Alternative stable states in coastal ecosystems, tipping points and the cost of doing nothing

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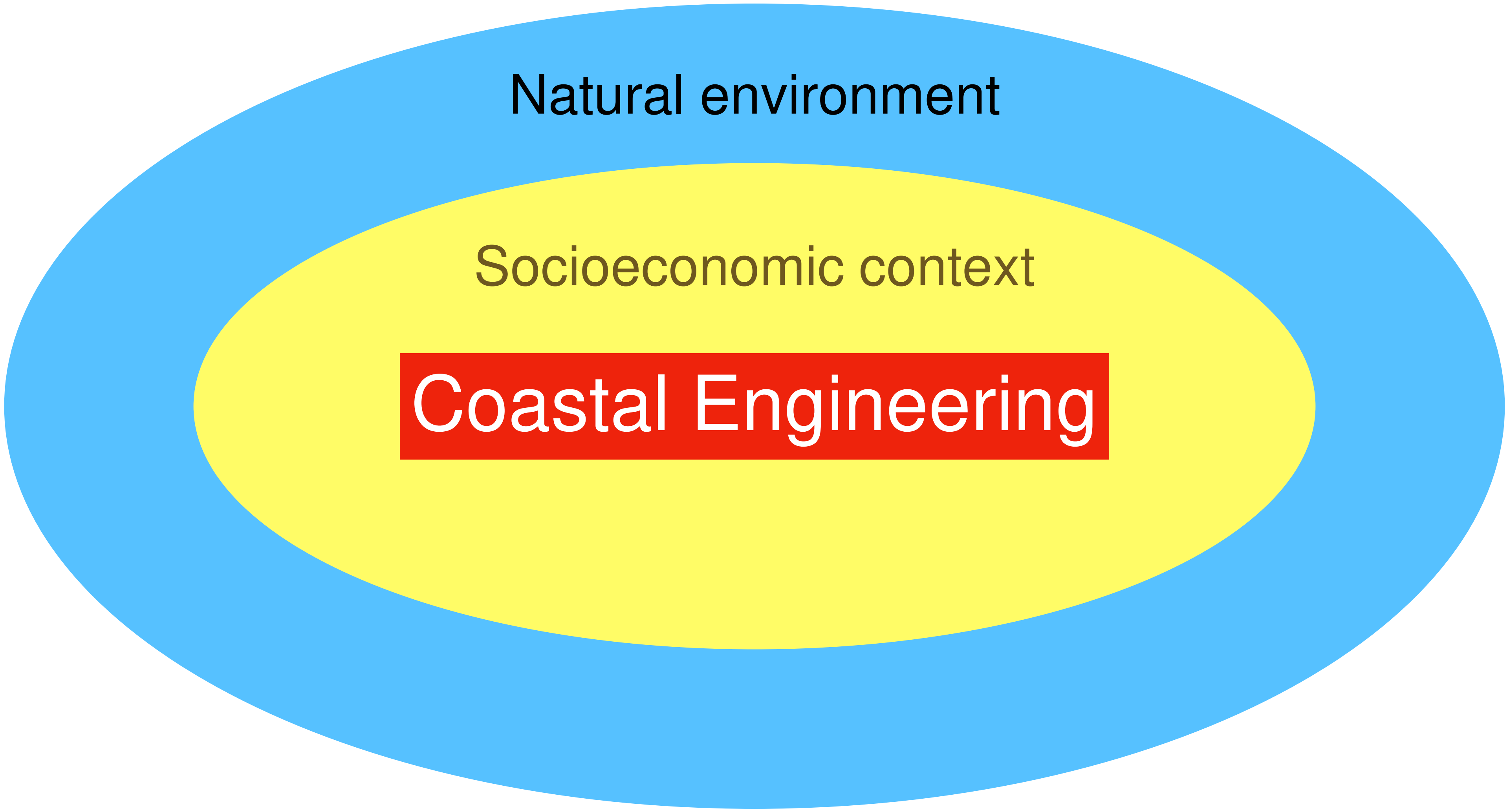
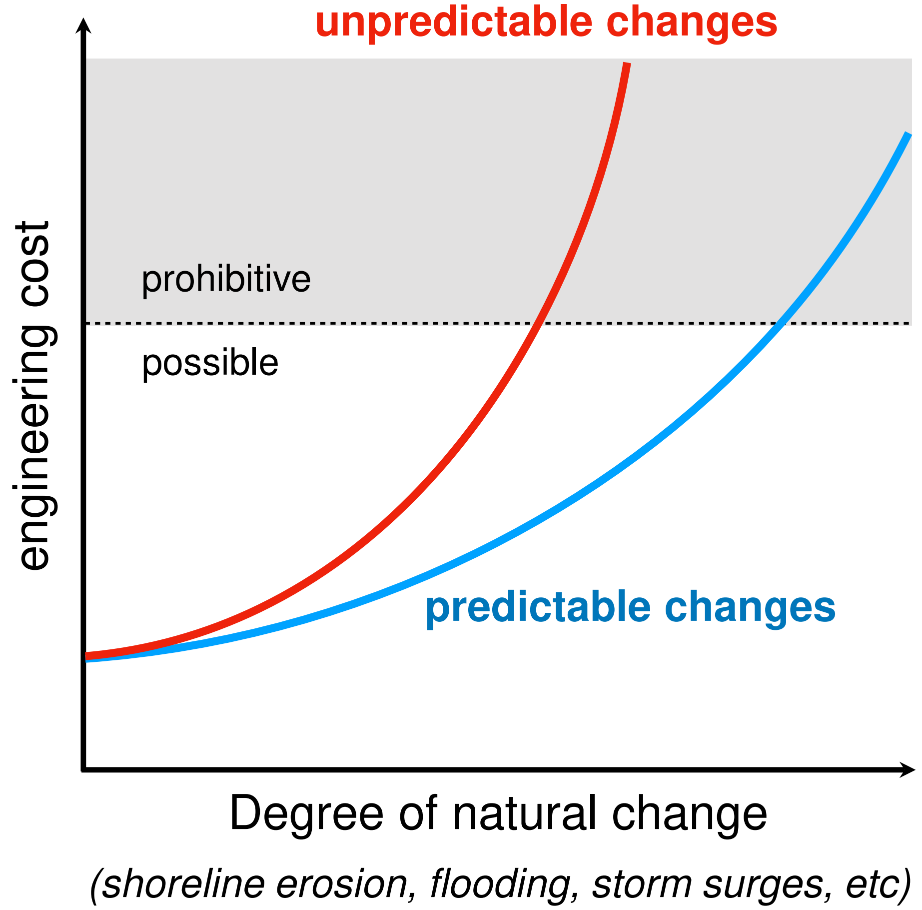
Why care about the natural dynamics of coastal systems?



The natural environment and natural processes control engineering costs…

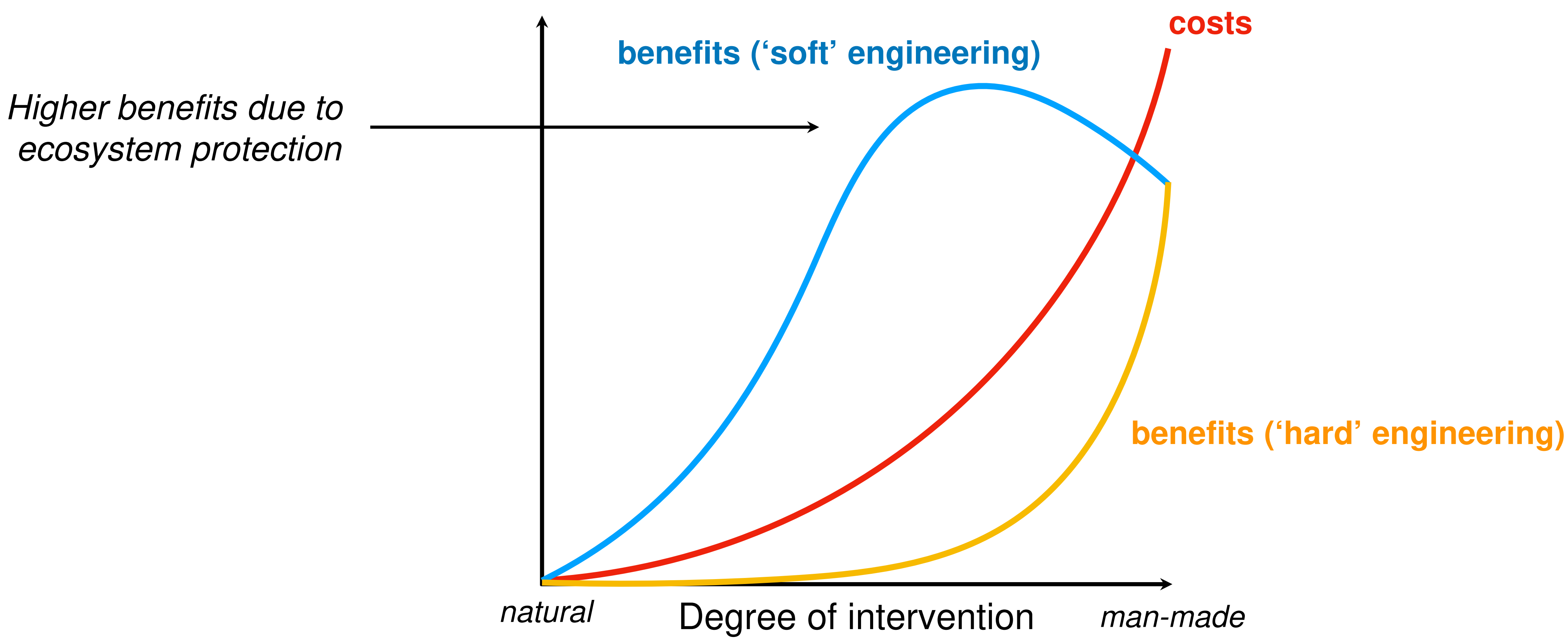
…but also offer new engineering opportunities

Why care about the natural dynamics of coastal systems?



