Integrating biological and physical processes to predict the impact of sea-level rise on tidal marsh habitat

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Abstract

The San Francisco Bay Estuary contains the largest extent of tidal marsh in the western United States and is home to several state and federally listed threatened and endangered species. Climate change threatens the habitats of these and other species through accelerated sea-level rise. These wetlands are sustained when the rate of relative sea-level rise is less than or in equilibrium with organic and inorganic inputs to the marsh surface. The Wetland Accretion Rate Model for Ecosystem Resilience, or WARMER, a 1-D model of elevation at a point representative of wetland habitat that incorporates both biological and physical processes of vertical marsh accretion, is currently being developed in order to better understand the threat of rising sea level on marsh sustainability. Processes included in the model are inorganic sediment deposition and organic matter production, decomposition, and compaction. WARMER builds upon existing wetland vertical accretion models by incorporating more realistic tidal forcing and sediment deposition processes as well as including a more realistic biomass production routine. The model will be applied to marshes across the San Francisco Bay Estuary in conjunction with wildlife monitoring as part of the USGS National Climate Change and Wildlife Science Center Project. Results will be used to evaluate the likely effect of sea-level rise on the elevation of habitat used by endangered and threatened species and the potential for these habitats to be drowned. This poster will present the theoretical framework for the model and describe how the model will be applied to various marsh habitats throughout the San Francisco Bay Estuary.

