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The impact of scale-dependent bio-morphodynamic feedback on estuarine landscape development and restoration

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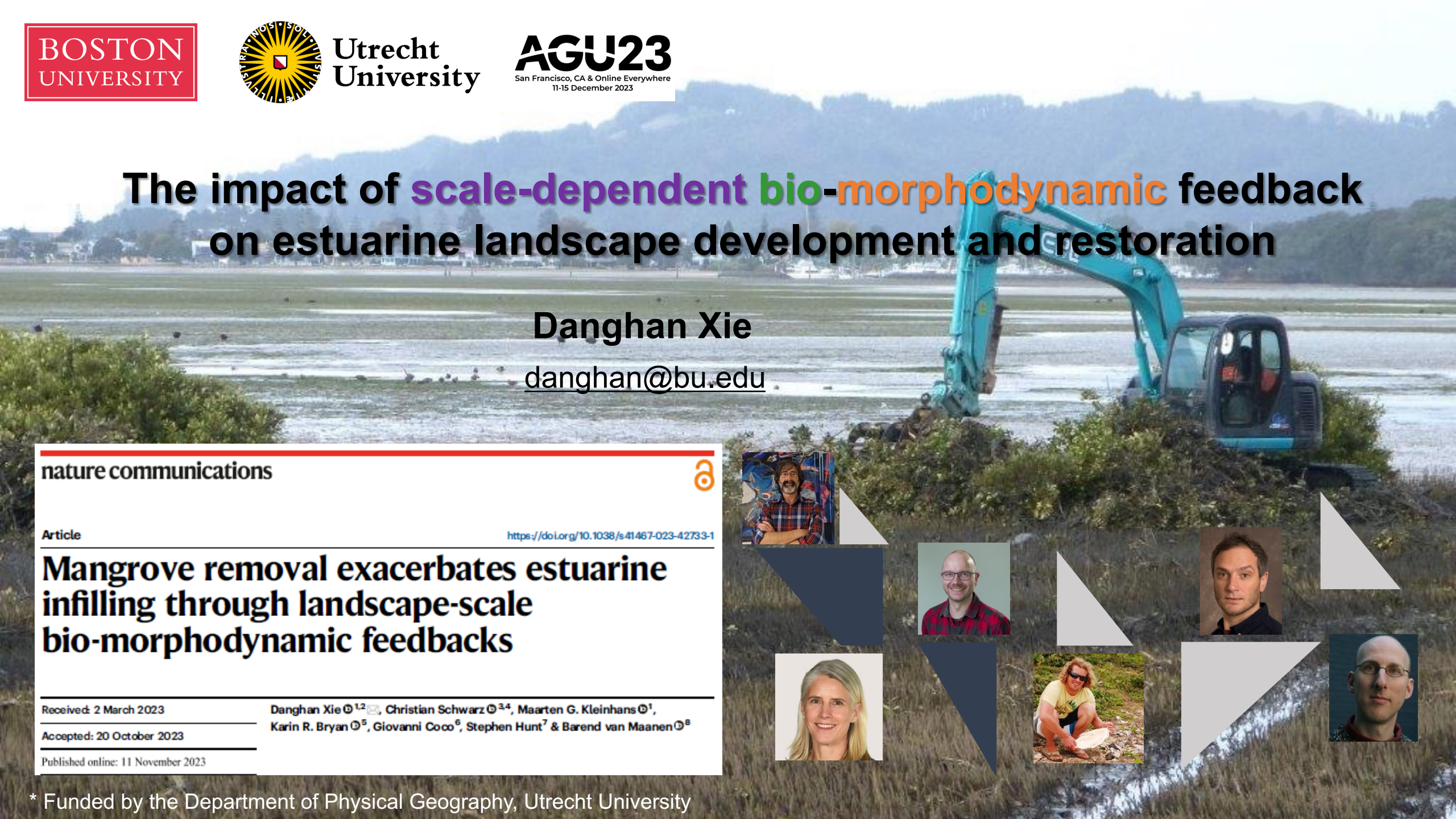

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Mangrove removal exacerbates estuarine infilling through landscape-scale bio-morphodynamic feedbacks

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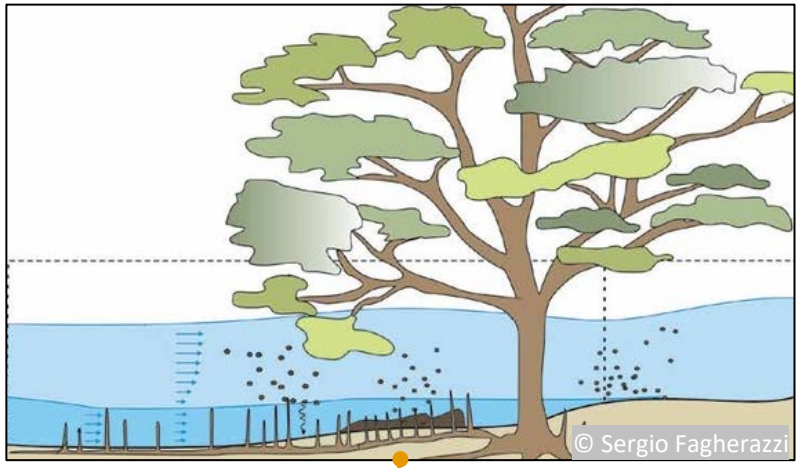
* Funded by the Department of Physical Geography, Utrecht University