Predictable natural dynamics minimize engineering costs…

Why care about the natural dynamics of coastal systems?



Predictable natural dynamics minimize engineering costs…
…and maximize the benefits

Natural dynamics of coastal systems

Ecosystem engineers:

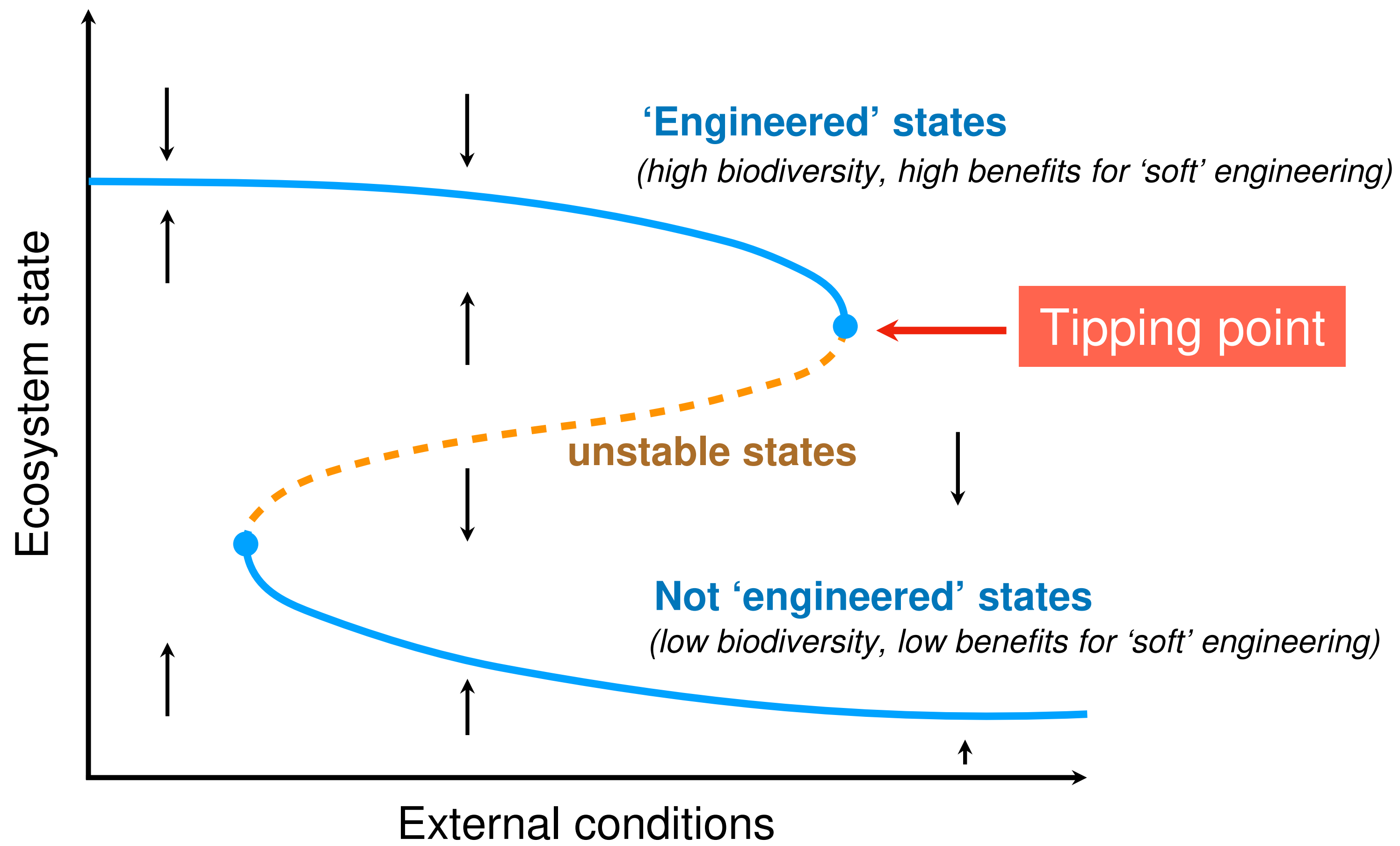
- Marshes
- Coastal dune vegetation
- Oysters
- Seagrasses

