

Background

In New Zealand, increases in riverine sediment supply to the coast has led to widespread accumulation of intertidal mud and mangrove expansion (Fig. 1). Mangroves are known to locally reduce tidal currents and facilitate mud deposition and bed accretion. To restore pre-disturbed conditions, both legal and illegal mangrove removal has occurred in recent years.

Objective:

To investigate whether local measures, like mangrove removal, can reduce estuarine mud infilling.

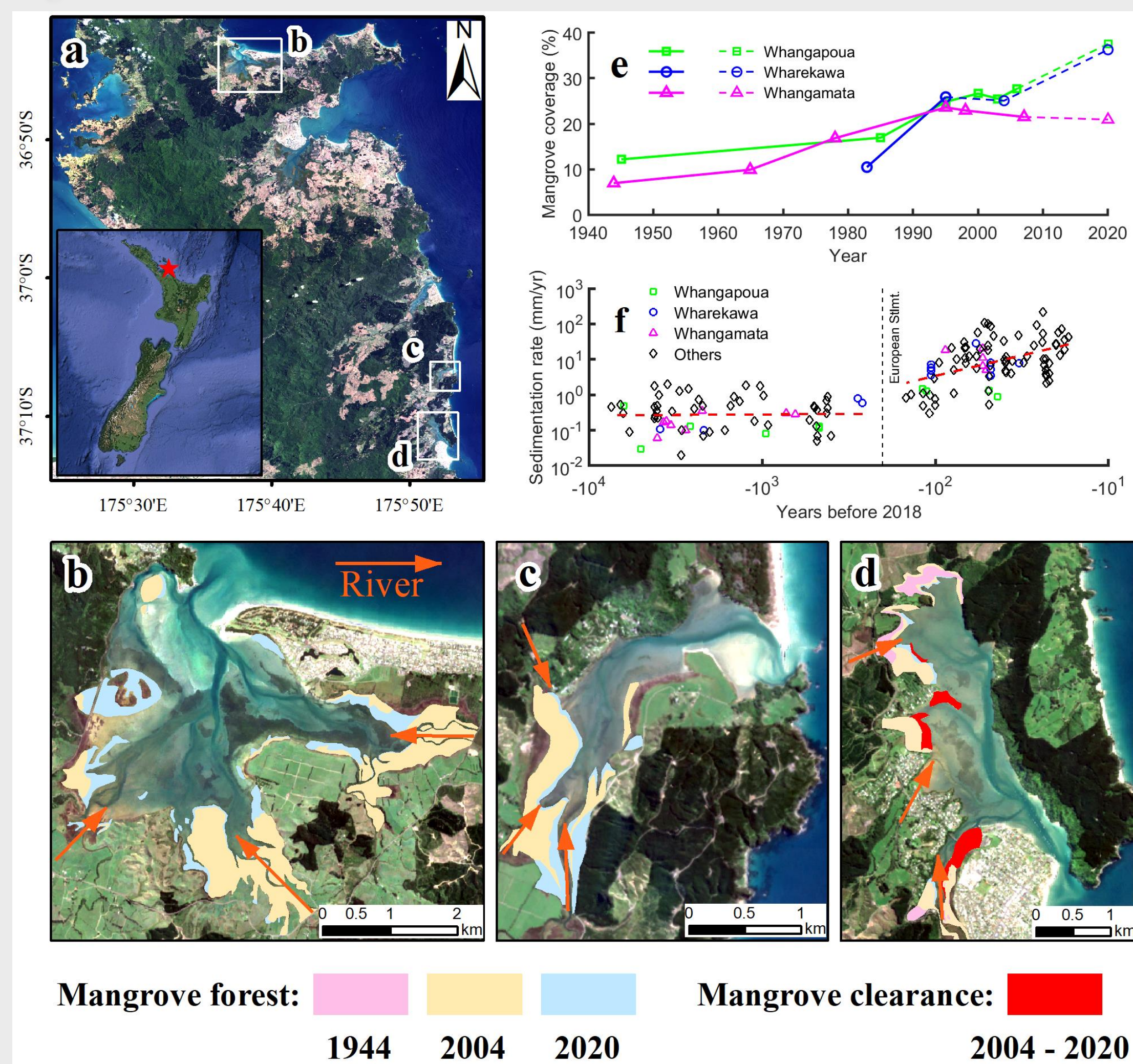


Fig. 1 Variation in mangrove distribution and sediment accumulation rates at three representative estuaries in New Zealand (a). b) Whangapoua estuary; c) Wharekawa estuary; d) Whangamatā estuary; e) Observed changes in mangrove coverage; f) Historical sediment accumulation rates.

