



## Editorial

## Salt marsh geomorphology: Physical and ecological effects on landform

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Evidence that the three-dimensional structure of salt marsh landscapes facilitates feedback between physical processes and biological communities is well documented in the literature. For example, geomorphic properties of intertidal wetlands such as land:water ratios, marsh elevation, marsh flooding frequency-duration-depth, drainage network configuration and density, and the ratio of marsh edge:marsh interior have all been shown to affect the distribution and density of salt marsh flora and fauna. Likewise, biological processes clearly exert important controls on salt marsh sedimentary processes. For example, the vegetation canopy may enhance depositional or erosional processes, benthic mats or biofilms may help stabilize unconsolidated sediment, burrowing organisms create preferential groundwater flow paths, and root systems may add cohesive strength to creek banks.

In order to facilitate scientific exchange between salt marsh biological and physical scientists we organized an American Geophysical Union-sponsored Chapman Conference in Halifax, Nova Scotia titled: *Salt Marsh Geomorphology: Physical and Ecological Effects on Landform*. Specifically, the major scientific goals of the meeting were to (1) discuss feedbacks between salt marsh ecosystem processes and sedimentary processes, and to (2) determine research questions of critical importance to guide our understanding of coupling ecosystem and geomorphic processes, and (3) how to apply these findings to salt marsh restoration. There were 73 delegates from 17 countries in attendance and the meeting consisted of 32 oral and 35 poster presentations, and discussion continued between physical and ecosystem scientists during two full day fieldtrips to the Bay of Fundy and to the Atlantic coastline.

One important outcome of the conference was the clear demonstration that morphological and ecological attributes of salt marshes vary significantly with geographic location and their unique sets of bio-physical processes. For example, characterization of forcing functions such as SSC, tidal range, vegetation effects, morphology, climate, hurricanes/cyclones

and hydrodynamics require both site specific and broader scale research in order to place salt marsh landscapes within a global framework. Moreover, in order to evaluate spatially variable evolution of salt marshes it is necessary to adopt standard measurement techniques and comparative analysis. A successful example of research with a standardized methodology is the Surface Elevation Table (SET, <http://www.pwrc.usgs.gov/set/>). The combination of a standardized method for accretion measurements and a broad network provides a scientific basis for comparative studies. However, it was discussed and demonstrated that use of these devices requires more than merely an elevation context, as is usually supplied. SET measurements also require a local geomorphic context, e.g. distance from the channel, micro topography around the SET, and changes in vegetation density to help assess spatial and temporal variability in net accumulation estimates.

Conference presentations also highlighted the complexity of biosedimentary processes and their effects on sediment mobility and geomorphology, and future research needs in this area. In this regard, coupled biological and physical models are coming on line, enabling comprehensive analyses of salt marsh biological and physical interactions, and their effects on geomorphology (see for example, D'Alpaos et al., this issue). Given the novelty of these types of models, some model parameters still need scientific testing. For example, we still lack a quantitative relationship for belowground organic production and the processes that control it, or a definitive way to express the effects of vegetation on hydrodynamics (see Moeller, this issue). Despite these limitations, numerical models of salt marsh evolution are highly effective at describing the complex interactions between biota and sediment transport processes, and can help drive field investigations on specific processes fundamental for the co-evolution of the salt marsh landscape.

Another important outcome of the meeting is that it reinforced the overall significance of a precise characterization

of equilibrium states for salt marsh landscapes. In fact, the final goal of any modeling approach should be the determination of the rates at which the coupled biological and physical systems covary toward equilibrium, or how the systems switch between different equilibrium configurations. It is anticipated that improved model results will help the marsh restoration community abandon the practice of replicating conditions at a “reference site” in favor of more physically based restoration criteria. Moreover, lessons learned from this scientific exchange have direct implications on the rehabilitation of the US Gulf Coast salt marsh landscapes that were devastated by hurricanes Katrina and Rita in 2005.

Katrina and Rita damaged or destroyed extensive residential and commercial infrastructure, and wildlife habitat and fisheries in and around salt marsh landscapes. Lessons learned from this conference and papers presented in this special issue will have important implications for identifying methods to “fix” damaged salt marsh. For example, Marani et al. (this issue) combine a series of observational techniques and modeling efforts to reveal aspects of the physical and ecological coevolution of a salt marsh landscape. This work demonstrates that modeling and field research are needed to jointly define the operative scales of sediment and water transport in salt marsh landscapes, to define the functional form of transport laws, and to constrain those that are in use today.

In this special issue we present a series of papers highlighting some of the meeting presentations and discussions. Papers range from field studies to numerical analyses of the interactions and feedback between physical forcings and flora and faunal response, in the context of salt marsh geomorphology. The first paper, D’Alpaos and colleagues use numerical simulations to investigate how physical and biological processes interact to affect tidal channel cross-sectional geometry. Leonard and Croft assess flow and turbulence conditions for flow through intertidal macrophytes, and Moeller presents a digital photographic method for measuring marsh vegetation properties that promote wave attenuation. Turner et al. investigate the spatial and temporal variability of volume changes in organic-rich salt marsh soils. Agrow and Fitzgerald quantify peat compaction and elevation changes in a salt marsh due to winter ice. Nyman et al. measured salt marsh accretion resulting from both organic and inorganic material accumulation and provide a quantitative comparison. Horton and colleagues use multivariate analyses to distinguish salt marsh diatom assemblages into distinct elevation zones. Morris uses numerical simulations to investigate feedbacks between physical processes and plant zonation. Minkoff et al. present a cellular automata model to investigate the long-term effects of interactions between crabs and vegetation on the initiation of tidal creeks.

Marani et al., as discussed above, combine different sets of data and physically-based modeling to understand the geomorphic evolution of a salt marsh landscape. Finally, Gardner and Wilson compare numerical model results to assess the most suitable approach for investigating near-surface hydrology and seepage in an intertidal salt marsh.

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