Infrastructure effects on estuarine wetlands increase their vulnerability to sea level rise

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Mangrove-Saltmarsh Wetlands

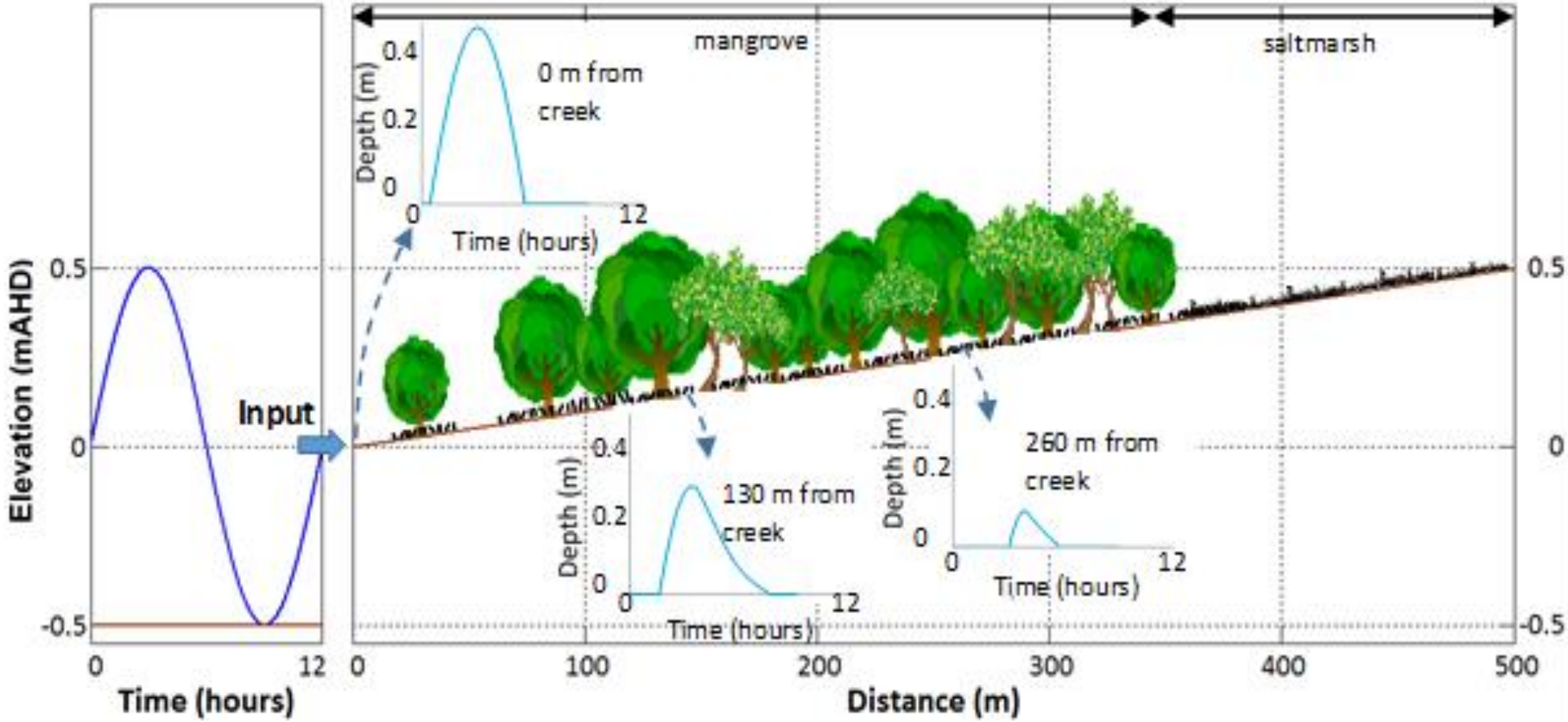
Disturbed Wetlands

Sea-level rise effects on wetlands

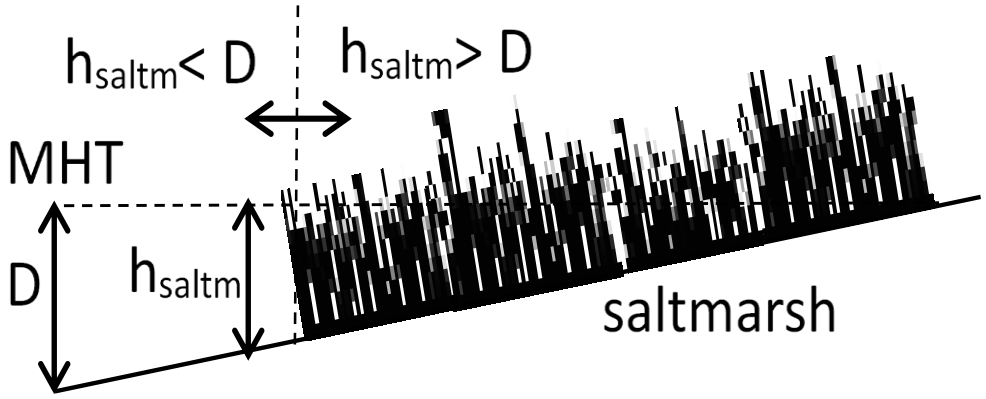
20 to 80% of worldwide coastal wetland loss by 2100
(Titus 1988, Nicholls et al. 2007, Craft et al. 2009, Spencer et al. 2016).

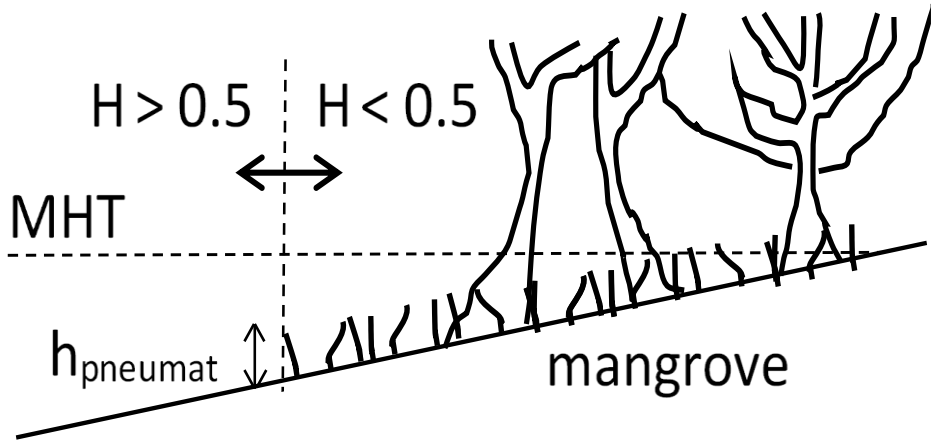
Ecogeomorphological feedbacks (i.e., wetland self-accretion mechanisms) can decrease wetland loss
(Kirwan et al. 2013, 2016)

Hydrodynamic attenuation modifies inundation of coastal areas (Passeri et al. 2015, Lentz, et al. 2016), which may have an effect on coastal wetlands


mangrove
saltmarsh
0 m from creek
130 m from creek
260 m from creek
Depth (m)
Time (hours)
Input
Elevation (mAHD)
Time (hours)
Distance (m)
0.5
0
-0.5
0
100
200
300
400
500
12
0.4
0.2

Vegetation response to hydrodynamics





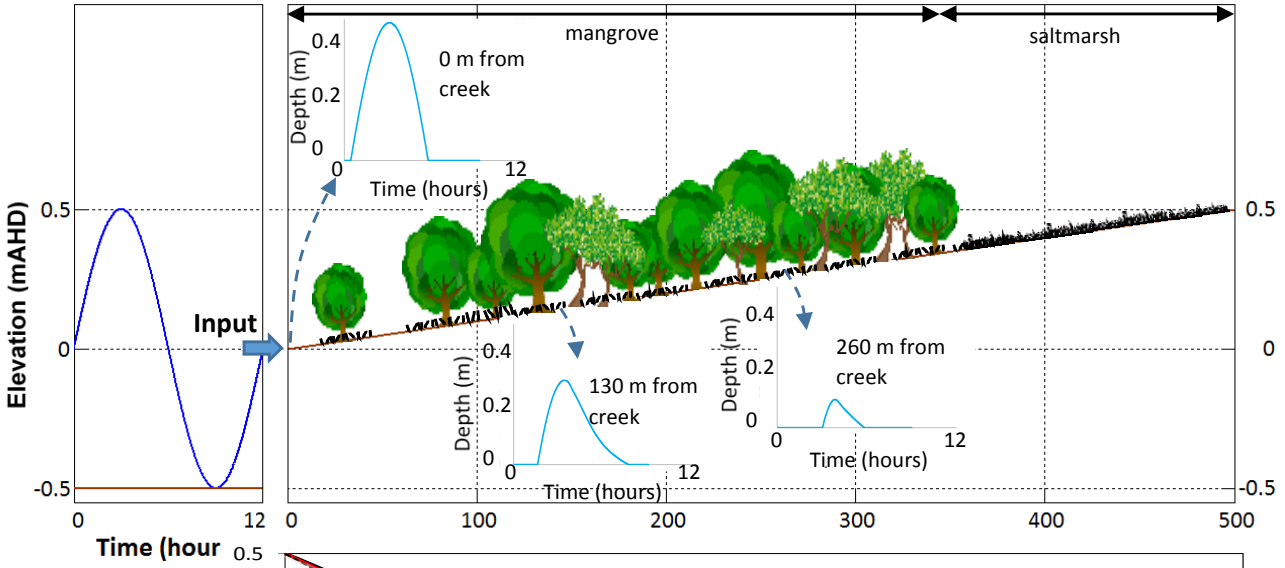
Saltmarsh controlled by inundation **depth**
(Morris et al. 2002, Mudd et al. 2004,
Kirwan & Murray 2007, D'Alpaos et al. 2007)

