University of Reading

Impact of grazing on saltmarshes study

Report prepared for Natural England

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Contents (click to update)

Introduction

Saltmarshes provide a range of important ecosystem services including physical and feeding habitats for breeding, wintering and migratory birds, carbon storage, water quality regulation, sediment accretion and flood defence. These habitats are highly productive ecosystems and support a range of halophytic plant communities, with vegetation typically managed through agri-environment schemes by livestock grazing (Mason et al., 2019). However, globally, saltmarshes are in decline, with both increases in grazing intensity and grazing abandonment recognised to be amongst the contributing factors. There is, therefore, a need for responsible management of saltmarsh habitats by land managers to halt or reverse the loss of this important habitat.

This report provides an assessment of the vegetation at two sites proposed for inclusion into an agri-environment scheme in the form of a Countryside Stewardship Higher Tier Agreement. The first site, the southern section of Egypt Marsh on the Tamar Estuary has historically not been grazed, but the introduction of grazing has been proposed (Figure 1). The second, located on the Tavy Estuary and referred to herein as Tavy River Marsh, is not currently under an agri-environment scheme but is subject to ad-hoc grazing. The Tavy River Marsh site is sub-dived into two areas, North and South, by a small channel draining the surrounding terrestrial hinterland.

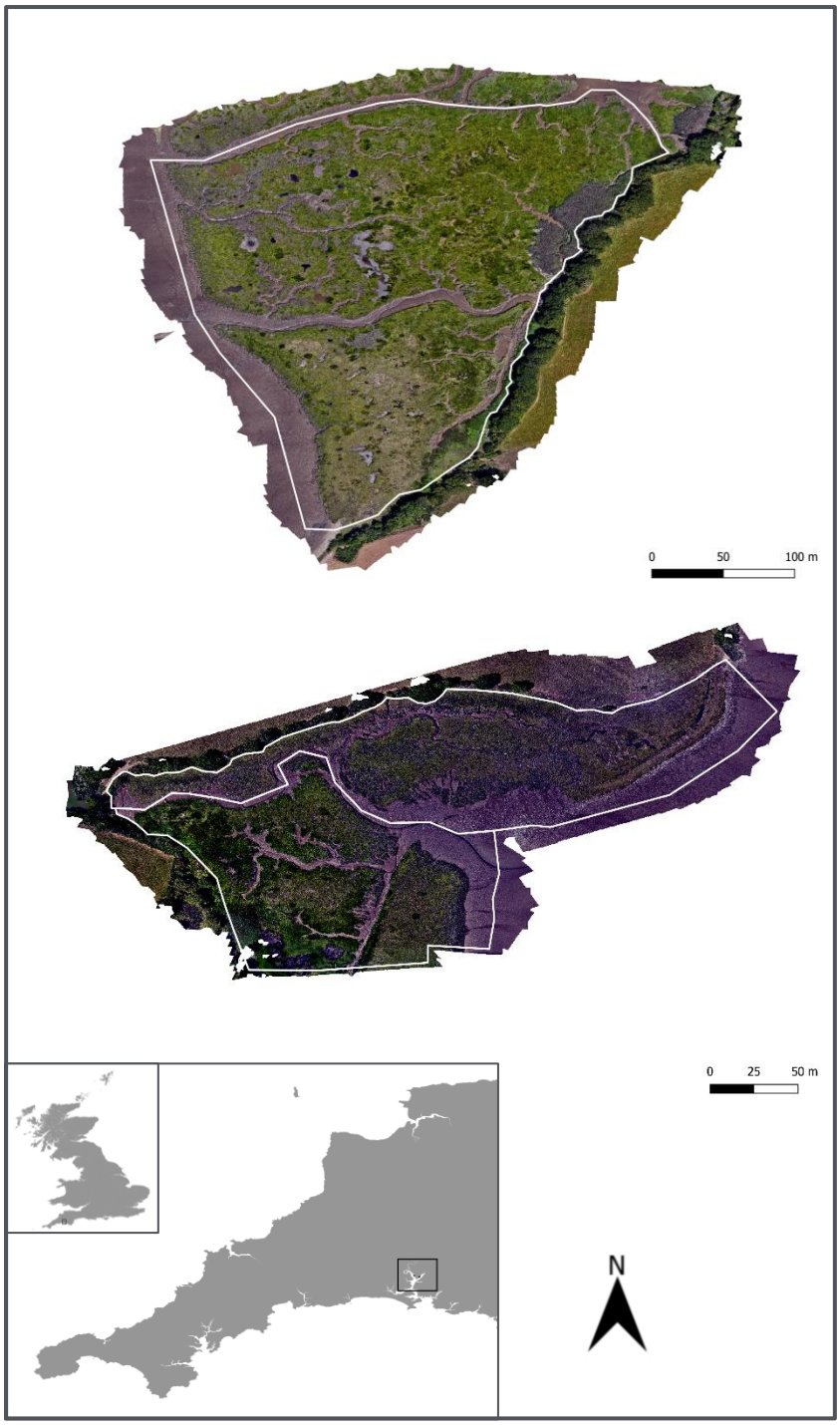

Figure 1: Location of the two study sites, Egypt Marsh (upper) and Tavy River Marsh (lower) with regions of interest indicated in white. Regional setting also included.

Methods

At both sites, vegetation cover was assessed at 14 sampling locations. Sampling locations were selected using a stratified sampling strategy to ensure a representative range of vegetation and habitat types were included. These were then divided into the

