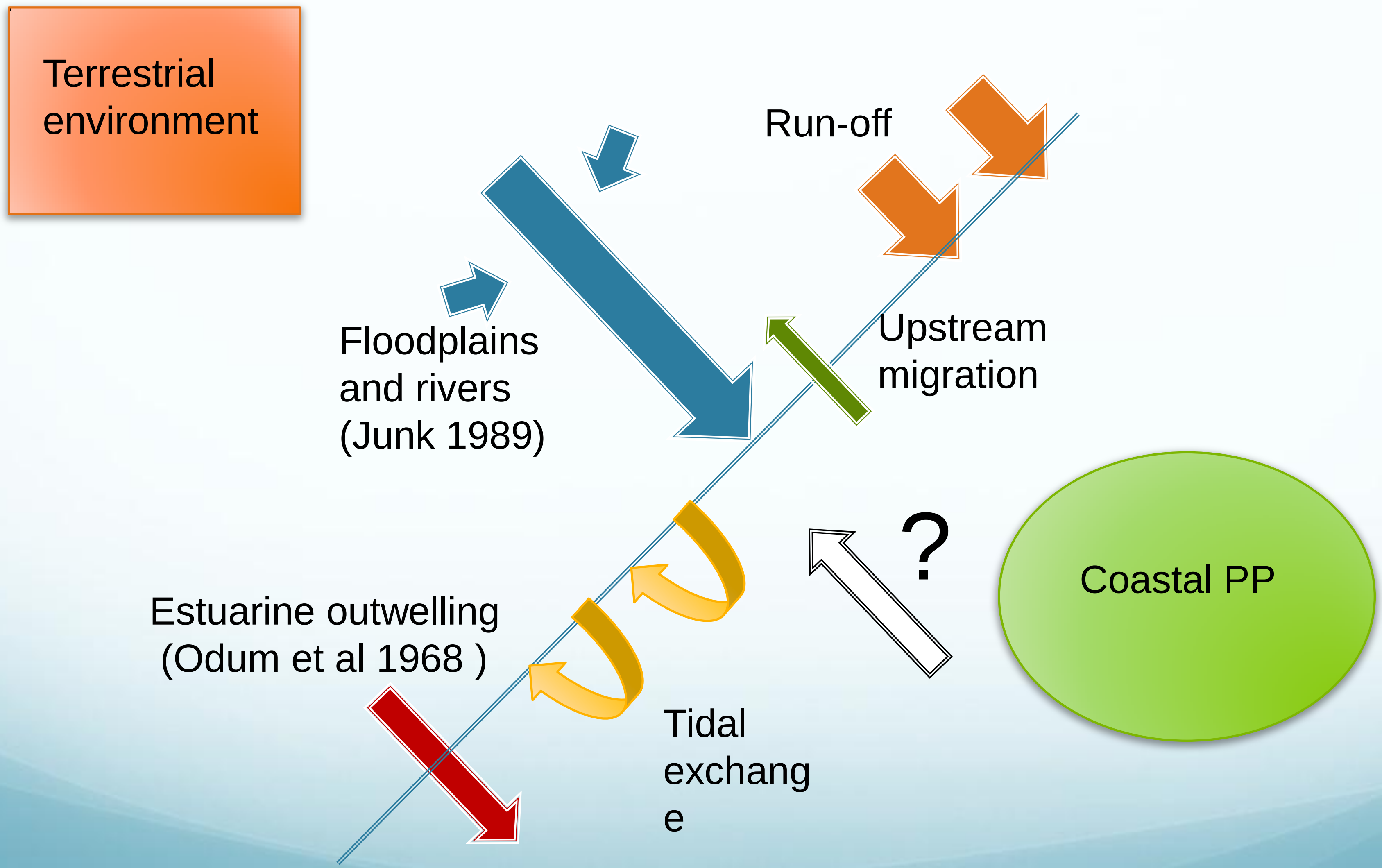
Marine subsidies delivered by birds to mangrove forests

Adame, M.F., Julieta N. Gamboa, J. Caamal, J.A. Herrera-Silveira.

