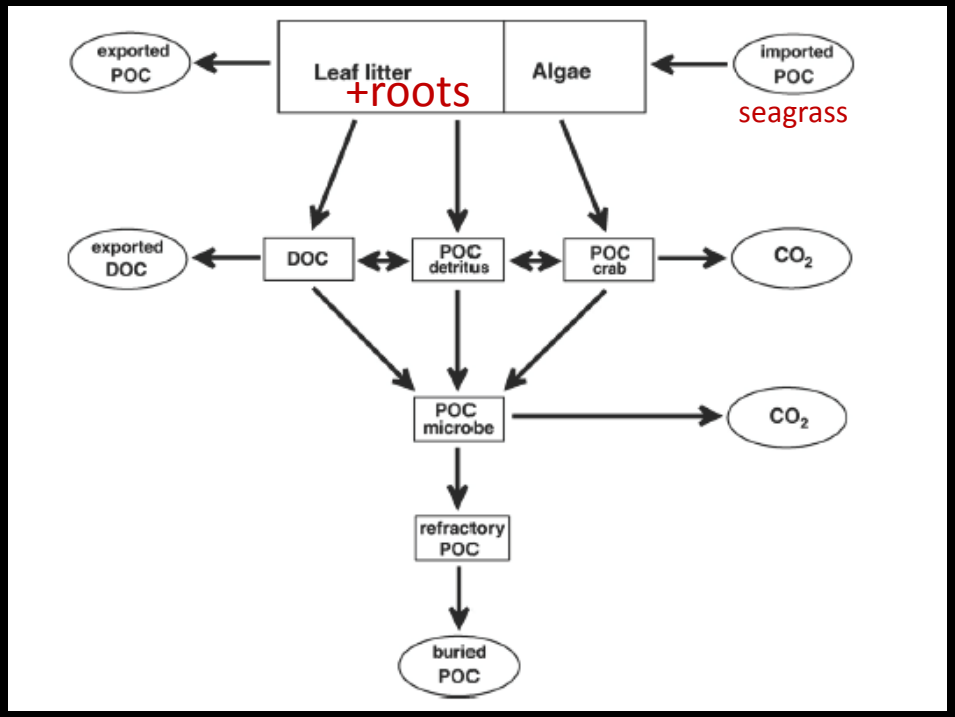
Twilley et al. 1998

Carbon budgets



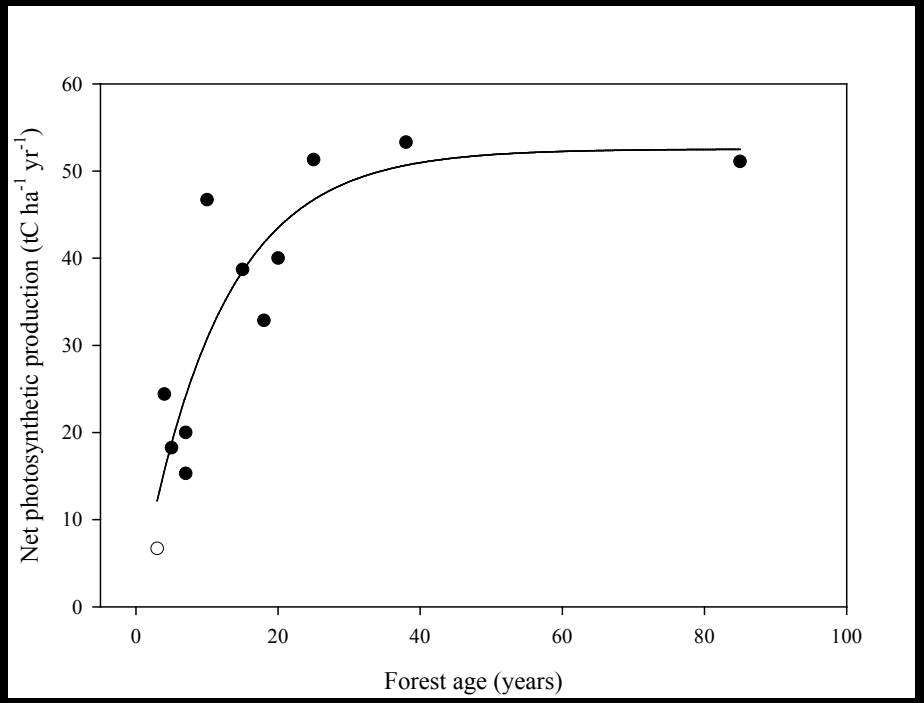
Global 1.1 Pg C yr^{-1}
NPP mangroves 1.1 based on 1.1 x 106 km^2
Storage in mangroves 0.11 Pg