D= Depth below Mean High Tide (MHT)

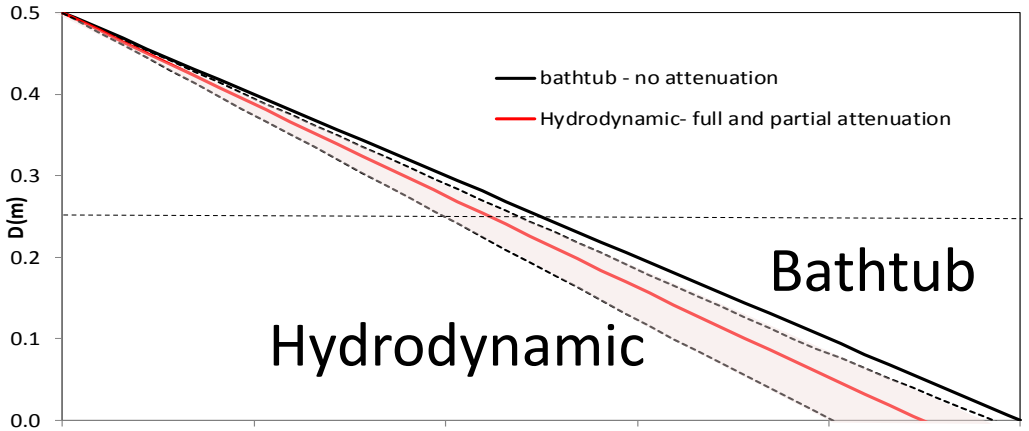
Mangrove controlled by inundation **time**
(Krauss et al. 2013, Crase et al. 2013)

H= Hydroperiod (proportion of time inundated)

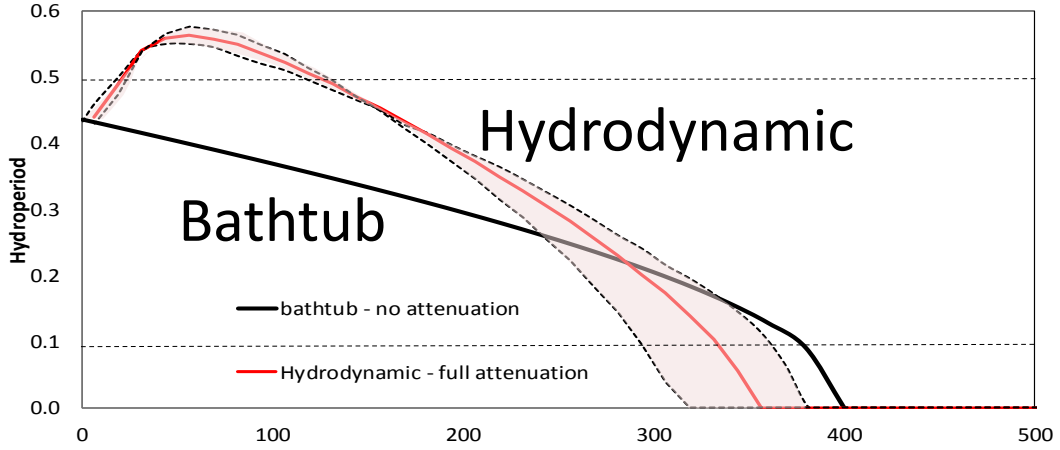
Attenuation due to vegetation



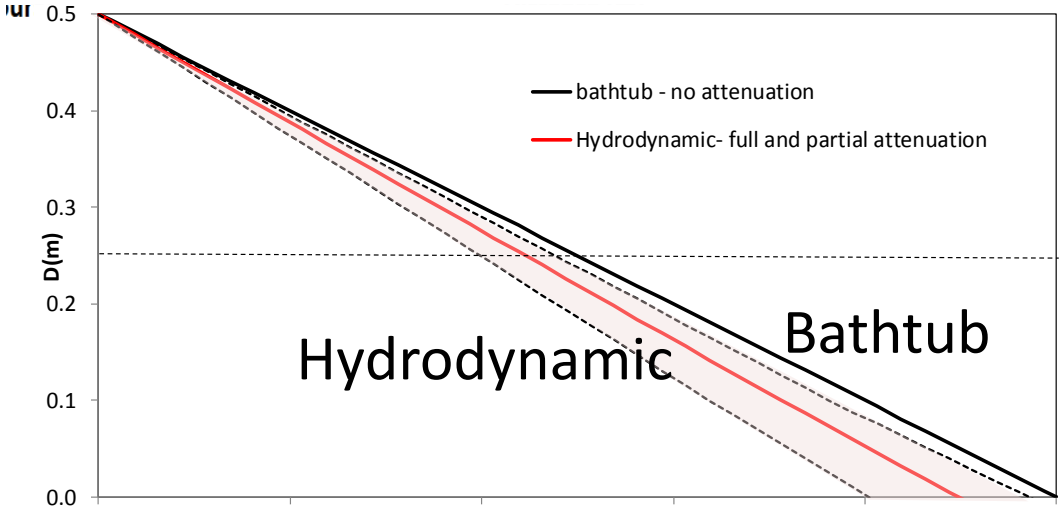
D

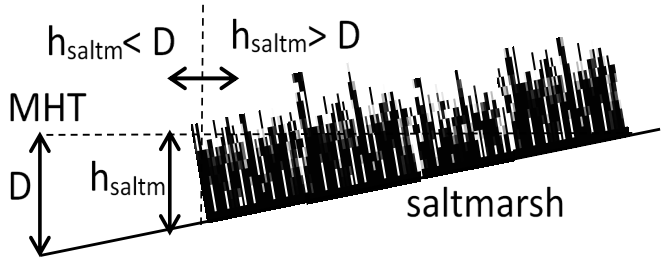


H



D





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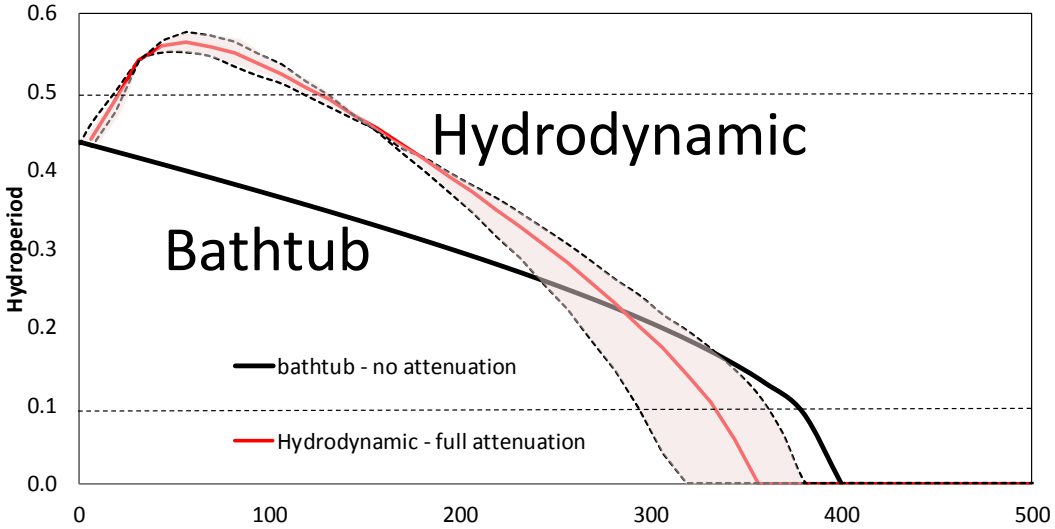
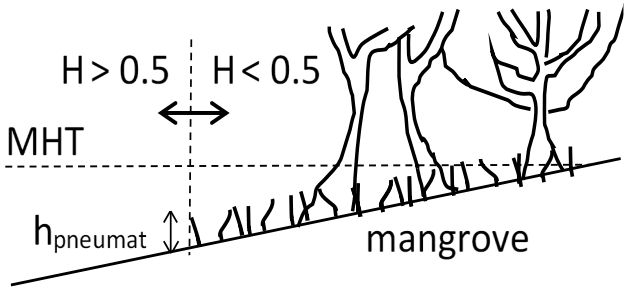
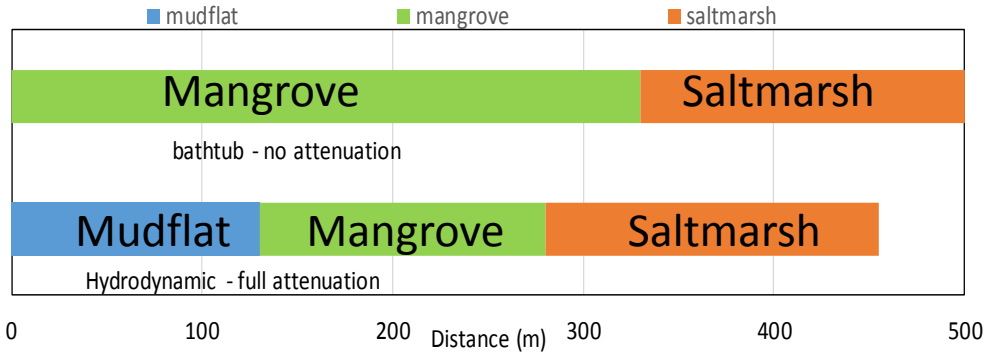




