Biodiversity, Ecosystem Functioning and Economic Value of Saltmarshes

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Introduction:

Saltmarshes supply an **important** range of **ecosystem services** (Figure 1) including coastal flood and erosion protection (Figure 2) but they are **in decline.** Better management of remaining marshes and the restoration or creation of new saltmarshes is essential to maintain these ecosystem services. The **ecosystem service approach** (MEA, 2005) aims to place a **meaningful economic value** on the **services** that they provide. Understanding the **potential economic value** of restoration, for example, will demonstrate the value of this intervention.

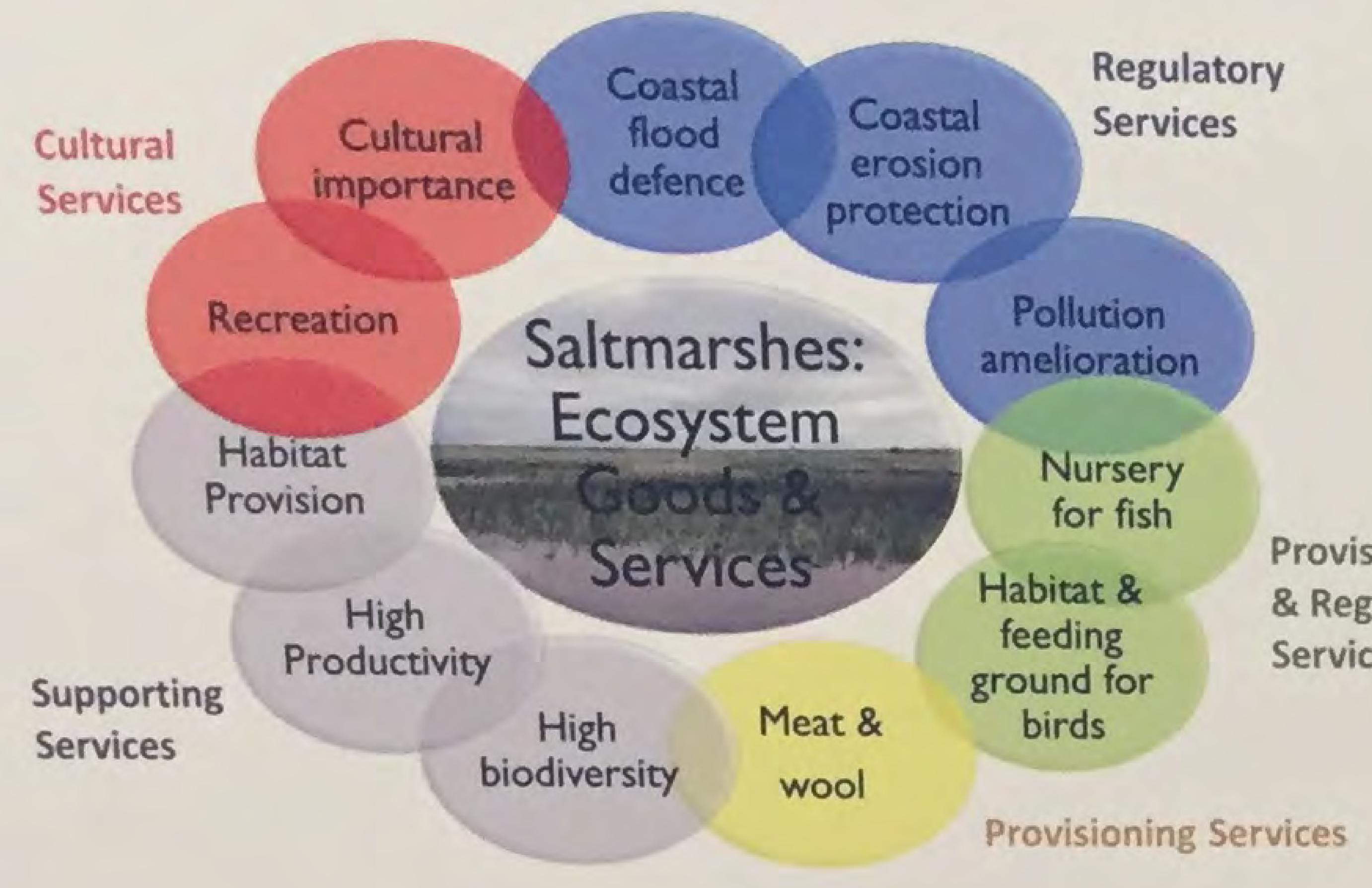

Figure 1: Example of the ecosystem services provided by saltmarshes.