organisms create & **maintain** their own habitat

Recover from disturbances

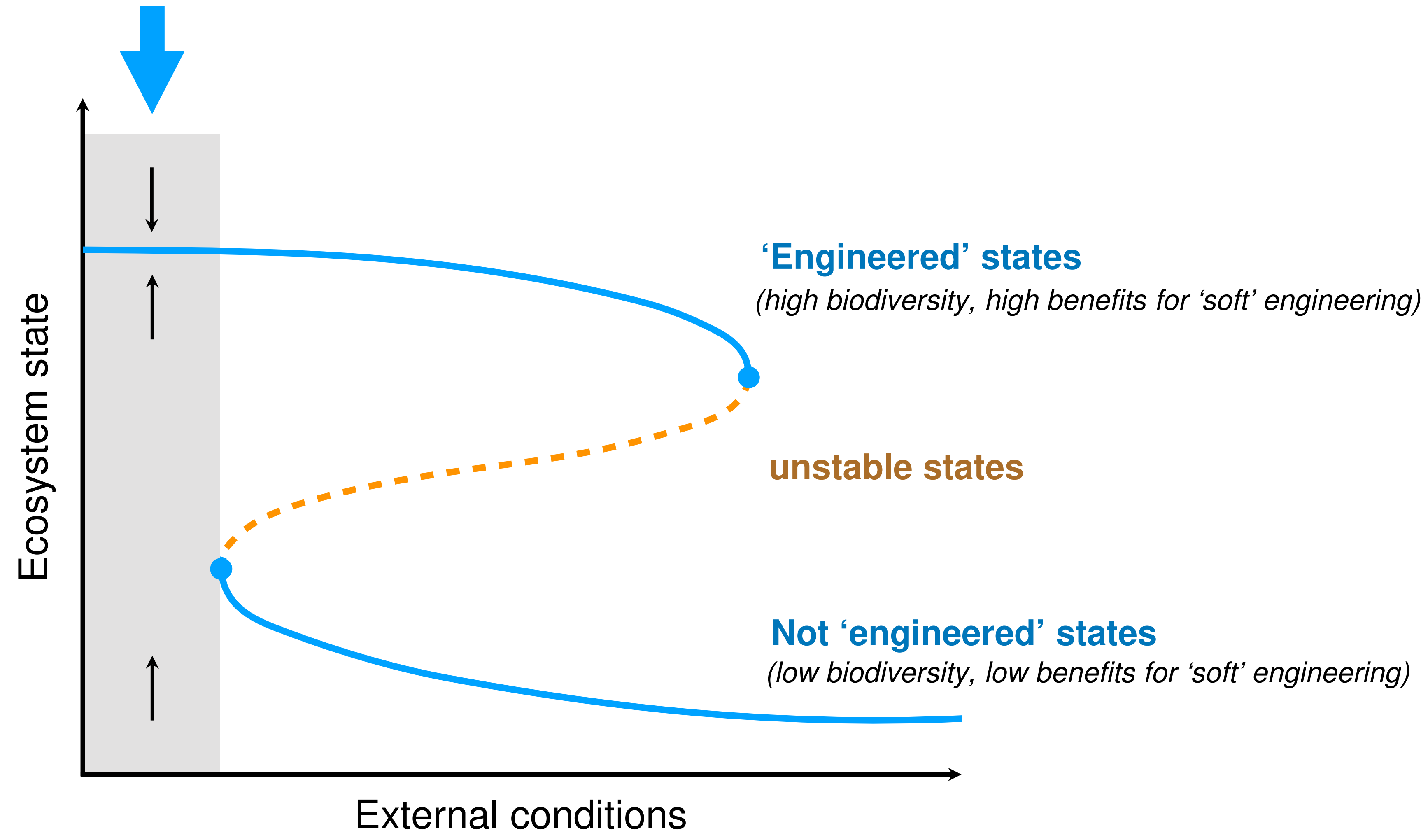
Dynamics of ecosystem engineers

Alternative stable states and tipping points



Dynamics of ecosystem engineers

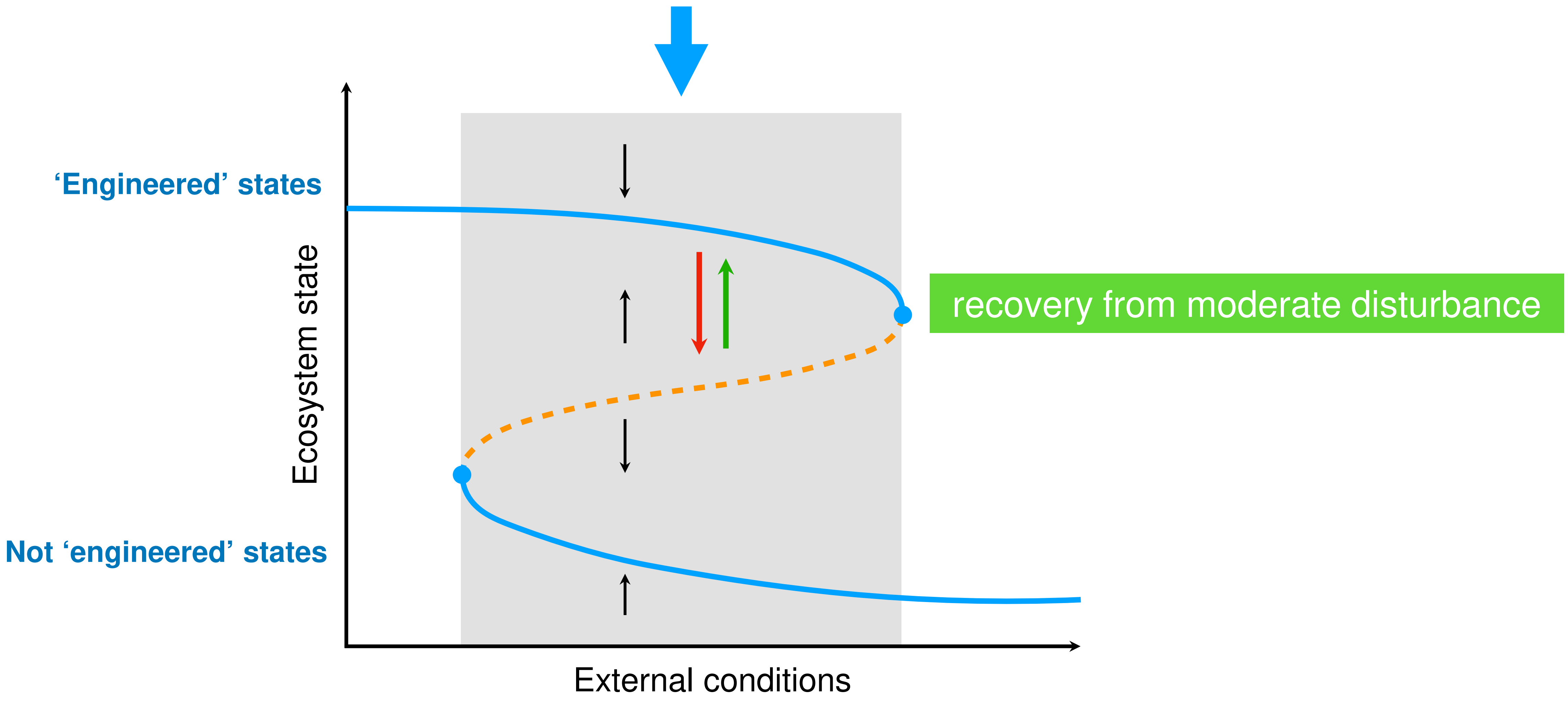
Maximum resilience: always recover from disturbances