following categories based on the marsh zonation: (i) Upper Marsh, (ii) Mid-lower Marsh, (iii) Spartina, and (iv) Reed. Using a 0.5 x 0.5 m^2 quadrat, component species were identified using Hubbard (1992), Rose (2006) and standard Field Studies Council saltmarsh vegetation identification guides. The relative percentage cover of each species was recorded, along with percentage cover of bare ground. Canopy height was measured at five replicate points at each location. Biomass samples were harvested from a 0.1 x 0.1 m section within each quadrat for processing. Sediment samples were also collected from a depth of approximately 5 cm to assess moisture and organic content. The number of samples in each category for the two sites can be found in Table 1. Following a walk-over survey on site, no evidence of grazing was found at the southern site at Tavy River Marsh including no evidence of poaching or grazing (i.e., all leaf blades and other vegetation present). Therefore, no vegetation measurements or sediment samples were taken from this site.

Above ground dry biomass was assessed by drying the harvested samples at 70 °C for 48 hours and weighing. Sediment samples were dried at 105 °C for 48 hours with moisture content calculated as the percentage change in mass before and after drying. Organic content was subsequently measured through a loss on ignition test, with samples placed in a furnace at 450 °C for six hours and calculated as the percentage difference in mass between the dry and ashed weight of the sediment.

Table 1: Number of samples taken in total and for each zonation category for vegetation and sediment analysis at the two study sites.

	Egypt Marsh	**Tavy River Marsh (North)**
Total	**14**	**14**
Upper	8	2
Mid-lower	4	10
Spartina	2	2

To assess differences in vegetation across the entirety of the sites, and in higher resolution, both sites were surveyed using a Mavic 3 m Uncrewed Aerial System (UAS). RGB, Green (560 ± 16 nm), Red (650 ± 16 nm), Red Edge (730 ± 16 nm), and Near Infra-Red (NIR, 860 ± 26 nm) images were collected by the UAS from a flight altitude of 40 m. Images were post-processed using Agisoft Metashape (v.2.0.2) and used to calculate 12 vegetation indices (Table 2).

Table 2: Vegetation Indices calculated from UAS data.