Sedimentation of Mangrove Forests

Bio-morphodynamic Feedback

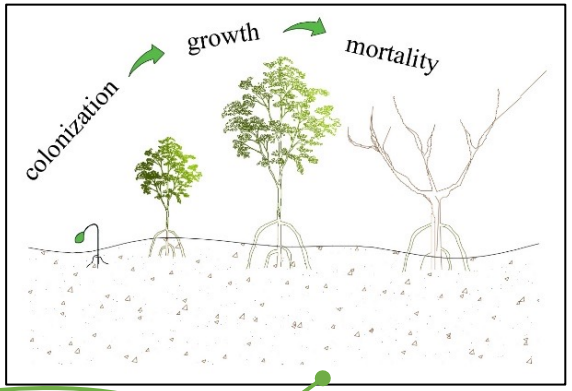
1. Slow down currents

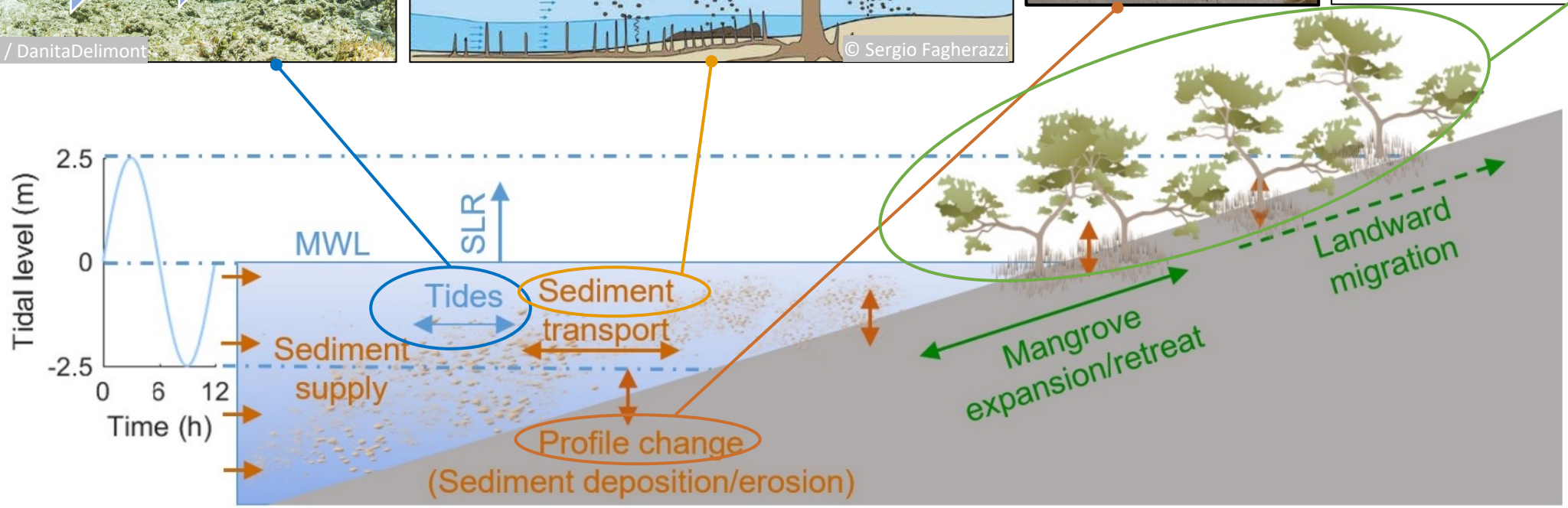
2. Facilitate sedimentation



3. Accretion

4. Vegetation dynamics



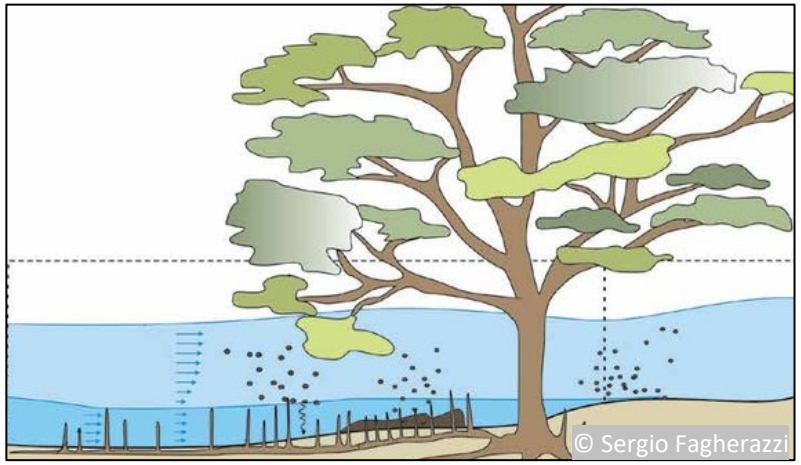


Xie et al., 2020 Environmental Research Letters

Local-scale Bio-morphodynamic Feedback

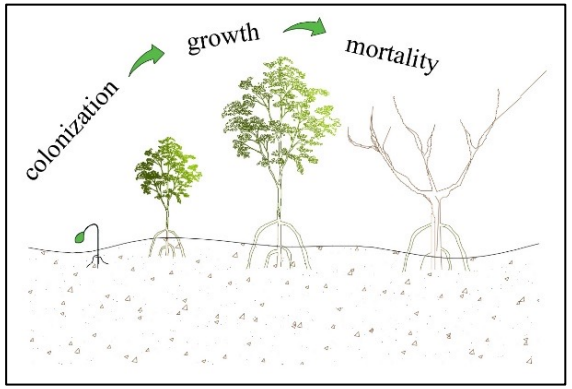
1. Slow down currents

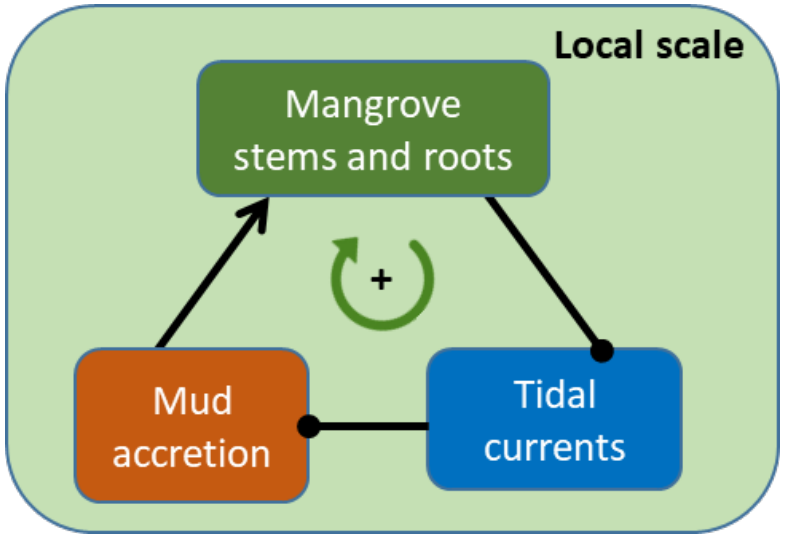
2. Facilitate sedimentation