Minimal engineering costs, maximum benefits

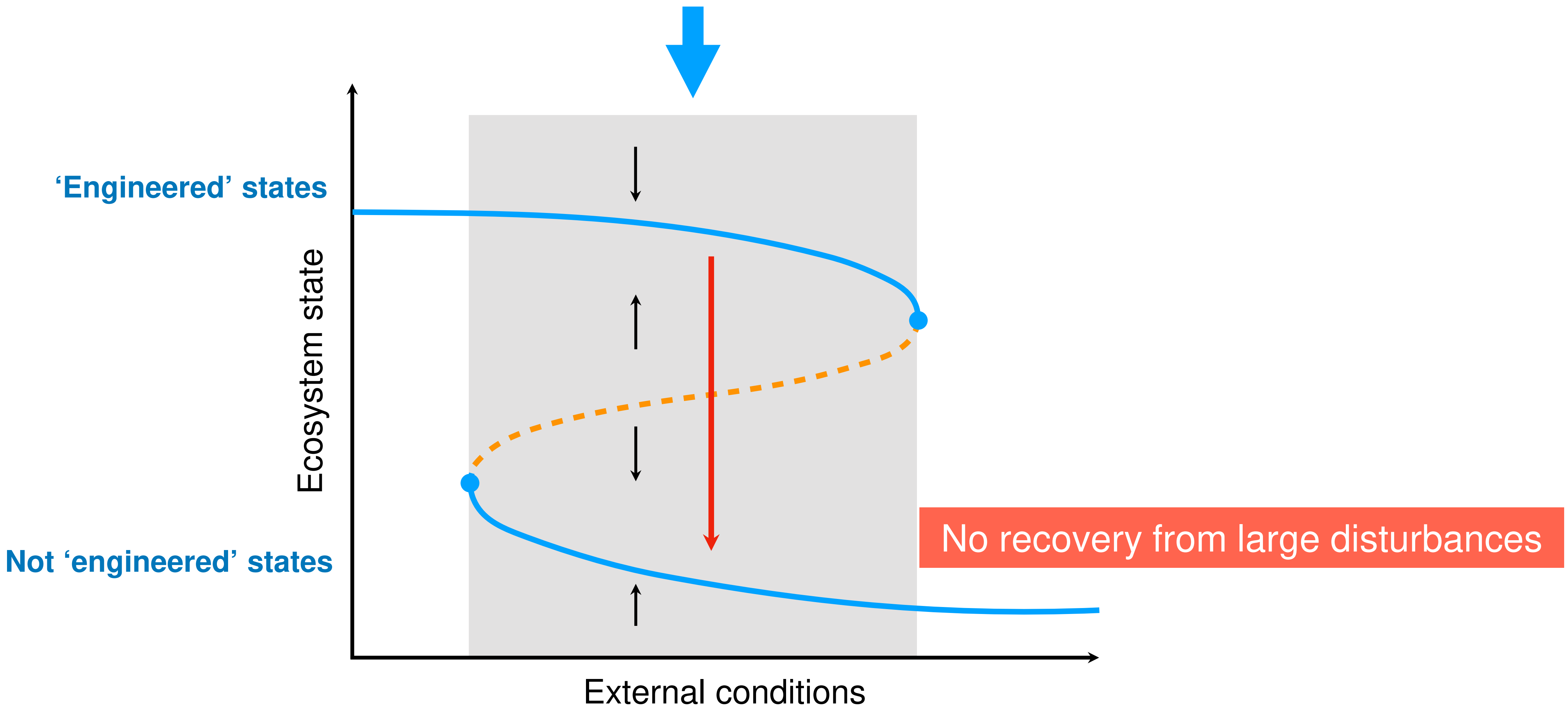
Dynamics of ecosystem engineers

Moderate resilience: recovery depends on disturbance



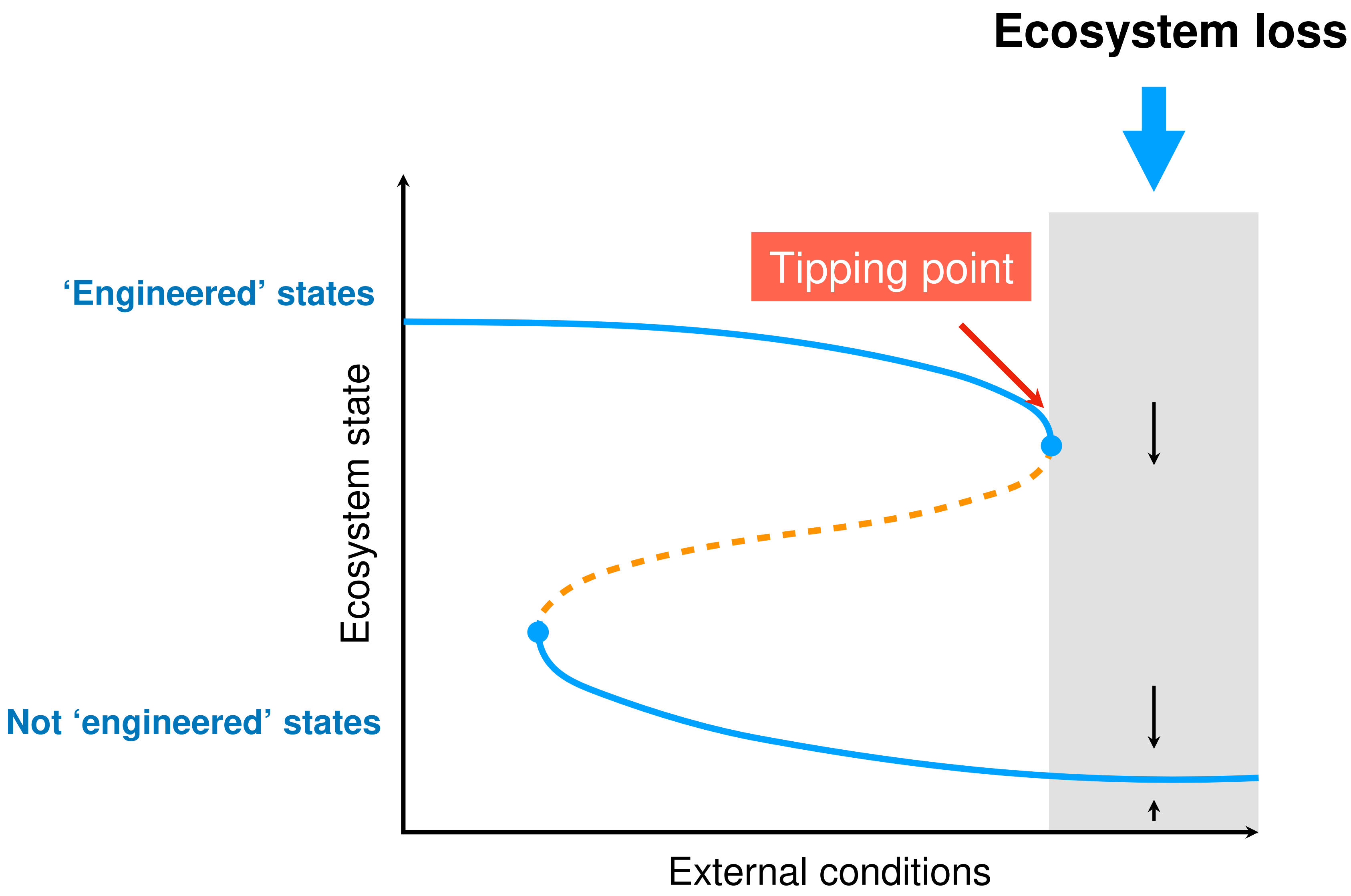
Dynamics of ecosystem engineers

Moderate resilience: recovery depends on disturbance



Moderate engineering costs due to ecosystem restoration