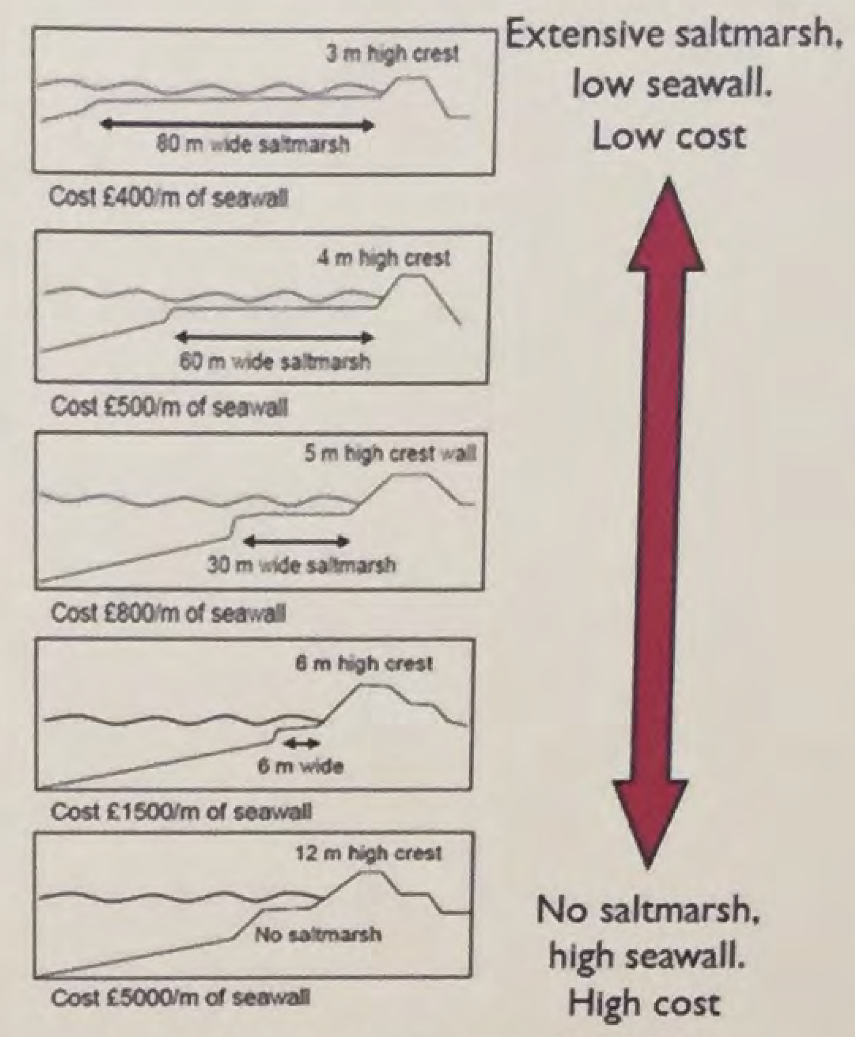

Figure 2: Indicative costs and heights of sea defences with different widths of saltmarsh fronting. Costs presented in early 1990'2 prices. Source: Doody et al. 1992.

Our ability to **value a system** is limited by our **knowledge of the ecosystem** and it's functional **attributes** (T.E.E.B., 2010). Knowledge of the expected development trajectory (Figure 3) of ecosystem functions for will assist in this.

