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Sand dune and saltmarsh resilience in the eye of Climate Change

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INTRODUCTION AND OBJECTIVES

Sand dunes and salt marshes are coastal ecosystems of high ecological interest being habitat to many species and providers of ecosystem services such as carbon and pollutant sequestration, water purification, recreation or cultural knowledge. Although, they are natural frontiers that protect our terrestrial land from the effect of sea-level raise and strong sea waves occurring, nowadays they are directly threatened by the sea level rise, river water regime change or water temperature increase due to climate change. According to the latest report (2007-2012), for the vast majority of Member States, 70% of coastal habitats were reported as being in an 'unfavourable' conservation status, and it is the same for the Basque Country. For example, of the 75% of the sand dunes systems present in Europe a century ago just 45% were in a natural way. Thus, there is an urgent need for these natural ecosystems to be preserved and restore, in order to be resilient to these new threats.

The aim of this work was to study the regeneration capacity of two coastal ecosystems (resilience), namely a sand dune and a salt marsh, based on plant diversity, as plants are good indicators of site conditions.

METHODOLOGY

Both study sites are located in the coast of Biscay in two estuaries: the sand dune restoration project in the Butroi estuary in Gorliz, and the salt marsh restoration project in the Barbadun estuary in Muskiz (Figure 1).The former project had two phases: one started in 2009 removing a car-park and the other in 2015 removing a restaurant (Figure 1, right site B). The A site had two sub-sites divided by a path to enter the beach (A1 and A2). The saltmarsh restoration started in 2008 after removing hydrocarbon reservoirs. Sampling was done in 2016 in the former and in 2018-19 in the latter. The methodology followed in both projects was quite similar, based on transects and using 2x1 m quadrats as sampled units, and estimating plant cover using a semi-quantitative of frequency-abundance that shows the cover following the DAFOR scale in ranges 1 to 5. Shannon and Simpson diversity indices were calculated in the sand dunes following the zoning from the lower zone to the higher zone, further from the sea. The nomenclature followed was that of Flora Europaea, except for *Tortula rurales* (Hedw.) Gaertn species.

Figure 1. Restoration sites: sand dune restoration before the car park in 2009 (A) and restaurant in 2015 removal (B) (left) and saltmarsh restoration before the refinery deposits removal (left) and after (right). In the salt marsh the red letters show the recovered site A and the control site C.

RESULTS

In the older sand dunes 17 sand dune plant species were present while in the 2015 site had just 11. The briofite *Tortula rurales*, species related to stabilized dunes was present on side (A1) while the species *Oenothera biennis*, related to disturbance, was only in the adjacent site (A2). Three species were only present in the younger site: *Aetheorhiza bulbosa*, *Eryngium maritimum* and *Malcomia littorea.* In the older sand dune the typical profile in plant diversity was already found (lower zone, middle and upper zone), diversity increasing from the seaside to the inland site and significant differences were found among the zones (Simpson, H= 20.858, p= 0.0001 y Shannon, H= 20.79, p= 0.0001 for A1; Simpson, H= 8.45, p= 0.004 and Shannon, H= 8.44, p= 0.004 for A2) This profile was not significantly found in the younger dune.

In the saltmarsh restoration site 13 plant species were present, *Sarcocornia fruticosa* and *Hamilione portulacoides* the most abundant ones, typical of the lower part of the saltmarsh, while there were also some typical of the higher part such as *Sarcocornia perennis*. Plant distribution in the recovering site was similar to that found in the natural site: *S. ramosissima, Aster tripolium* eta *Puccinellia marítima* in the lower site of the salt marsh and *Sarcocornia fruticosa*, *Limonium vulgare* or *I.crithmoides* in the higher part of the salt marsh.

Species in the sand dune restoring sites	A1	A2	B	Species in the salt marsh site	A	C
Aetheorhiza bulbosa subsp. bulbosa (L.) Cass.	-	-	1	Ammophila arenaria (L.)	-	-
Anthyllis vulneraria subsp. iberica (W. Becker) Jalas ex	2	4	-	Aster tripolium (L.)	3	-
Ammophila arenaria subsp. australis (L.)	5	5	4	Festuca rubra L.	2	-
Cakile marítima Scop	-	-	1	Halimione portulacoides (L.) Aellen	4	4
Calystegia soldanella (L.) R. Br.	3	2	1	Inula crithmoides (L.) Dumort	2	5
Carex arenaria L.	2	1	2	Limonium vulgare Mill.	2	2
Cistus salvifolius L.	1	1	-	Limonium ovalifolium (Poir.) Kuntze	1	-
Conyza sumatrensis (Retz. E. Walker)	1	1	-	Plantago maritima L.	1	1
Elymus farctus (Viv.) Runemark	1	1	1	Puccinellia maritima (Jacq.) Parl.	2	-
Eryngium maritimum L.	-	-	1	Salicornia ramosissima J. Woods	5	4
Euphorbia paralias L.	1	1	2	Sarcocornia fruticosa (L.) A.J.Scott	4	4
Festuca juncifolia St. –Amans	1	2	-	Sarcocornia perennis (Mill.) A.J.Scott	2	-
Herniaria ciliolata subsp. robusta Chaudhri	1	1	-	Suaeda maritima (L.)	2	-
Leontodon taraxacoides (Vill.) Mérat subsp. taraxacoides	1	-	-	Stenotaphrum secundatum (Walt.) Kuntze	-	-
Lotus corniculatus L.	1	1	-	Triglochin maritima L.	2	-
Malcomia littorea (L.) R. Br.	-	-	1	Zostera noltii Hornemann.	2	-
Medicago littoralis Rohde ex Loisel	2	2	1			
Oenothera biennis L.	1	2	1			
Pancratium maritimum L.	1	-	-			
Sonchus sp.	1	1	-			
Tortula rurales (Hedw.) Gaertn	1	-	-			

Table 1. Plant species abundance in the studied sand dunes (A1 and A2 where the car-park was removed in 2009 and B where the restaurant was removed in 2015) and in the saltmarsh (A restoring site since 2008 and C natural site) (1=Rare, 2= Occasional, 3=Frequent, 4=Abundant y 5=Dominant).

CONCLUSION

Both sites have shown a good recovery trend in species numbers (resilience), even if still far from maturation, however, the sites are restoring the habitat conditions for the typical species. The dynamic nature of these ecosystems favours the recovery process of them, so as also recovering their natural function of protection of the land and resilience from the expected effects of climate change on sea strength and level by 2050.