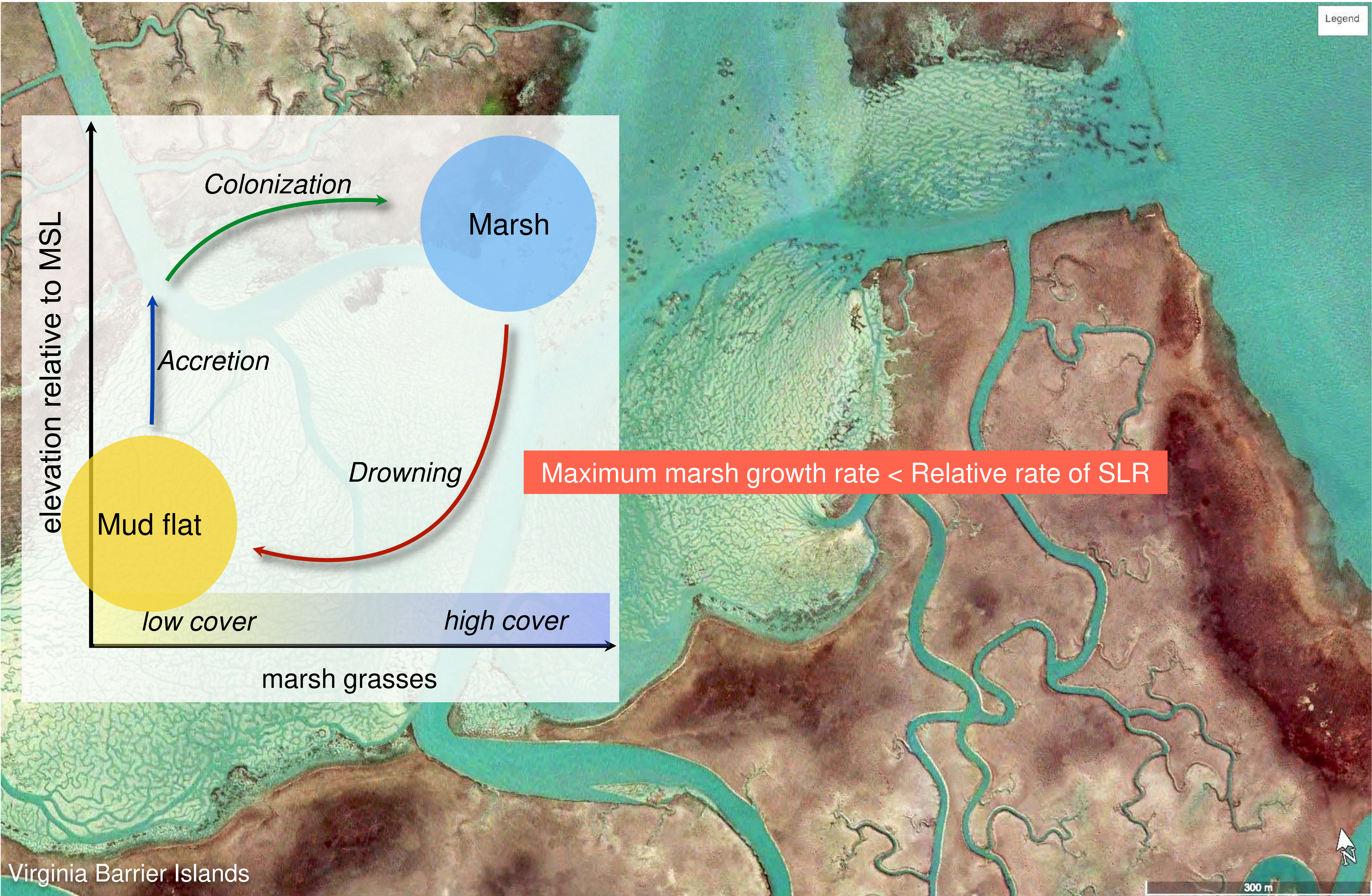
Dynamics of ecosystem engineers



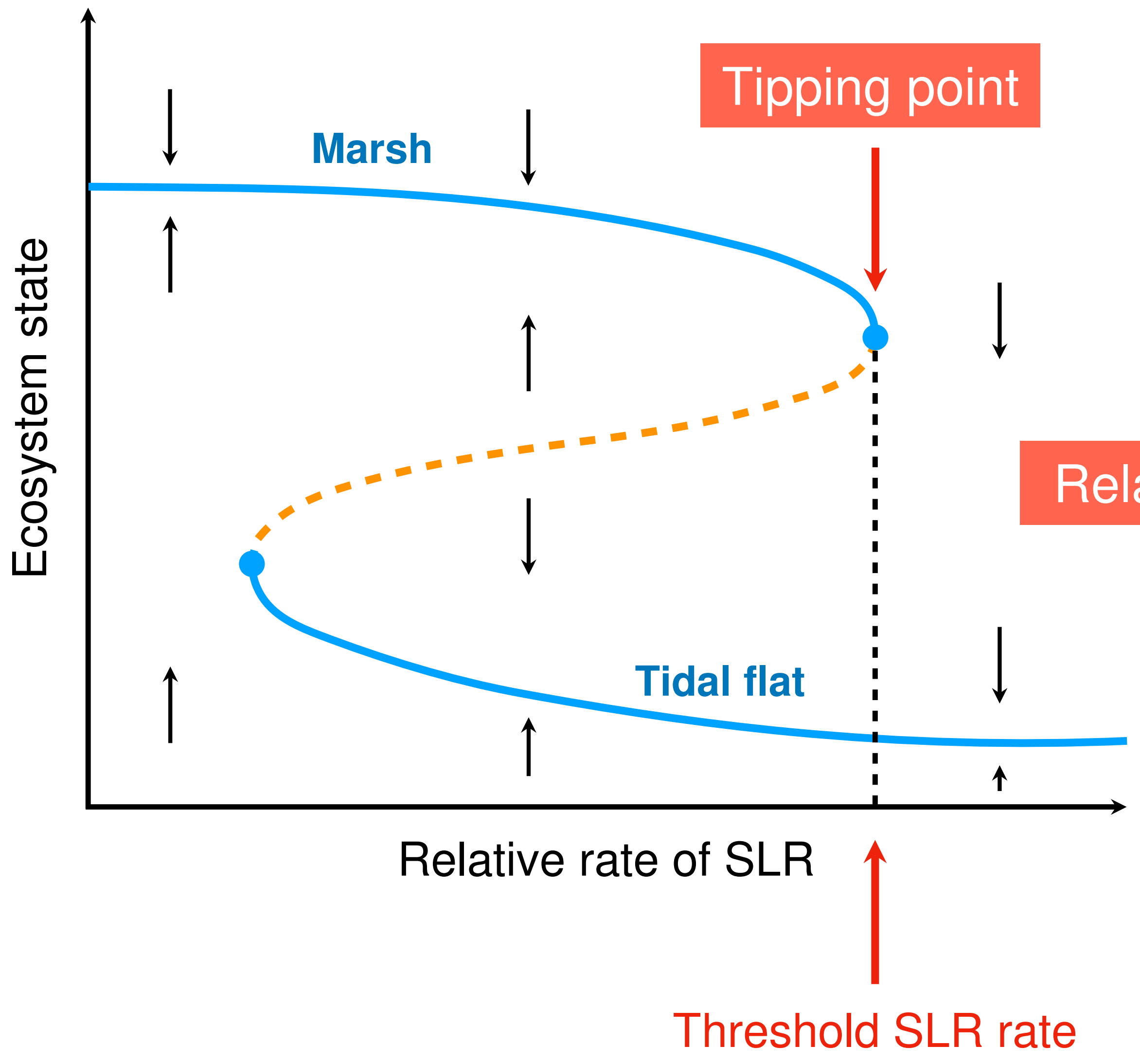
Maximum engineering costs to maintain an unstable ecosystem

Dynamics of ecosystem engineers: **marshes**

Dynamics of ecosystem engineers: **marshes**

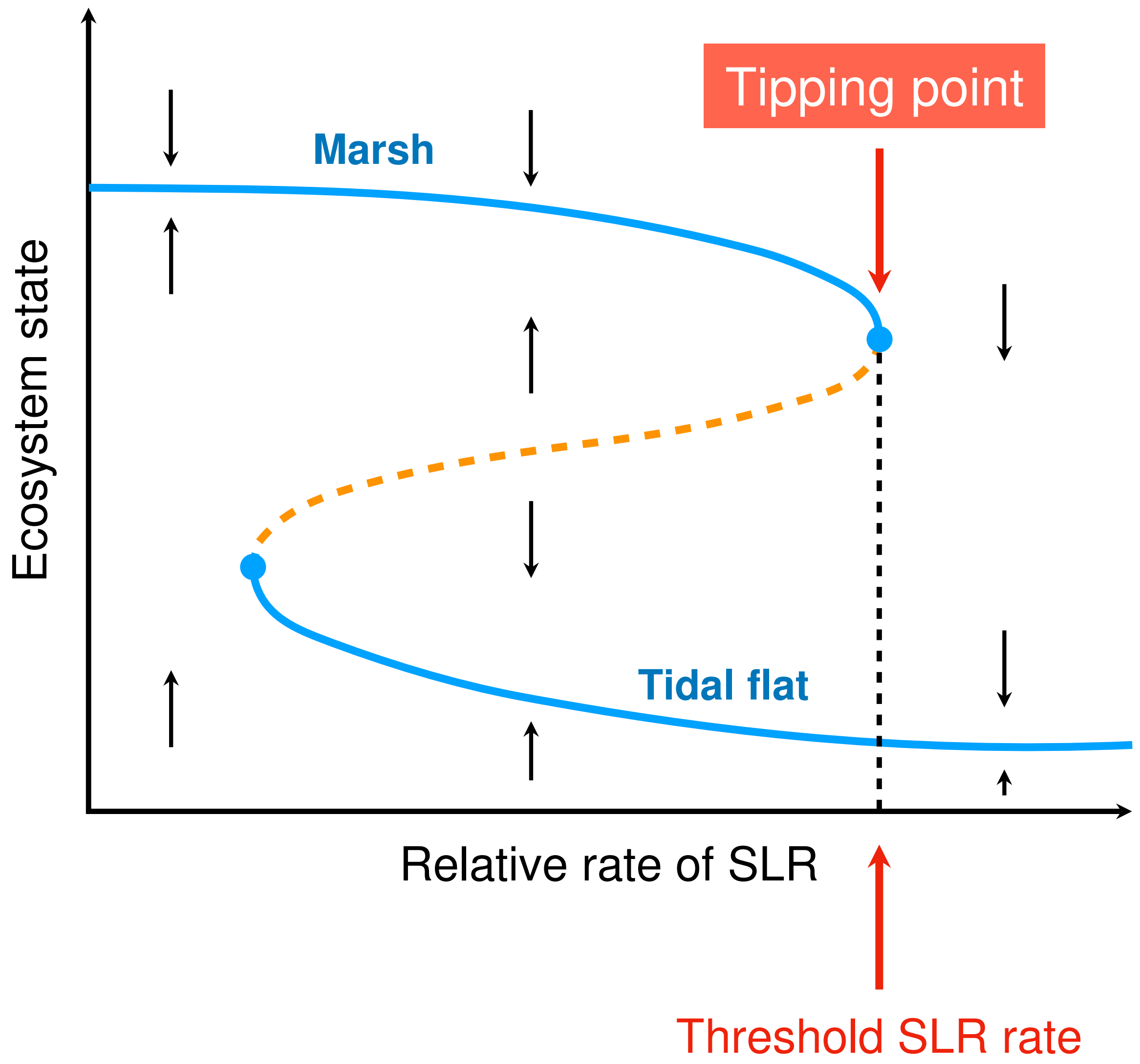


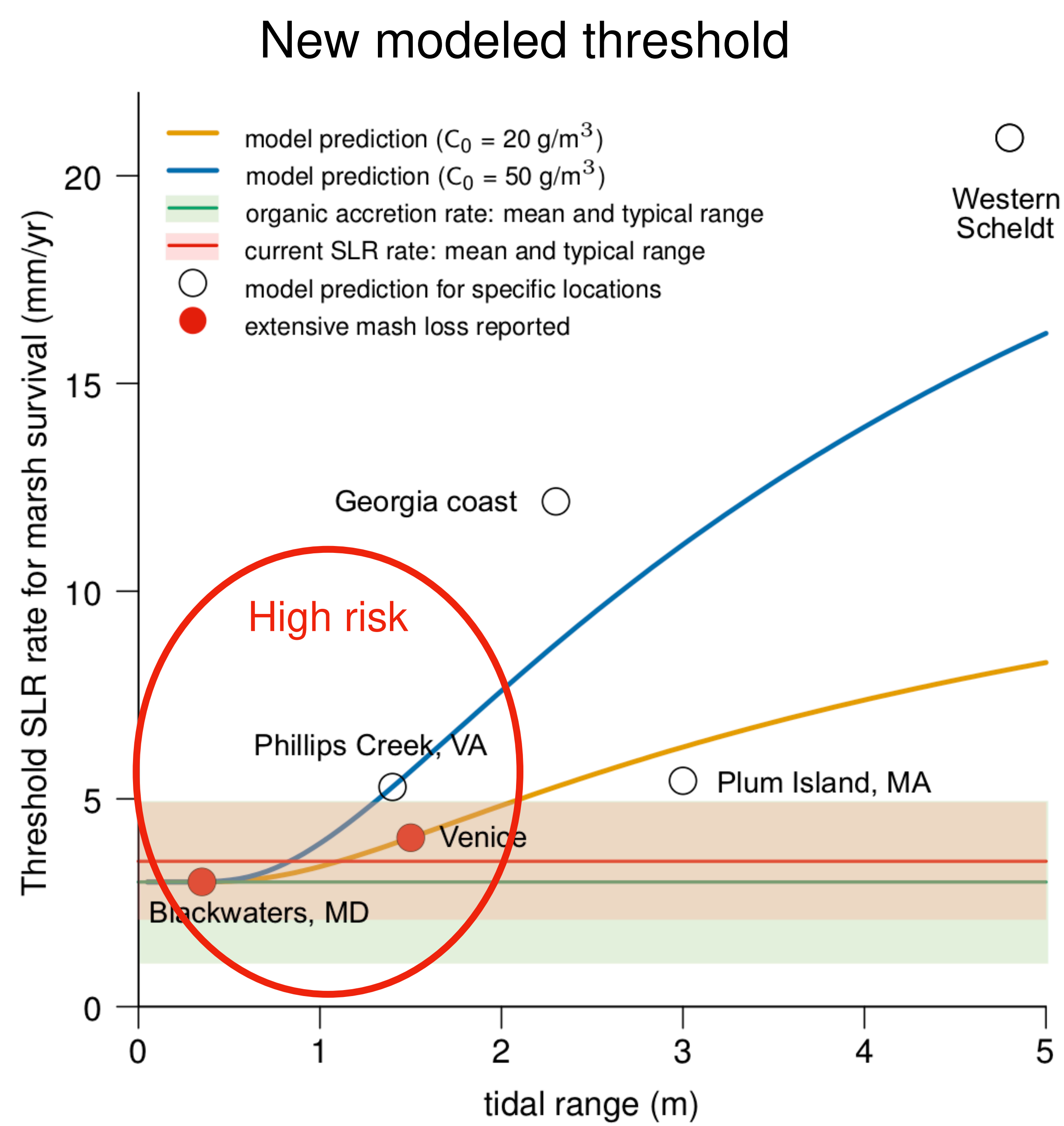
Dynamics of ecosystem engineers: **marshes**