Index	Equation
Enhanced Normalised Difference Vegetation Index (ENDVI)	((NIR+Green)-(2xBlue)) / ((NIR+Green)+(2xBlue))
Green Infrared Percentage Vegetation Index (GIPVI)	NIR/(NIR+G)
Green Normalised Difference Vegetation Index (GNDVI)	(NIR-G) / (NIR+G)
Green Red Difference Index (GRDI)	(G-R) / (G+R)
Green Soil Adjusted Vegetation Index (GSAVI)	1.5x((NIR-Green) / (NIR+Green+0.5))
Modified Soil Adjusted Vegetation Index (MSAVI)	$(2 * NIR + 1 – sqrt ((2 * NIR + 1)^2 – 8 * (NIR - R))) / 2$
MSRred edge	$(NIR/Rededge)-1/\sqrt{(NIR/Rededge) + 1}$
Normalised Difference Vegetation Index (NDVI)	(NIR-R) / (NIR+R)
Optimised Soil Adjusted Vegetation Index (OSAVI)	(NIR-Red) / (NIR+Red+0.16)
Red Edge Normalised Difference Vegetation Index (NDVIre)	(NIR-Rededge) / (NIR + Rededge)
Red Edge Simple Ratio (SRre)	NIR/R
Soil Adjusted Vegetation Index (SAVI)	(1.5x(NIR-Red)) / (NIR+Red+0.5)

Results

Although the average number of species per quadrat (Figure 2) was similar overall between the two sites (Egypt Marsh = 3 ± 1.58, Tavy River Marsh North = 2.79 ± 0.89), variability was found between the different zones at the two sites, especially between the Upper Marsh and Spartina zones. Above ground dry biomass (Figure 3) and canopy height (Figure 4) were greater at the ungrazed Egypt Marsh site, with more areas of bare ground (Figure 5) detected at Tavy River Marsh North. Moisture content (Figure 6) and organic content (Figure 7) varied between the two sites with no consistent trend or pattern.

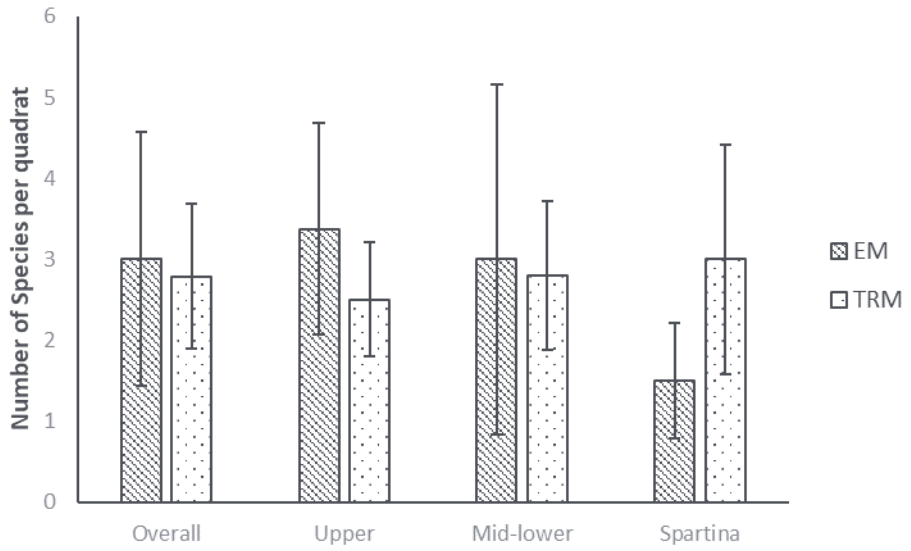

Figure 2: Mean number of species per quadrat for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