3. Accretion

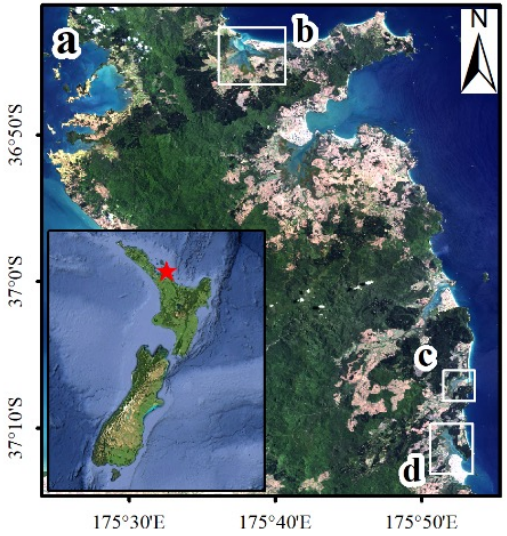
4. Vegetation dynamics

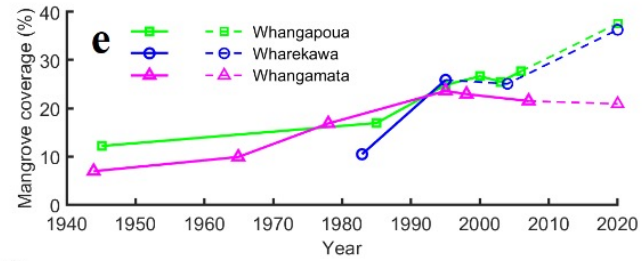


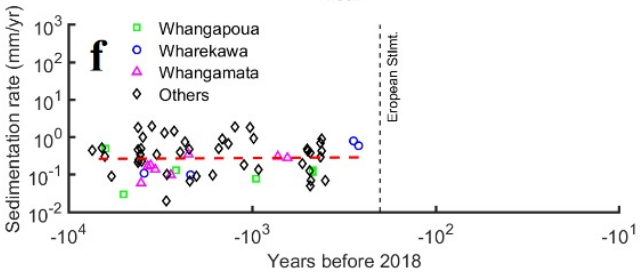


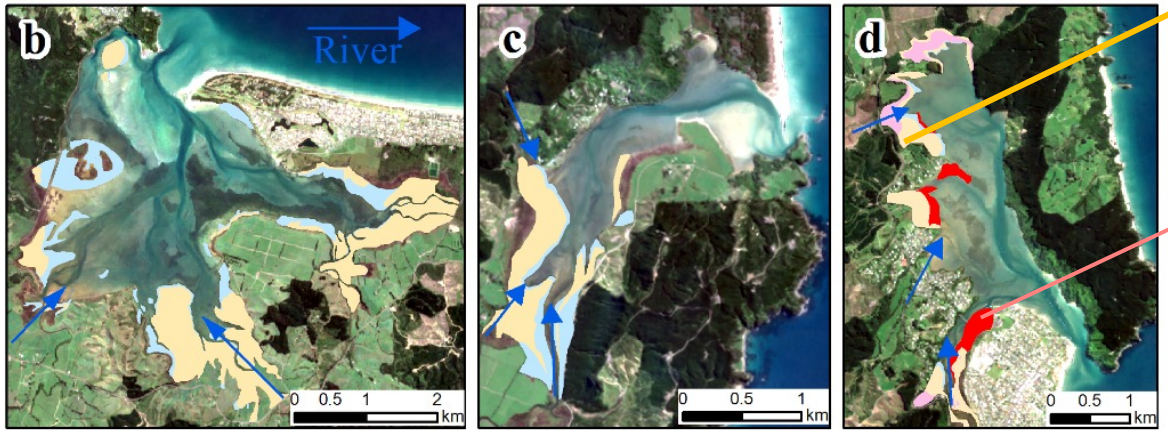
Mangroves trap mud

Mangrove Removal in New Zealand







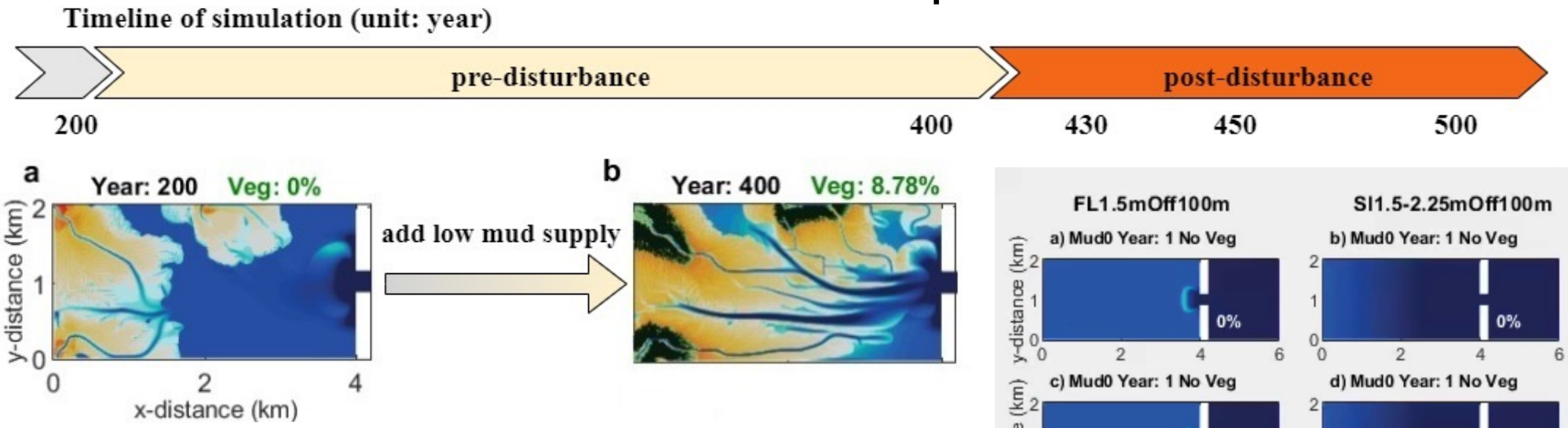


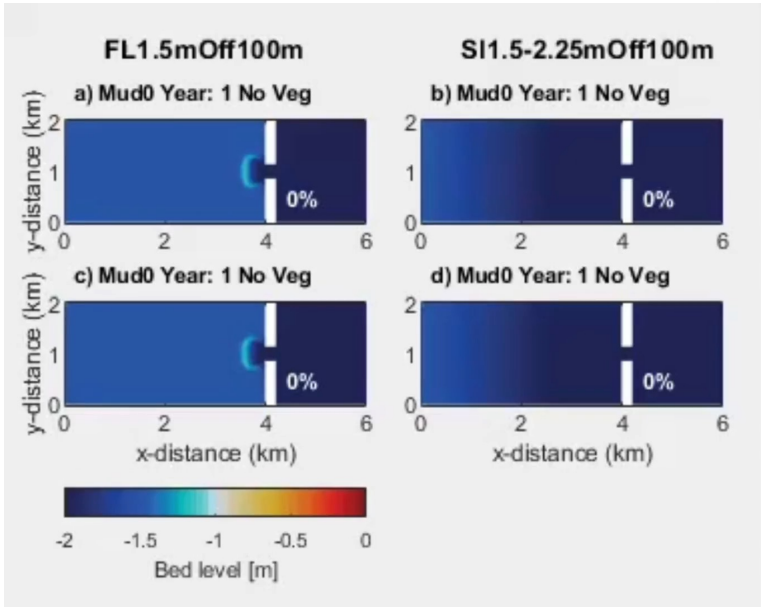
Mangrove expansion with increasing muddy sediment input

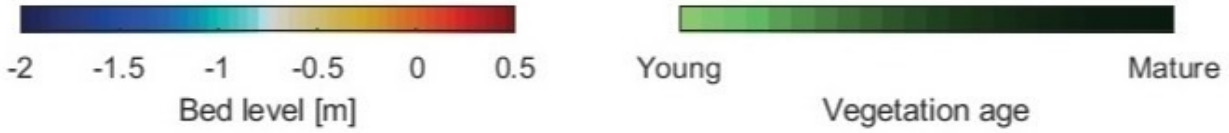
Is cutting off mangroves an efficient way?