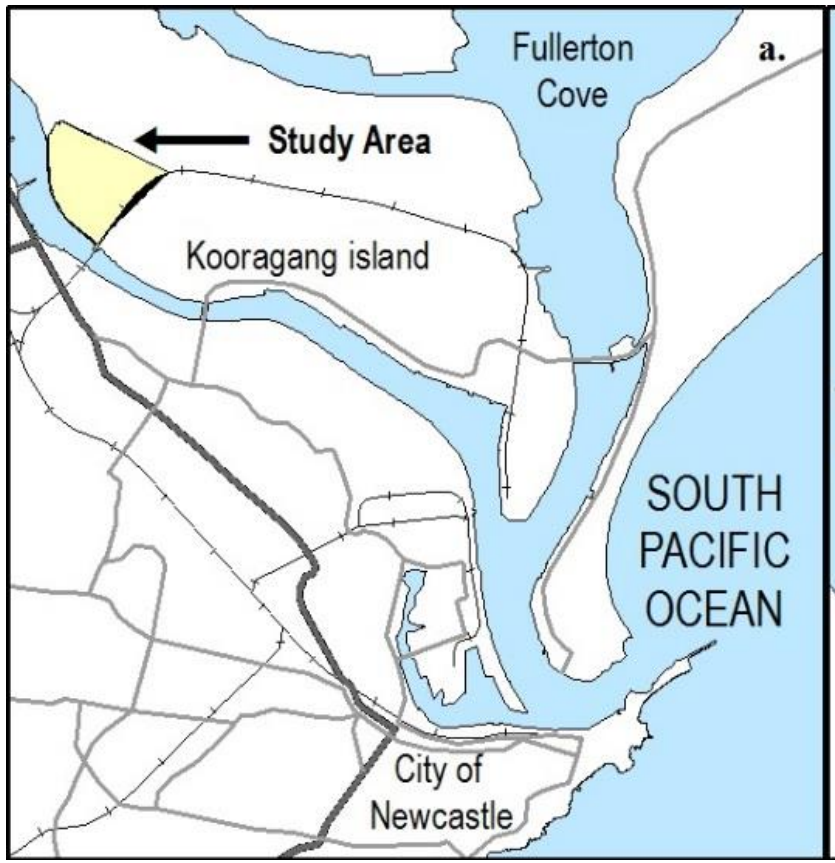
Vegetation

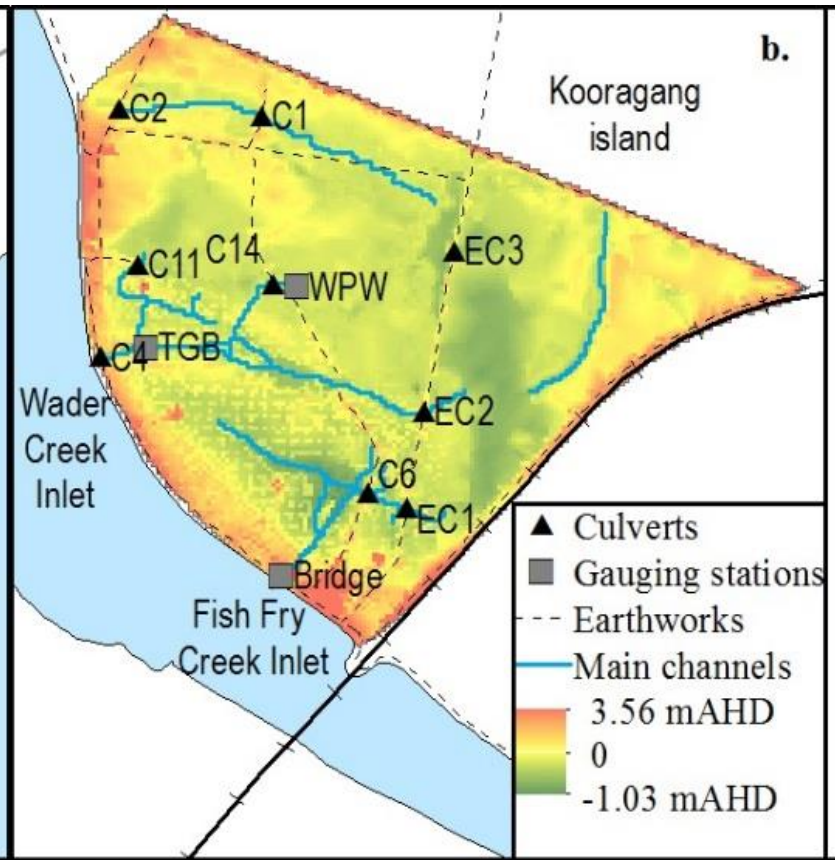


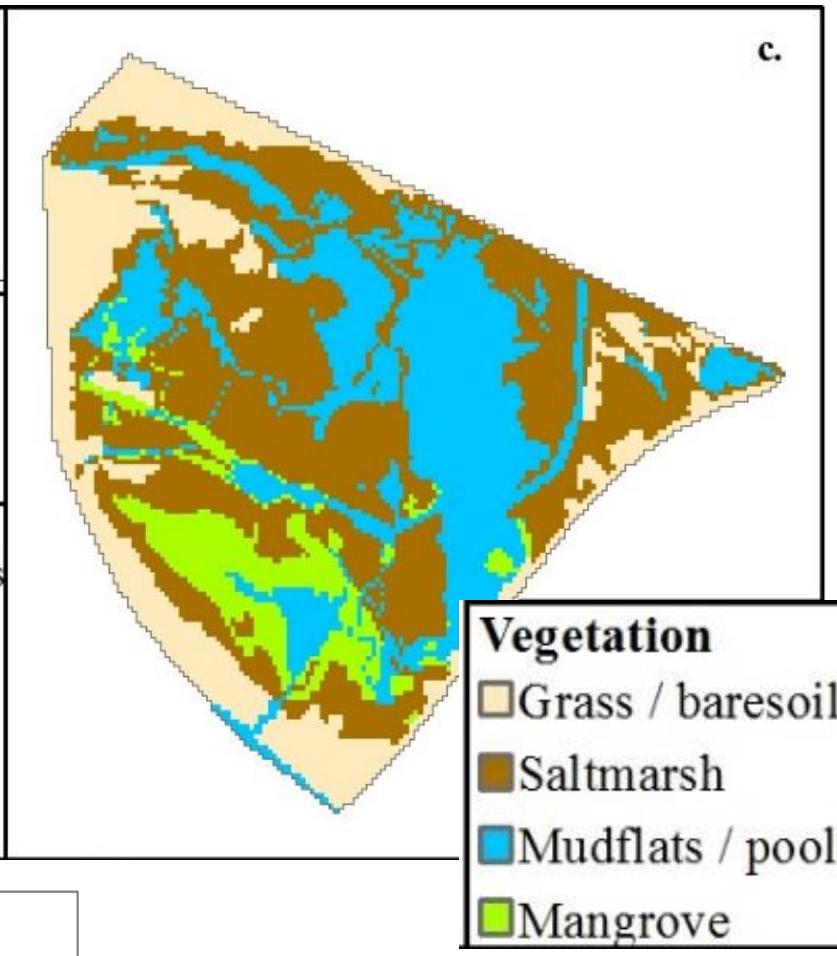
Bathtub

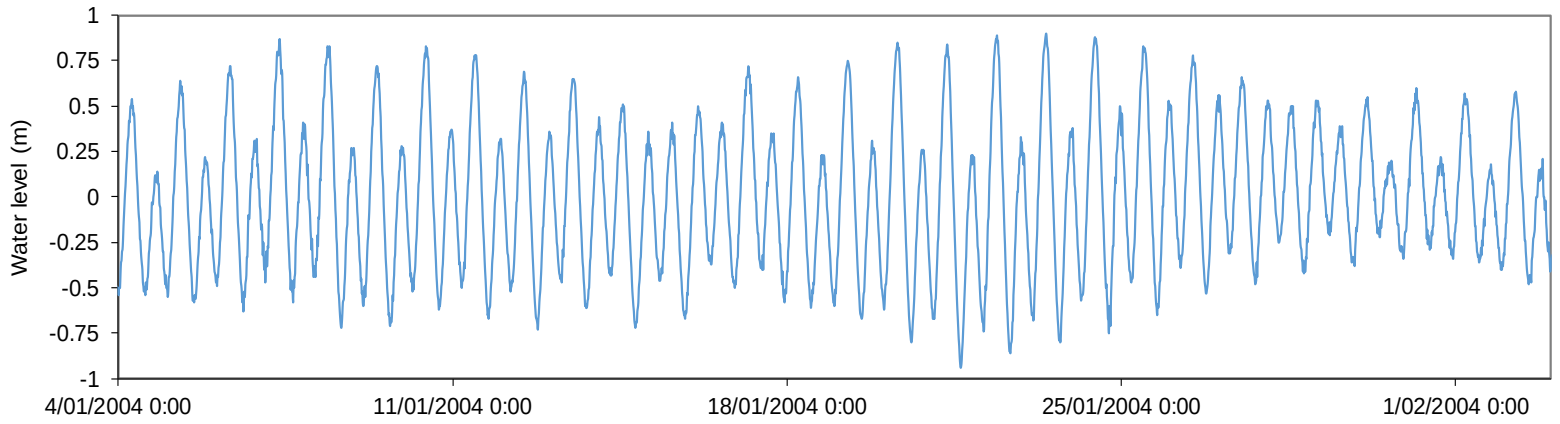
Hydrodynamic

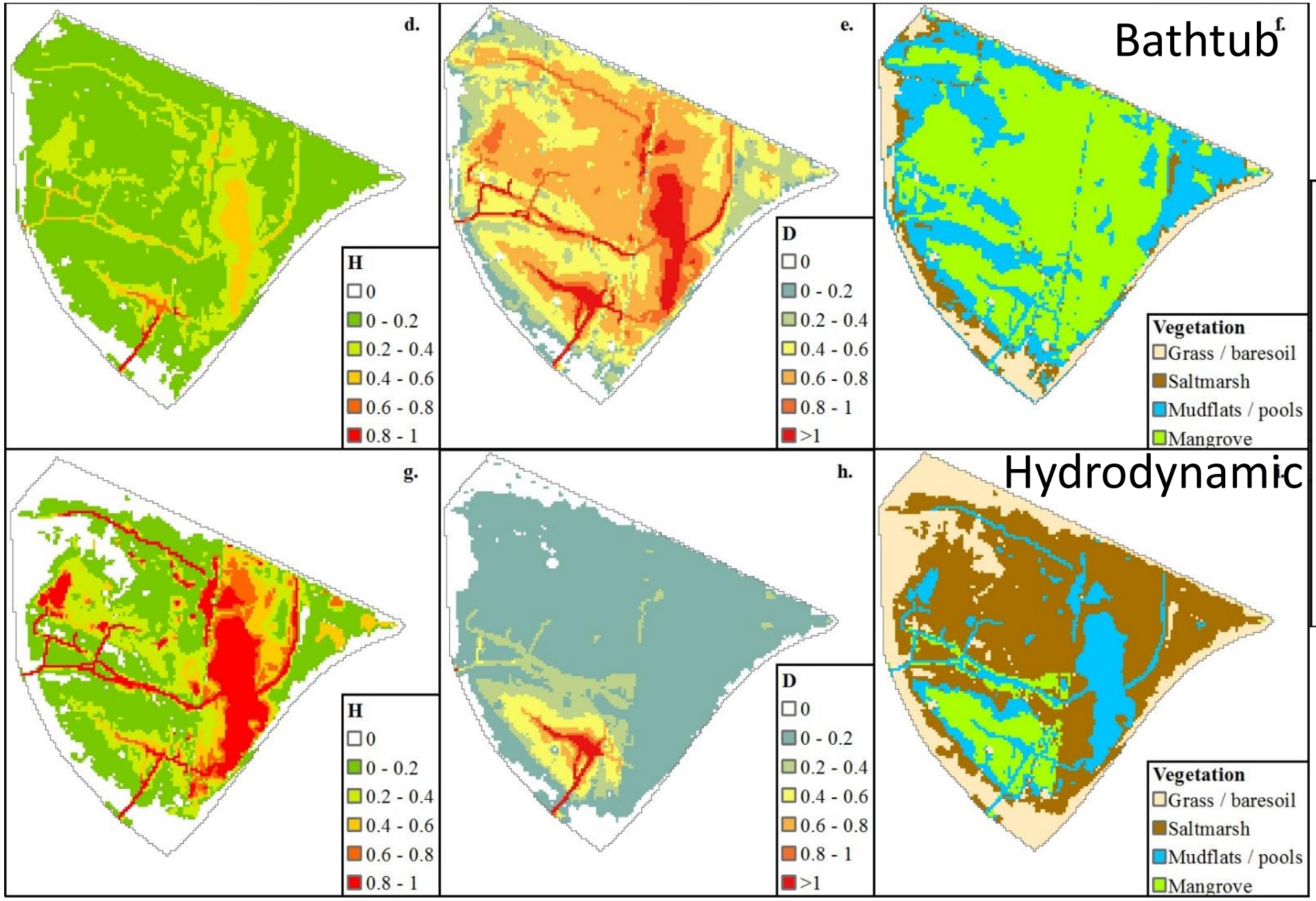
Attenuation due to vegetation and infrastructure





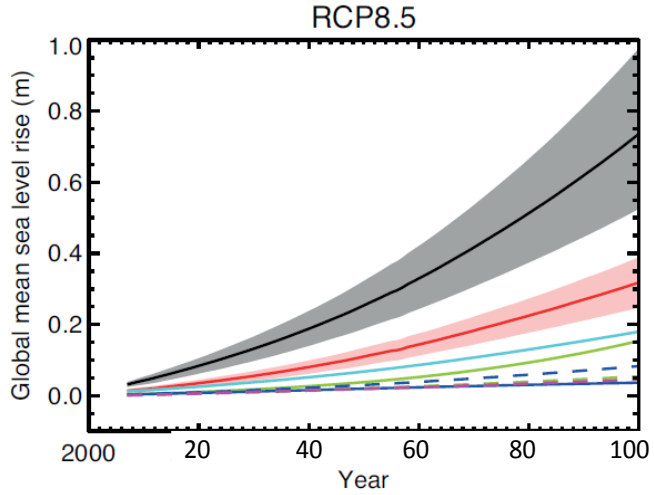





d.
H
0
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
e.
D
0
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
>1
Bathtub
f.
Vegetation
Grass / baresoil
Saltmarsh
Mudflats / pools
Mangrove
g.
H
0
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