Impacts of increased sediment supply

1. At the pre-disturbance stage (year 200-400), mangroves first colonized levees close to river mouths and slowly expanded seaward (Fig. 2a-b);
2. At the disturbance period (year 400-500), accelerated estuarine infilling led to a seaward expansion of mangrove forests along channels (Fig. 2b-c).

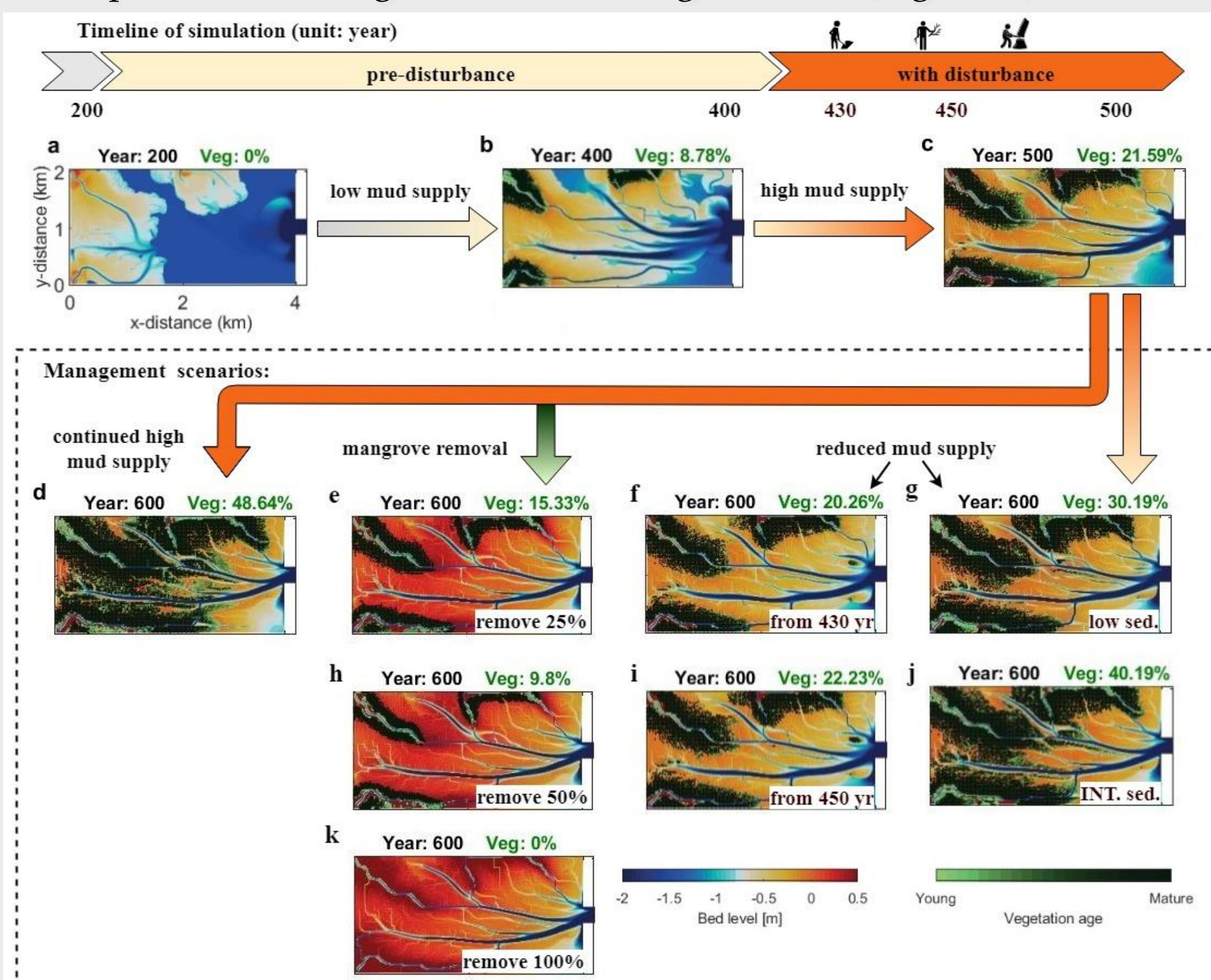


Fig. 2 Mangrove distribution and morphological development phases.