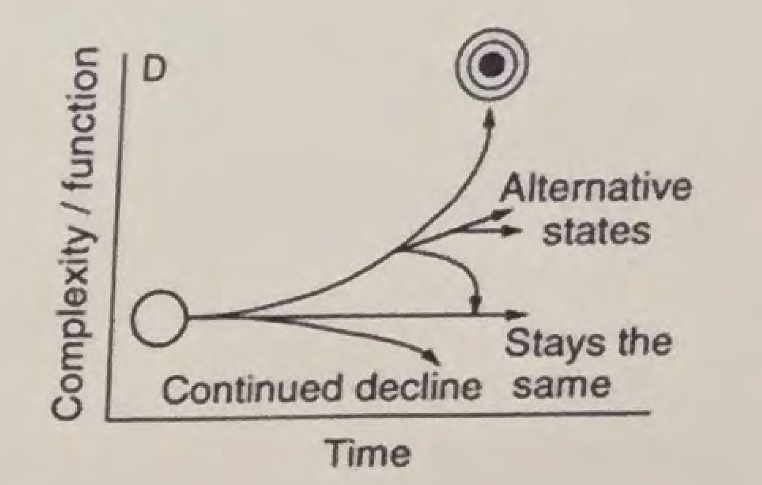

Figure 3: Hypothetical development trajectory for an ecosystem function and the possible outcomes. Natural ecosystem conditions represented by bullseye, degraded ecosystem by open circle. Source: Zedler and Callaway, 1999.

How long does restoration take?

Biodiversity and ecosystem functions of natural and restored saltmarsh and mudflats were measured in the Eden estuary (Table 1).

Table 1: Ecosystem functions and biodiversity measurements from March 2012 to March 2014 for natural saltmarsh, mudflats and transplanted saltmarsh sites (2003 to 2013) in the Eden estuary, Fife

Variable	Measurement/Sample collected	Results summarised
Macrophyte structure	Plant density and height	Approx. 10 yr. to attain comparable levels
Macrofauna Biodiversity & Community Structure	Species number and diversity	Between 5 and 10 years, however distance to existing saltmarsh is significant.
Sediment Stability	Sediment cohesion and shear strength	Temporal (seasonal) and spatial variation was found to be high for all of these variables and more influential than the length of time since transplantation. Some trends were observed however none were significant.
EPS Composition	Protein and carbohydrate content	
Surface Sediment Composition	Water content, organic matter, bulk density, grain size	
Microphytobenthos biomass	Fluorescence and chlorophyll content	

Macrophyte Structure

Following transplantation **plant height and density take** at least **10 years** to attain levels **similar** to that of a **natural saltmarsh** (Figure 4 -6).

Macrophyte structure is important for ecosystem services including **habitat provision, coastal erosion protection, coastal flood defence and productivity**. Knowledge of the time it takes for these ecosystem services to develop to a similar level of that of a natural saltmarsh is **important for coastal managers**.

Seasonal variation: Cores collected every two months between November 2012 and April 2013.