h.
D
0
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
>1
Hydrodynamic
Vegetation
Grass / baresoil
Saltmarsh
Mudflats / pools
Mangrove
Measured
c.
Vegetation
Grass / baresoil
Saltmarsh
Mudflats / pools
Mangrove
Vegetation
Grass / baresoil
Saltmarsh
Mudflats / pools
Mangrove

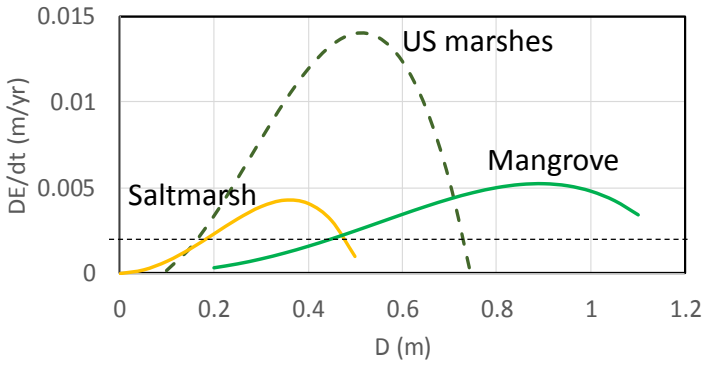
Wetland Evolution

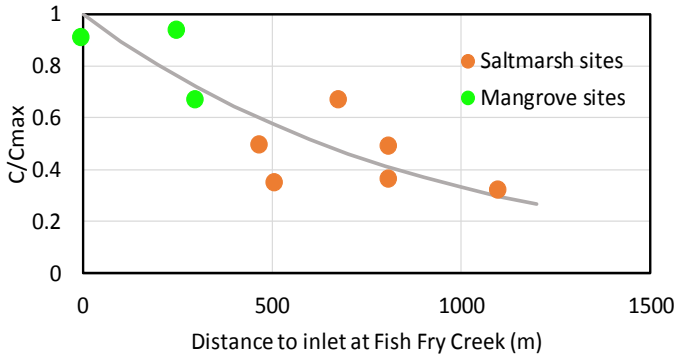
Sea-level rise
IPCC AR5 PCP8.5

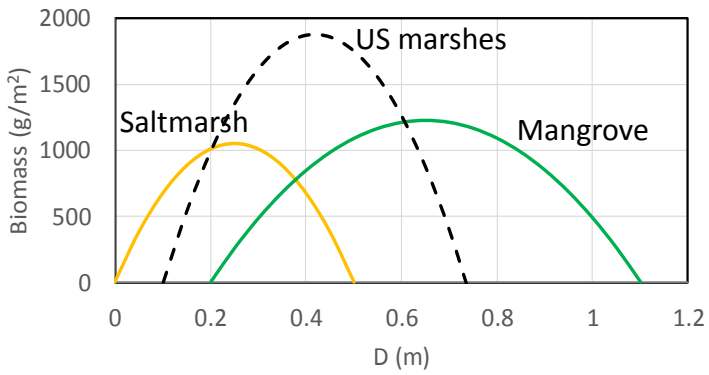


Bio-geomorphic accretion
(Kirwan et al., 2010, Morris et al., 2002, D'alpaos et al., 2007)

