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Spatial variation in carbon storage within managed and unmanaged saltmarsh systems: A case study in the Rogerstown Estuary, Ireland

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1. Introduction

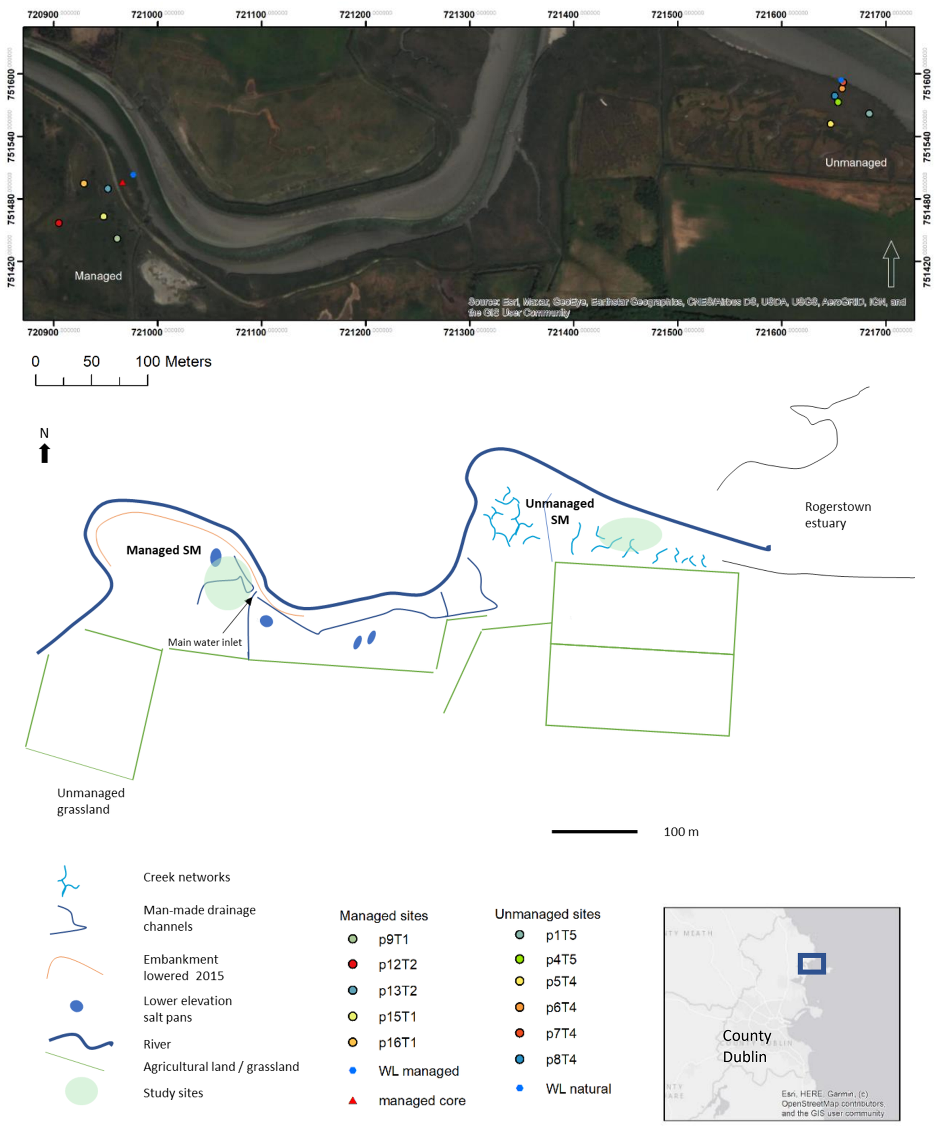


Figure 1. Turvey Nature Reserve, Rogerstown, field sample sites (pilot) and site sketch

Saltmarshes:

- Provide ecosystem services such as flood protection and carbon sequestration (e.g. Möller et al., 2021).
- Are degrading (largely due human impacts)
- Show high within-marsh process variability (e.g. drainage, accretion, plant productivity; Table 1)

Required knowledge for marsh restoration that is not currently available:

- Accurate, context-specific carbon burial rates
- Knowledge on within-marsh carbon burial variability
- Potential carbon storage controls (e.g. topography, biomass, drainage, sediment accretion)

Table 1. Comparison of saltmarsh carbon estimates in various regions.