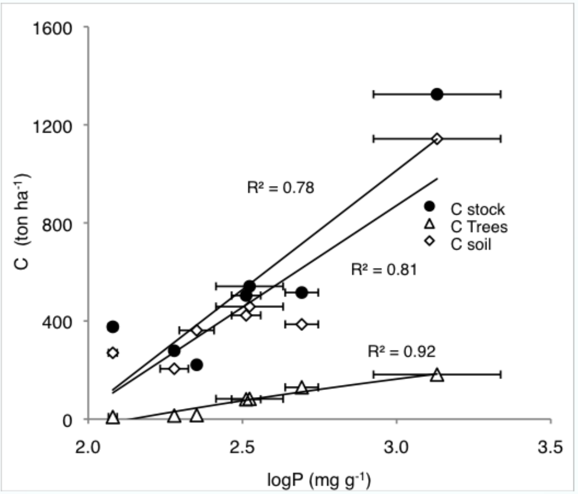
Transfer of material between terrestrial-marine systems (Polis et al. 1997)



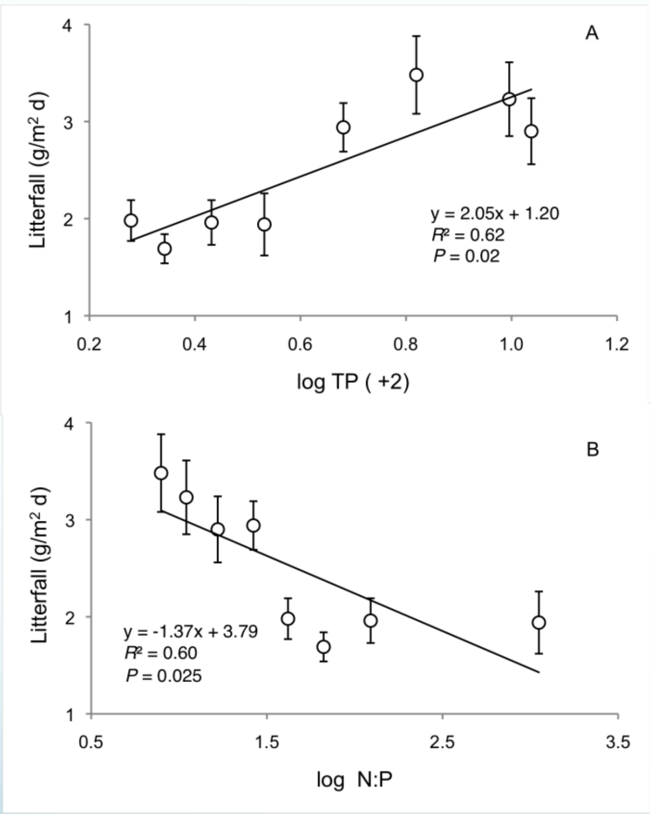
The Yucatan Peninsula

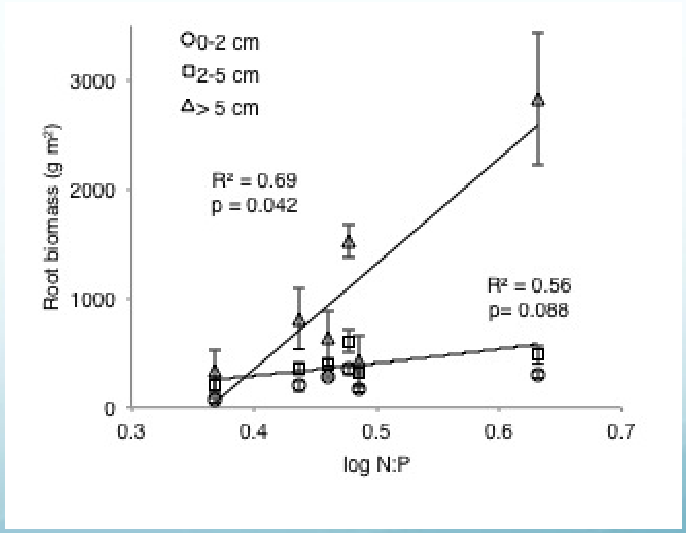
- Large areas of mangrove forests (~ 430,000 ha)
- Wetlands of international importance: 12 Ramsar sites, 4 Biosphere Reserves, one World Heritage site.
- Karstic- groundwater system, no rivers
- Microtidal
- Oligotrophic –occasional nutrient inputs during storms and hurricanes