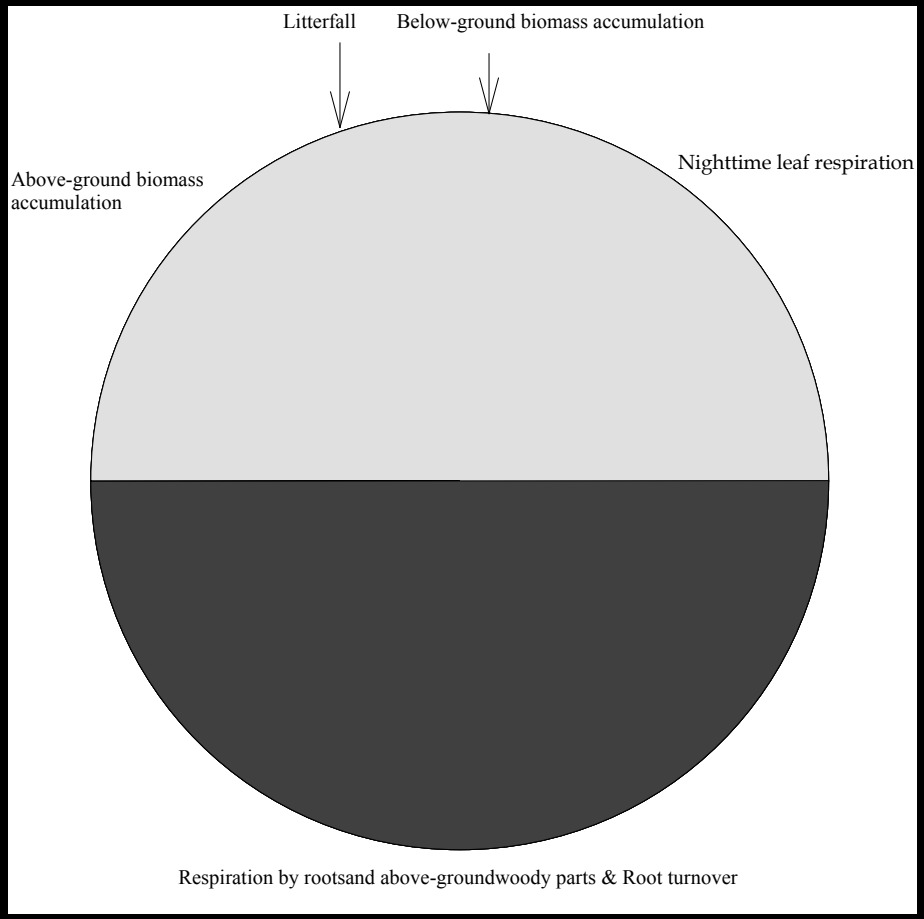
Duarte and Cebrian 1996



Boullion et al. 2008

CO_2 fixation and growth of trees

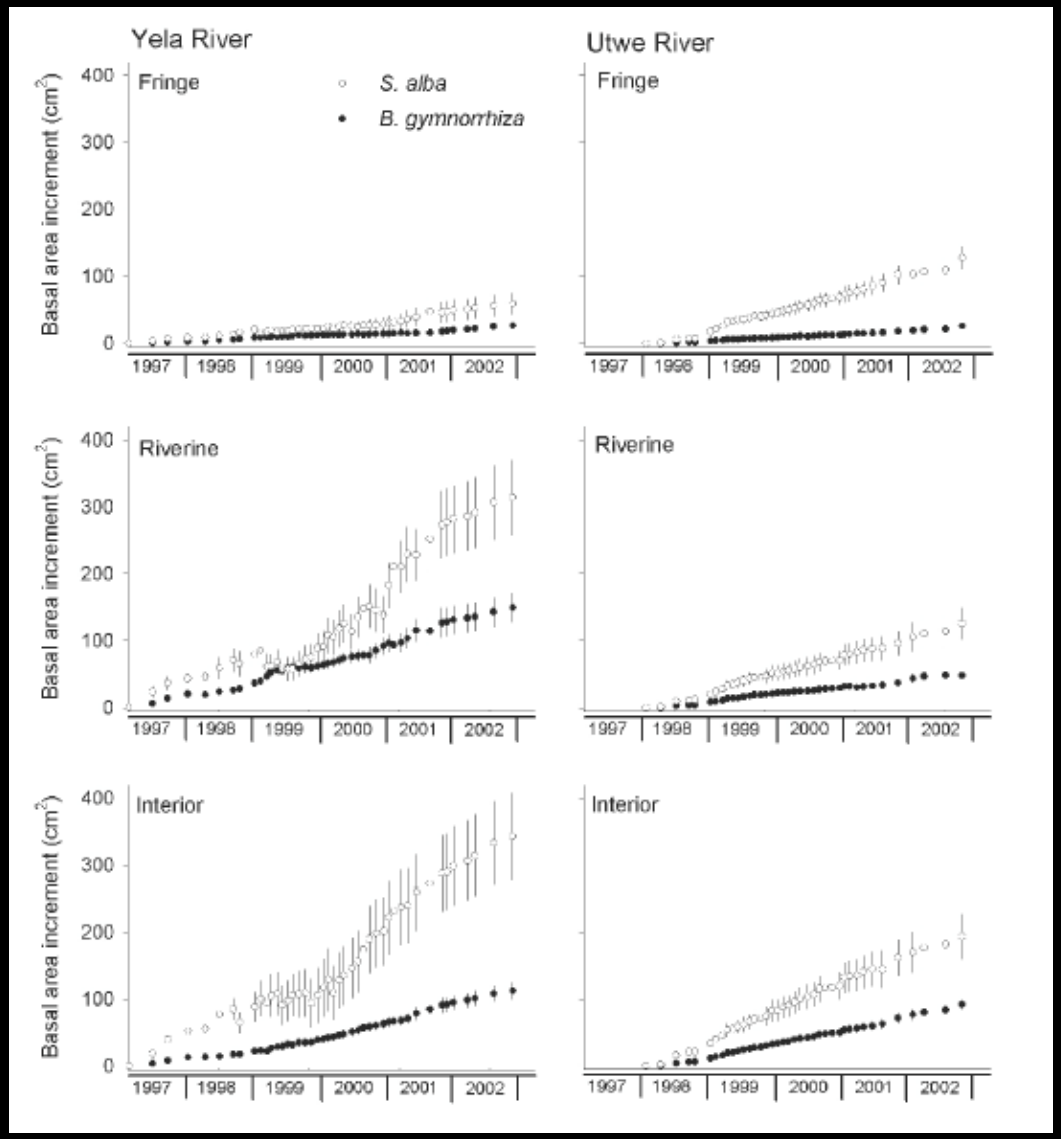




- Most C is respired
- ~20% remains in the biomass
- Most is in the above-ground components