Location	Site	Carbon Stocks/Content	Carbon Accumulation Rate	Notes	Ref
Global	Saltmarsh review		210 ± 20 g m^{-2} yr^{-1}	Review	Chmura et al 2003
Global	SM surface 0.5m	430 ± 30 Tg C		Review	Chmura et al 2003
Global average	SM		2.42 (±0.26) t C ha^{-1} yr^{-1}		Ouyang and Lee 2014
Global average	Northern Europe SM		3.15 (±0.63) t C ha^{-1} yr^{-1}		Ouyang and Lee 2014
Schiermonnikoog, Netherlands	Back barrier SM 45 yr	0.33 g cm^{-2}		Measured TOC	Elschot et al 2015
Schiermonnikoog, Netherlands	Back barrier SM 15 yrs old		12.6 ±0.9 $\times 10^{-3}$ g cm^{-2} yr^{-1}	Field	Elschot et al 2015
Tollesbury, Essex	Restored SM 0-20 yrs	21.5 t C ha^{-1}	1.04 t C ha^{-1} yr^{-1}	Model+field	Burden et al 2019
Tollesbury, Essex	Restored SM 20-50 yr	40.7 t C ha^{-1}	0.64 t C ha^{-1} yr^{-1}	Model+field	Burden et al 2019
Tollesbury, Essex	Restored SM 50-100 y	73.4 t C ha^{-1}	0.65 t C ha^{-1} yr^{-1}	Model+field	Burden et al 2019
Tollesbury, Essex	Natural 0-30 cm	6.9 ±1.4 kg m^{-1}		Model+field	Burden et al 2019
Tollesbury, Essex	Restored 0-30cm	5.9 ±1.0 kg m^{-1}		Model+field	Burden et al 2019
South Korea	Natural	19.8 kg m^{-1}		Model soil C	Byun et al 2019
South Korea	Restored	14.6 kg m^{-1}		Model soil C	Byun et al 2019
E. Australia Subtropical estuarine	SM 0-3m	823 ±138 Mg C ha^{-1}		Field, Mean	Cacho et al 2021
E. Australia Subtropical estuarine	Boambee Creek down	1.34%		Field	Cacho et al 2021
E. Australia Subtropical estuarine	Boambee Creek down	163.6 ±75.9 Mg C ha^{-1}		Field	Cacho et al 2021
E. Australia Subtropical estuarine	Boambee Creek upstr	2.85%		Field	Cacho et al 2021
E. Australia Subtropical estuarine	Boambee Creek upstr	1525.6 ±327.4 Mg C ha^{-1}		Field	Cacho et al 2021

3. Initial results

Within-site variation: across plots with different local conditions e.g. elevation, vegetation spp., highest at 5 m from river, variable with creek distance (Fig. 3)

Near-surface depth variation (pilot): Greatest change in SOC between 10 – 20 cm (Fig. 4)

Sediment properties: potential influencing factors / trends:

- C density declines at median MC%
- Min at D20 and max at D5
- Factors: **Elevation** – higher at D20 than D5; **vegetation** - D20 herbaceous, D5 mixed *Atriplex portulacoides* and herbaceous