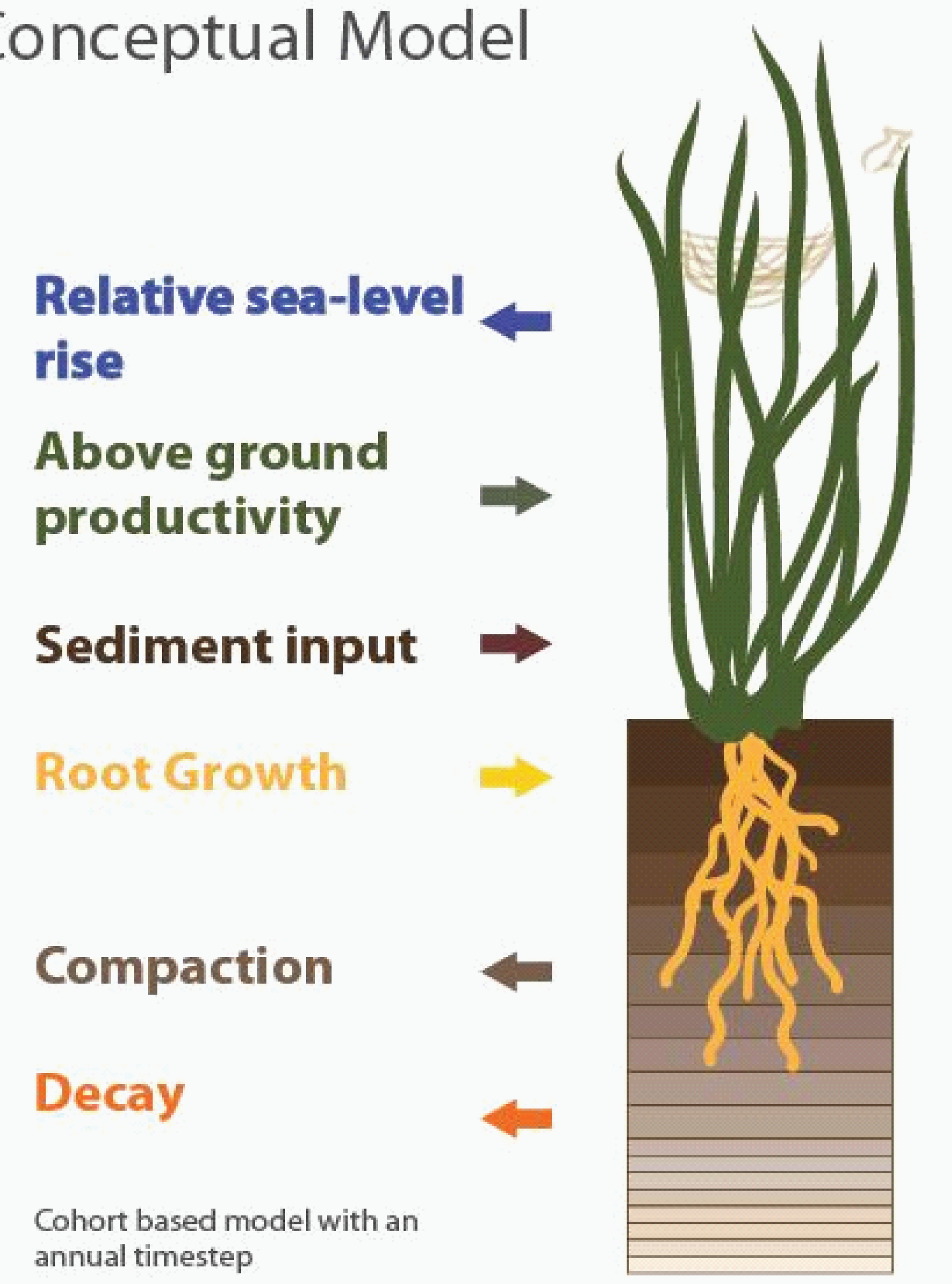
Objective

The objective of this project is to modify the Callaway et al. (1996) wetland accretion model to implement a more mechanistic model of the vertical processes that comprise wetland accretion. The 1-D model will be a tool that can be used to qualitatively evaluate and rank wetland habitats within San Francisco Bay by their functional resiliency to relative sea-level rise.

Expected outcomes

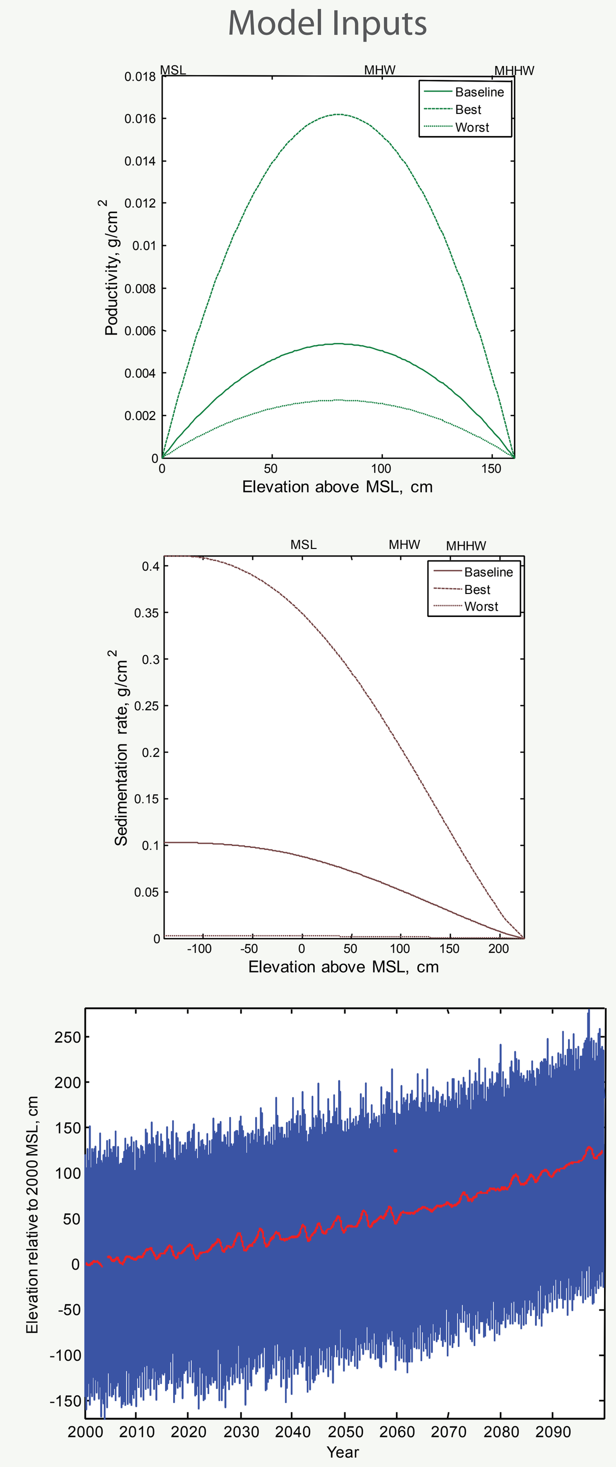
- Model results will indicate the trajectory of relative elevation of marsh surfaces under predicted conditions of relative sea-level rise.
- The model results can be used to assess which habitats are at risk and which are most resilient given predicted changes in relative sea-level.
- At risk habitats can be evaluated based on our understanding of vegetation regimes and habitat use by endangered and threatened species such as the California clapper rail, California black rail, and the salt marsh harvest mouse.
- Ultimate functional habitat resilience is function of relative elevation, vegetation and tidal inundation pattern.
- The model can be explored to determine the range of values for sediment deposition, organic matter production, RSLR, initial elevation, and other variables that lead to stable marsh habitats.

