

Improving saltmarshes ecosystem services through restoration actions

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¿How historical **estuarine** restoration actions in the Iberian Peninsula have increased the **coastal protection** and the **carbon sink** function of these ecosystems?

Background

Saltmarshes provide multiple ecosystem services to societies (i.e. maintaining healthy water, protecting coastal areas from flooding and erosion, providing nursery grounds and food for many fish and birds species and supporting recreational activities), but they have been historically threatened and impacted by human actions and 50% of saltmarshes are either lost or degraded worldwide.

Evolution of saltmarsh communities in restored areas



Over the last decades, the collective awareness of local populations, the greater scientific knowledge, as well as new European environmental policies, have highlighted the values of these natural habitats and enhanced the implementation of environmental restoration actions. Historically, these restoration actions were designed to enhance biodiversity and cultural and recreational services without considering other potential co-benefits. The quantification of these additional services would allow to remark the importance of estuarine restoration actions and to adapt their design to take full advantage of all the ecosystem services that these communities may provide.

Objective

- To estimate the impact of historical estuarine restoration actions in the Peninsula Iberica in terms of:
- The coastal protection benefits provided by saltmarshes
- The carbon storage by saltmarshes

The lack of homogenous information about the evolution of estuaries after the restoration actions led to a restrospective analysis of restored areas using information from European databases (i.e. Corine Land Cover data) and information from remote sensors (satellite imagery).

Assessment of Ecosystem Services

Carbon storage

Coastal defense



The carbon sequestration capacity of estuarine ecosystems was assessed based on a large sampling campaign of soil C_{org} deposits from 5 European estuaries The average value of carbon storage in saltmarsh communities was 50±2 Mg Corg ha-1 in the top 30 cm of soil, which corresponds to 183 Mg CO2 ha-1 sequestered in the soil compartment. The unvegetated mudflats and sandflats soil stocks per surface area were about 40 Mg Corg ha-1 (136 Mg CO2 ha-1), while the largest stock (65-100 Mg Corg ha-1; 226-368 Mg CO2 ha-1) were found in a high marsh community formed by *Juncus* spp. and the invasive species *Baccharis halimifolia*.



Restoration actions improved carbon sequestration in the estuarine areas of Bahía de Santander, A Xunqueira, Bahía de Cádiz, Doñana, Urdaibai, Zarautz, Caminha, Figueira da Foz and Tagus estuary, where the saltmarsh communities increased. On the other hand, soil C_{org} deposits are expected to have decreased in Estuaries of Sado, Ría de Alvor and Ría Formosa, where high marshes surface area has decreased as a result of estuarine restoration actions. The carbon sequestration capacity in estuarine areas of Oyambre, Joyel, Tina Menor and Txingudi, where saltmarsh communities increased due to the removal of the IAS *Baccharis halimifolia*, would depend on the remaining habitat, being negligible if high marsh species remain.

The role of estuarine vegetation was analyzed by modelling the impacts of flooding and erosion in Santander Bay, Santoña Marshes, Oyambre and Mondego estuary under different climate scenarios, taking into account the vegetation role in coastal flooding, current velocities and sediment trapping.



Examples of Flood area(m²) in Oyambre and Santoña estuaries in different Climate Change scenarios

Following the **Benefit transfer method**...

$ESV = \sum (Ak * V Ck))$

	Name	Rate (ha/y)	Protected population (people/ha/y)	Protected building assess (€/ha/y)	Country	Spain									
1	Alvor	-0.32	-5	-6,187€	Portugal										
2	Arousa	0.29	53	9,690€	Portugal										
3	Aveiro	14.64	103	20,837€	Portugal										
4	Cádiz	15.42	2868	522,333€	Spain	Portugal									
5	Caminha	5.07	36	7,217€	Portugal										
7	Figueira da Foz	2.18	405	73,812€	Portugal		0 1	0 200	300	400	500	600	700	800	
8	Formosa	-55.54	0	-13,051€	Portugal		0 1	200	500					000	
9	Joyel	-0.51	0	-119€	Spain	Mean protected building (€/ha/year)									
10	Odiel	63.02	945	1,212,999€	Spain		T		i.	1	0.		,		
11	Oyambre	6.15	0	1,446€	Spain										
12	Sado	-5.11	-77	-98,304€	Portugal	Spain									
13 Marismas Blancas 0.35 5 6,642 € Spain															
14	Тејо	3.89	58	74,876€	Portugal										
15	Tina Menor	6.24	0	1,466€	Spain										
16	Txingudi	0.43	6	8,229€	Spain	Portugal									
17	Urdibai	17.22	3203	583,502€	Spain										
18	Zarautz	0.18	3	3,438€	Spain										

Restoration policies in Spain have provided a greater benefit in terms of protection of the population and buildings against flood events. But, it should be highlighted that the Spanish estuarine ecosystems presents a higher protection capacity than the Portuguese estuarine ecosystems

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Odiel marshes, Cádiz bay and Urdaibai estuary have restored a higher number of hectares and therefore they provide greater protection than other estuaries. The loss of intertidal ecosystems in Ría Formosa and Estuario do Sado)produces a reduction in the protection against flooding over 77 and 5 people, respectively.

The restoration of saltmarsh ecosystems has provided the protection of several infrastructures against flooding events. This protection has been quantified in 1,21 million € in Odiel estuary, while in the Urdaibai estuary and the Cádiz marshes this quantification is around 0,5 million of €.

Conclusions

- The impact of the restoration actions in the carbon storage depends on the changes in high marsh surface area in relation to other estuarine habitats.
- Estuarine systems offer different coastal protection capacity levels to population and infrastructures. Cádiz and Urdaibai have a protection capacity of 27% and 42% higher than the mean protection value of all the Spanish estuaries analyzed. The estuarine ecosystems in the Aveiro estuary quadruple their coastal protection capacity compared to the mean protection value of all the Portuguese estuaries analyzed.
- There area relevant differences between the Spanish study sites, where carbon sequestration and coastal protection services would have mostly increased, and the Portuguese study sites, where the greatest losses
 of these services have been estimated.
- Quantification of C_{org} sequestration (stocks and burial rates) and coastal protection services provided by estuarine ecosystems before and after the implementation of different restoration actions (including the elimination of *Baccharis halimifolia*) is needed in order to better predict the outcomes of estuarine restoration projects



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