Relative rate of SLR = Maximum marsh growth rate

Dynamics of ecosystem engineers: marshes



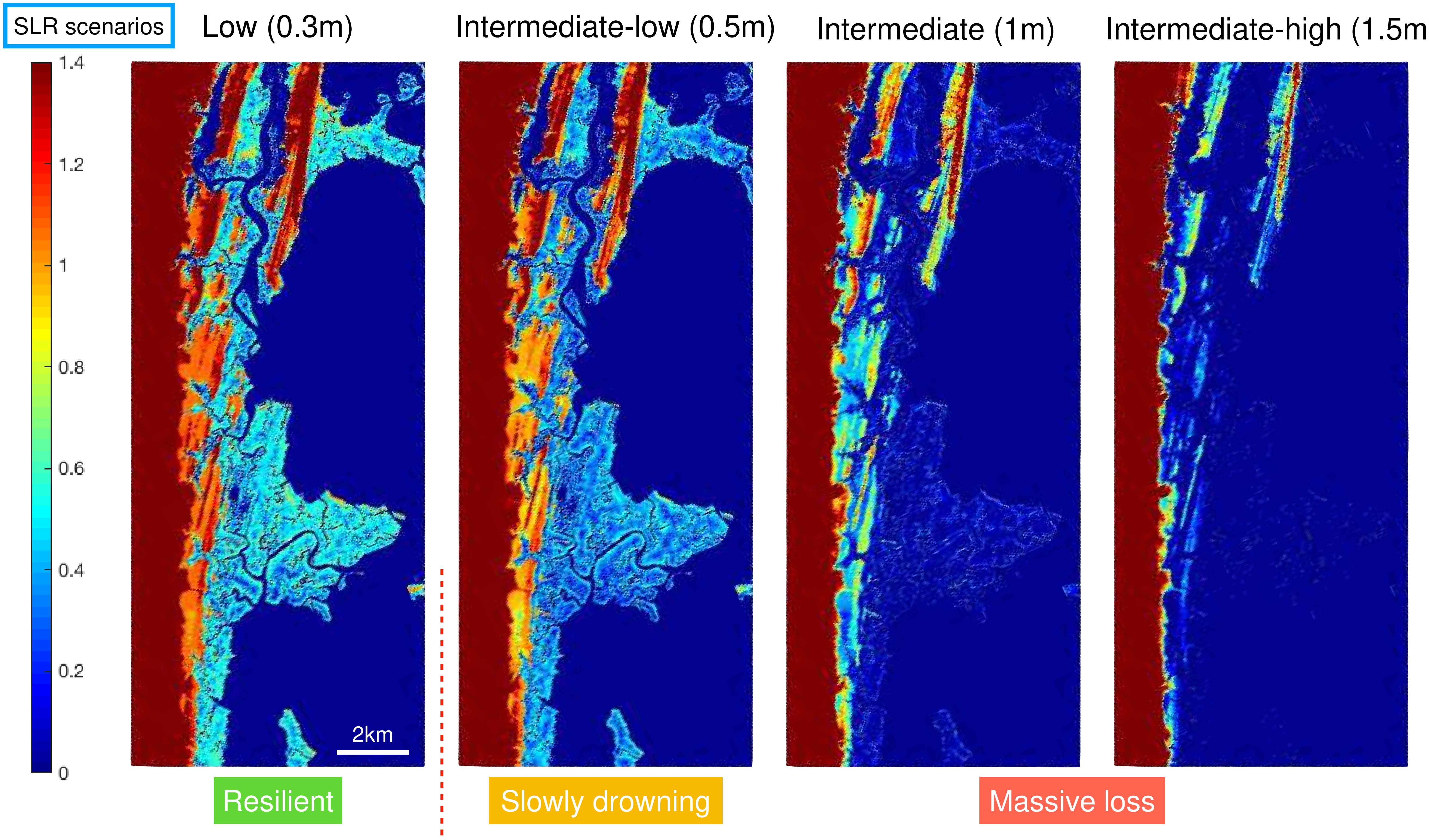


Threshold of microtidal marshes controlled by organic accretion

Duran Vinent et al. *Submitted*

Simulations of marsh response to SLR (Virginia)