Xie et al., 2023 Nature Communications

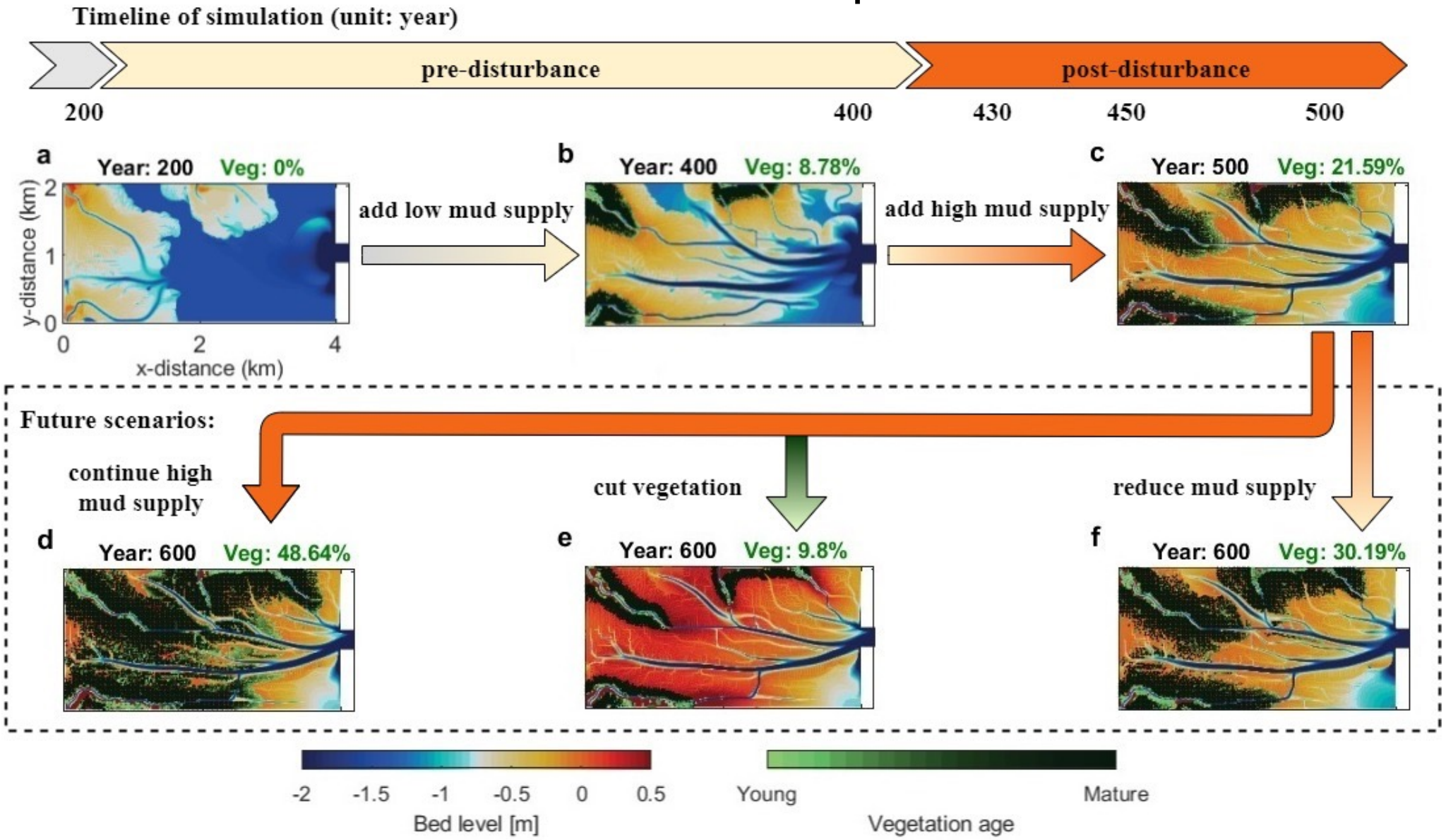
Model Setup


Timeline of simulation (unit: year)
pre-disturbance
post-disturbance
200
400
430
450
500
a
Year: 200 Veg: 0%
y-distance (km)
x-distance (km)
add low mud supply
b
Year: 400 Veg: 8.78%