Unpublished data – please contact author

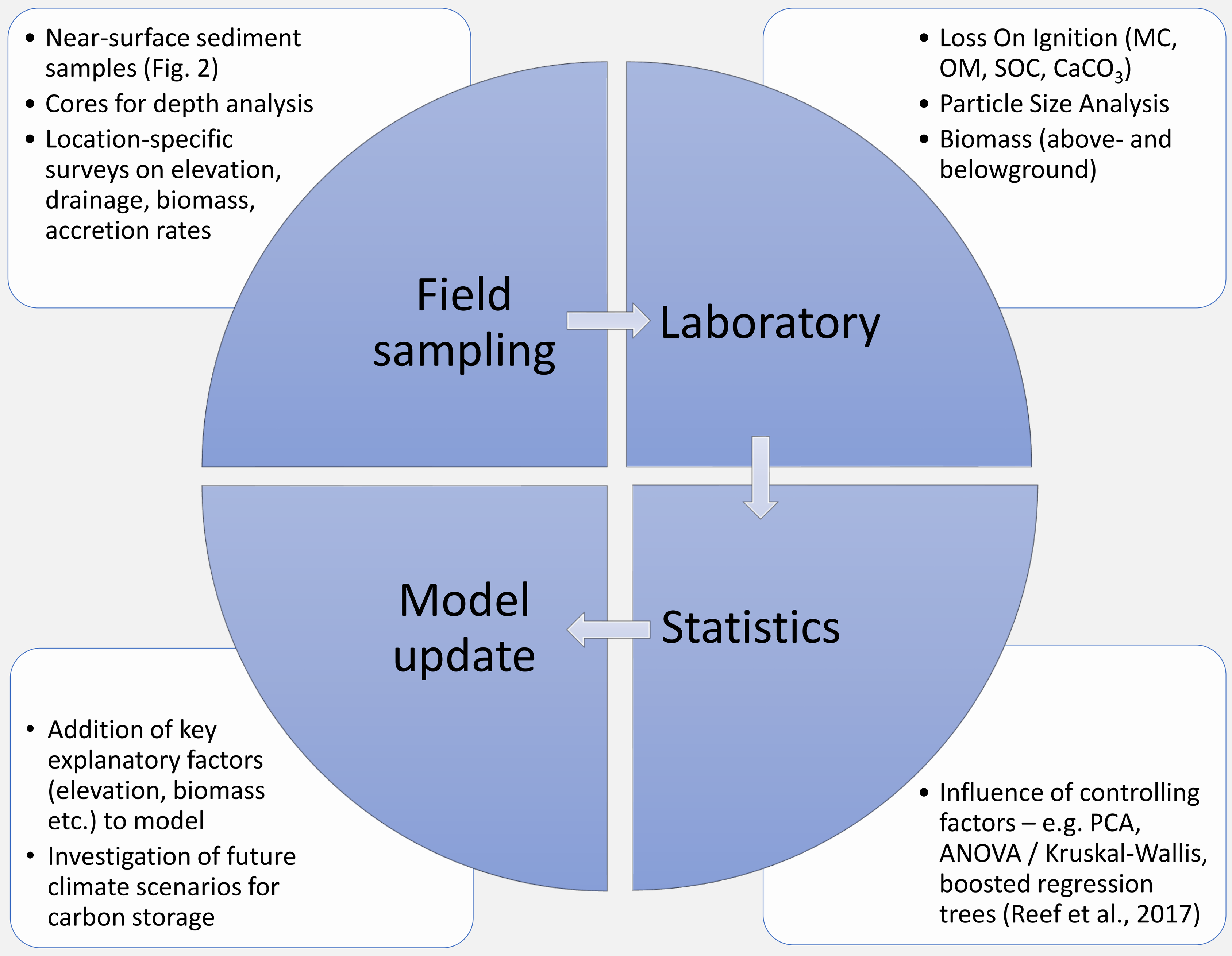
1. Introduction (continued)

Aim: Determine and explain within-marsh system (10-100 m) carbon content variability across managed / unmanaged saltmarsh sites (Fig. 1)

Objectives:

- Investigate how and why SOC varies spatially at the near-surface and with depth within a saltmarsh system (metres – 10s metres scale)
- Update existing carbon accumulation model (Burden et al., 2019) through quantification of potential key controlling factors on SOC
- Utilise updated model to investigate impacts on carbon burial rates under future climate scenarios