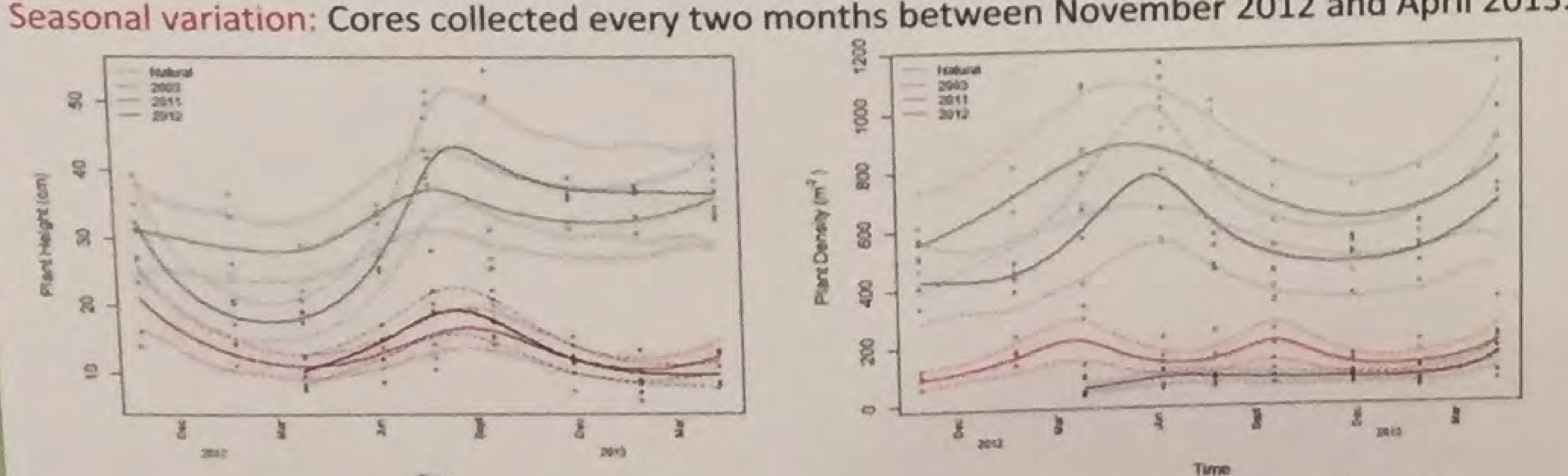

Figure 4: Changes in plant height (left) and density (right) over time for natural and transplanted sites in the Eden estuary. Plotted using a Gamma Generalised Additive Model with inverse link function. Points represent data. Solid lines represent model plot. Dashed lines represent confidence intervals (2 x standard error).

Annual variation: Cores from March 2012, March 2013 and March 2014.

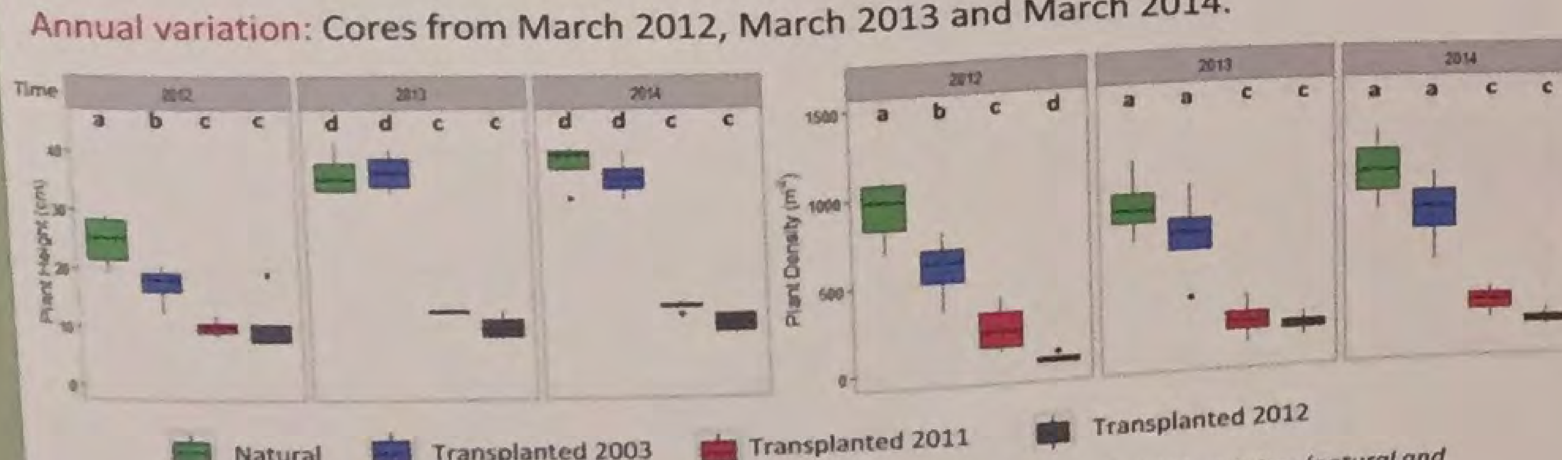

Figure 5: Changes in plant height (left) and density (right) between years (2012, 2013 and 2014) and sites (natural and transplanted sites) in the Eden estuary. Letters indicate significant differences using ANOVA and post-hoc Tukey tests.

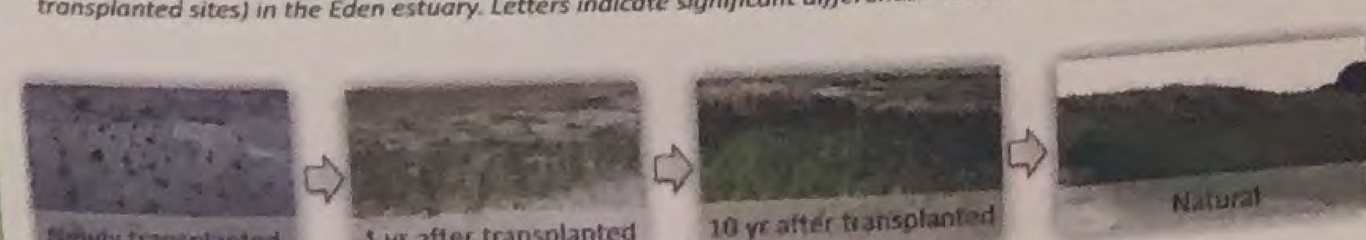

Figure 6: Photos of saltmarsh after transplantation.