Surface elevation (m) relative to MSL for 2100

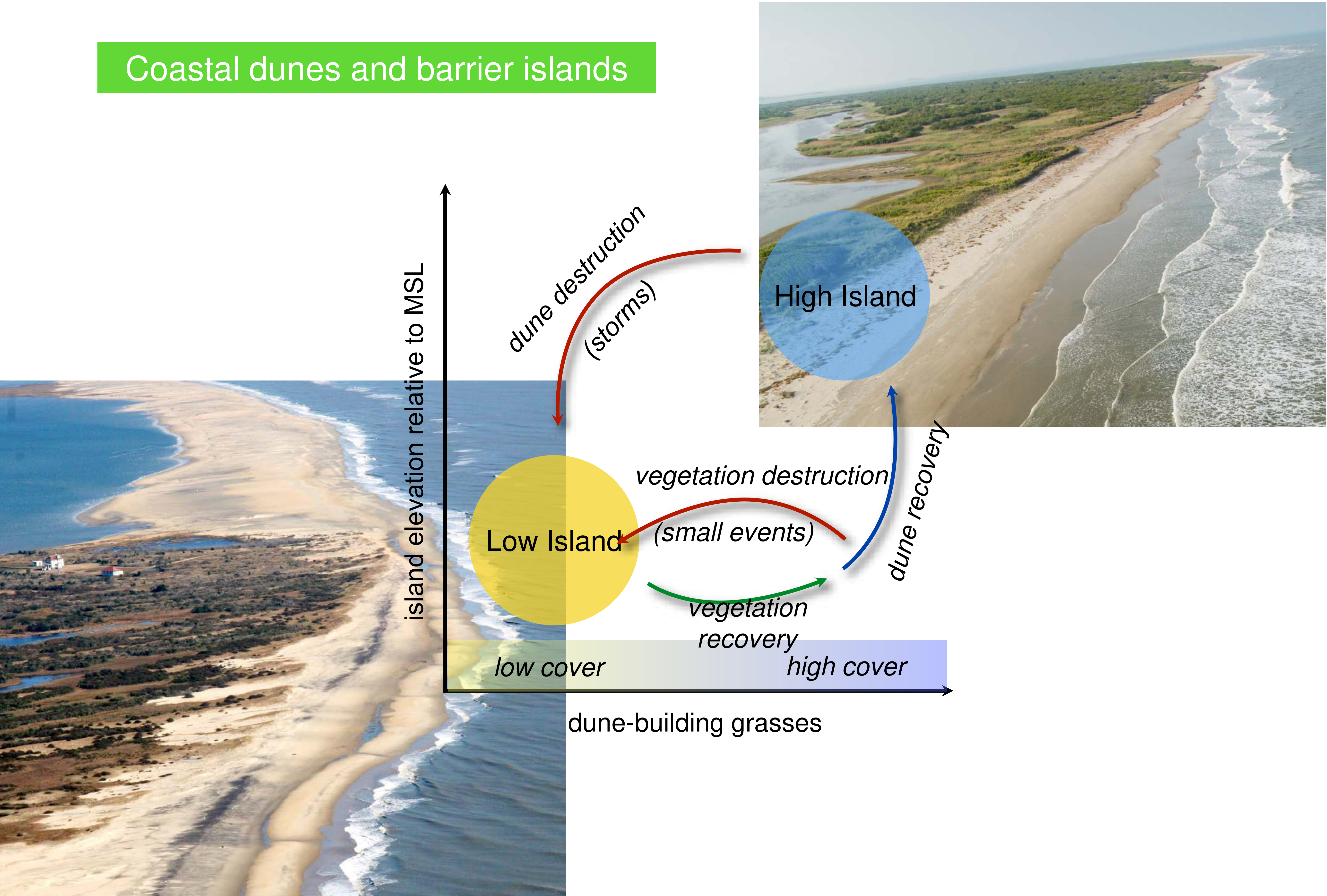


Crossing of the tipping point

Duran Vinent et al. *in prep*

Dynamics of ecosystem engineers: **dune vegetation**

Coastal dunes and barrier islands



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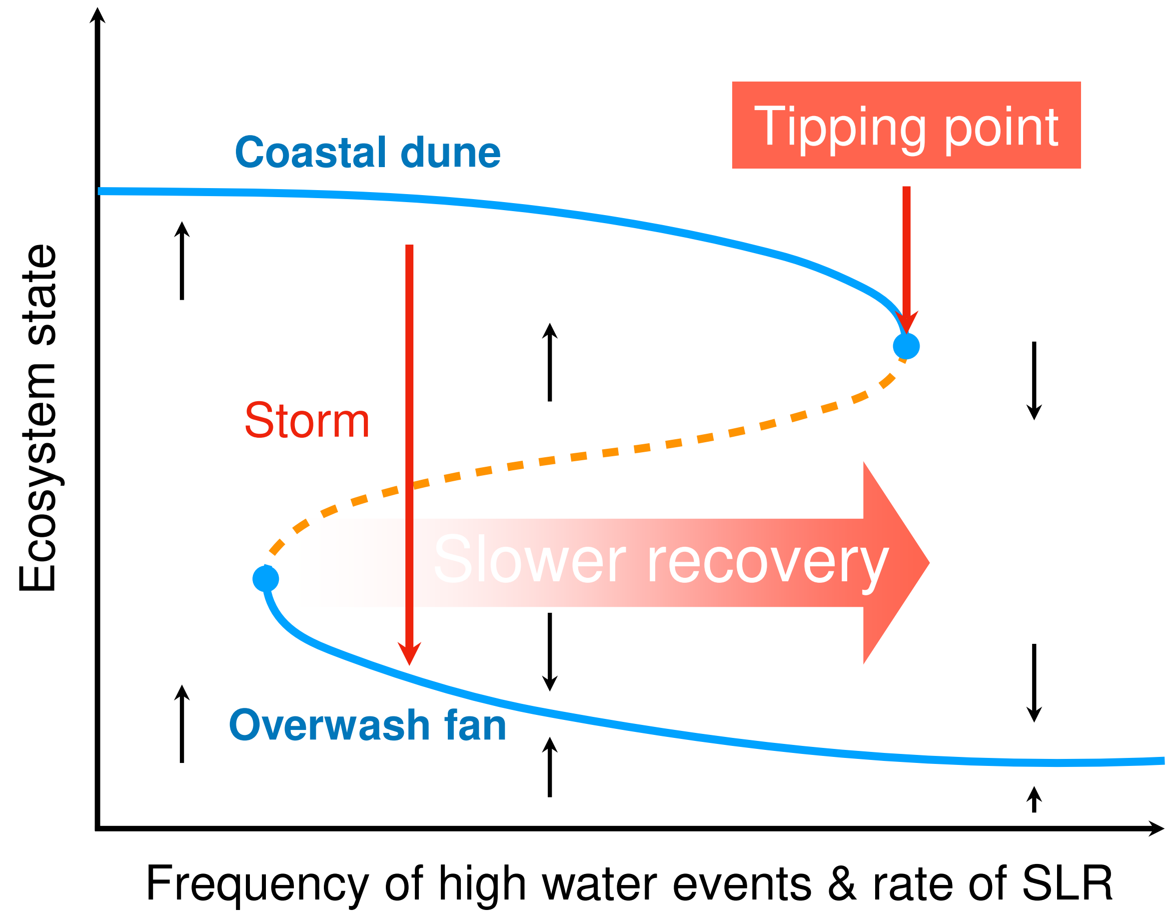
Coastal dunes and barrier islands