Mangroves in the Yucatan Peninsula are phosphorus limited



Tree and soil C pools



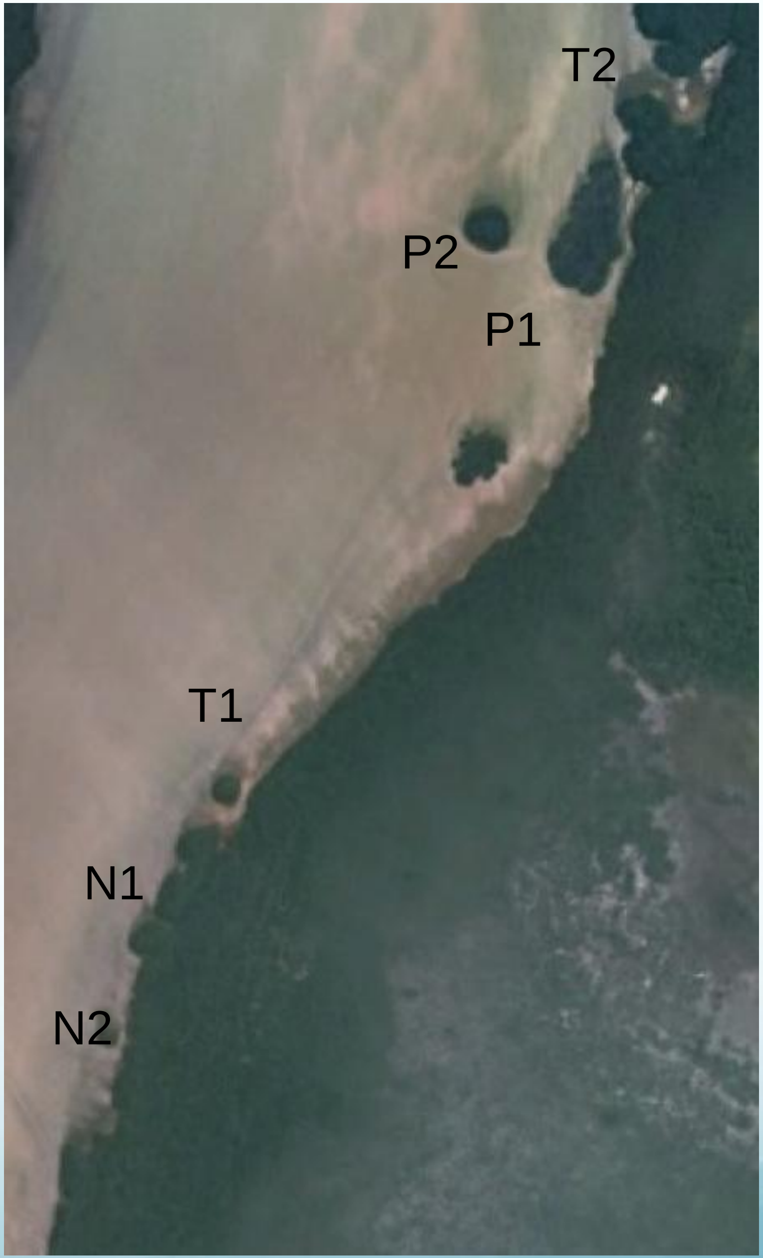


Litterfall

Root biomass

Celestun Biosphere Reserve

- Coastal lagoon with ground freshwater inputs
- > 90,000 ha mangrove forest
- Flamingo population and > 120 sp of resident and migratory birds (Ramsar site)