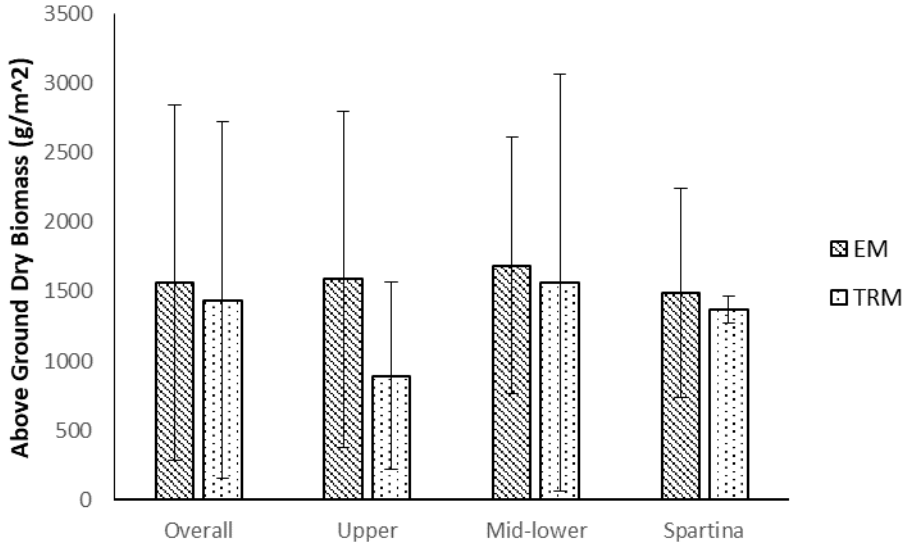

Figure 3: Mean above ground dry biomass for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

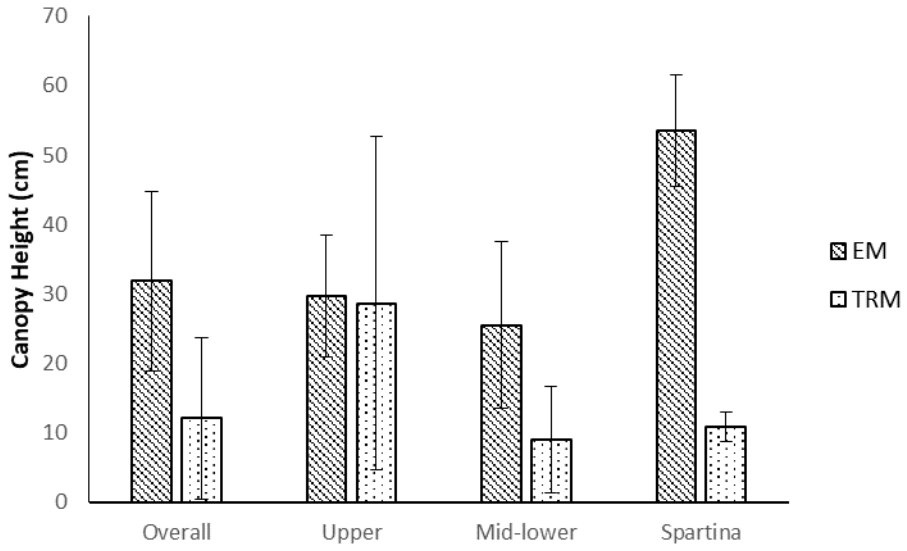

Figure 4: Mean canopy height for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

