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Mangrove and saltmarsh surface elevation dynamics in relation to environmental variables in Southeastern Australia|

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MANGROVE AND SALTMARSH SURFACE ELEVATION DYNAMICS IN RELATION TO ENVIRONMENTAL VARIABLES IN SOUTHEASTERN AUSTRALIA

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CERTIFICATION

I, Kerrylee Rogers, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Earth and Environmental Sciences, Faculty of Science, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Kerrylee Rogers

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ABSTRACT

Research has demonstrated that at many sites in Southeastern Australia, there have been changes in the extent of mangrove and saltmarsh communities over the past five decades. In particular, this has been characterised by encroachment of saltmarsh by mangrove. Changes in the relationship between marsh elevation and water levels, facilitated either by altered tidal regimes, eustatic sea-level rise or marsh subsidence/autocompaction, have been hypothesised as the driver of these community-scale changes. In addition, the evidence for future sea-level rise is compelling and abundant. However, our understanding of marsh sedimentary and elevation dynamics in relation to sea-level and the impacts of sea-level rise on mangrove and saltmarsh in Southeastern Australia is limited. The aim of this study was to examine marsh elevation trajectories in relation to sea-level change, establish the contribution of sedimentation to these changes and determine the vulnerability of mangrove and saltmarsh to submergence from sea-level rise.

This research has been carried out over approximately 1 500 km of coastline and at wide range of sites in Southeastern Australia, including the Tweed River, Hunter River, Hawkesbury River, Parramatta River, Minnamurra River, Jervis Bay and Western Port Bay. Photogrammetric mapping of mangrove and saltmarsh extent was compiled for each study site and tidal inundation models were developed to determine the vertical and horizontal change in mangrove and saltmarsh extent since the commencement of aerial photography. A network of Surface Elevation Tables was established to examine marsh elevation trajectories in relation to sea-level changes and determine the environmental variables influencing marsh elevation. Feldspar marker horizons were established in mangrove and saltmarsh to examine contemporary sediment accretion trajectories and determine the contribution of sedimentation to marsh elevation. Sediment cores from saltmarshes in Western Port Bay were ^{210}Pb dated to establish historic sedimentation rates and make comparisons with sea-level changes. To ascertain whether mangrove and saltmarsh distribution changes were related to sea-level rise, sedimentation and/or subsidence, comparisons were made between changes in vegetation extent, sedimentation, marsh elevation changes and sea-level changes.

Contemporary rates of sediment accretion varied greatly, but generally agreed with historic rates of sedimentation determined for the past 100 years at Western Port Bay. Inundation frequency, tidal range and geomorphology were all shown to influence sediment accretion at study sites. Surface elevation changes were strongly correlated to *El Niño* intensity (Southern Oscillation Index) and rainfall. Mean sedimentation contributed to approximately 67% of surface elevation change in saltmarsh settings and 51% in mangrove settings. A consistent relationship between sediment accretion and surface elevation changes was not observed.

At most study sites sediment accretion exceeded surface elevation changes due to subsurface processes causing subsidence/autocompaction. The bulk of subsidence was attributed to reduced rainfall in association with the 2002 to 2004 *El Niño* related drought, which was shown to cause groundwater reserves to be depleted. Surface elevation exceeded sediment accretion in the saltmarsh at three study sites and this was attributed to ponding of surface water causing sediments to swell due to pore-water storage increases, and increased primary productivity and associated below-ground root development that displaced the marsh surface.

Rates of sediment accretion generally kept pace with or exceeded sea-level changes, However, since subsurface processes of subsidence/autocompaction and uplift influenced marsh elevations, it was more appropriate to determine mangrove and saltmarsh vulnerability to sea-level rise on the basis of an elevation deficit, defined as the difference between rates of marsh elevation change and sea-level change over the same study period. Elevation deficits indicated that the vulnerability of mangrove and saltmarsh in Southeastern Australia to submergence was low.

Submergence may not be the only possible impact of sea-level rise on mangrove and saltmarsh communities. No relationship was found between mangrove increase and sedimentation or saltmarsh decline and sedimentation. However, a significant relationship was established between rates of surface elevation change in the saltmarsh and rates of mangrove area increase. By determining the vertical gradient over which mangrove had increased extent and relative sea-level rise, which incorporates mangrove surface elevation changes and eustatic sea-level rise, a significant correlation was found between relative sea-level rise and the vertical

component of landward mangrove encroachment. Observed changes to mangrove and saltmarsh extent in Southeastern Australia over the past 50 years were attributed to subsidence and sea-level rise.

Several sedimentation and surface elevation trends in Southeastern Australia were typical of marshes within the international SET network. Sedimentation was equivalent to surface elevation change at few sites and marsh elevations were typically influenced by subsidence. Mangrove sediment accretion may also be globally predicted on the basis of tide range and long-term sea-level rise at study sites. However, marsh surface dynamics in Southeastern Australia differ from global trends due to the upper intertidal location of saltmarshes, the strong influence of drought on marsh elevations and generally lower rates of sea-level rise.

The results of this study have important implications for current estuary management practices. For example, interference with natural sediment movements within estuaries by trapping sediments and associated nutrients upstream may actually reduce sediment availability to mangrove and saltmarsh communities and increase their vulnerability to the impacts of sea-level rise. Also, the finding that groundwater plays an important role in maintaining marsh surface elevation has implications on the management of groundwater resources and the role of climate change on the long-term survival of mangrove and saltmarsh communities.

PUBLICATIONS RELATED TO THIS RESEARCH

Rogers K., Saintilan, N., and Cahoon, D.R. (in press) Surface elevation dynamics in a regenerating mangrove forest at Homebush Bay, Australia. *Wetlands Ecology and Management*.

Rogers, K., Saintilan N., and Heijnis, H. (in press) Mangrove encroachment of saltmarsh in Western Port Bay, Victoria: the role of sedimentation, subsidence and sea-level rise. *Estuaries*

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