T2
P2
P1
T1
N1
N2

Permanent bird colonies

Phalacocorax auritus

Fregata magnificens

Ardea alba

Evidence of bird-derived nutrient inputs

Temporal bird colonies

T1

Pelecanus occidentalis

Phalacocorax auritus

No bird colonies

N1

N2

- What is the difference among these islands?
- What is the effect of bird colonies in mangrove production?
- Are birds providing marine subsidies to these mangrove forests?

Methods

- Forest structure
- Physicochemical characteristics of soil (phosphorus, OC, pH, interstitial salinity)
- Leaf nutrients- nutrient reabsorption efficiency
- Water samples (salinity, DO, SRP) throughout the lagoon (8 stations)
- Three seasons: wet, winter, dry

Forest structure

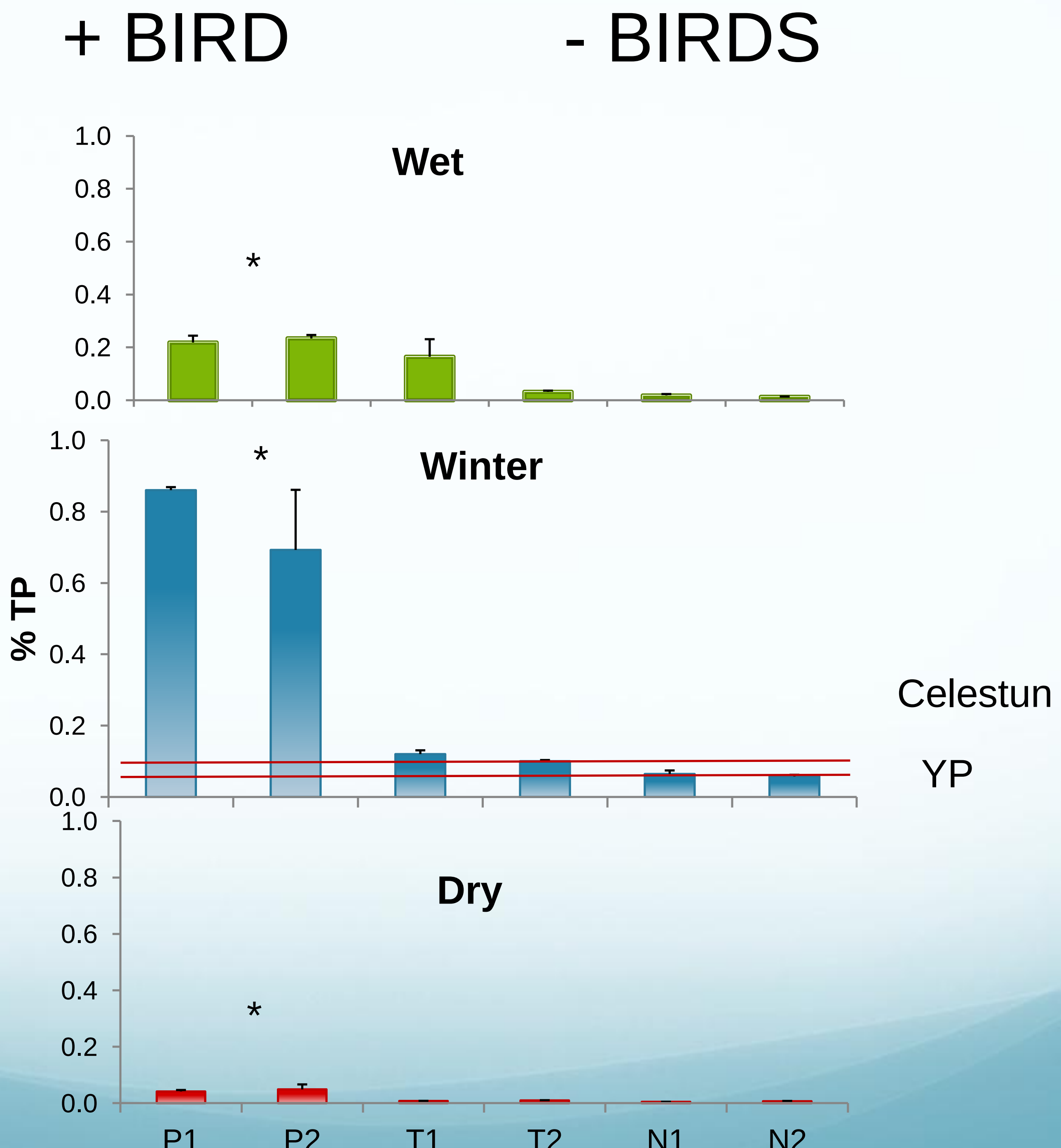
	Tree density (tree/ha)	Tree biomass (ton/ha)	% *Rhizophora mangle*	% *Laguncunaria racemosa*	% *Avicennnia germinans*
P1	3770	252	60	20	20
P2	5470	662	29	54	18
T1	2654	392	45	35	20
T2	5824	736	28	70	3
N1	6389	323	60	32	11
N2	4581	368	52	48	0