Impacts of management actions

1. Mangrove removal enhanced estuarine infilling;
2. Catchment sediment yield had a much stronger control on key characteristics than mangrove removal;
3. Higher mud supply accelerated estuarine infilling and mangrove expansion, while lower mud supply slowed them down.

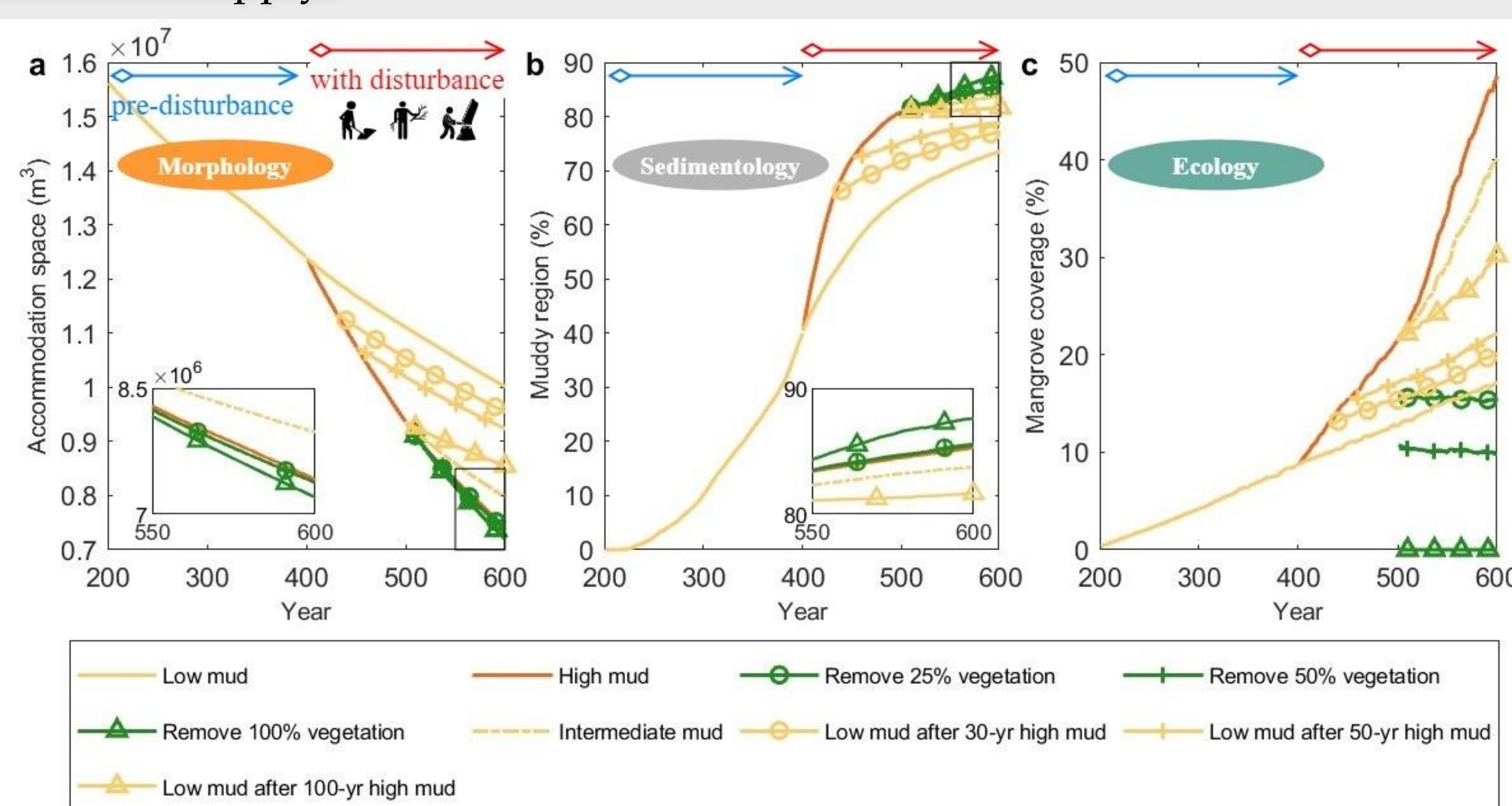
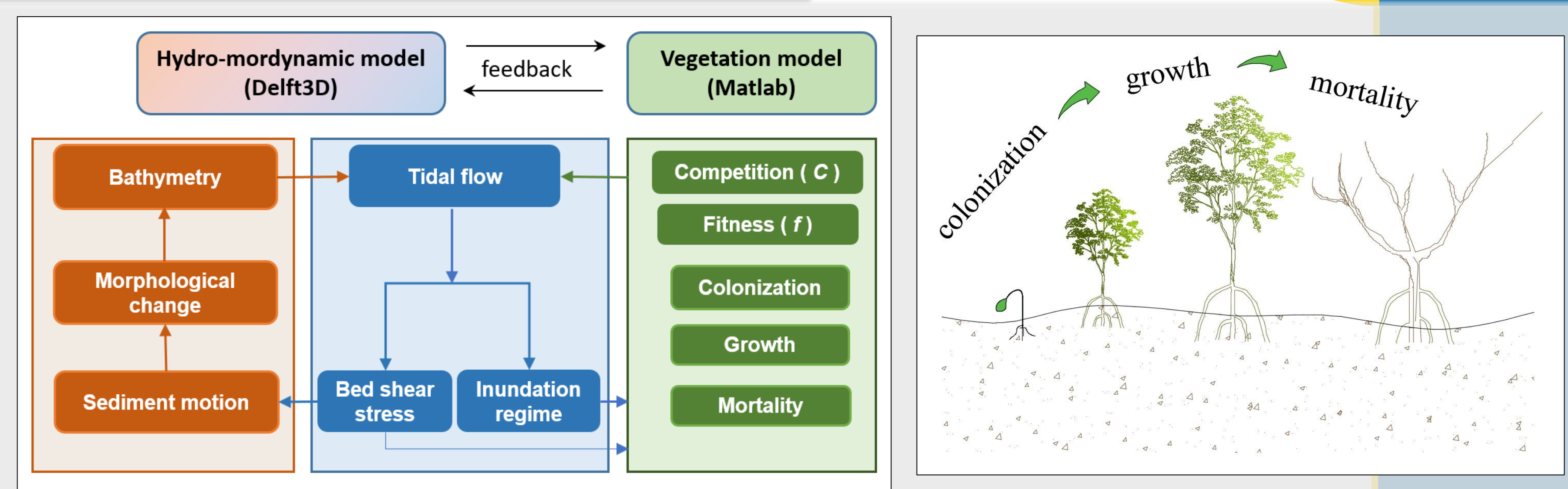