Is the "function" of coastal defence valued?

The **risk of coastal flooding** has **increased** over the past decades as a result of climate change. **Damage** from flooding has **high economic and emotional costs.**

Decision makers consider:

- The selection of the **type of defences** (Table 2)
- The **location of the defences**: what will be protected
- **Locals' preferences:** council tax pays for coastal defences

Table 2: Advantages and disadvantages of coastal flood defence options. Installation costs based on data collected from the Eden Estuary.

Natural/Soft Defences	Manmade/ Hard Defences	Combined Defences
Progressive protection	Instant protection	Instant and progressive protection
Sustainable	Lifetime of 15-40	Life of sea wall extended
No on going cost	On going cost	Minimal on going cost
Blends with environment	Dramatic change to landscape	Some change to landscape
Additional habitat for wildlife	No additional habitat for wildlife	Some additional habitat for wildlife
Installation cost ~£100 m^{-1}	Installation cost ~£600 m^{-1}	Installation cost ~£450 m^{-1}

Locals **willingness to pay** and **preferences** for **coastal flood defences in the Eden estuary** was conducted using a **choice experiment** (Hensher et al., 2005). c

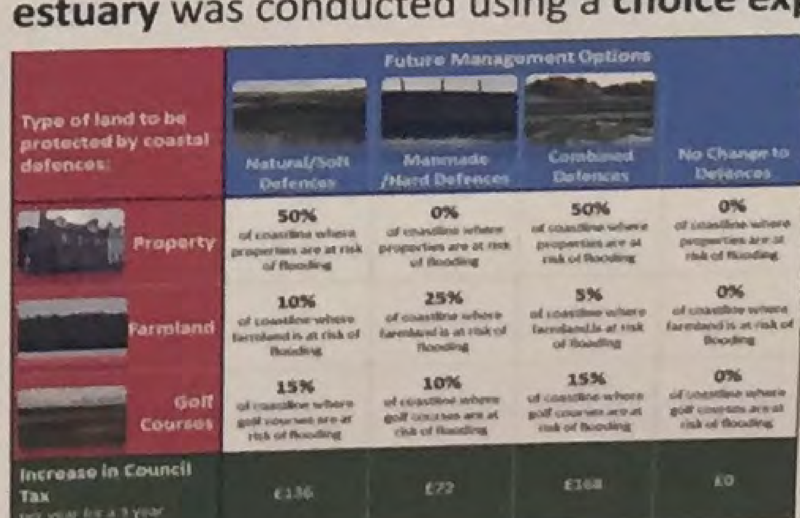

Figure 7: Example choice card for valuation of Eden coastal defences

- Survey was completed online and included a background information video, choice set of 8 cards (Figure 7) and socio-demographic questions.
- 247 respondents within the target sample area completed the survey.

Willingness To Pay

- Respondents had a **preference for combined defences** over soft defences (Table 3).
- The majority of respondents **disliked** the **hard defences**, however a small group opted for them (latent class analysis not shown here).
- Respondents were willing to **pay more to protect property** compared to farmland or gold fairways.

Table 3: Willingness to Pay Estimates for coastal defences in the Eden Estuary using a random parameters logit model.

ATTRIBUTE	WTP (£ per household)			PROBABILITY
	Mean	95% Confidence Interval		
Soft Defences	£553	-£209	£1,316	0.000
Hard Defences	-£2,899	-£5,042	-£756	0.012
Combined Defences	£1,021	£296	£1,745	0.000
Farmland	£30	£7	£52	0.000
Property	£77	£27	£126	0.000
Golf fairways	NA	NA	NA	NS

"Farmland should be allowed to flood if it protects property"

"Golf courses should pay for their own protection – they have enough money!"

Summary

When restoring saltmarshes **functions are restored at different rates** but this research suggests we **can successfully restore ecosystem functioning** of saltmarshes through transplantation.
The public **value combined coastal defences over soft** through. The majority **dislike hard coastal defences.**

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