(Diagrams by D. Kleine and T. Saxby)

Soil

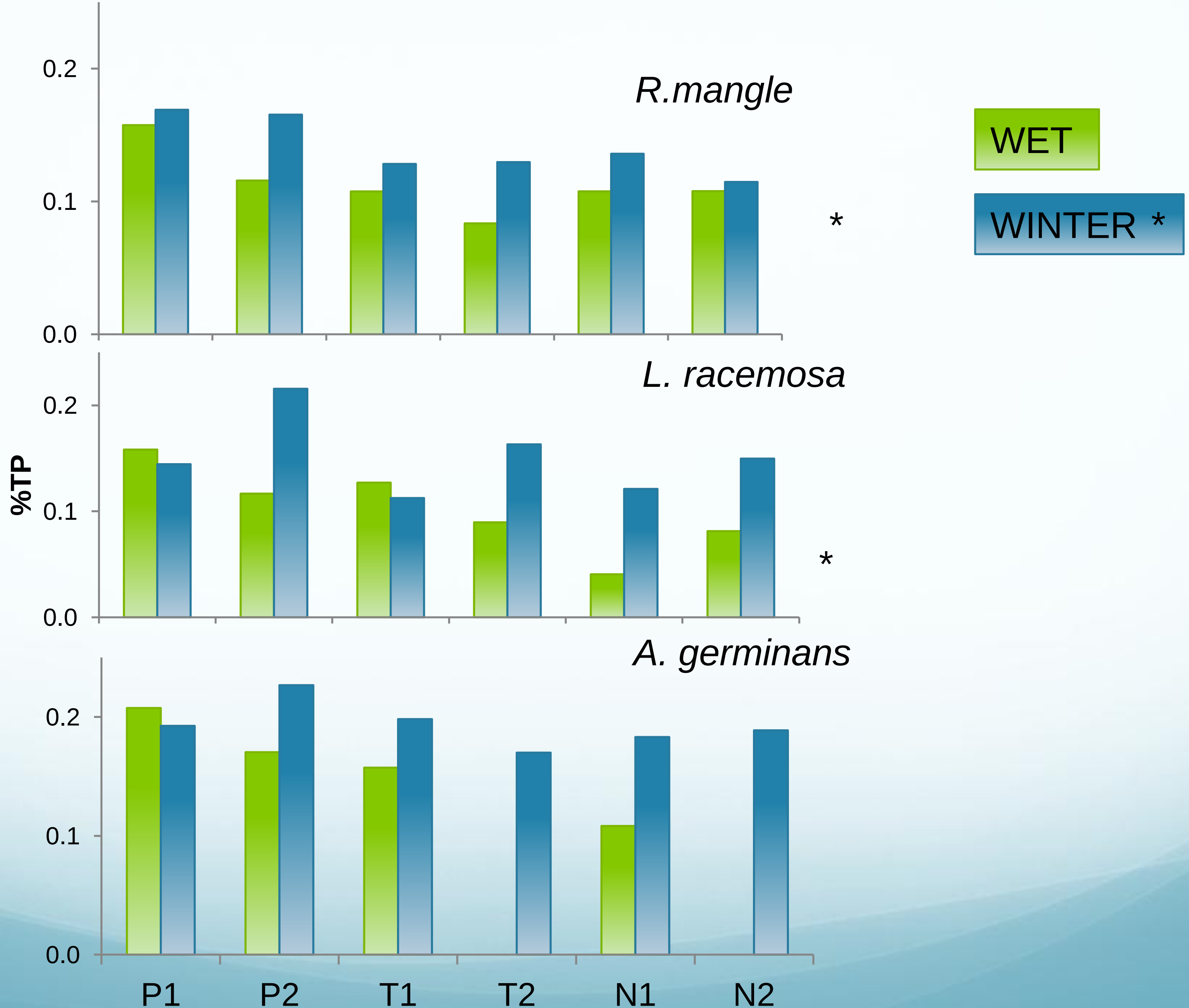
	Soil density (g/cm^3)	pH	Interstitial salinity	OC (%)	Soil depth (Z)
1-Permanent	0.4 ± 0.0	7.0 ± 0.3	38 ± 2*	31 ± 7	1.9 ± 0.0
2-Permanent	0.3 ± 0.1	6.6 ± 0.2	41 ± 2*	30 ± 4	1.9 ± 0.0
1-Temporal	0.4 ± 0.0	7.3 ± 0.1	45 ± 5*	27 ± 7	1.9 ± 0.1
2-Temporal	0.4 ± 0.1	7.0 ± 0.1	39 ± 2*	21 ± 5	1.6 ± 0.0
1-None	0.4 ± 0.0	7.2 ± 0.1	32 ± 4	23 ± 2	1.6 ± 0.1
2-None	0.4 ± 0.1	6.7 ± 0.1	28 ± 3	25 ± 5	1.8 ± 0.0