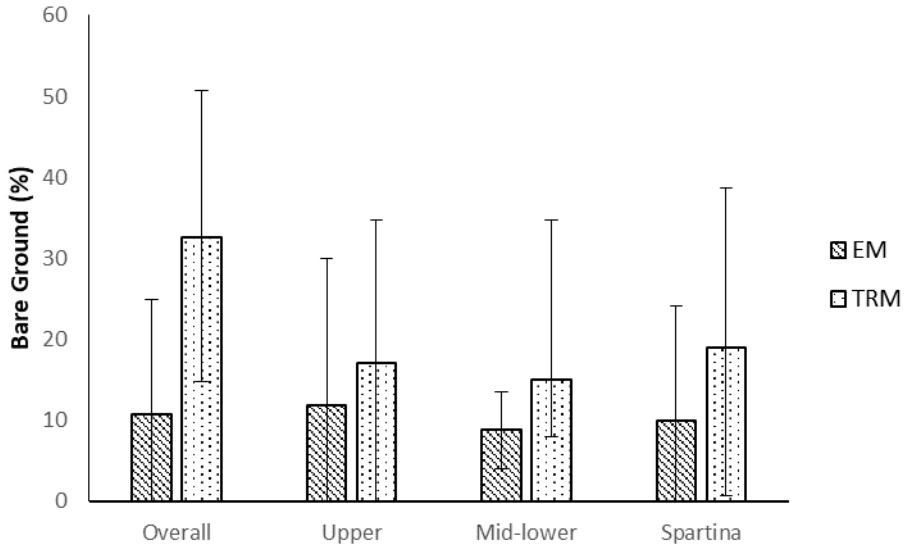

Figure 5: Mean bare ground for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

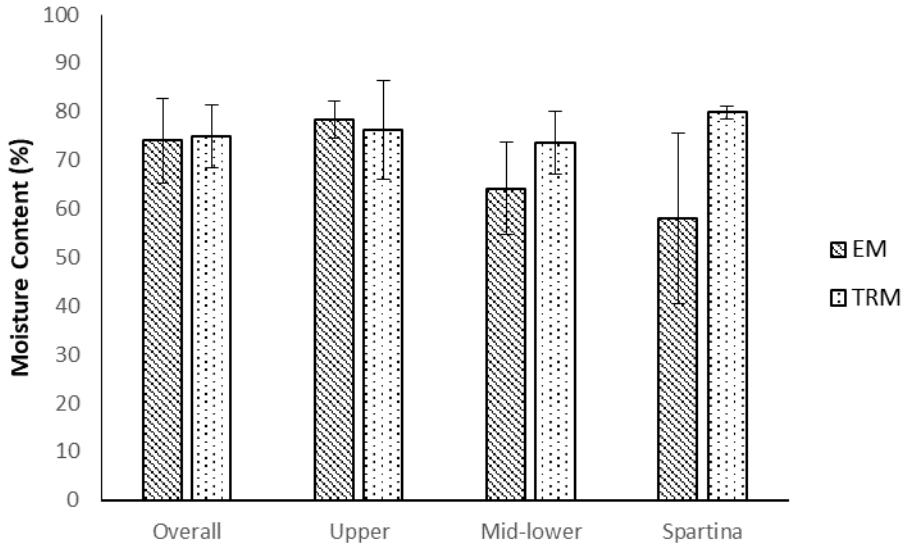

Figure 6: Mean sediment moisture content for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

