COEVOLUTION OF HYDRAULIC, SOIL AND VEGETATION PROCESSES IN ESTUARINE WETLANDS.

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1. Background

Estuarine wetlands are among the most productive ecosystems on Earth, providing habitat for commercially important fish species and migratory shorebirds, serving as nurseries for many other marine organisms and supporting the productivity of adjacent coastal waters. Typically, these wetlands are driven by tidal hydrodynamics and are net sinks for sediment and soil carbon. Their distribution in the tidal frame depends on a delicate balance between topographic gradient, the rate of vertical soil development, and the rate of sea-level change. The complex interactions between hydrodynamics, ecology and soil processes that govern this balance produce positive feedbacks and system self-organization. As complex systems, these wetlands demonstrate resilience under a wide range of conditions but they have been observed to collapse or move to another equilibrium state above certain thresholds.

Sea level rise associated with accelerated global warming has the potential to profoundly affect estuarine wetlands in Australia. Many wetlands in Australia are comprised by mangrove on the sea side and saltmarsh on the land side. Sea-level rise has promoted mangrove landward migration, but barriers to saltmarsh migration have resulted in net wetland loss. This poster examines potential effects of sea-level rise on an estuarine wetland of South eastern Australia (Fig 1). Long term vegetation changes and soil build up rates are incorporated into continuous hydrodynamic simulations of an estuarine wetland under different sea level rise scenarios.

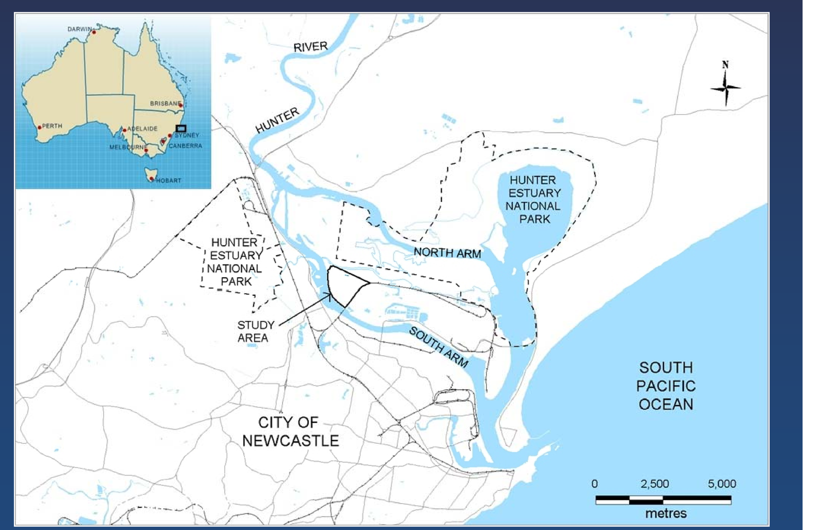

Figure 1 - Location of the Hunter estuary, NSW, Australia (32º51'52"S, 151º 42'15"E), and the study area for this research

2. Site Characterization

Substrates of the study area are Grey Mangrove *Avicennia marina*, permanent tidal pools, intertidal saltmarsh pannes, *Sporobolus virginicus* saltmarsh and *Sarcocornia quinqueflora* saltmarsh (Fig. 2). Saltmarsh pannes and tidal pools may be unvegetated or covered by dense stands of benthic algal matting or filamentous algae, respectively.

Shorebird habitat is closely linked to vegetation distribution. Wader birds preference for roosting includes saltmarsh, mudflat and saltmarsh panes, and excludes mangrove. Past mangrove encroachment on saltmarsh has resulted in decline of birds use of the study site (Rodriguez and Howe, 2013).