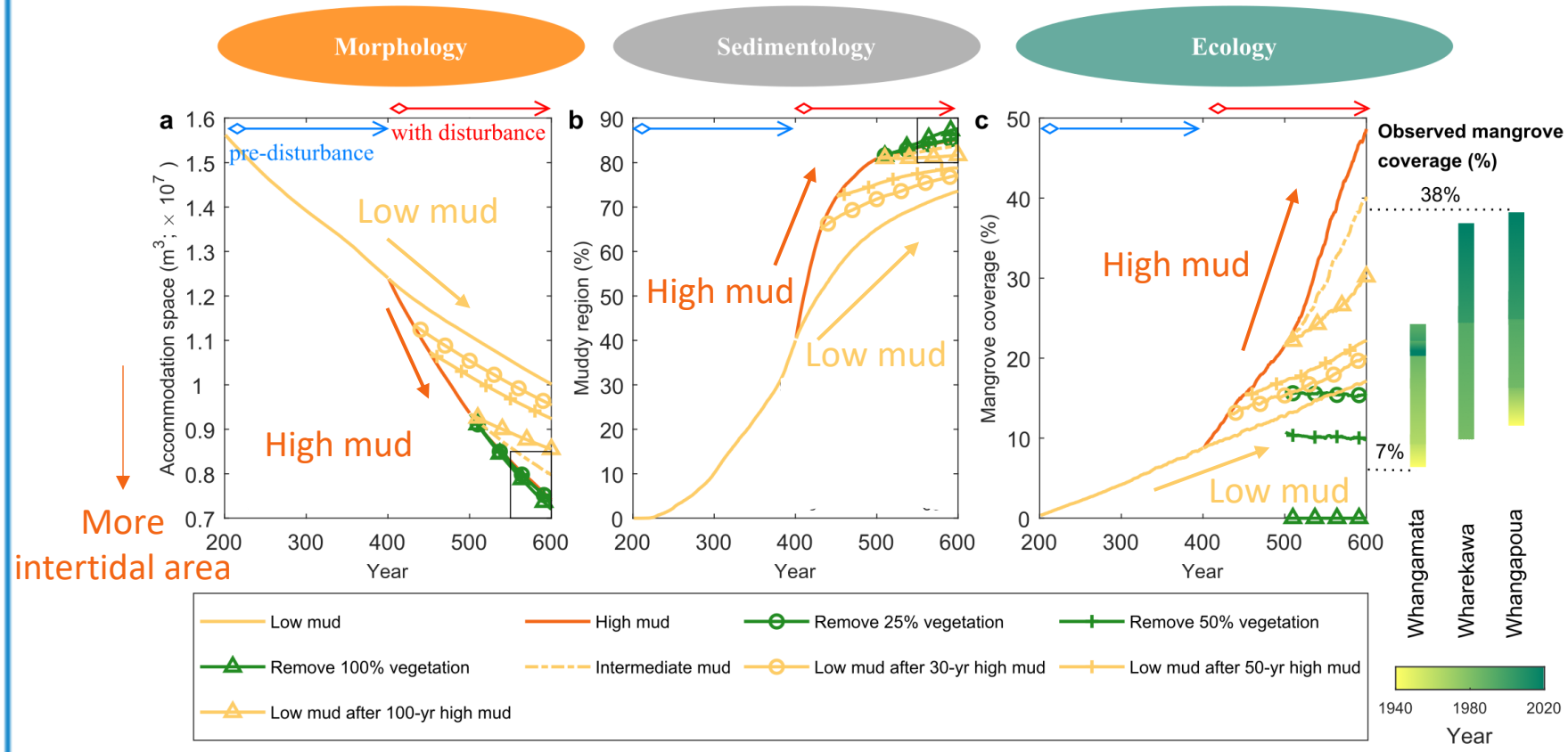

FL1.5mOff100m
SI1.5-2.25mOff100m
a) Mud0 Year: 1 No Veg
b) Mud0 Year: 1 No Veg
c) Mud0 Year: 1 No Veg
d) Mud0 Year: 1 No Veg
0%
y-distance (km)
x-distance (km)
-2 -1.5 -1 -0.5 0
Bed level [m]


-2 -1.5 -1 -0.5 0 0.5
Bed level [m]
Young
Mature
Vegetation age

Model Setup


Timeline of simulation (unit: year)
pre-disturbance
post-disturbance
200
400
430
450
500
a
Year: 200 Veg: 0%
b
Year: 400 Veg: 8.78%
c
Year: 500 Veg: 21.59%
add low mud supply
add high mud supply
y-distance (km)
x-distance (km)
Future scenarios:
continue high mud supply
cut vegetation
reduce mud supply
d
Year: 600 Veg: 48.64%
e
Year: 600 Veg: 9.8%
f
Year: 600 Veg: 30.19%
-2 -1.5 -1 -0.5 0 0.5
Bed level [m]
Young
Mature
Vegetation age

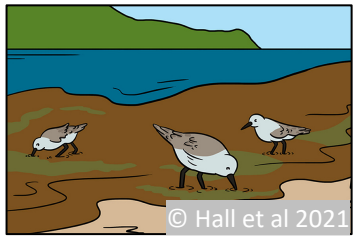
Mangroves and Mud



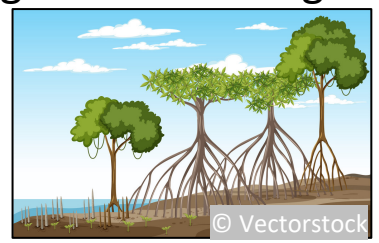
***Accommodation space: the space available for sedimentation. Sediment deposition reduces accommodation space.**