2. Full study methods



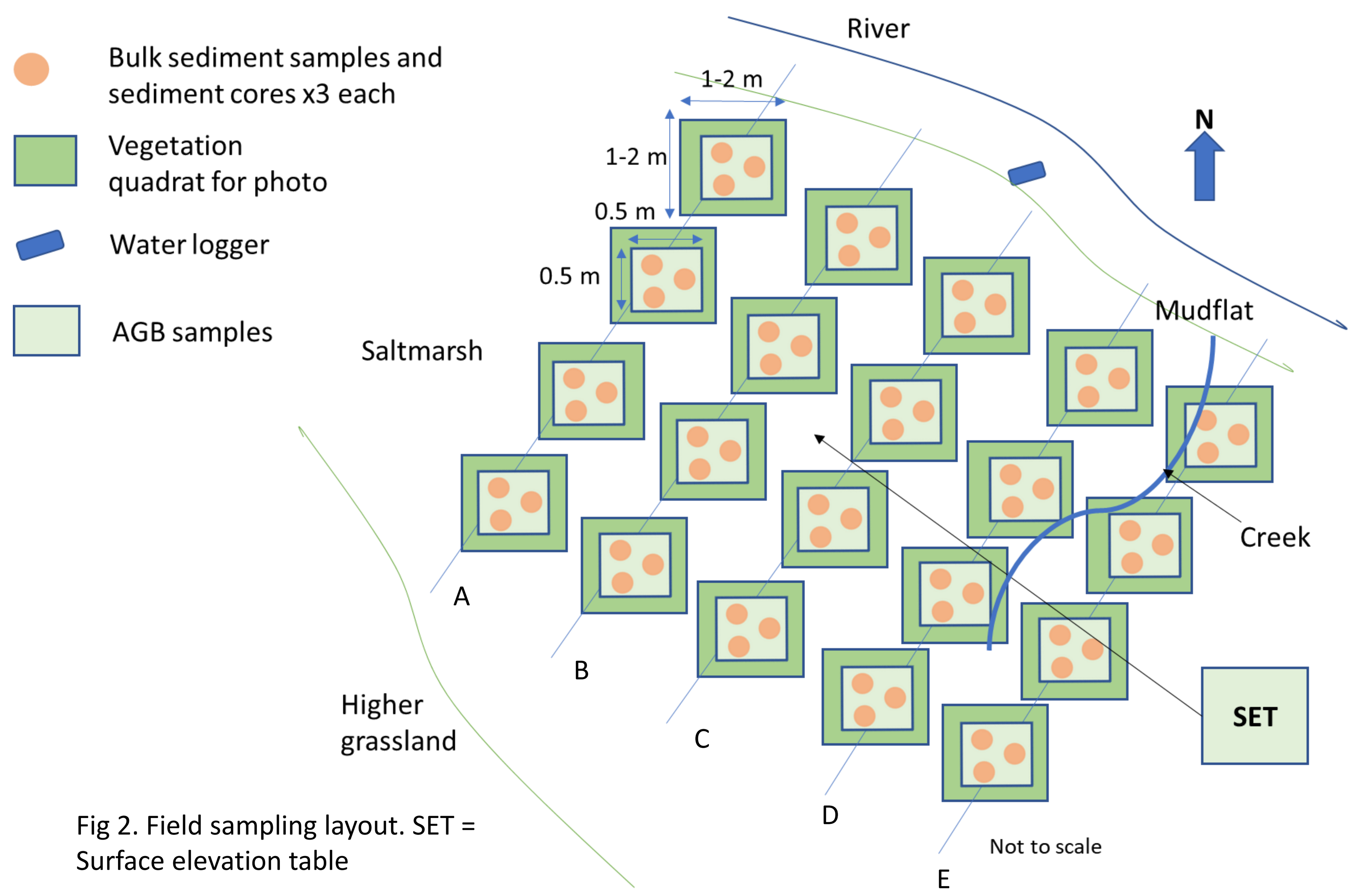


Fig 2. Field sampling layout. SET = Surface elevation table

4. Expected outcomes

- **Current stage:** Laboratory for PSA and exploratory statistical analysis
- **Next steps:** Statistical analysis - within-site and between-site SOC spatial variation; relative impact of various factors (e.g. biomass, drainage, accretion) on SOC
- **Model SOC distribution:** Improve an existing carbon accumulation model; investigate future carbon storage potential of saltmarsh systems under future climate scenarios (e.g. various SLR scenarios) using the model
- **Use:** Outputs help constrain uncertainties around scaled-up carbon accumulation estimates per unit area saltmarsh for regional, national and international inventories

References: Burden A. et al. (2019) Biol. Lett. 15: 20180773. http://dx.doi.org/10.1098/rsbl.2018.0773; Byun, C. et al. (2019) J. Ecol. Environ. 43, 8; Cacho, S.R. et al. (2021) Reg. Studies Mar. Sci., 45, Article 101840; Chmura, G. L. et al. (2003) Global Biogeochem. Cycles, 17(4), 1111, doi:10.1029/2002GB001917; Elschot, K. et al. (2015) Mar. Ecol.-Prog. Ser., 537, 9– 21, doi:10.3354/meps11447; Möller, I. et al. (2021) In: Saltmarsh Restoration Handbook: UK and Ireland (eds. R. Hudson, J. Kenworthy and M. Best), pp.2-17. EA, Bristol, UK; Ouyang, X. and Lee, S.Y. (2014) Biogeosciences, 11, 5057–5071; Reef et al. (2017) Global Change Bio, 23, 881 doi: 10.1111/gcb.13396.

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