Fig. 3 Temporal changes of key morphological, sedimentological and ecological characteristics of the estuarine environment.

Bio-morphodynamic modelling



Changing sedimentation patterns

1. Within channels, mangrove removal led to higher mud thickness with less erosion and higher bed elevation;
2. In unchannelized areas, mangrove removal increased sedimentation rates, mud thickness and bed elevation in areas further away from channels;
3. Reduced mud supply, sediment patterns retain similar to the pre-disturbance stage.

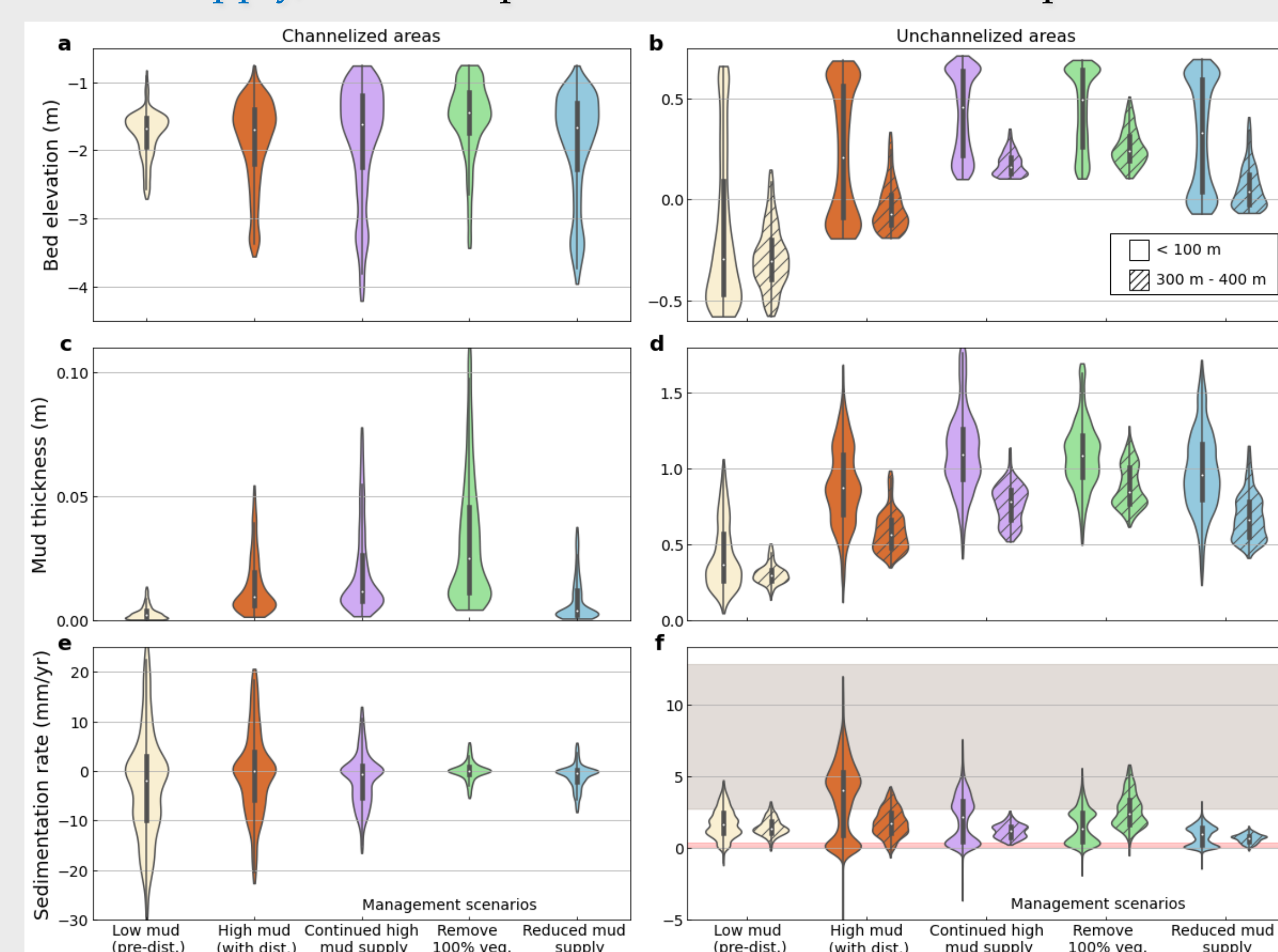


Fig. 4 Comparison of the distribution of bed surface properties.

Anthro-bio-morphodynamic feedbacks

1. Local scale: mangroves reduce tidal currents and facilitate mud accretion, which in turn enhances mangrove growth;
2. Estuary scale: mangrove removal reinforces estuarine mud infilling and intertidal habitat creation due to more extensive accretion across the estuary;
3. Source-to-sink scale: a reduction in upstream mud supply can reduce mud accumulation and mangrove expansion rates.

