Predicting sea level rise impacts on coastal wetlands restored by tidal reintroduction

The restoration of coastal wetlands can help climate change mitigation by avoiding greenhouse gas (GHG) emissions and increasing rates of sequestration in plant biomass and soil. However, sea level rise will affect coastal wetlands in the future, leading to uncertainty about the amount of abatement that we should expect. We need predictive models which can help us understand how climate change will affect coastal ecosystems and the outcomes of restoration projects.

How will sea level rise affect coastal ecosystems?

Sea level rise (SLR) will affect coastal wetlands, and potentially the effectiveness of restoration, because the distribution of coastal wetland vegetation is strongly affected by elevatiion relative to tides. For example, mangroves primarily live in the intertidal zone between mean tide and high tide level. As sea levels rise, this zone gradually moves inland if soil elevation does not keep pace – resulting in losses, gains, and transitions in ecosystem types. The balance between habitat loss and gain due to sea level rise on coastal wetlands determines whether sea level rise poses a risk or an opportunity to the outcomes of wetland restoration projects.

Coastal ecosystems can respond to deepening water from SLR through the following mechanisms:

- loss of mangroves at the deep edge through submersion
- vertical accretion of the seafloor upwards through the trapping of sediments and organic matter to keep pace with rising seas
- migration inland, and/or transition from one ecosystem type to another that is adapted to deeper waters. For instance, saltmarshes can transition to mangroves, and mangroves to seagrass.

How the research addresses the problem

We are developing a spatially explicit model which can predict the impacts of sea level rise on wetland restoration projects in Australia which removes barriers (e.g. bund walls) to seawater to allow 'tidal reintroduction' **(Figure 1).** These barriers were often installed to expand agricultural areas by preventing tides from inudating them. Tidal reintroduction allows coastal wetlands to re-establish this can generate benefits such as reduced emissions of greenhouse gases, and increased rates of sequestration of organic carbon.

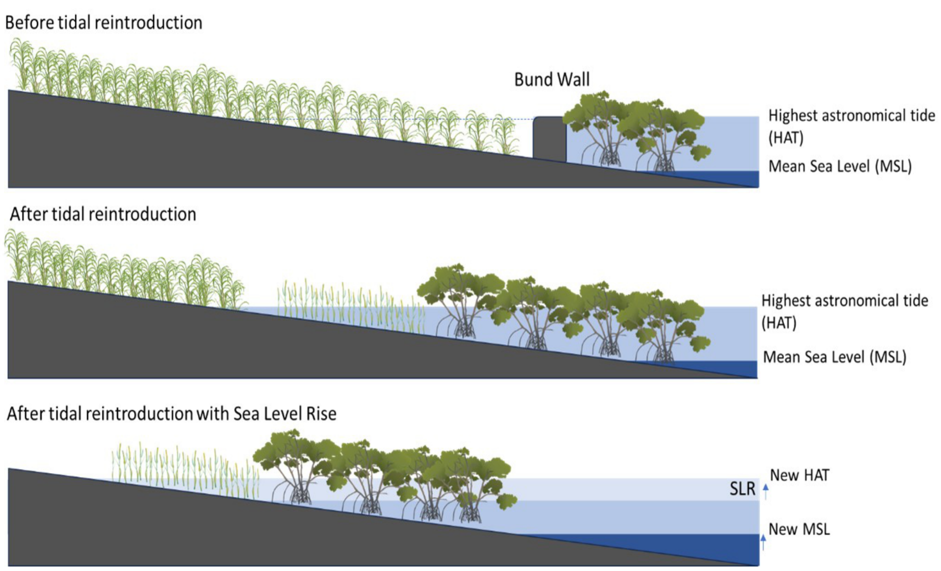

Figure 1. Conceptual model showing a coastal seascape with a bund wall blocking the sea water from ingress inland, allowing for crop land and grazing land. Removal of the bund wall ('tidal reintroduction') is a coastal wetland restoration method approved by the Clean Energy Regulator in Australia for carbon credits. Tidal reintroduction allows mangroves and saltmarshes to reestablish.

Our objectives are to:

- represent key biophysical responses of coastal wetlands to restoration (tidal reintroduction) and sea level rise, such as loss, accretion, migration, and ecosystem transitions, in a model;
- create a tool which is flexible and can be applied over a range of spatial extents, from local to regional to state to continental, depending on objectives and the input data which are available;
- use the model to explore how carbon abatement varies according to different sea level rise scenarios.

Prior to our research there was a gap in models available to address these objectives. Previous models which were designed to be applicable over large spatial extents (state-national level) have limited information on key processes, such as accretion or migration. Other models designed to represent the important processes are not practical to apply over large spatial areas, due to either low data availability or high processing requirement.

Figure 2 . Left photo showing pre restoration site (cane field) and right photo showing the Blue Heart restoration site on the Sunshine Coast, QLD, Australia. Photo credit: Cath Lovelock.

A new model for predicting sea level rise impacts

The model is a spatial implementation of **BlueCAM** - Blue Carbon Accounting Model (Lovelock et al. 2023) adapted to allow for future scenarios of sea level rise. BlueCAM is the tool developed by the Australian Clean Energy Regulator and implemented through the Australian Carbon Credit Units (ACCU) Scheme to predict the outcomes of wetland restoration following tidal introduction. The original BlueCAM model is implemented in an Microsoft Excel spreadsheet and is used for reporting abatement after a project has started at a single (or a few) sites. It was not developed as a tool to predict abatement in the future and cannot explicitly account for sea level rise for projections of potential abatement.

This project has adapted elements of BlueCAM, to account for future sea level rise and associated ecological processes, which can be implemented over large spatial extents (e.g. Natural Resource Management (NRM) to state or national scales). The model is conservative, using parameters for current rates of sediment accretion although accretion rates may increase with increasing rates of sea level rise.

Findings

Outcomes of the model suggest that sea level rise can pose both a risk and opportunity to blue carbon projects. If coastal wetlands are prevented from migrating inland, for instance, due to the presence of coastal defence infrastructure, like seawalls, bund walls or levees, then 'coastal squeeze' will occur resulting in wetland loss. Allowing for inland migration at coastal restoration sites is critically important to maintaining carbon sequestration and other ecological functions and services as sea levels rise.

References: Lovelock CE, Adame MF, Bradley J, Dittmann S, Hagger V, Hickey SM, Hutley LB, Jones A, Kelleway JJ, Lavery PS (2023) An Australian blue carbon method to estimate climate change mitigation benefits of coastal wetland restoration. Restoration Ecology 31:e13739

For further information

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