More mud input

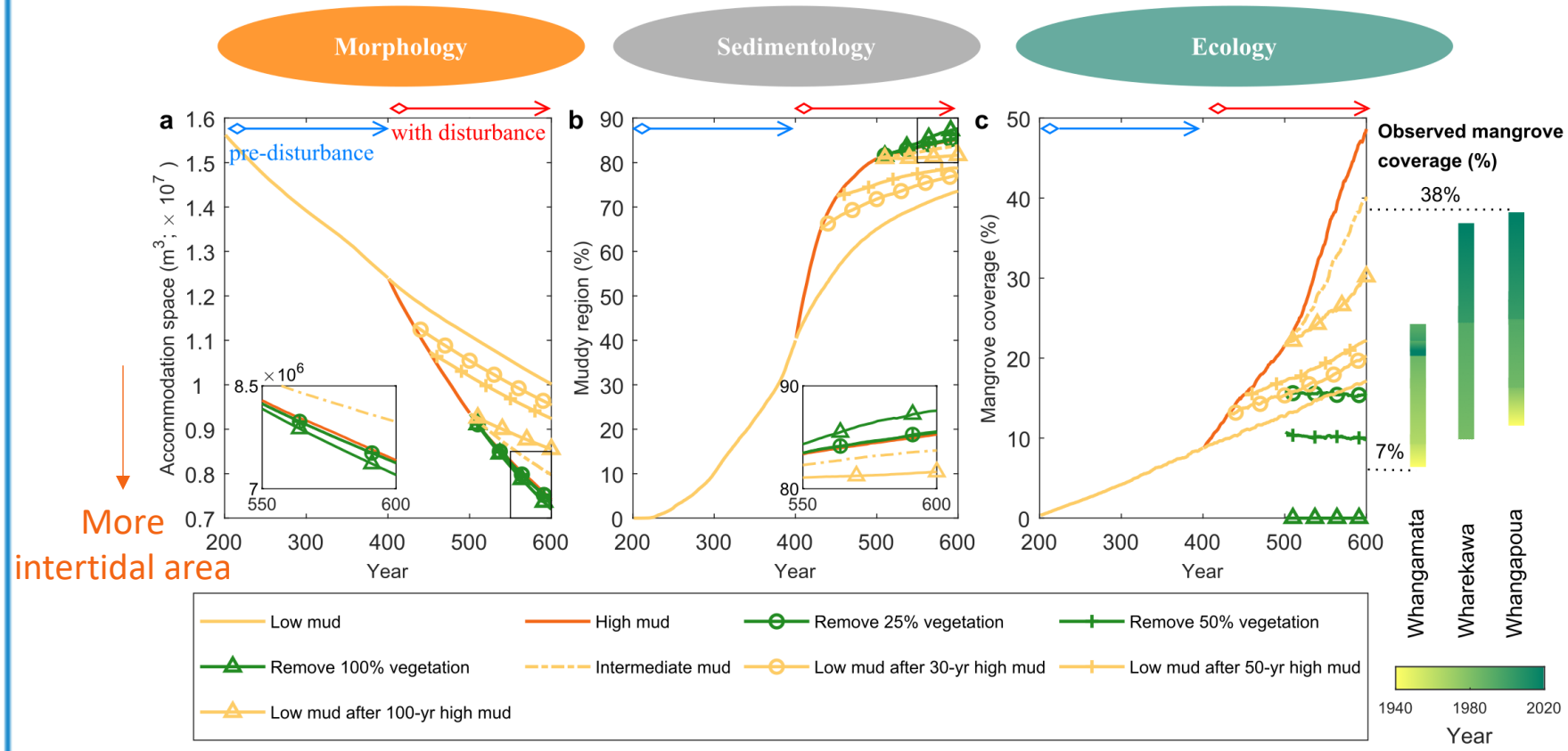
Larger tidal flats



Higher vegetation coverage

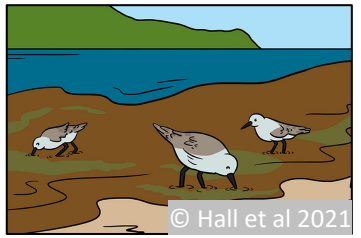


Mangrove Removal Causes More Mud



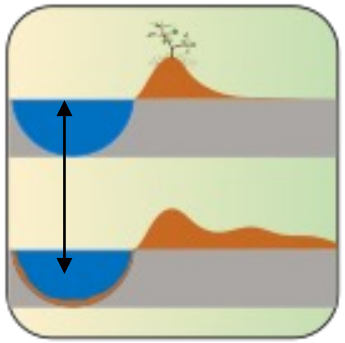
Mangrove removal

Larger tidal flats

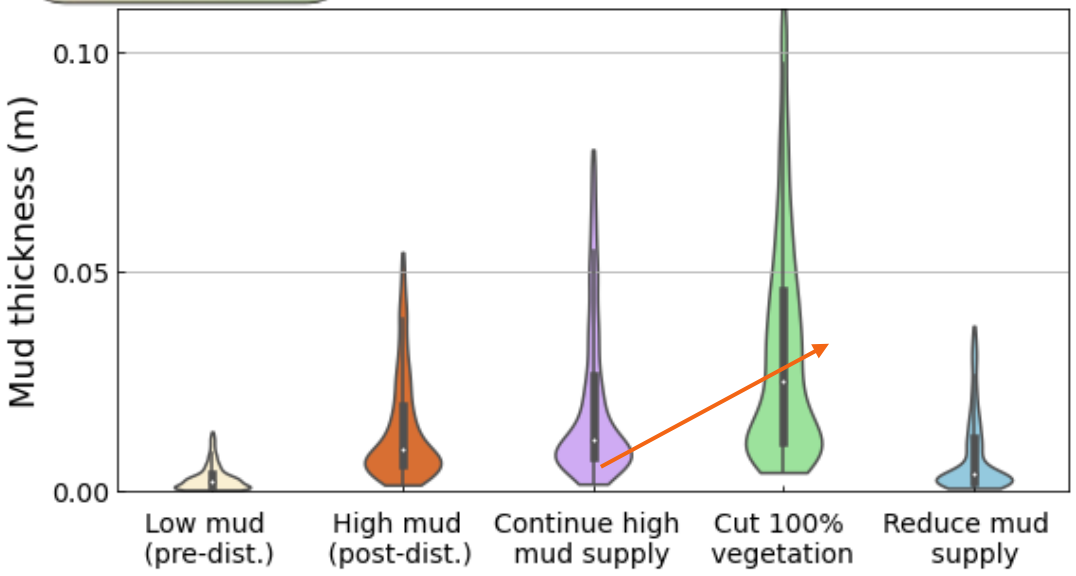


***Accommodation space: the space available for sedimentation. Sediment deposition reduces accommodation space.**

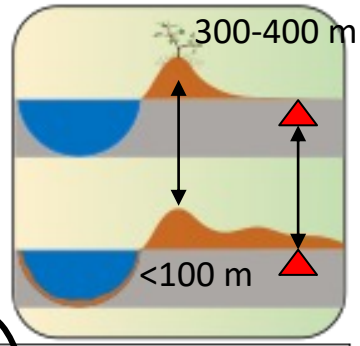