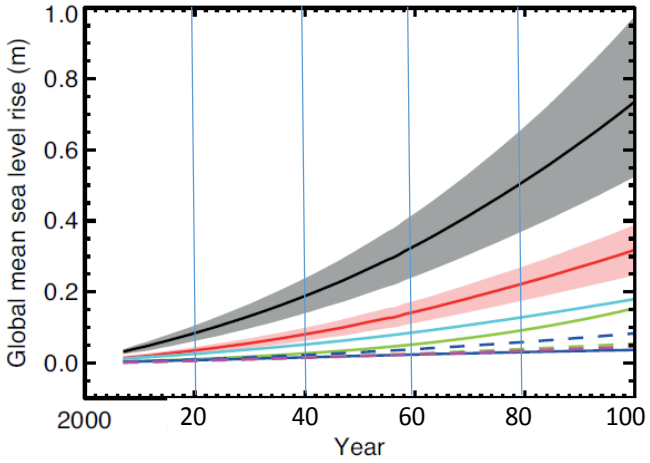
$$\frac{dE}{dt} = C(q + kB)D$$

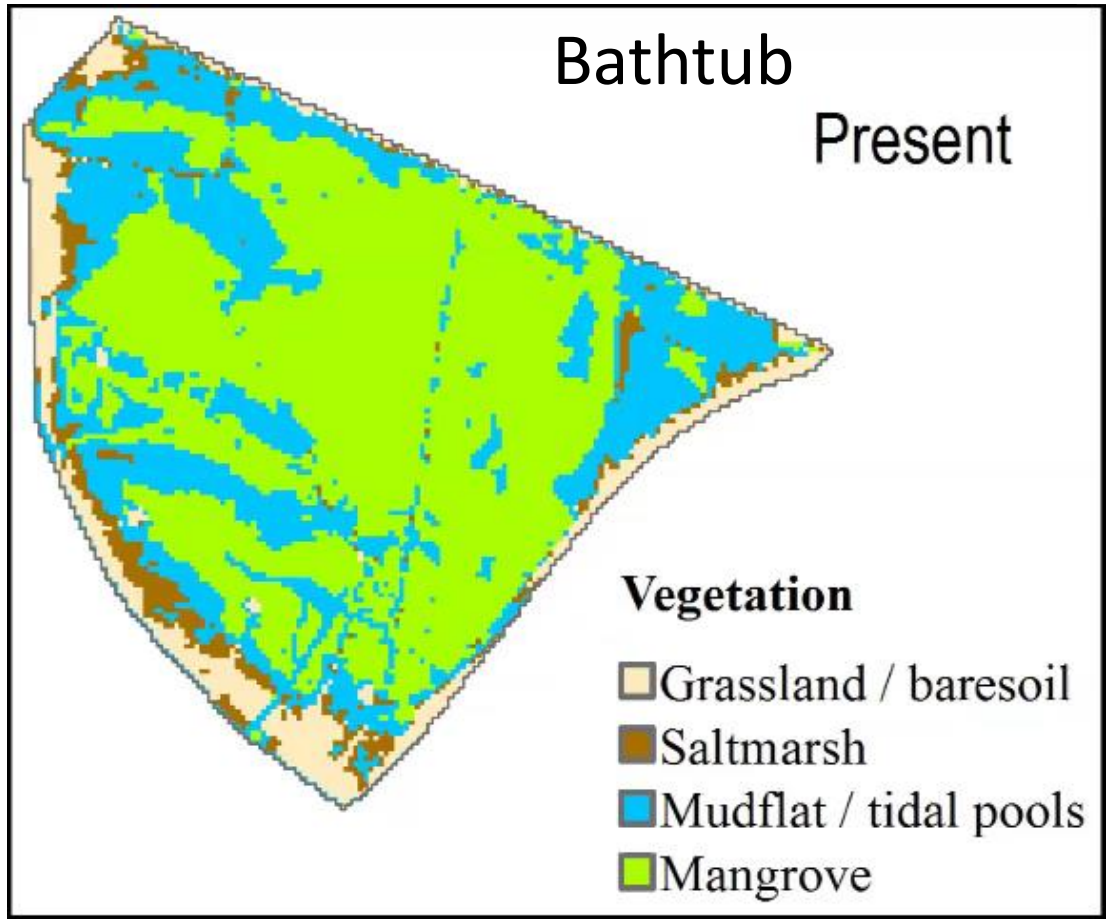


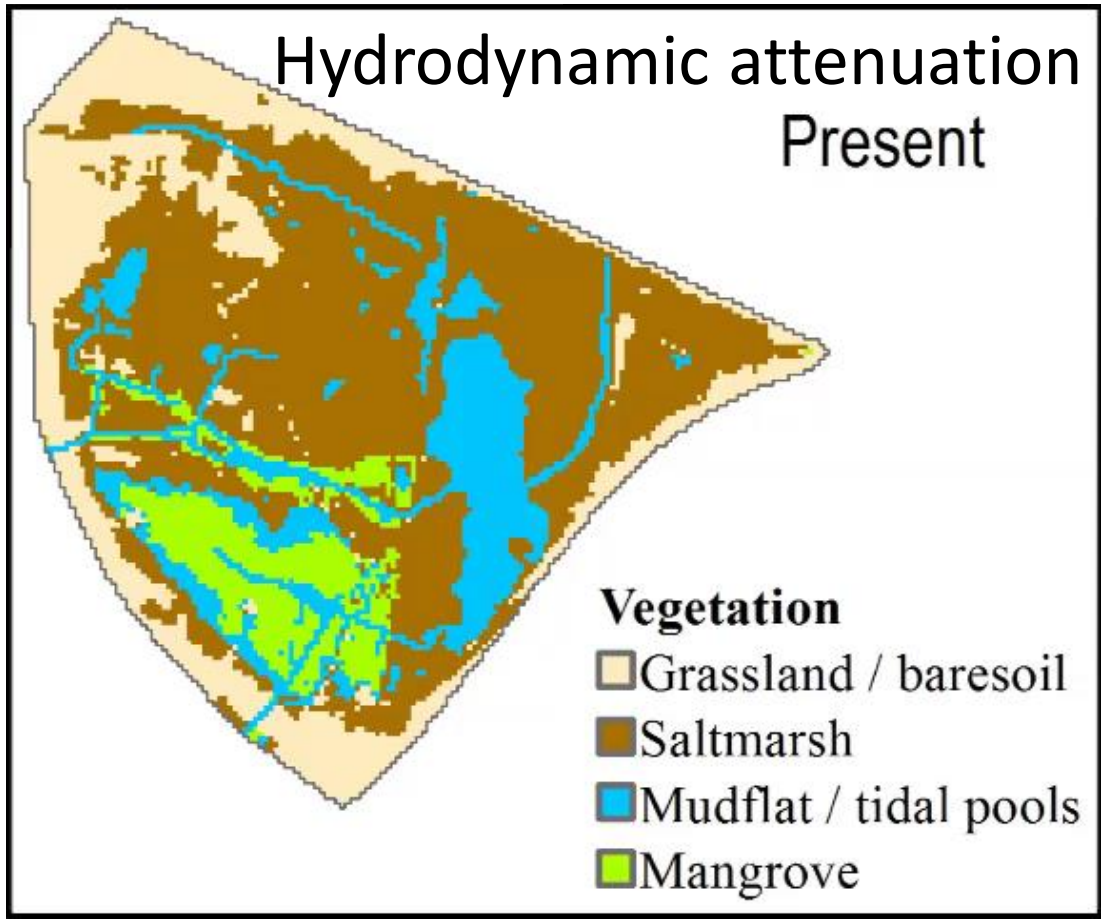




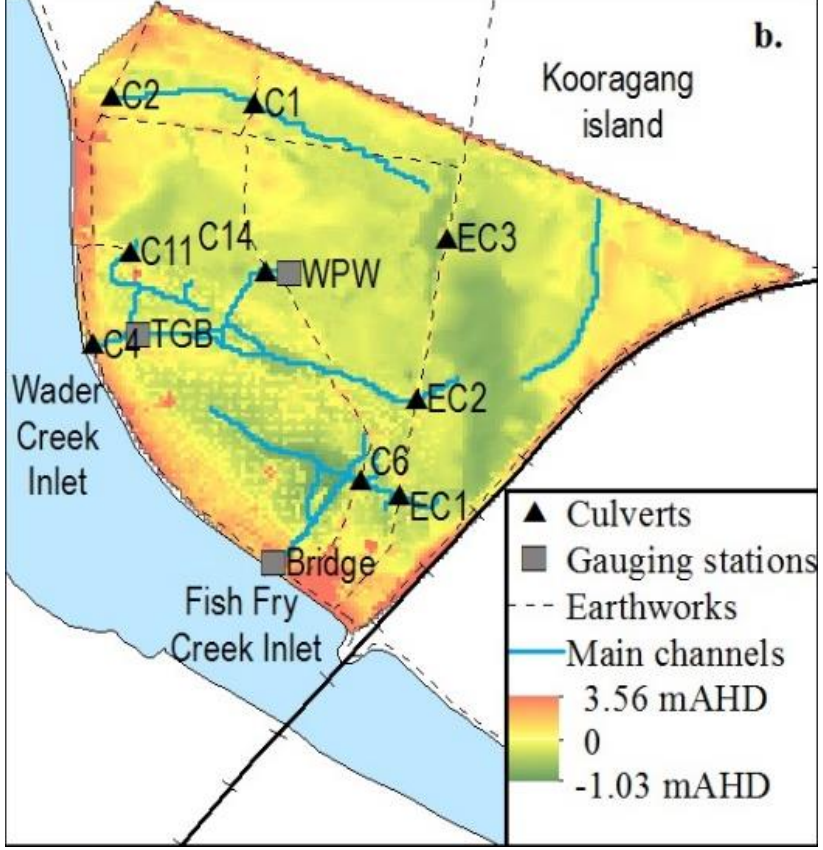
Long term wetland evolution





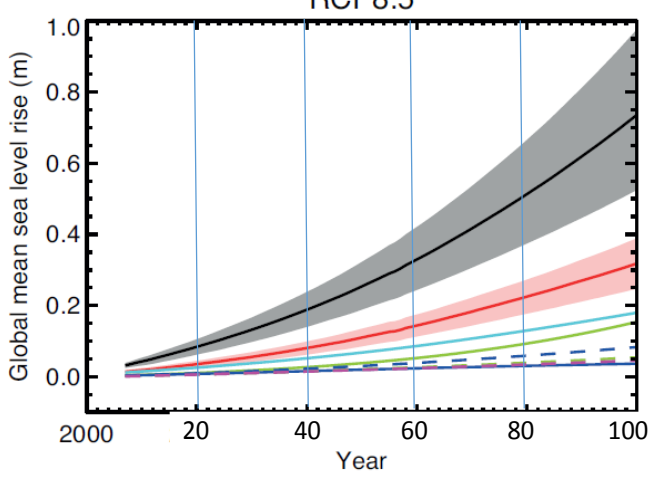