Alongi 2010

Woody biomass increments



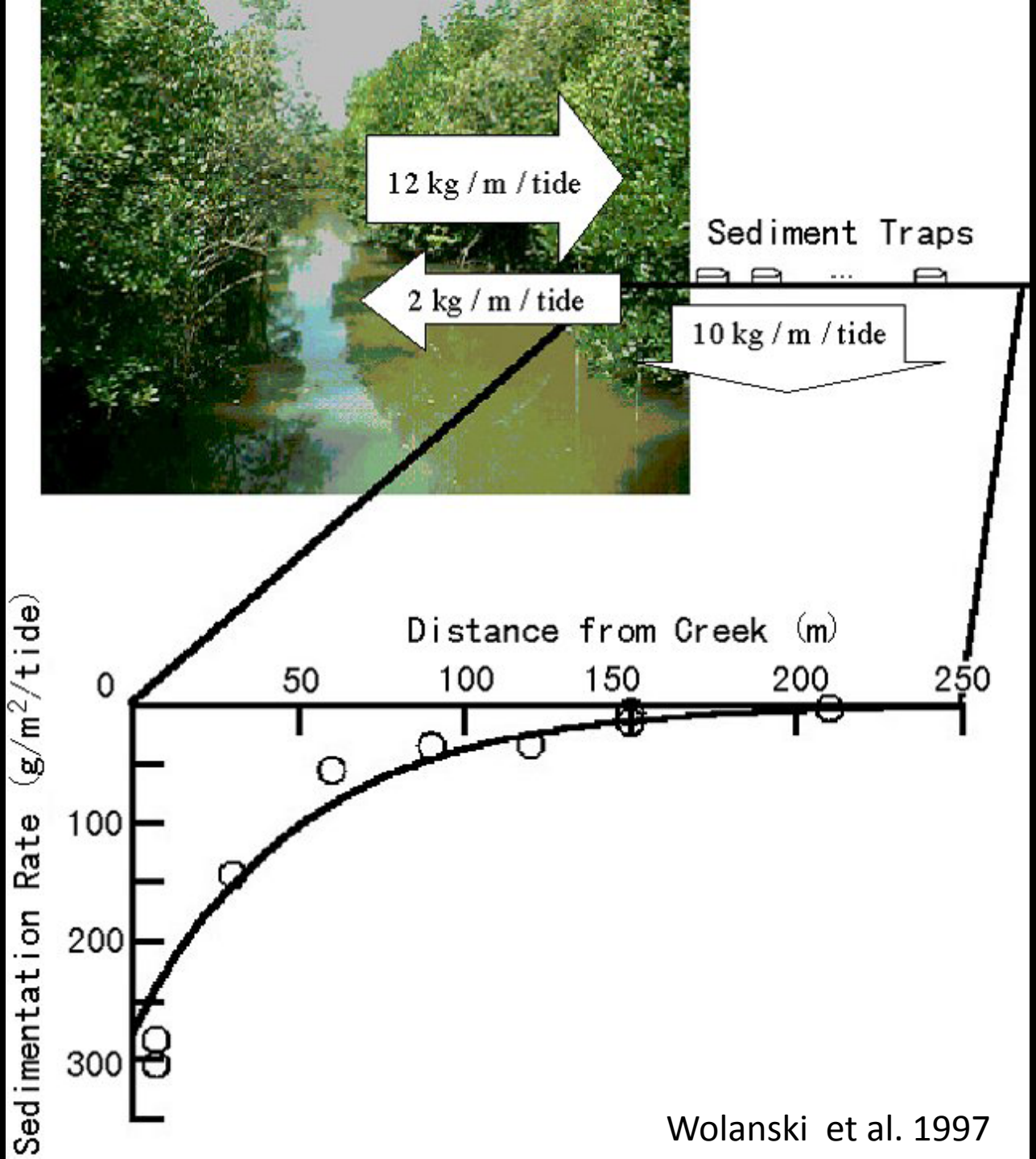
- Varies among species
- Varies with environment
- Varies over time

C stored - Roots and sediments

Biophysical controls on accretion and elevation change in Caribbean mangrove ecosystems

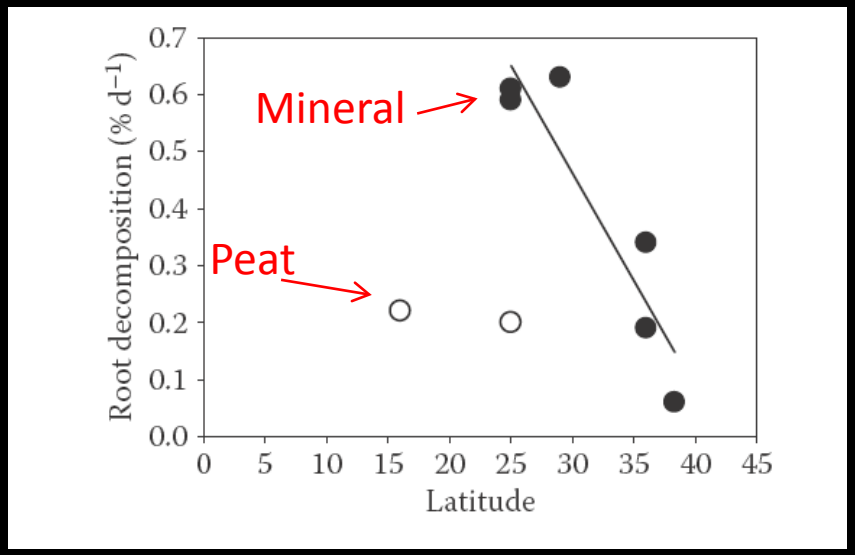
Karen L. McKee (2010)