Conceptual Model

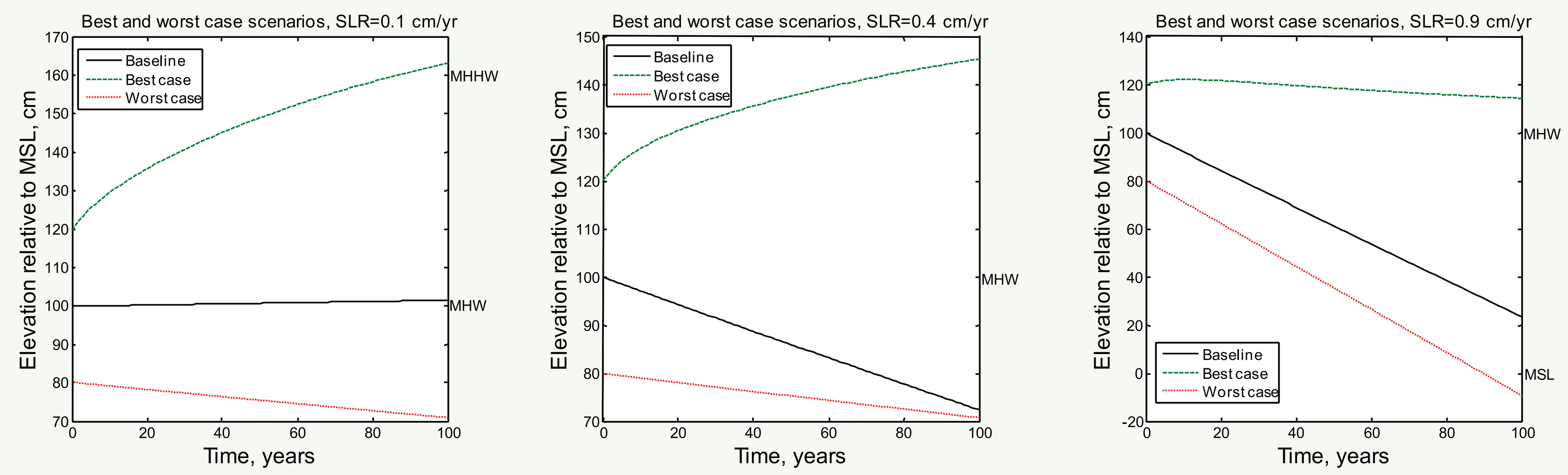


Arrows indicate whether each process increases or reduces relative elevation.

Model Inputs



Preliminary results with constant rate of sea-level rise



Model Sensitivity

- The model can be used to identify the critical rate of sea-level rise (slope of the sea-level curve) at wich wetland elevations begin to decrease for individual wetlands.
- The time history of accretion is important.
- The model is most sensitive to sediment input, the rate of sea-level rise and the porosity of deposited soil.
- Initial elevation does not have a large impact on the trajectory of the wetland surface for these scenarios.

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Useful References

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