Soil TP



+ BIRD
- BIRDS
Wet
Winter
Dry
% TP
1.0
0.8
0.6
0.4
0.2
0.0
*
Celestun
YP
P1
P2
T1
T2
N1
N2

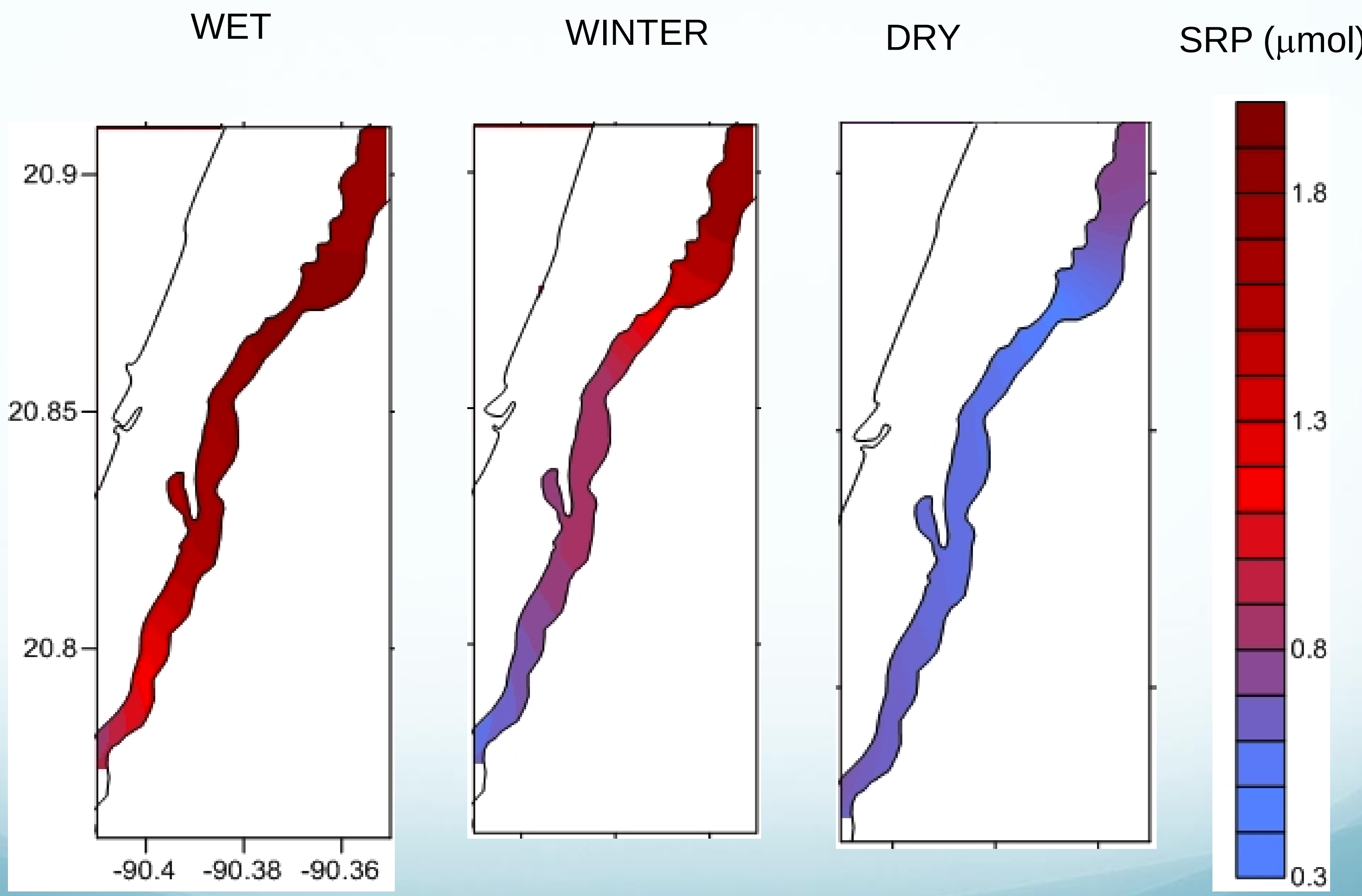
TP in leaves



R.mangle
L. racemosa
A. germinans
%TP
0.0
0.1
0.2
P1
P2
T1
T2
N1
N2
*
*
WET
WINTER *

