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Simple models can reveal insightful science: data-fitted models of intertidal seagrass as a case study

Matthew P Adams [a,b], **Xinyan Wang** [a,c,d], **Dongdong Shao** [c,d]

[a] *School of Mathematical Sciences and Centre for Data Science, Queensland University of Technology, Brisbane, Australia*
[b] *Securing Antarctica's Environmental Future, Queensland University of Technology, Brisbane, Australia*
[c] *State Key Laboratory of Wetland Conservation and Restoration and School of Environment, Beijing Normal University, Beijing, China*
[d] *Yellow River Estuary Wetland Ecosystem Observation and Research Station, Ministry of Education, Dongying, China*
Email: mp.adams@qut.edu.au

Abstract: In an era of large language models trained on copious amounts of data, research findings made using simple models can appear comparatively quaint. However, as scientists, the work we do provides the fundamental research findings that *are* the training data for large language models now used widely by the general public to gather information (generative artificial intelligence models such as ChatGPT and Claude). Thus, our role as scientists is elevated – our research outcomes are likely more accessible than they have ever been before in history. Similarly, simple models can reveal insights quickly, easily and unambiguously, without the "black box" stigma.

In this talk I present a recent example of "simple" modelling that revealed insights about the optimal habitat of seagrasses (Wang et al. 2024). Previous model formulations have quantitatively defined the role of abiotic factors such as light and temperature on seagrass growth and recovery. Such models make the simplifying assumption that the seagrasses are growing in the "subtidal" zone – that is, they are fully submerged. Most of these models ignore that desiccation (drying) can drastically alter the growth and degradation of seagrasses that are present in the "intertidal" zone – areas where seagrasses are exposed to air for parts of the day when tides recede.

In the present work we comprehensively collated data from 9 experimental studies on the quantitative responses of seagrass to desiccation. We then used this data to parameterise the relationship between air exposure, seagrass leaf water content and photosynthetic efficiency to inform new growth rate functions for generalisable intertidal seagrass growth models. We tested the applicability of these model formulations for scenarios with varying physiological process assumptions, seagrass species, tidal conditions, meadow elevations and water turbidity. We found that neglecting air-exposed physiological responses (i.e., leaf water content loss and reduced photosynthetic efficiency) can substantially overestimate seagrass growth rates. We also observed a trade-off between light deprivation and desiccation on intertidal seagrass growth under specific tidal ranges and turbidity conditions. This can yield an "optimal" elevation where overall stress of desiccation (increasing with meadow elevation) and light deprivation (decreasing with meadow elevation) are minimized.

This work provides conceptual and quantitative guidance for ecological modellers to include air exposure responses of intertidal seagrasses in coastal ecosystem models. The model also helps to evaluate the viability of intertidal seagrass habitats and inform decisions on coastal ecosystem management under changing environmental conditions.

Although the present work is quite specific in its scope (although we could envision that the model formulations we developed have utility for modelling plants other than seagrasses), the argument I make in this talk is that efforts to obtain such domain-specific knowledge should not be neglected. Such specific research studies (in aggregate) will be what likely most improves our collective global knowledge. In short, simple models can be sufficient to reveal insightful science.

REFERENCES

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