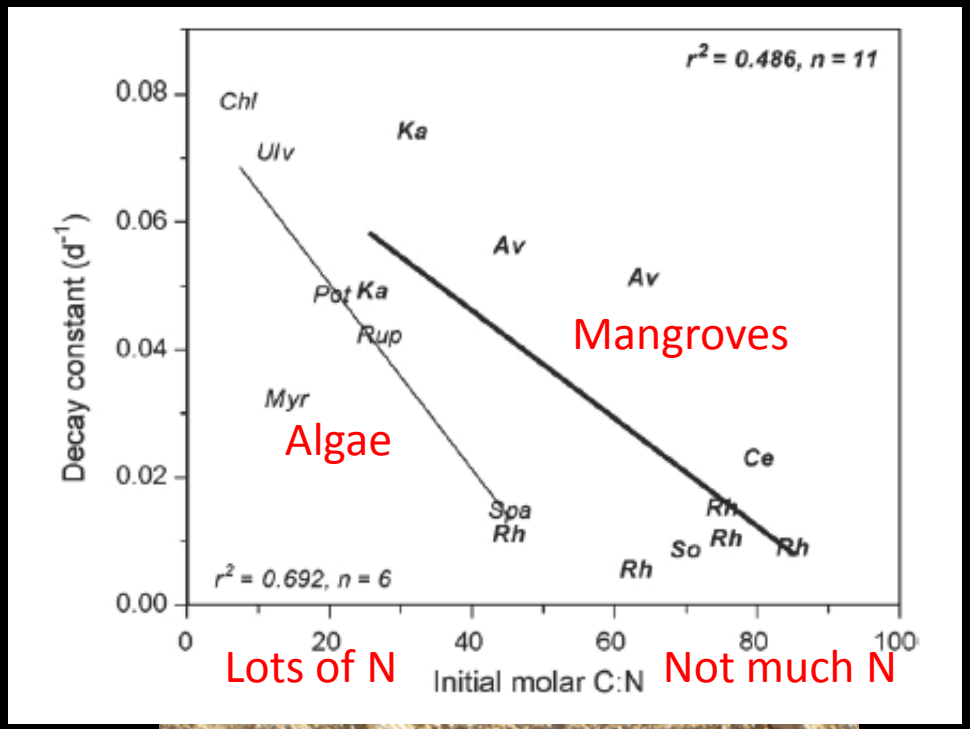
Indo-Pacific



Wolanski et al. 1997

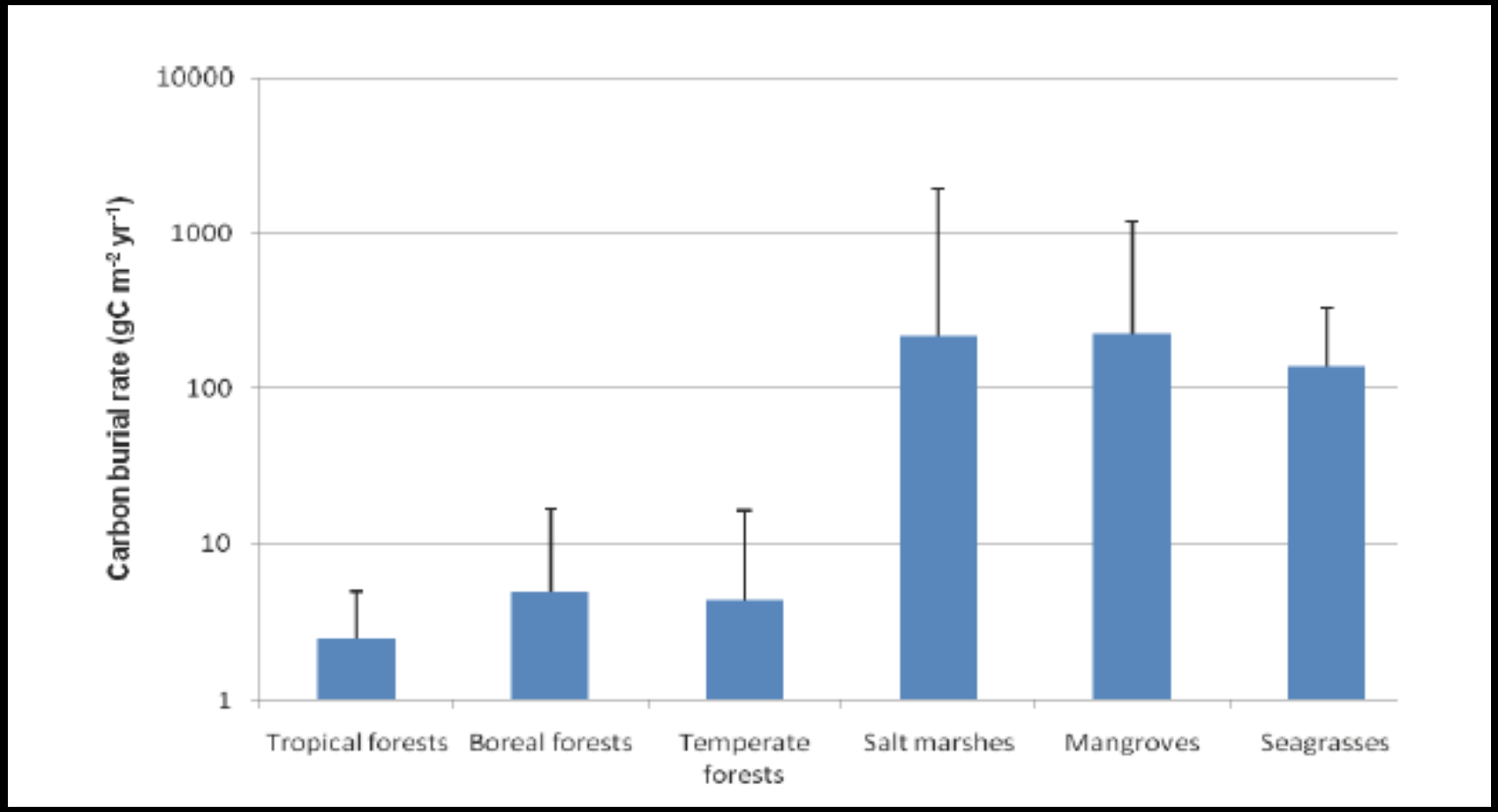
Decomposition





- Latitude (temperature)
- Tissue quality
- Fauna

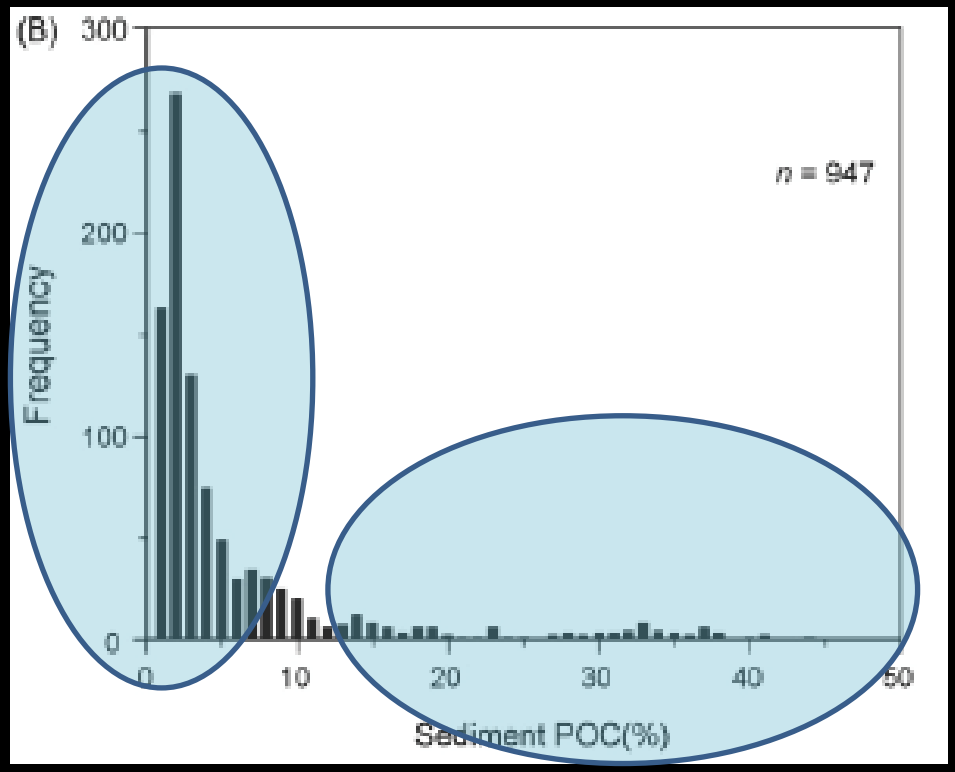
The big picture:



McCleod et al. in review

Mangrove data is derived from Chmura et al. 2003

Drilling down into the detail - stocks



Boullion et al. 2008
Mean 2.2% C

Duarte et al. 2005
Mean 8.5% C

- Hot spots?
- What conditions?