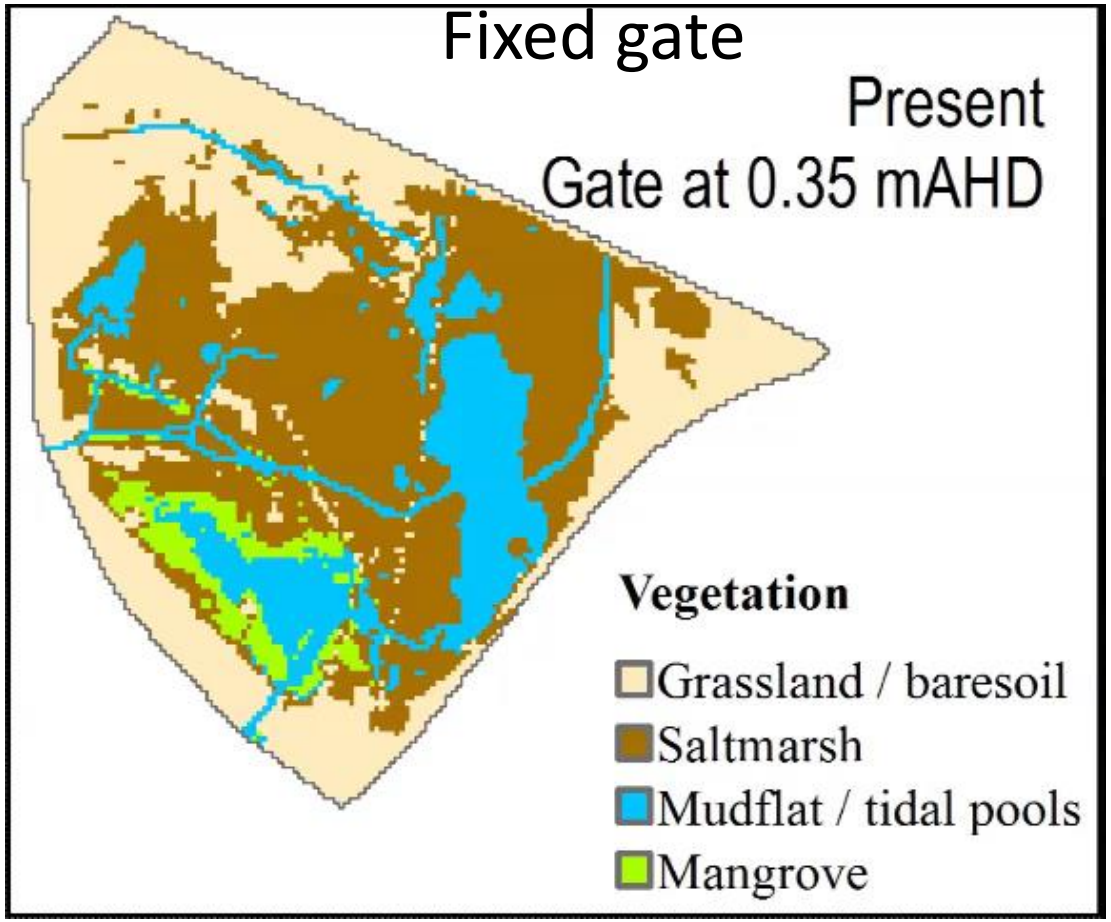
Long term wetland evolution – Average results on WPW

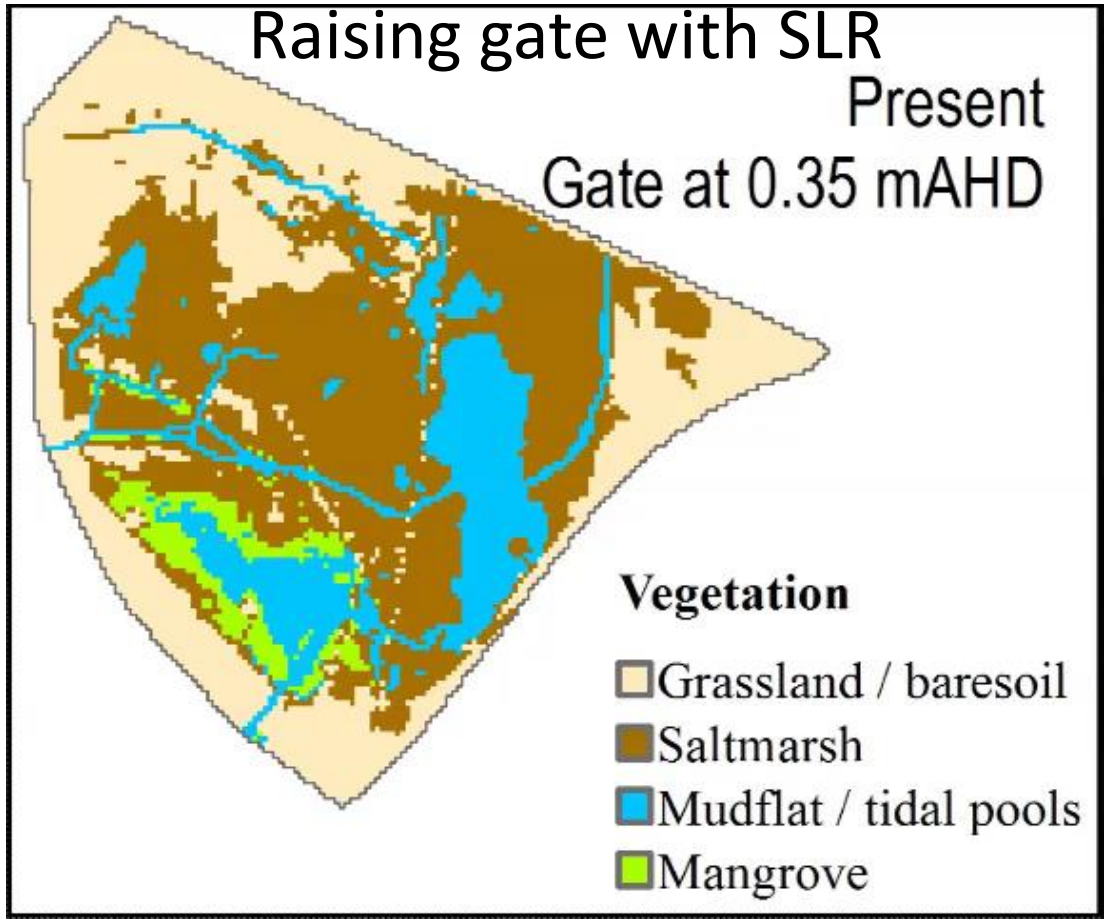


SLR (mm/yr)	Accretion (mm/yr)	D_{bath} (mm/yr)	D_{hydr} (mm/yr)	H_{bath} (1/yr)	H_{hydr} (1/yr)
0.008	0.002	0.006	0.006	0.0025	0.0075