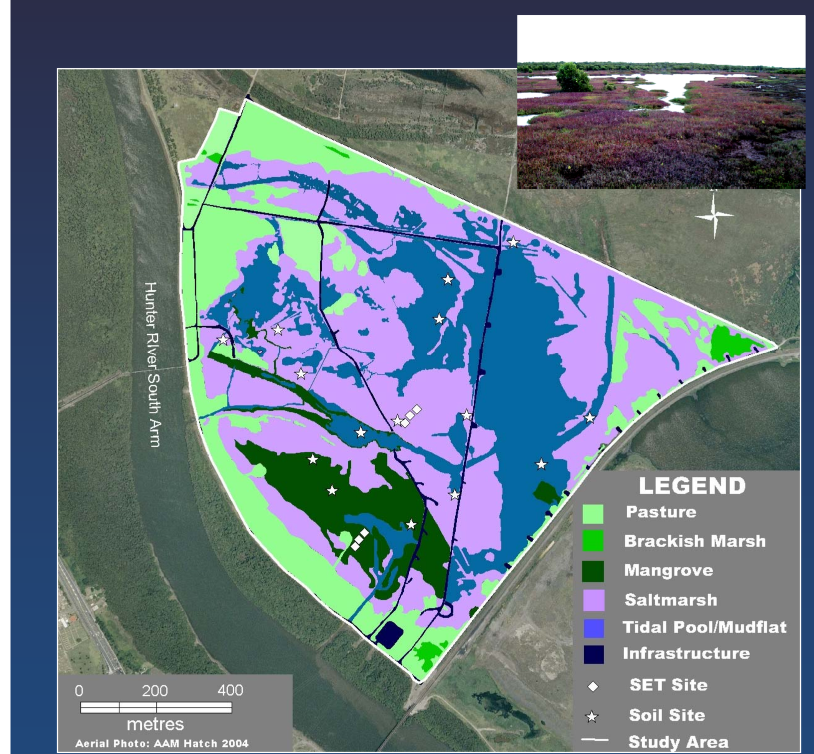

Figure 2 – Vegetation distribution within the study area showing location of surface elevation tables (SETs)

Figure 3 – Migratory shorebird habitat

3. Model Formulation

Predicting estuarine wetlands response to sea-level rise requires modelling the coevolving dynamics of water flow, soil and vegetation. This paper presents preliminary results of our recently developed numerical model for wetland dynamics in wetlands of the Hunter estuary of NSW. The model simulates continuous tidal inflow into the wetland, and accounts for the effect of varying vegetation types on flow resistance.