*Is C content of soils correlated with rates of C burial?

Carbon hot spots?

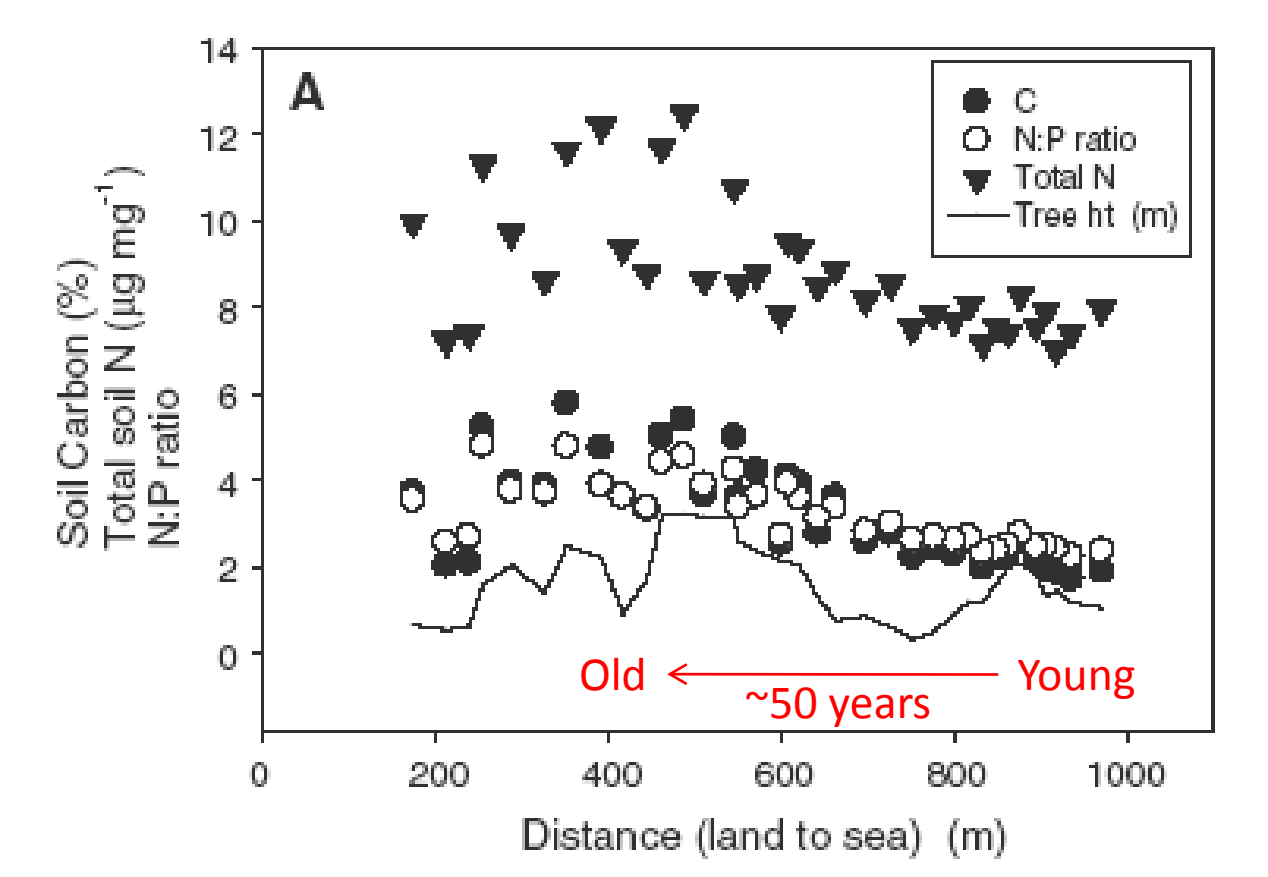
- Substrates: carbonates, granites, sands (low nutrients?)
- Hydrologically isolated (tidal range, position)?
- Species (*Rhizophora?*)
- History – e.g. mangroves colonized peat accumulated by other species

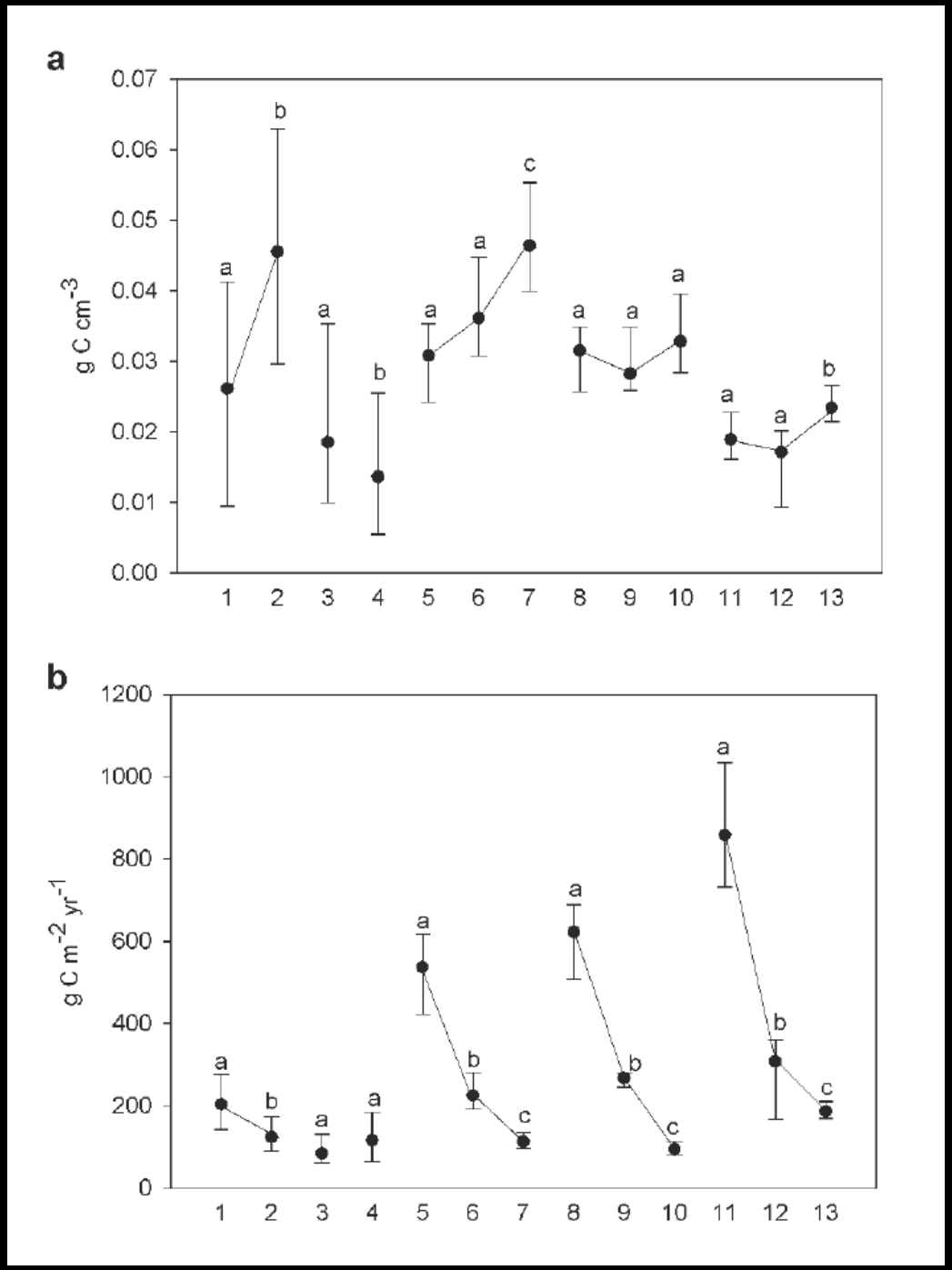
Ecological “rules”:

- Fast growing trees (+nutrients) allocate less biomass to roots
- Slow growing trees (low nutrients) allocate proportionally more to roots, BUT they grow slowly (slow accumulation)

Preservation AND Restoration

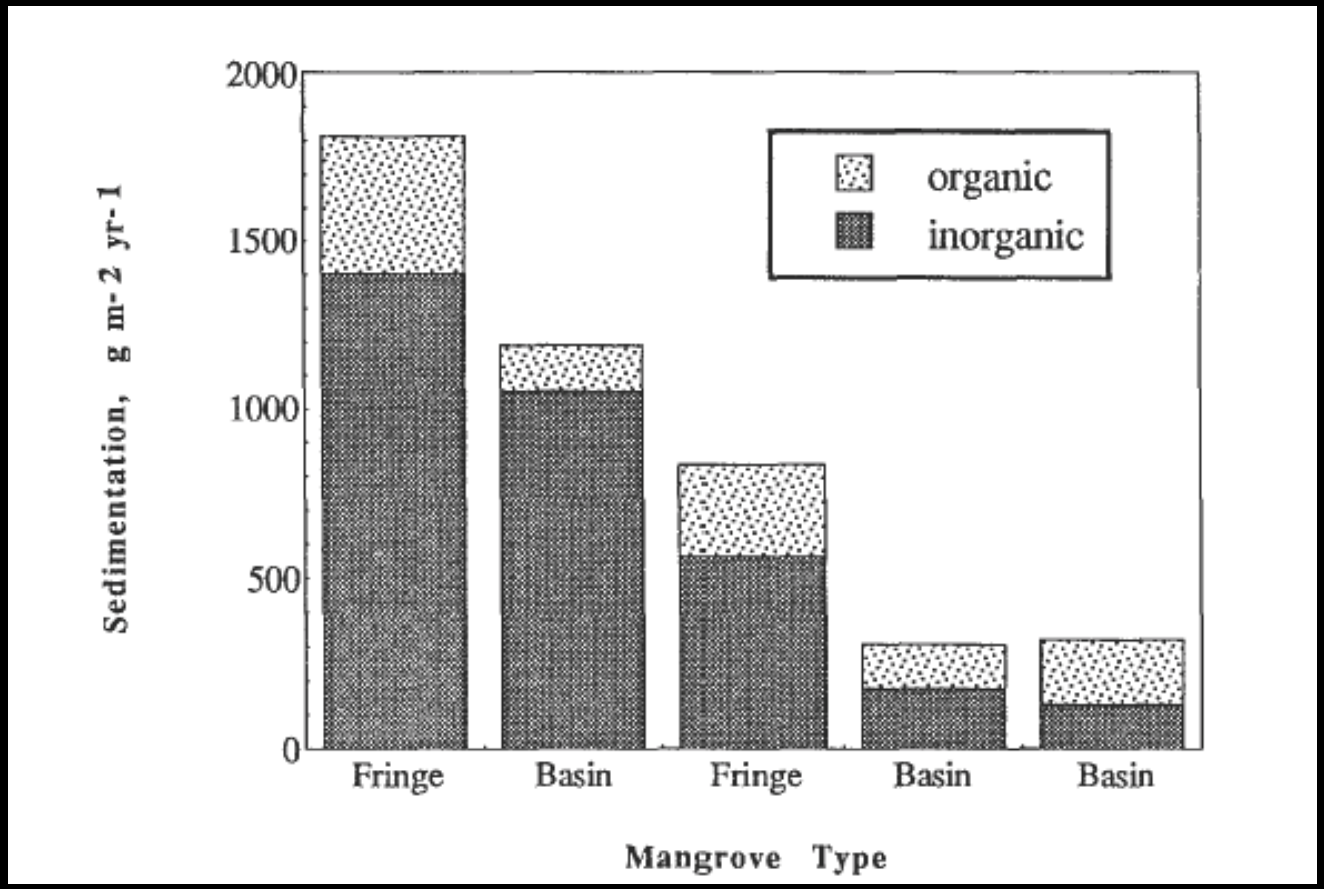
Forest age - restoration





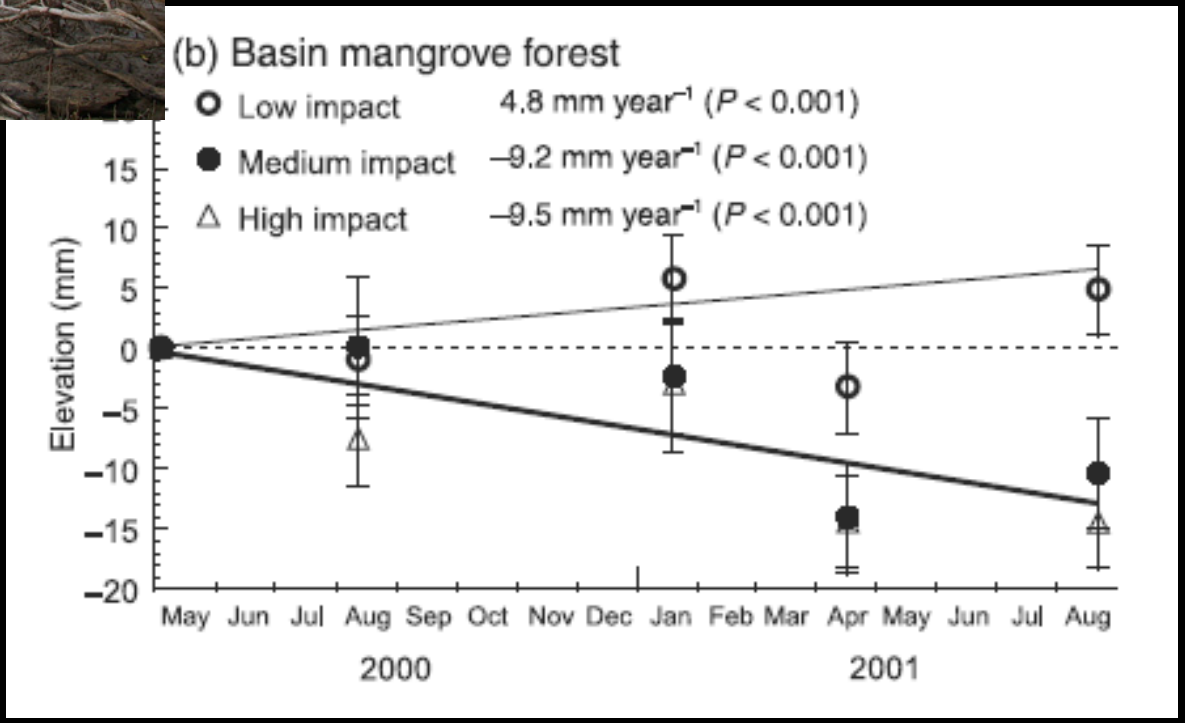
Carbon density
1. Fringing mangrove
2. Basin mangrove

Carbon burial
1. Fringing mangrove
2. Basin mangrove



Twilley et al. 1992

Disturbance



Losses

Table 3. Human use of mangrove area leading to loss of habitat, by continent.

Activity	Area affected by each activity (10^3 km^2)					Percentage of total[1]
	Asia	Americas	Africa	Australia	World total	
Shrimp culture	12	2.3	–	0.005	14	38
Forest use	4.6	4.9	–	–	9.5	26
Fish culture	4.9	–	–	–	4.9	14
Diversion of freshwater	4.0	–	0.09	–	4.1	11
Land reclamation	1.9	–	–	–	1.9	5
Herbicides	1.0	–	–	–	1	3
Agriculture	0.8	–	–	–	0.8	1
Salt ponds	0.02	–	0.03	–	0.05	–
Coastal development	0.05	–	–	–	0.05	–
Total area	29	7	0.12	0.005	36	
Percentage of mangrove area represented	85	75	2	100	66	

Source: Data from Linden and Jernelov 1980, Saenger et al. 1983, Ong 1995, Fortes 1988, Jory 1997, Stonich et al. 1999.