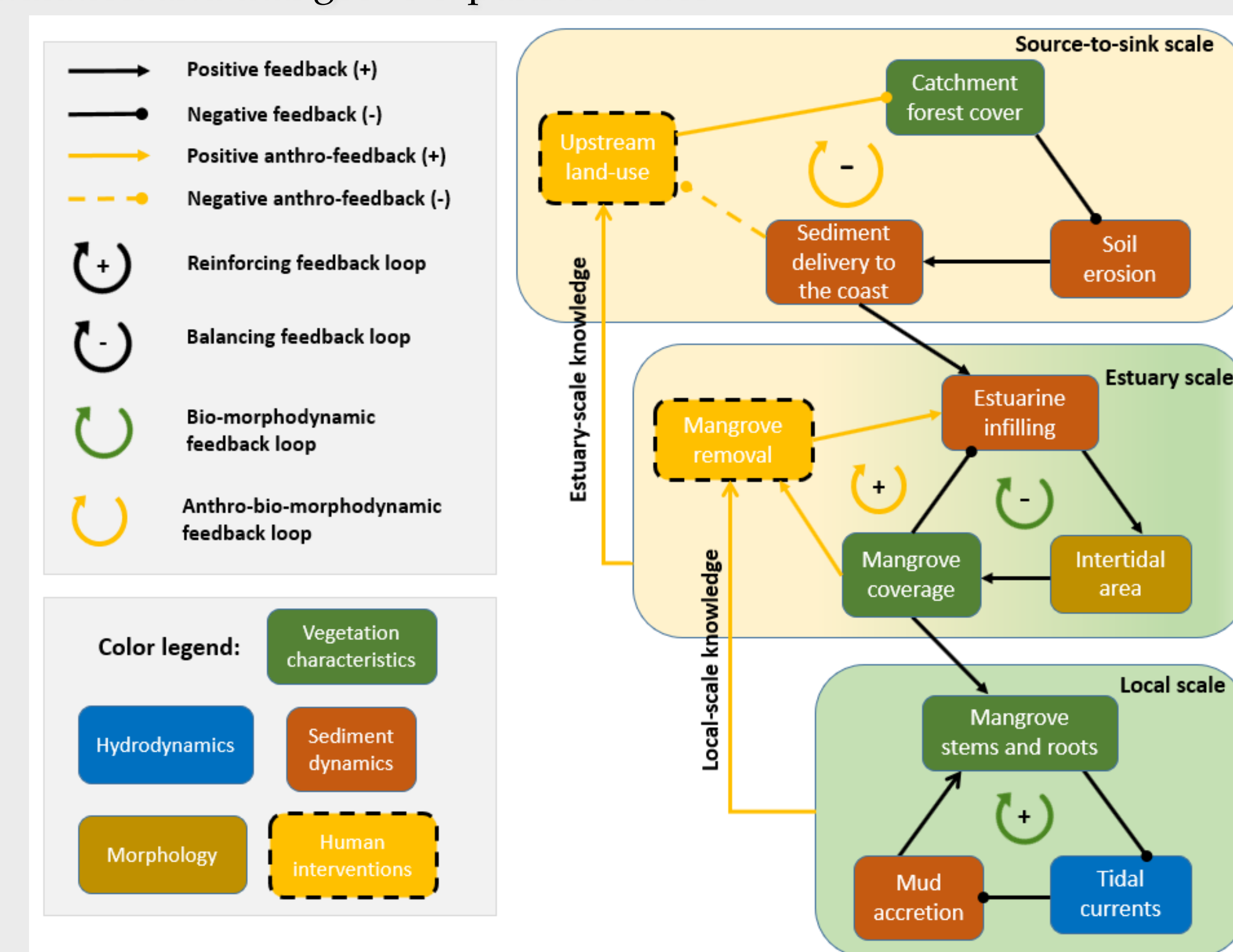


Fig. 5 Conceptual diagram outlining distinct bio-morphodynamic and anthro-bio-morphodynamic feedbacks at the local, estuary and source-to-sink scale.

Conclusions

1. Mangrove removal initiatives, guided by knowledge on local-scale bio-morphodynamic feedbacks, cannot mitigate estuarine mud-infilling and restore antecedent sandy ecosystems.
2. Unexpectedly, removal of mangroves enhances estuary-scale sediment trapping due to altered sedimentation patterns.
3. Only reductions in upstream sediment supply can limit estuarine muddification.

Bio-morphodynamic feedbacks can have contrasting effects at local and estuary scales. More holistic management approaches are needed.

We acknowledge the funding and grant by 1) Department of Physical Geography, Utrecht University, 2) FUTURE COAST AOTEAROA (grant no. C01X2107), and 3) Natural Environment Research Council (grant no. NE/V012800/1).



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Code