Long term wetland evolution with inlet control





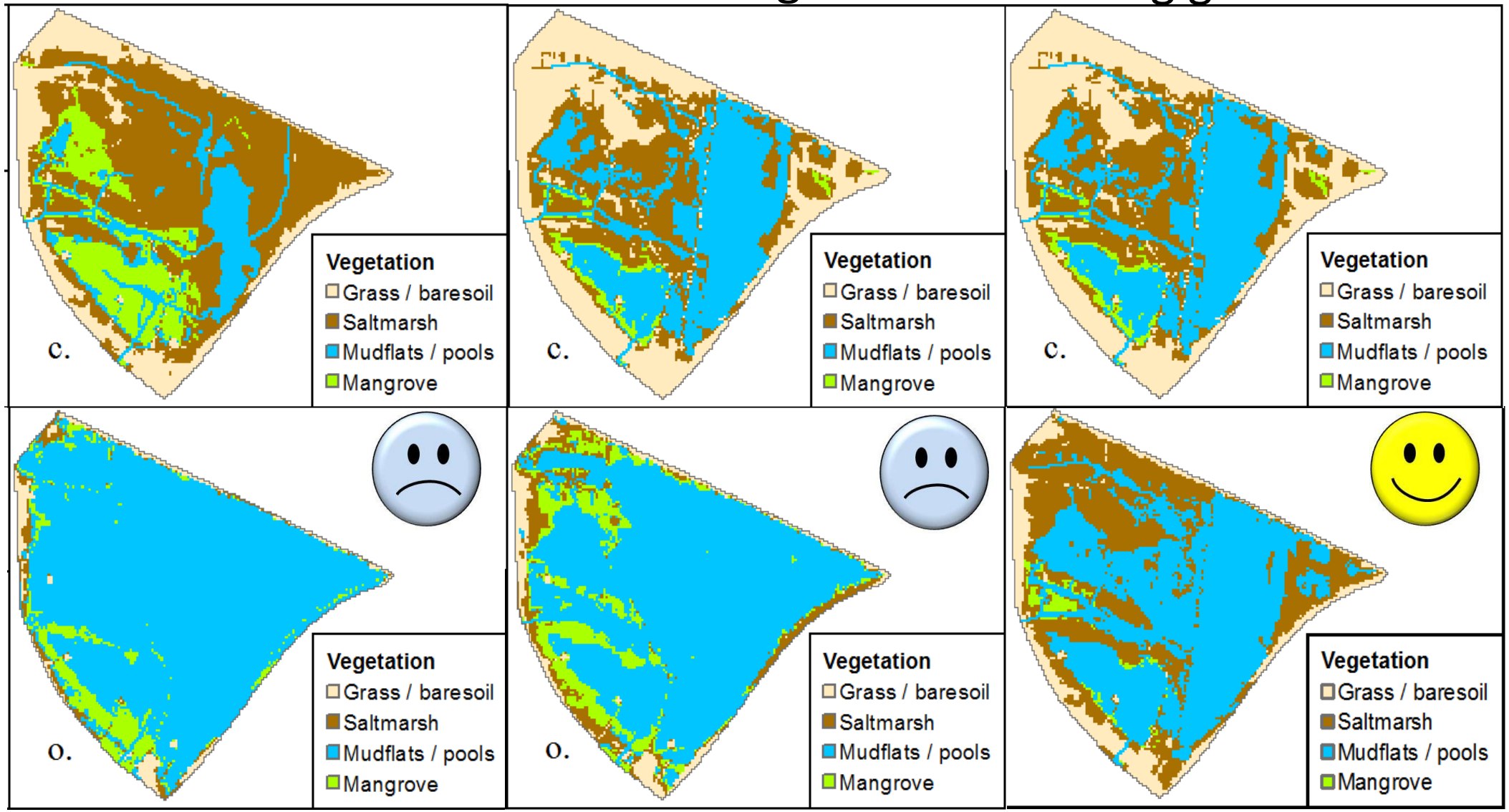


Inlet control effects

No control

Fixed gate

Raising gate with SLR



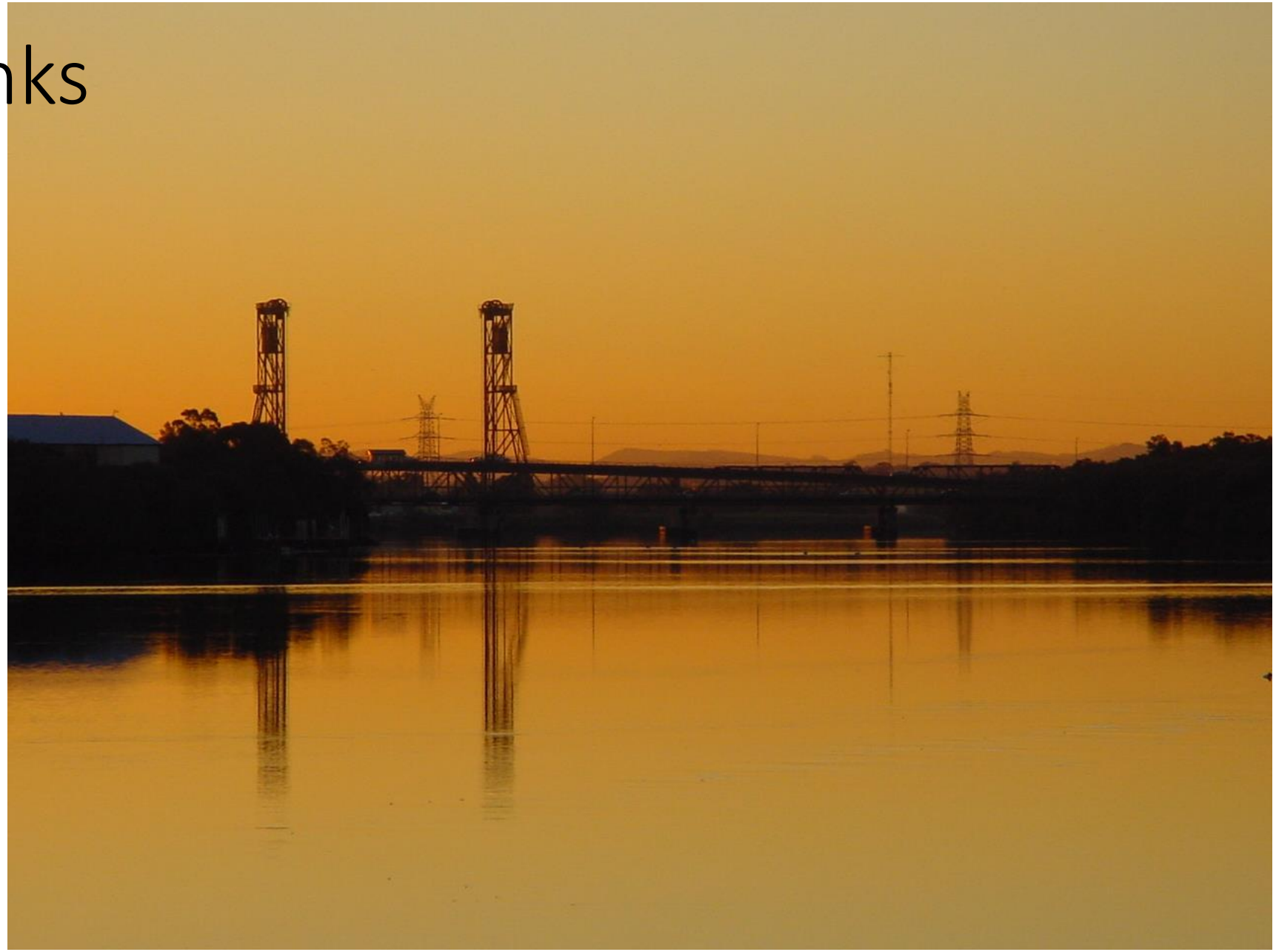
20 years

100 years

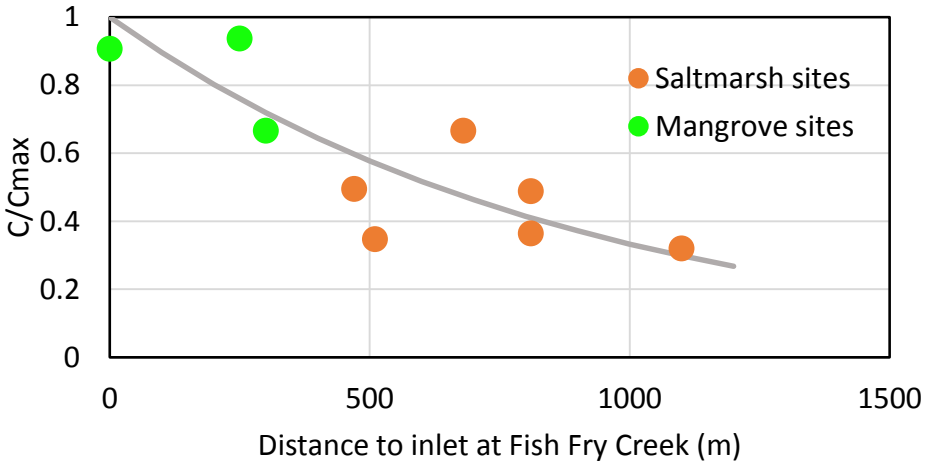
Conclusions

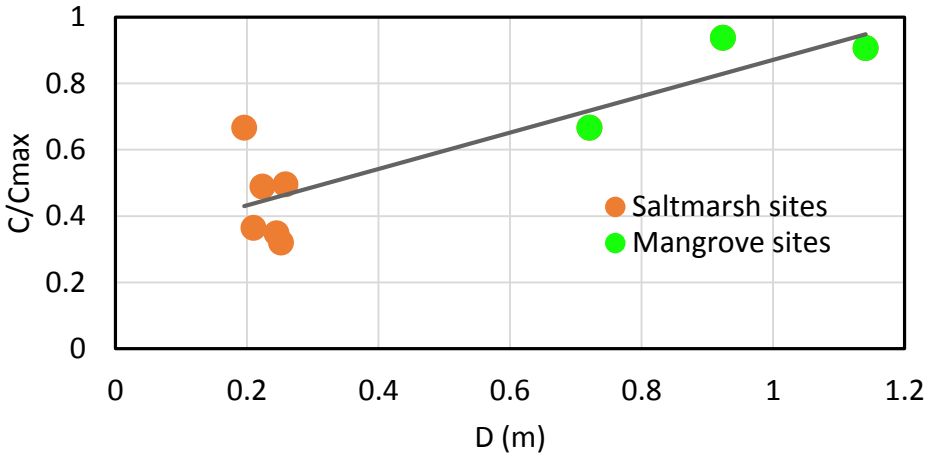
- A hydrodynamic -vegetation-soil evolution model has been applied to a wetland in Australia to assess vegetation changes under sea-level rise including attenuation effects
- Compared with bathtub predictions, attenuation effects due to infrastructure and vegetation resistance accelerates wetland loss by about 30-40%. The main reason is the accelerated increase in Hydroperiod.
- Inlet control can reduce wetland loss to some extent but only if it adapts to sea-level rise.
- Increasing sediment supply by a factor of 3 (not shown) reduces wetland loss but it does not totally prevent it.