1. Does not total 100% because of rounding.

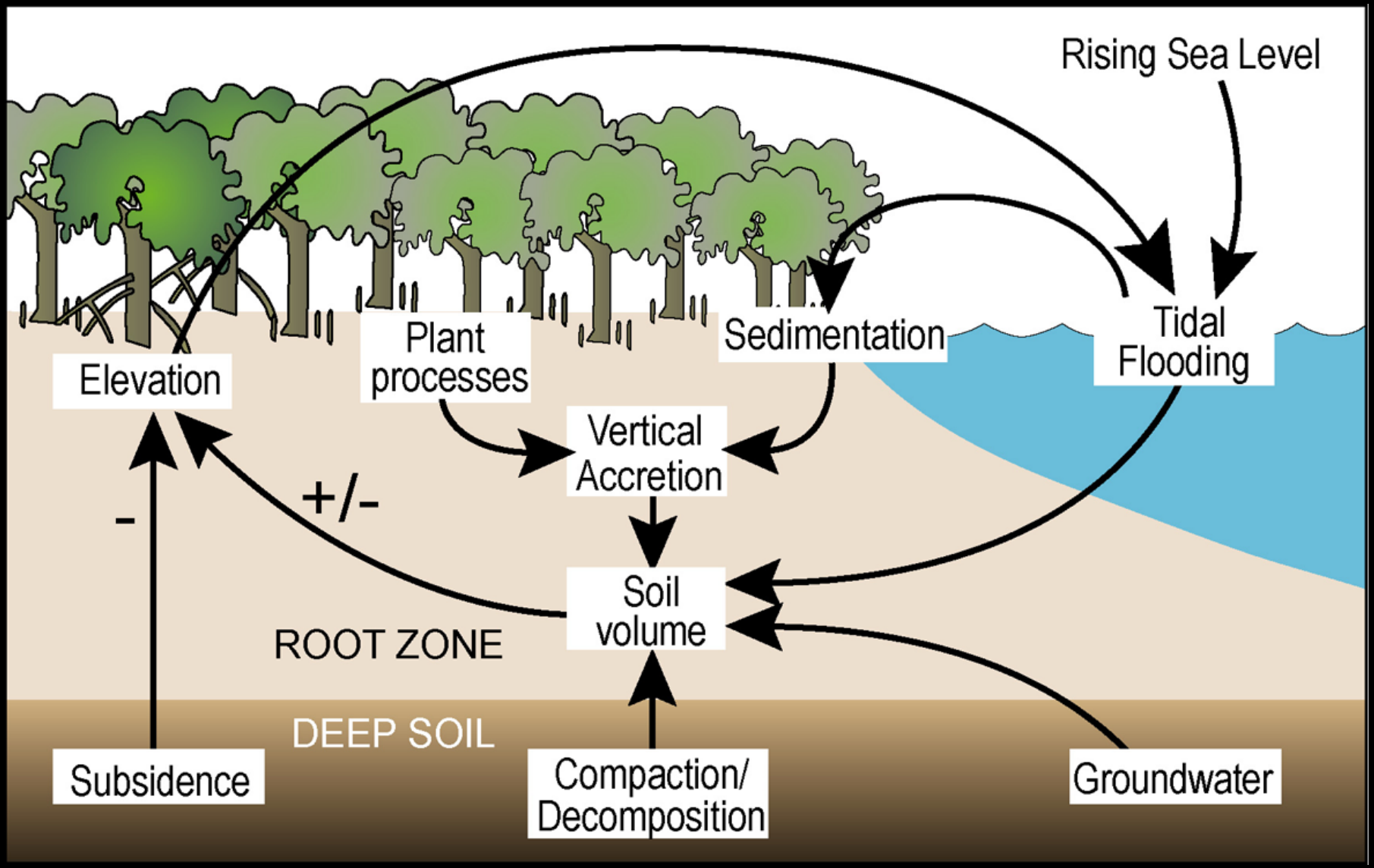
Carbon market needs

- Quantification – extrapolation/allometries
- Verification/monitoring
- Insurance against risk

Habitat gains with sea level rise

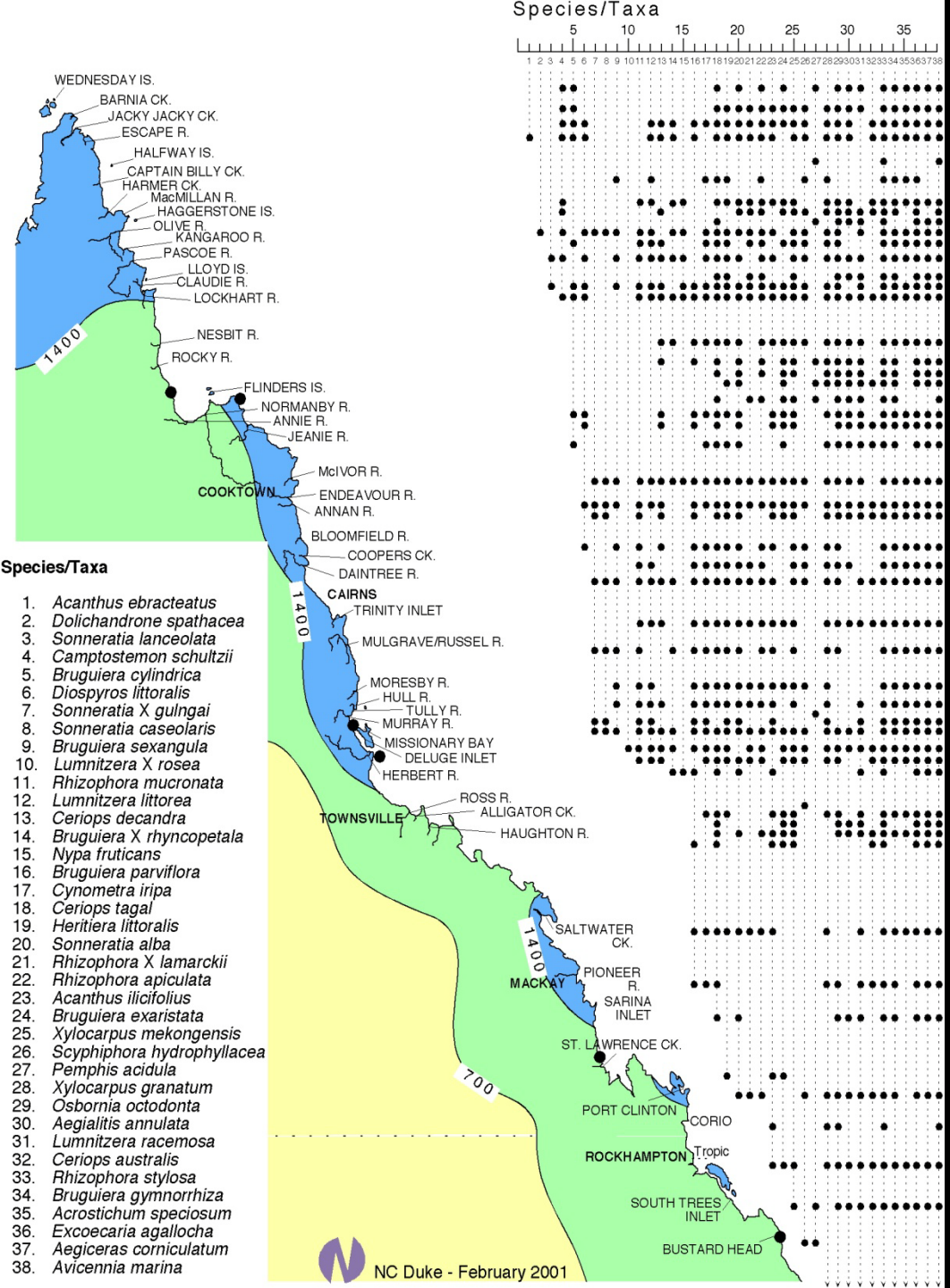
Arid zone

The model - feedbacks



Biodiversity

Photos: Helen Penrose



Species/Taxa

1. *Acanthus ebracteatus*
2. *Dolichandrone spathacea*
3. *Sonneratia lanceolata*
4. *Camptostemon schultzii*
5. *Bruguiera cylindrica*
6. *Diospyros littoralis*
7. *Sonneratia X gulngai*
8. *Sonneratia caseolaris*
9. *Bruguiera sexangula*
10. *Lumnitzera X rosea*
11. *Rhizophora mucronata*
12. *Lumnitzera littorea*
13. *Ceriops decandra*
14. *Bruguiera X rhyncopetala*
15. *Nypa fruticans*
16. *Bruguiera parviflora*
17. *Cynometra iripa*
18. *Ceriops tagal*
19. *Heritiera littoralis*
20. *Sonneratia alba*
21. *Rhizophora X lamarckii*
22. *Rhizophora apiculata*
23. *Acanthus ilicifolius*
24. *Bruguiera exaristata*
25. *Xylocarpus mekongensis*
26. *Scyphiphora hydrophyllacea*
27. *Pemphis acidula*
28. *Xylocarpus granatum*
29. *Osbornia octodonta*
30. *Aegialitis annulata*
31. *Lumnitzera racemosa*
32. *Ceriops australis*
33. *Rhizophora stylosa*
34. *Bruguiera gymnorrhiza*
35. *Acrostichum speciosum*
36. *Excoecaria agallocha*
37. *Aegiceras corniculatum*
38. *Avicennia marina*