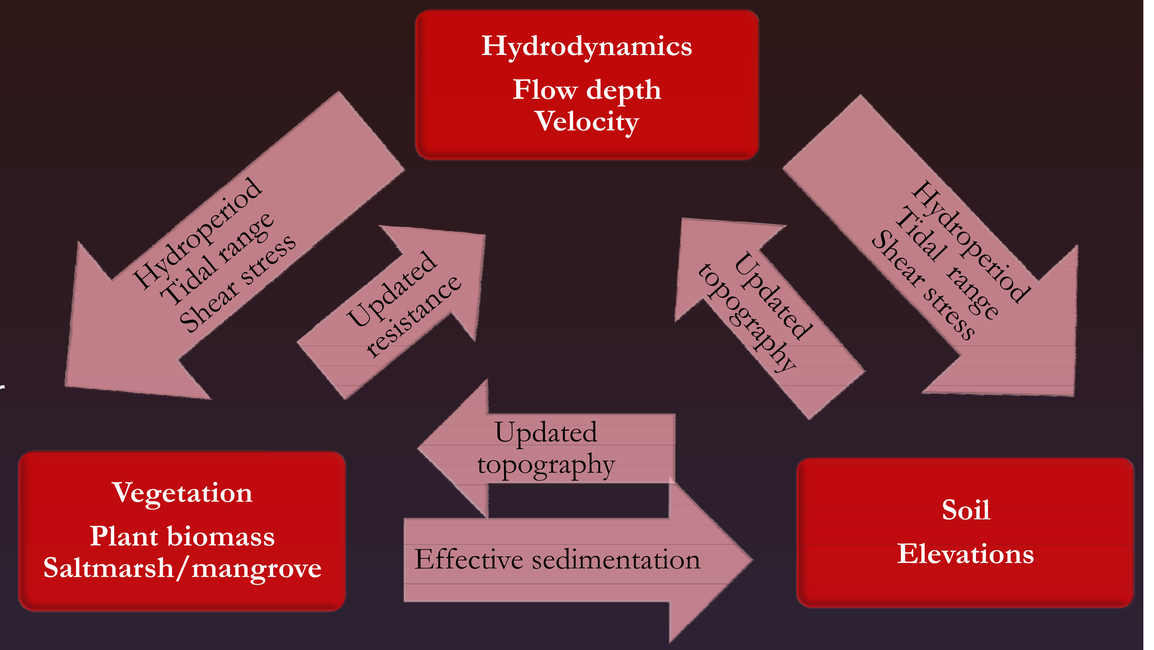

Figure 4 – Model components and feedbacks

Coevolution effects appear as vegetation types are updated based on their preference to prevailing hydrodynamic conditions. The model also considers that accretion values vary with vegetation type. Simulations are driven using local information collected over several years, which includes estuary water levels, accretion rates, flow resistance and vegetation preference to hydraulic conditions.

Hydrodynamic Module

We use a 2D flood model VMMHH 1.0 (Riccardi 2000), which is based on the inter-connected cells scheme and includes both river (1-D) and floodplain cells. Mass conservation is solved implicitly (Fig. 5) and the momentum equation is replaced by discharge laws that depend of the type of link between cells. Links can be culverts, weirs, channel flow, etc.

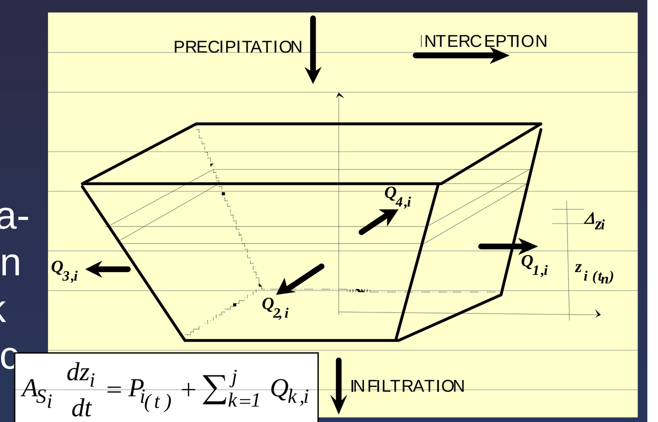

Figure 5 – Cells model

Vegetation Module

Vegetation is defined based on observed preference of mangrove and saltmarsh to Hydroperiod (H) and Tidal Range (R_T) based on measurements (Howe et al. 2010) (Fig. 6 and Table 1)

Figure 6 – Classification of vegetation sites based on Hydroperiod and Tidal Range

Table 1 – Values of H, R_T and elevation from classification

	Mangrove	Tidal pool/mudflat		Saltmarsh
Elevation [mAHD]	-	≥ 0.35 m + SLR[3]	< 0.35 m + SLR[3]	≥ 0.35 m + SLR[2]
R_T [m]	-	> 0.40	≤ 0.40	≤ 0.40
H	≤ 0.45	> 0.45		> 0.45

Soil Evolution Module

Change in soil surface elevation is defined based on observed surface elevation tables (SETs) data over 2000-2010 period (Howe et al. 2009) (Fig. 7 and Table 2)

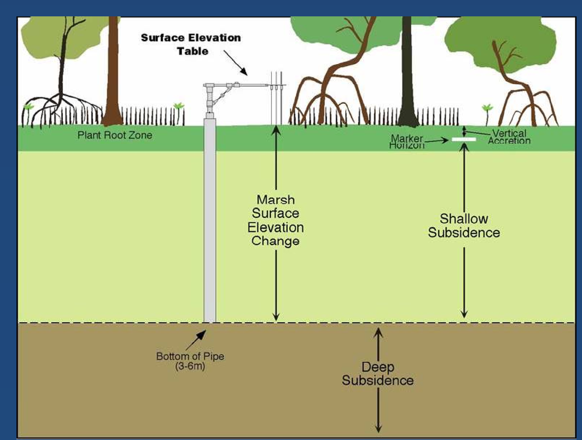

Figure 7 – SET (after Cahoon et al. 2002)

Table 2 – Values of surface elevation change

	Mangrove	Tidal pool/mudflat	Saltmarsh
Mean surface elevation change [mm y^{-1}]	2.45	-	2.02

4. Model Setup and Results

Setup

The domain included most part of the wetland, internal culverts and channels (Fig. 8). Input at the wetland entrance for the numerical model consisted of hourly water level data based on observations and modified for different sea-level rise scenarios (Fig. 9). The hydrodynamic model results successfully simulated tidal attenuation due to internal culverts (Fig.10).