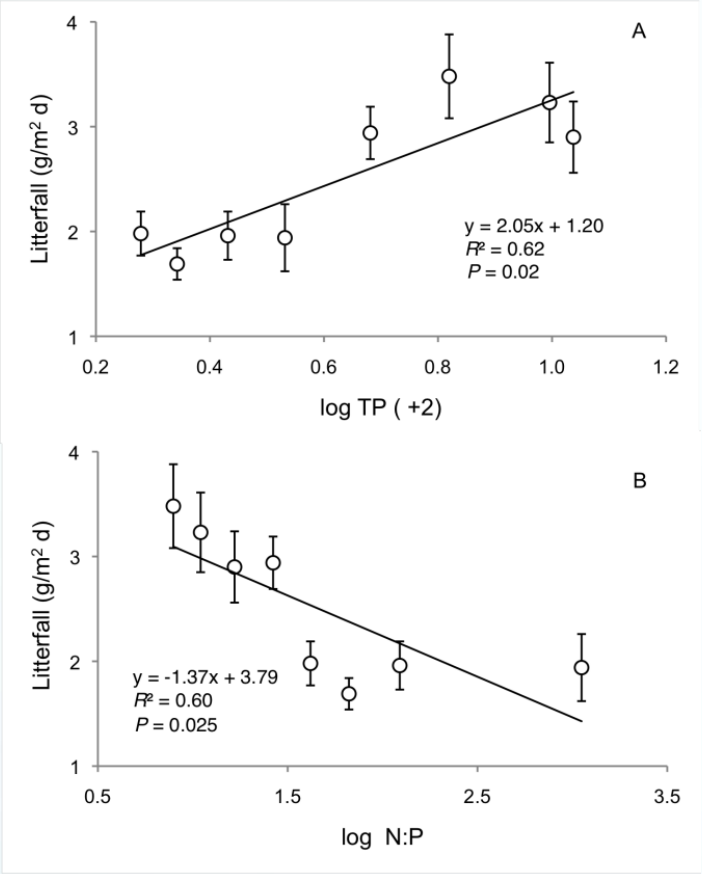
Nutrient reabsorption

		Wet	Winter
Permanent	*Rm*	22 %	58 %
	Lr	44 %	43 %
	Ag	-	24 %
Temporal	*Rm*	53 %	60 %
	Lr	60 %	66 %
	Ag	-	62 %
None	*Rm*	55 %	59%
	Lr	41 %	66%
	Ag	-	


WET
WINTER
DRY
SRP (μmol)
20.9
20.85
20.8
-90.4
-90.38
-90.36
1.8
1.3
0.8
0.3

- + *Avicennia germinans* _
- + interstitial salinity _
- + OC soil _
- + soil TP _
- + leaf TP _
- _ nutrient reabsorption +

Sediment accretion is mainly a result of autochthonous production (Mc Kee et al 2007)



BIRDS *(Phalacocorax auritus)* → Soil TP → litterfall production → Soil OC → Soil elevation → High interstitial salinity → *A. germinans* → BIRDS *(Phalacocorax auritus)*

Marine subsidies to other coastal ecosystems

Sea birds and algae wrack and carrion in:

1. Coral cays, GB Reef, Australia (Heatwole, 1971)
2. Desert coast, BC, Mexico (Polis and Hurd 1996).
3. Volcanic islands, Aleutians Is.(Maron et al. 2006)
4. Rocky intertidal community (Bosman and Hockey, 1986)