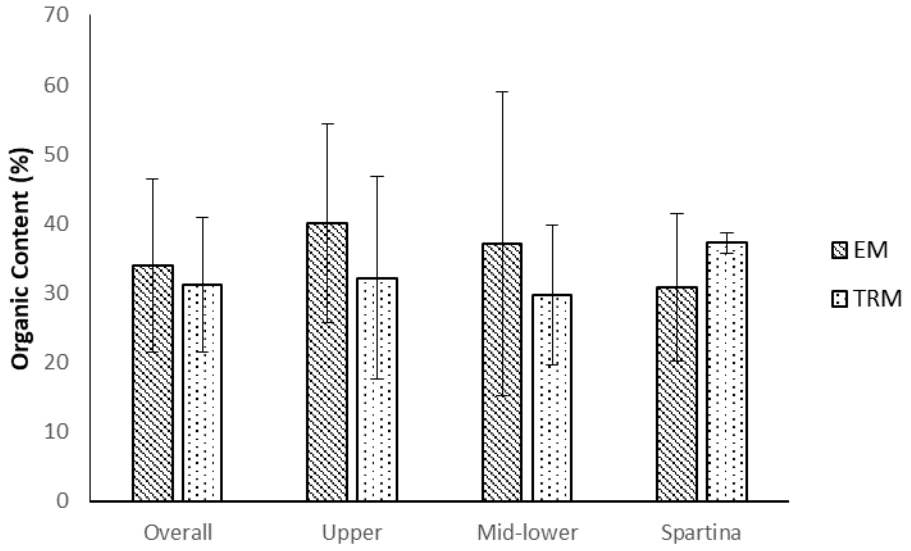

Figure 7: Mean sediment organic content for different vegetation zones at Egypt Marsh (EM) and Tavy River Marsh (TRM). Error bars represent the standard deviation.

Tavy River Marsh North experienced higher average values than Egypt Marsh for all vegetation indices except two (Table 3). GRDI, which is sensitive to leaf density, was 5.48% higher at Eygpt Marsh compared to Tavy River Marsh North and MSred edge, which is influenced by leaf area, was 3.31% higher. A similar pattern was detected in comparisons between Egypt Marsh and Tavy River Marsh South. Overall, values were typically more variable at Egypt Marsh, indicated by the standard deviation, in comparison to both Tavy River Marsh North and South.

At Tavy River Marsh, average values were higher and more variable at the southern site in comparison to the northern site, with the exception of ENDVI. The greatest difference (-0.81%) between the north and south sites was found in the GNDVI, a measure of the health of green vegetation with increased sensitivity to chlorophyll concentrations than the commonly used NDVI.

Table 3: Mean values (± standard deviation) and percentage differences for the 12 vegetation indices calculated

Index	Egypt Marsh		Tavy River Marsh North		Tavy River Marsh South		Egypt Marsh / Tavy River Marsh North (% difference)	Egypt Marsh / Tavy River Marsh South (% difference)	Tavy River Marsh North / South (% difference)
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation			
ENDVI	0.13	0.39	-0.96	0.08	-0.87	0.23	-1.14	-1.15	-0.02
GIPVI	0.53	0.09	0.78	0.05	0.84	0.06	-0.32	-0.37	0.08
GNDVI	0.06	0.17	0.57	0.10	0.68	0.12	-0.90	-0.91	0.23
GRDI	0.24	0.12	0.04	0.09	0.19	0.13	5.48	0.27	4.34
GSAVI	0.09	0.26	0.85	0.16	1.02	0.18	-0.90	-0.91	0.23
MSAVI	0.35	0.49	0.72	0.14	0.85	0.12	-0.52	-0.59	0.22
MSRed_edge	0.79	0.17	0.18	0.07	0.28	0.10	3.31	1.83	0.51
NDVI	0.28	0.25	0.58	0.15	0.75	0.15	-0.52	-0.63	0.35
NDVIre	-0.07	0.06	0.17	0.06	0.24	0.07	-1.44	-1.30	0.46
OSAVI	0.28	0.25	0.58	0.15	0.75	0.15	-0.52	-0.63	0.35
SAVI	0.42	0.38	0.87	0.22	1.13	0.22	-0.52	-0.63	0.35
SRre	0.87	0.1	1.41	0.17	1.65	0.26	-0.38	-0.47	0.16

Implications and future work

Differences in above ground dry biomass, canopy height and bare ground were found between Egypt Marsh and Tavy River Marsh North which can most likely be associated with grazing. Whilst variability overall was less apparent in terms of species cover, variability was identified between different zones. Typically, vegetation indices calculated from UAS imagery were higher at Tavy River Marsh than Egypt Marsh, indicative of higher levels of vegetation cover. However, these differences are relatively small (typically < 1%) and are likely to be the result of differences in species composition, density and abiotic factors such as nutrients availability and aspect. Differences in the vegetation indices between the northern and southern sites at Tavy River Marsh confirmed observations made in the field regarding grazed and ungrazed areas at this site. The indices were more variable at Egypt Marsh than at both the Tavy River Marsh sites. It has been demonstrated that variability in vegetation indices has a strong association with biomass (Villoslada et al., 2020) and indicates that the ungrazed Egypt Marsh has higher biomass, which is consistent with measured biomass values.