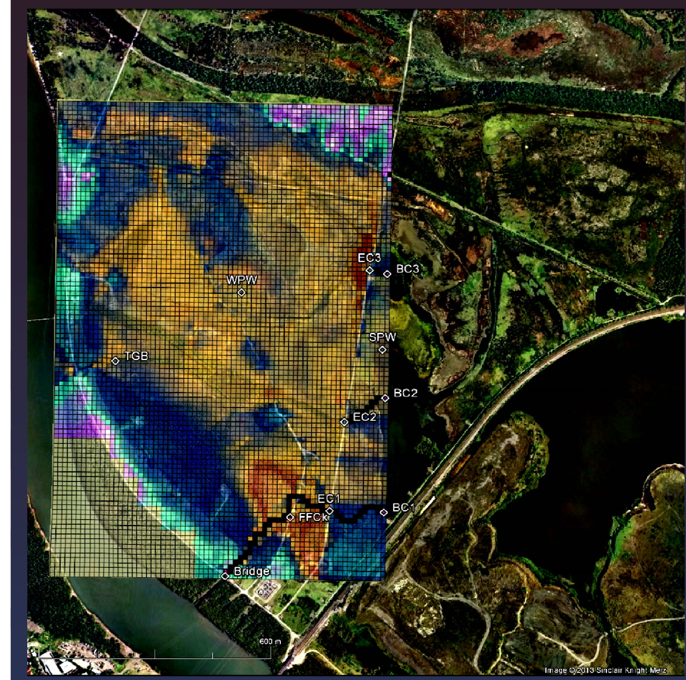

Figure 8 – Computational domain.

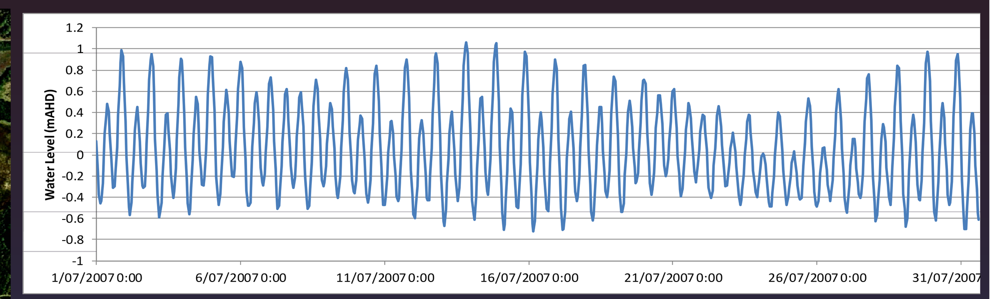

Figure 9 – Tidal input at wetland entrance.

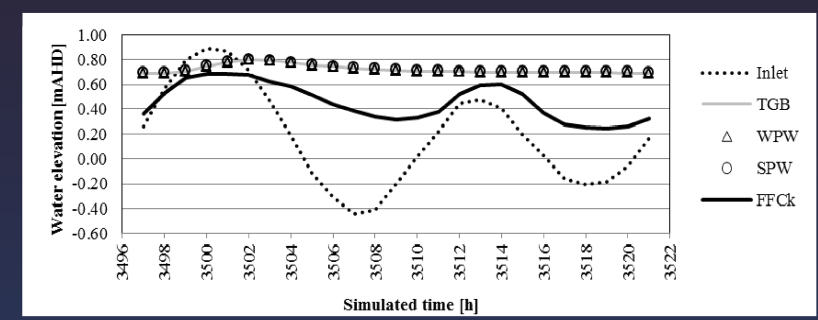

Figure 10 – Hydrodynamic model results.