Mangrove Removal Causes More Mud: *why*



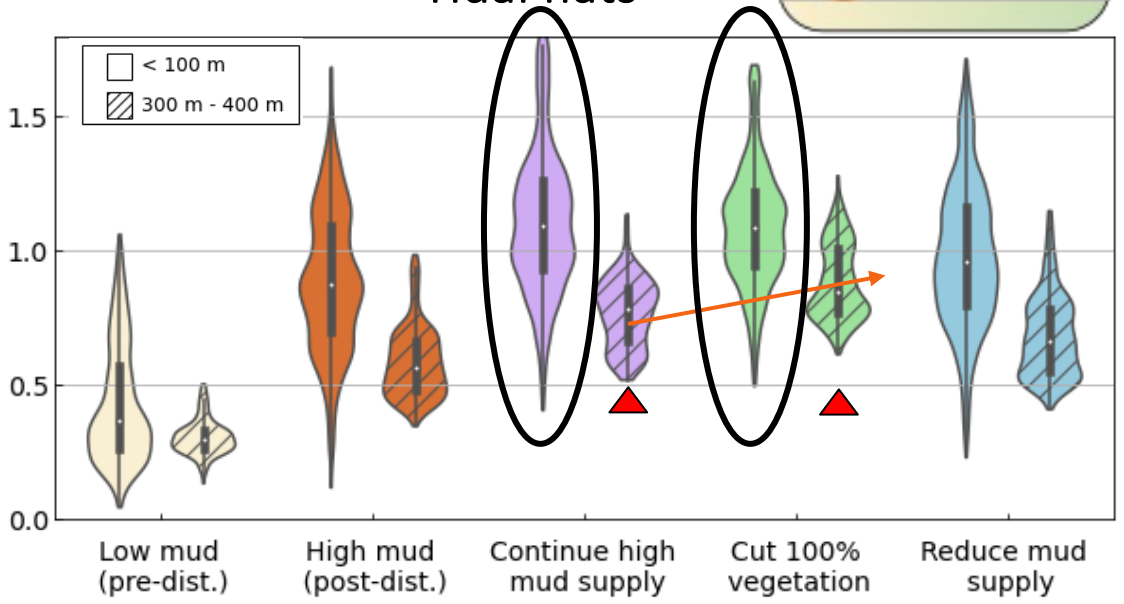
Channelized area



More Mud in the channels

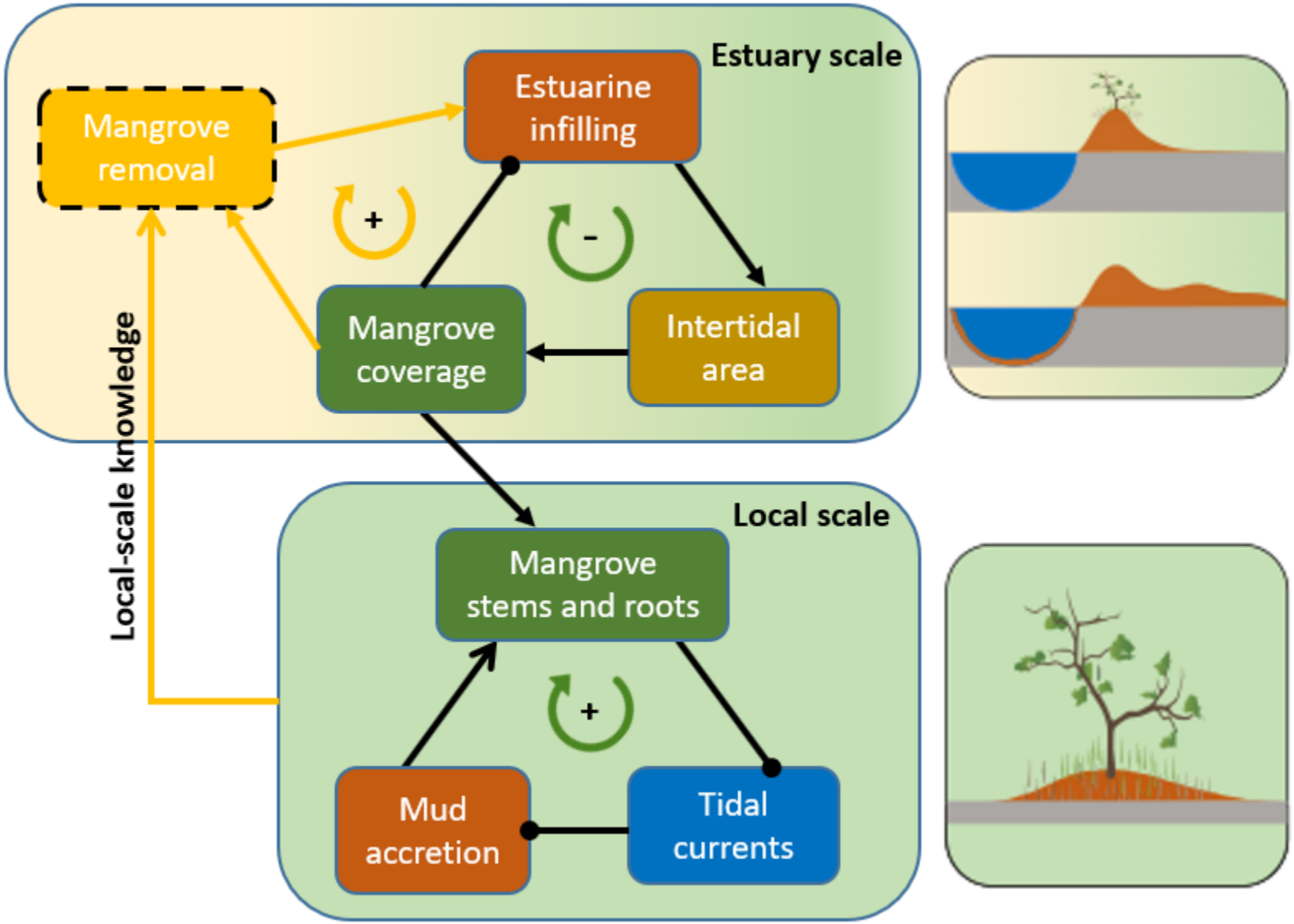


Tidal flats

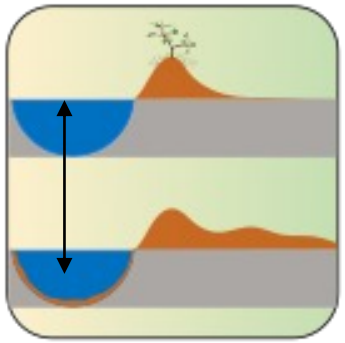


Mud redistributes further away from the channels

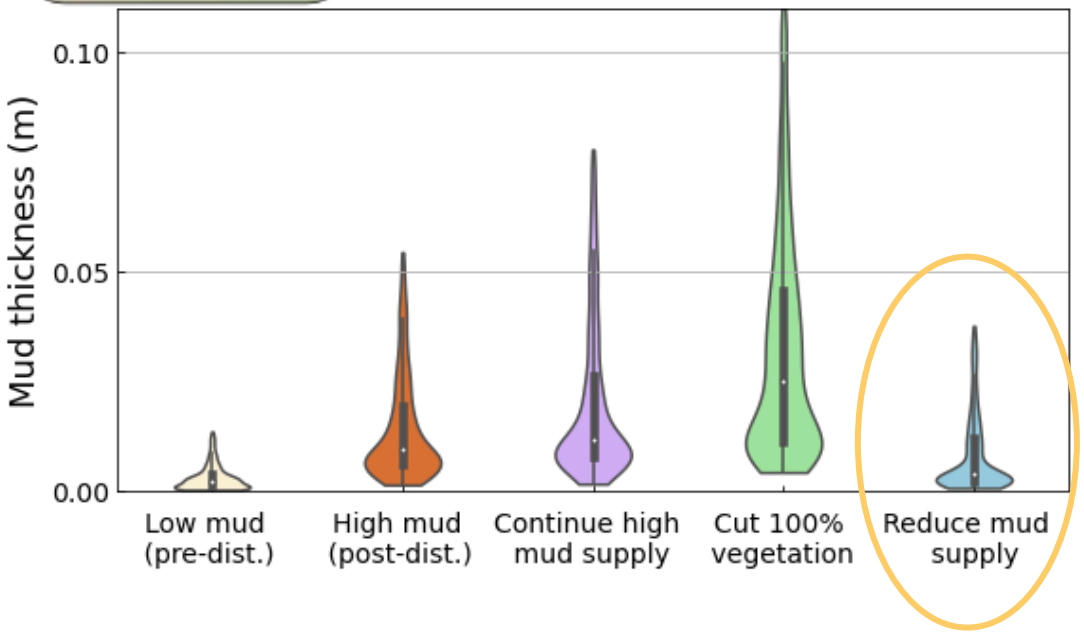
Estuary-scale Bio-morphodynamic Feedback