Future work should assess the movement of cattle around the site to inform direct sampling for areas most likely to be affected by grazing to compare with areas less subjected to grazing pressure. This includes tracking how often and for how long cattle access the marsh, the areas visited, and the length of time that active grazing takes place, to allow for an assessment of the impact of grazing within the same marsh, minimising the impact of spatial differences. The response of the marsh to any introduction of controlled grazing through a stewardship or other agri-environment scheme should also be assessed to evaluate its effectiveness as management strategy. This includes assessing the impact of differences in stock density and the timing of rotations. Other potential factors such as carbon storage should be monitored to investigate potential impacts of modified grazing regimes.

References

Hubbard, C.E., 1992 (4th ed.). *Grasses – a guide to their structure, identification, uses and distribution in the British Isles.* Penguin Books, London.

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Villoslada, M., Bergamo, T.F., Ward, R.D., Burnside, N.G., Joyce, C.B., Bunce, R.G.H., Sepp, K., 2020. Fine scale plant community assessment in coastal meadows using UAV based multispectral data. Ecological Indicators 111, 105979.

Appendix 1: Quadrat Data

Egypt Marsh

	EM 1	EM 2	EM 3	EM 4	EM 5	EM 6	EM 7	EM 8	EM 9	EM 10	EM 11	EM 12	EM 13	EM 14
Zonation	**Spartina**	**Spartina**	**Upper**	**Upper**	**Upper**	**Upper**	**Upper**	**Upper**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Upper**	**Upper**
Percentage cover / Species														
Agrostis stolonifera														
Armeria maritima														
Aster tripolium			10	35		10						<5	5	5
Atriplex prostrata (A. Hastata)				<5								<5	5	
Atriplex littoralis														
Atriplex portulacoides (Hailimione portulacoides)									95	75		5		
Bolboschoenus maritimus							80	80						
Cochlearia anglica														5
Juncus gerardii													10	
Festuca rubra	45	15	40				5		10	5	25		70	
Phragmites australis					20	40								
Puccinellia maritima					100								80	
Spartina anglica	100	70								5	95	20		5
Spergularia media								<5						
Triglochin maritima (T. maritimum)			80	50	5	40		10				50	10	35
Number of species	2	2	3	3	3	3	2	3	2	3	2	6	6	4
Bare ground	20	0	0	0	0	15	40	40	15	10	5	5	0	0
Litter	50	15	20	10	10	15	<5	5	5	10	15	10	5	15

Tavy River Marsh

	TRM 1	TRM 2	TRM 3	TRM 4	TRM 5	TRM 6	TRM 7	TRM 8	TRM 9	TRM 10	TRM 11	TRM 12	TRM 13	TRM 14
Zonation	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Mid-lower**	**Upper**	**Upper**	**Spartina**	**Spartina**
Percentage cover / Species														
Agrostis stolonifera													5	10
Armeria maritima														
Aster tripolium														
Atriplex prostrata (A. Hastata)							5				<5		<5	
Atriplex littoralis														
Atriplex portulacoides (Halimione portulacoides)	90	95	100	100		<5		15						
Bolboschoenus maritimus											80	55		
Cochlearia anglica														
Juncus gerardii														
Festuca rubra					65	95	20	70	40	20		5	15	
Phragmites australis														
Puccinellia maritima														
Spartina anglica				<5		50	75	25	5	30		25	30	90
Spergularia media		<5												
Triglochin maritima (T. maritimum)		40	35	10	85		30	5	15	35				
Number of species	1	3	2	3	2	3	4	4	3	3	2	3	4	2
Bare ground	10	15	0	0	0	5	10	30	45	55	20	45	20	10
Litter	0	0	0	0	<5	0	20	0	0	0	0	15	0	0