Results - vegetation evolution

The model was run for a 20-year period considering two different IPCC rates of sea-level rise: 8 and 11 mm/y (Fig. 11). Evolution of vegetation distribution outputs given by model runs confirms the expected response of estuarine wetlands to sea-level rise: saltmarsh areas migrate inland in order to maintain a favourable position in the tidal frame, but in parts of the wetlands buffer areas for landward migration are not available and saltmarsh-vegetated area is replaced by tidal pool/mudflat. Using the two different sea-level rise rate scenarios of 8 mm/y and 11 mm/y vegetated area losses ranged from 6.33 % to 13.77 % for mangrove and from 47.04 % to 54.45 % for saltmarsh, respectively (Fig. 12).

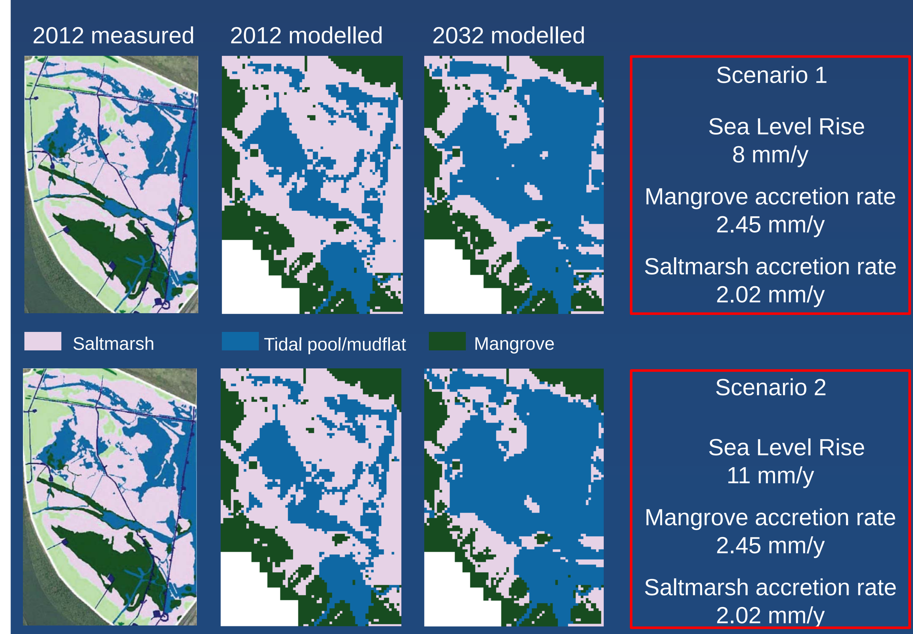

Figure 11 – Model predictions of vegetation evolution

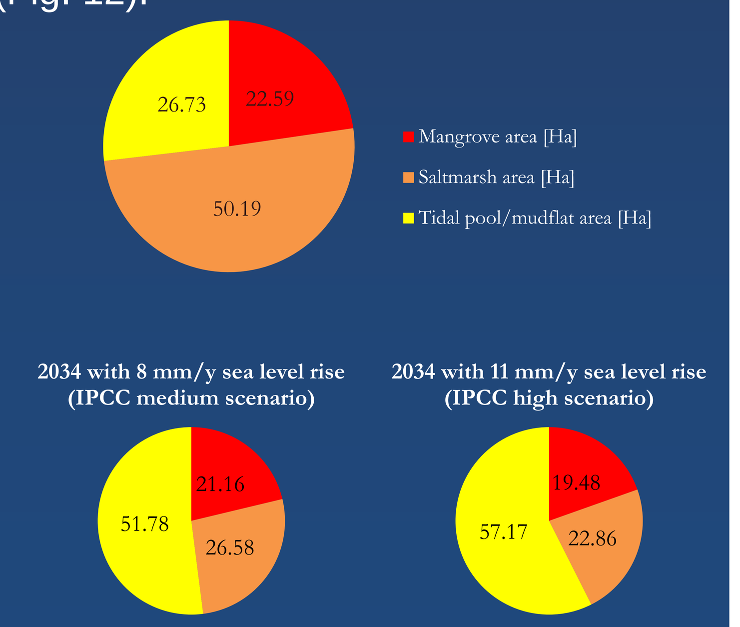

Figure 12 – Vegetation changes for two sea-level rise scenarios

6. References

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