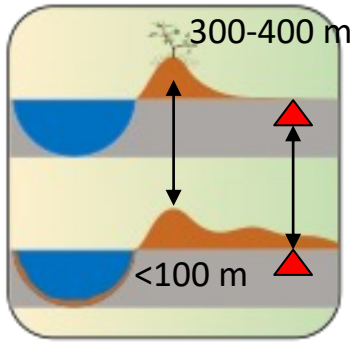
Reduce Mud Supply Mitigates Muddification



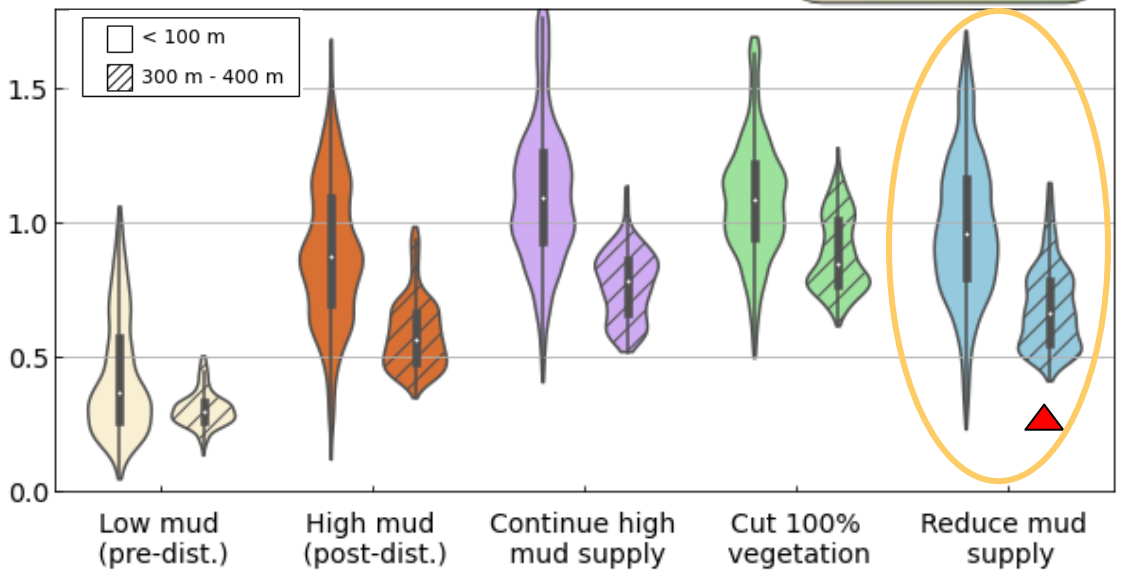
Channelized area



Less Mud in the channels

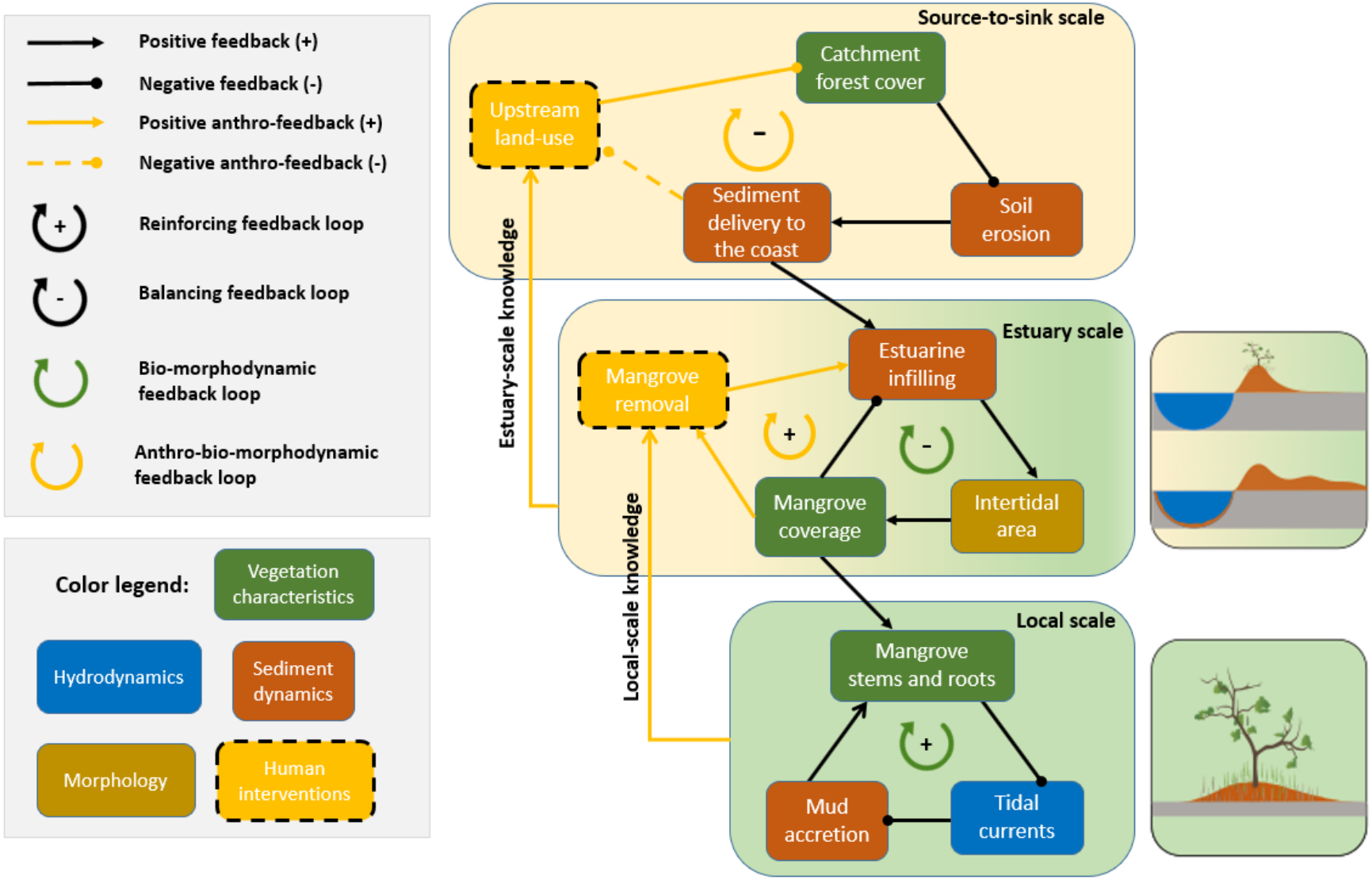


Tidal flats



Less Mud in the tidal flats

Anthro-bio-morphodynamic feedbacks



Stop cutting off mangroves, but please manage the upstream land use

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code