The importance of allochthonous inputs is largely dependent on productivity gradients (Polis 1997)

Implications

- Mangrove health is associated to bird populations (Holguin et al. 2006) –important to understand relations between mangrove production-seabirds

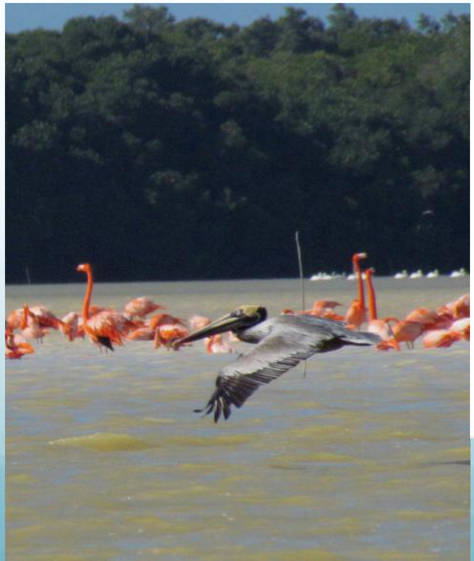
- Insight on effects of eutrophication in mangrove forests

- Sea level rise can decrease island elevation- decrease in salinity- decrease *Av. germinans*- decrease in habitat availability for some sp of birds.

Some coastal wetlands of the Yucatan Peninsula, due to its karstic nature and P deficiency, might be one of the unique examples where marine outweigh terrestrial nutrient subsidies.

What's next?

- Isotopic values (^{13}C and ^{15}N) of soil and leaves to verify marine origin of TP in mangrove forests
- Measuring accretion and respiration rates in soils with birds vs no birds
- Nutrient inputs of flamingos to seagrass beds?
- More bird watching, ceviche and beers..

Thank you !!

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