Thanks

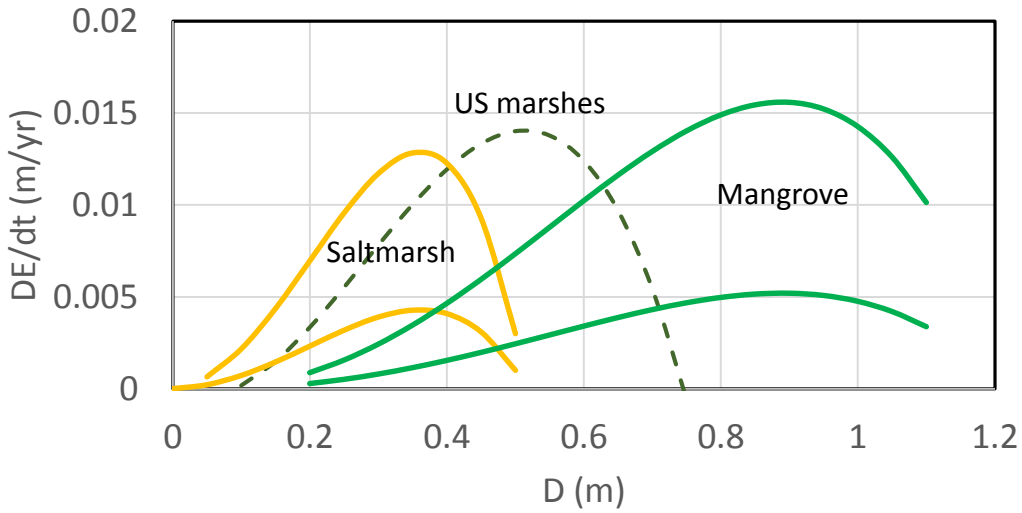


Suspended sediment concentration

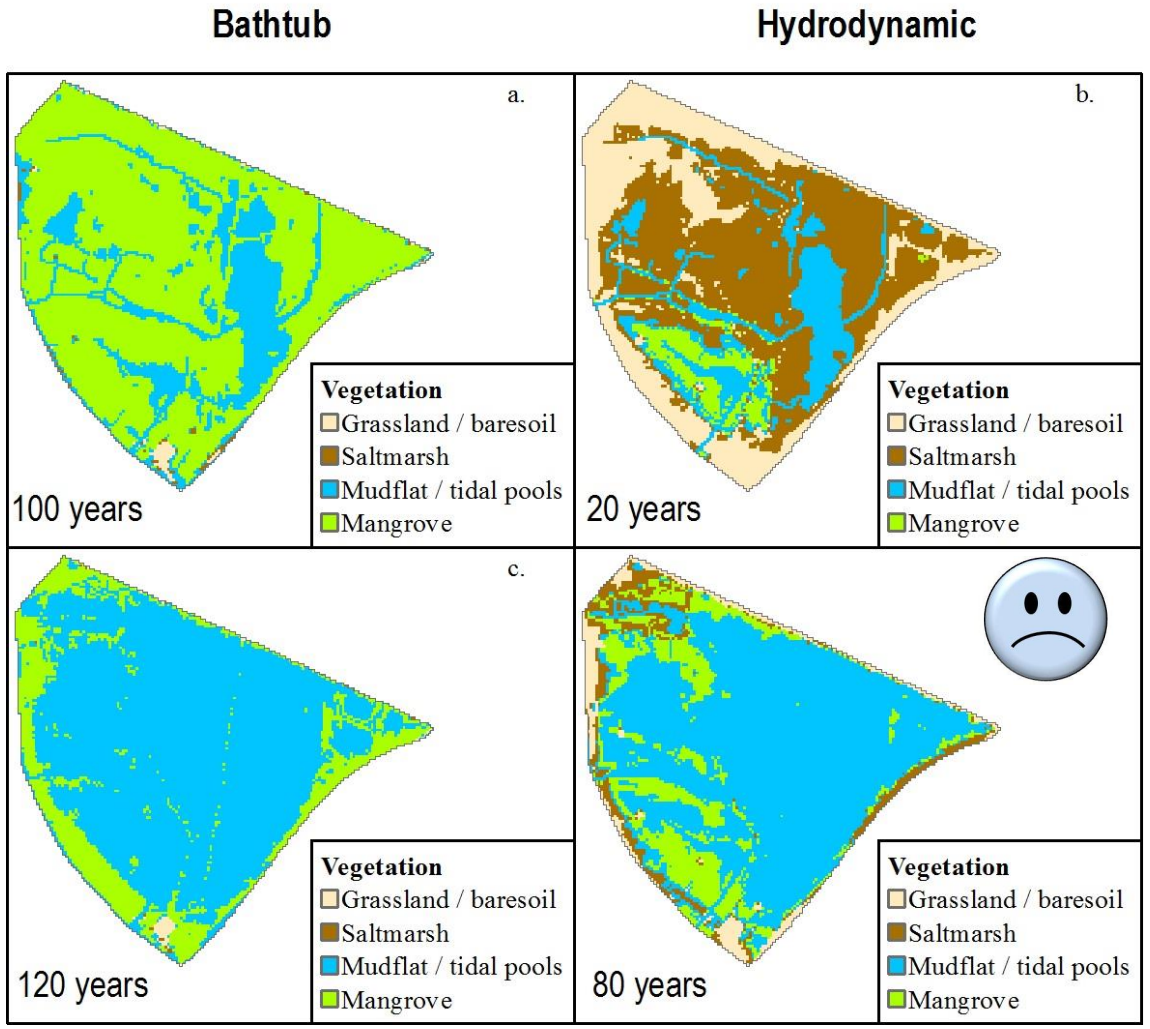




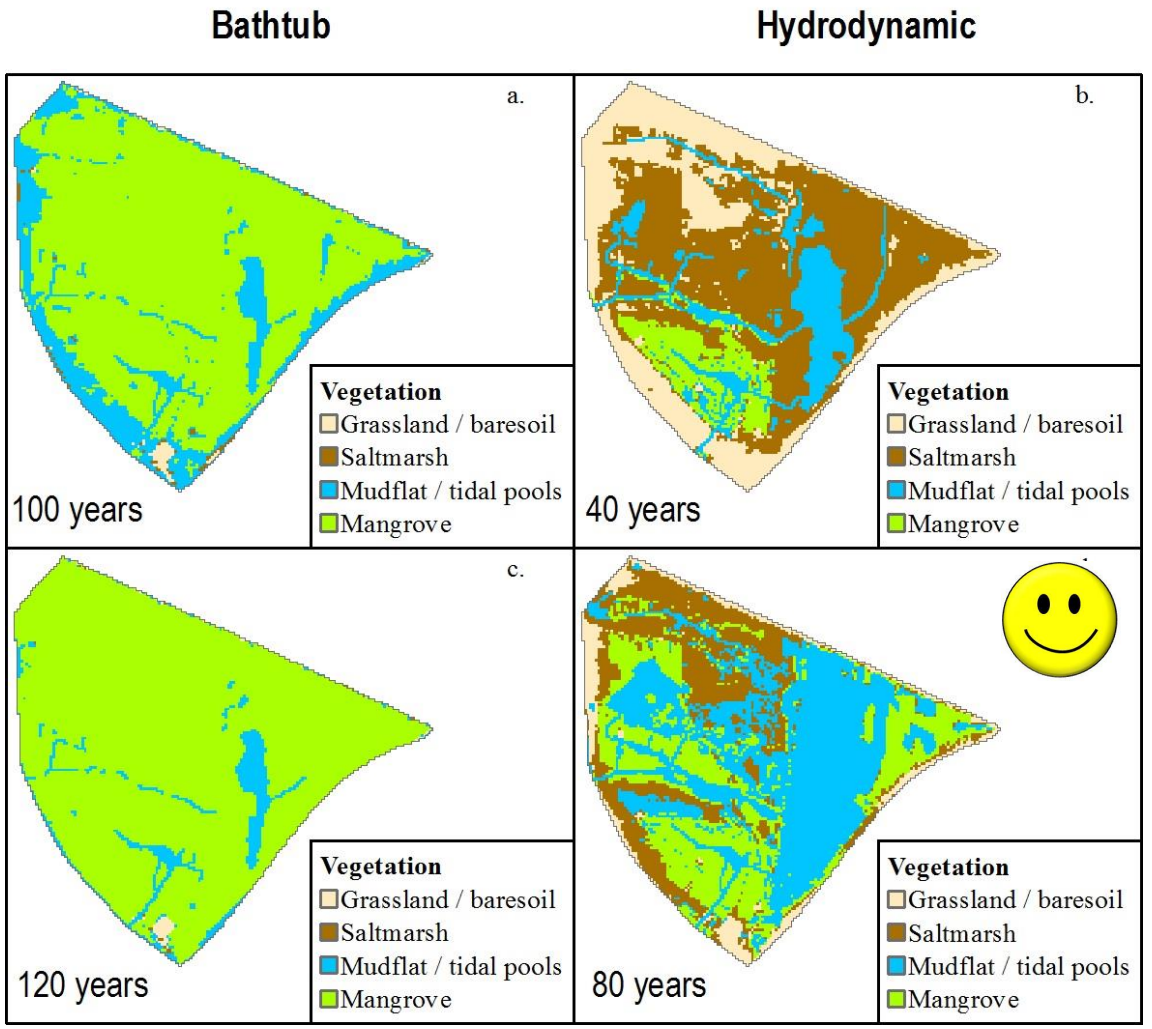
Increasing sediment concentration



Increasing sediment supply



Low sediment (Cmax = 37 g/m^3)



High sediment (Cmax = 111 g/m^3)

Hydrographs