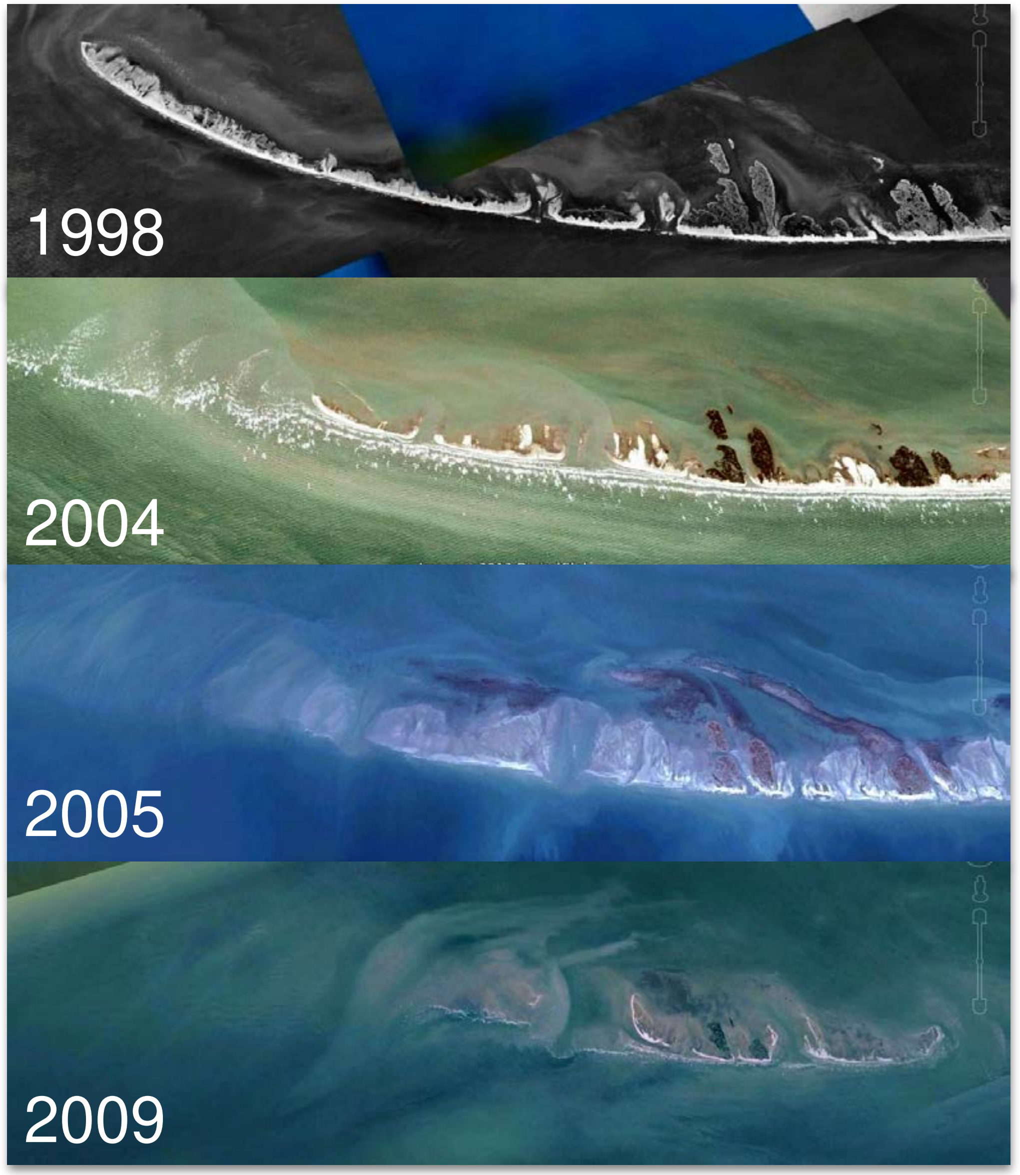


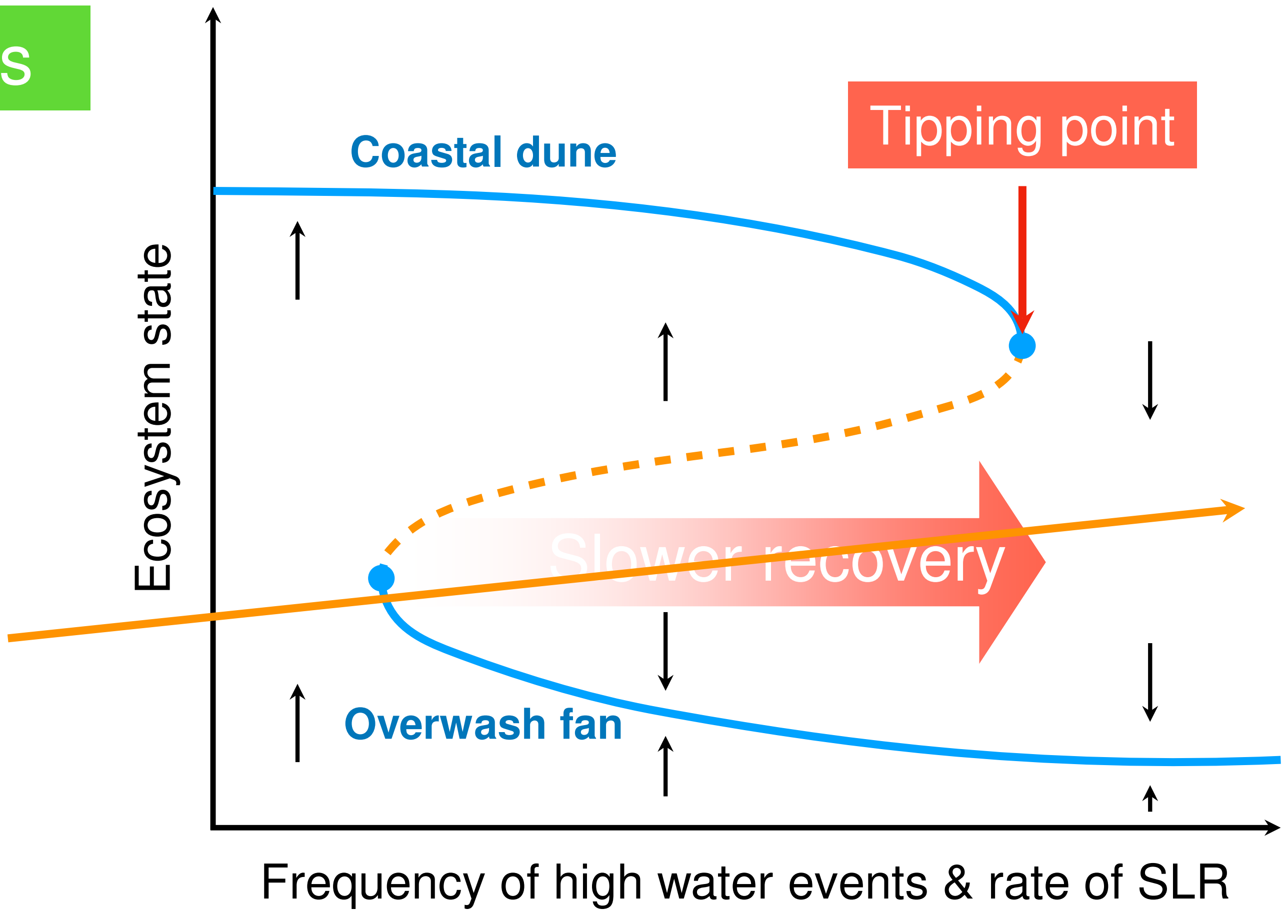
Duran & Moore, Nat. Clim. Change (2015)

Dynamics of ecosystem engineers: **dune vegetation**

Coastal dunes and barrier islands

Chandeleur islands





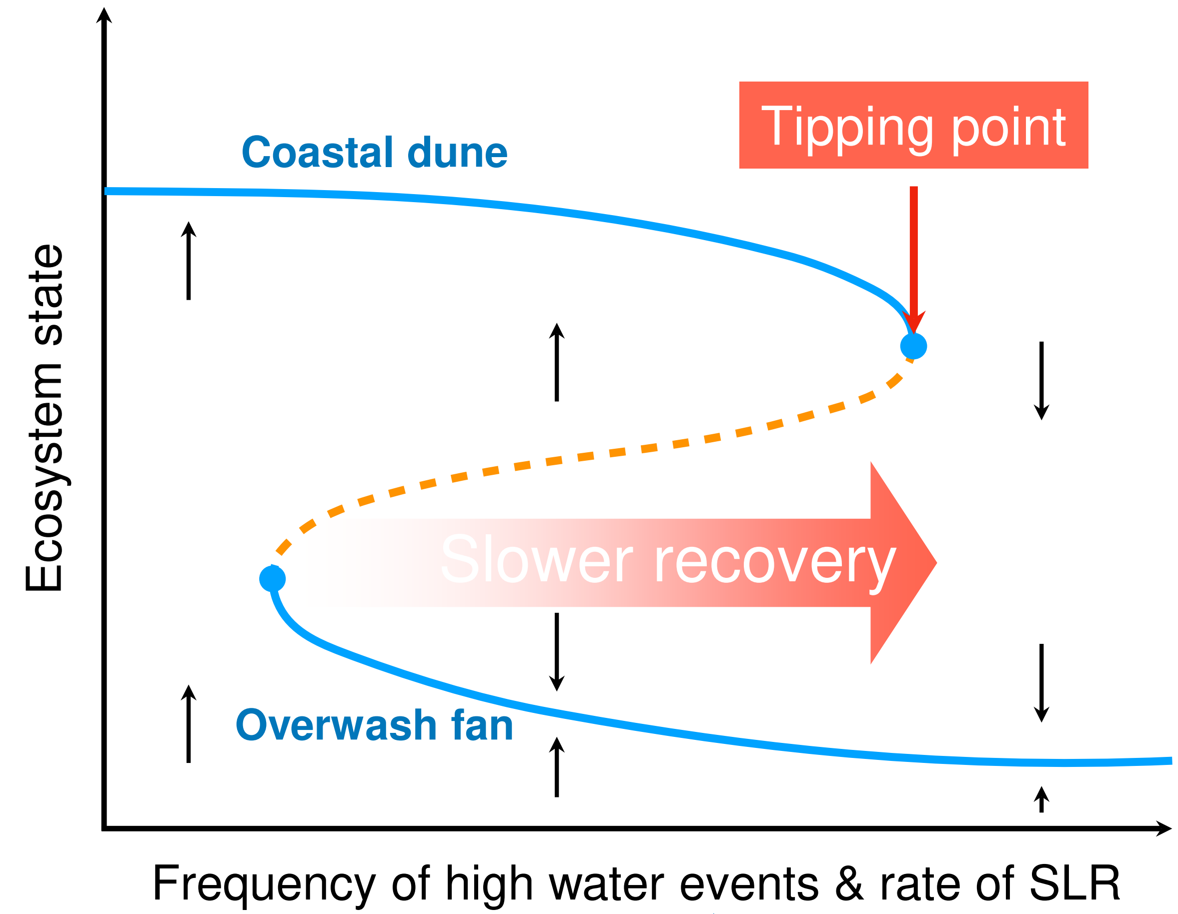
No recovery from large disturbances

reduction of sand supply

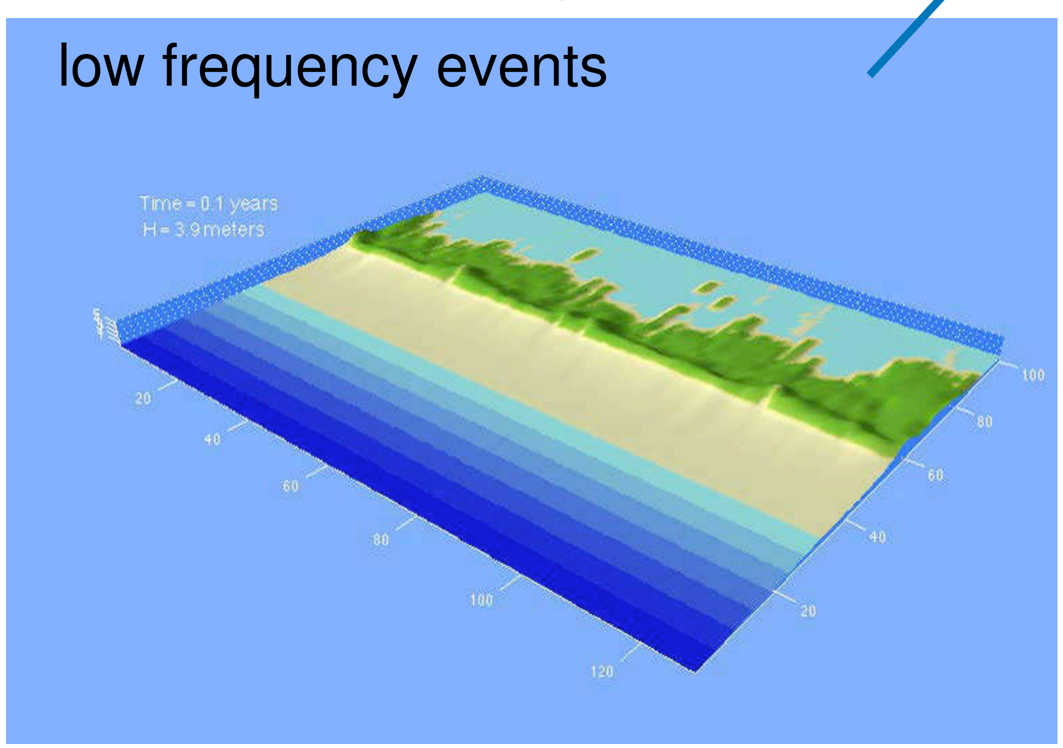
increase of relative sea level rise

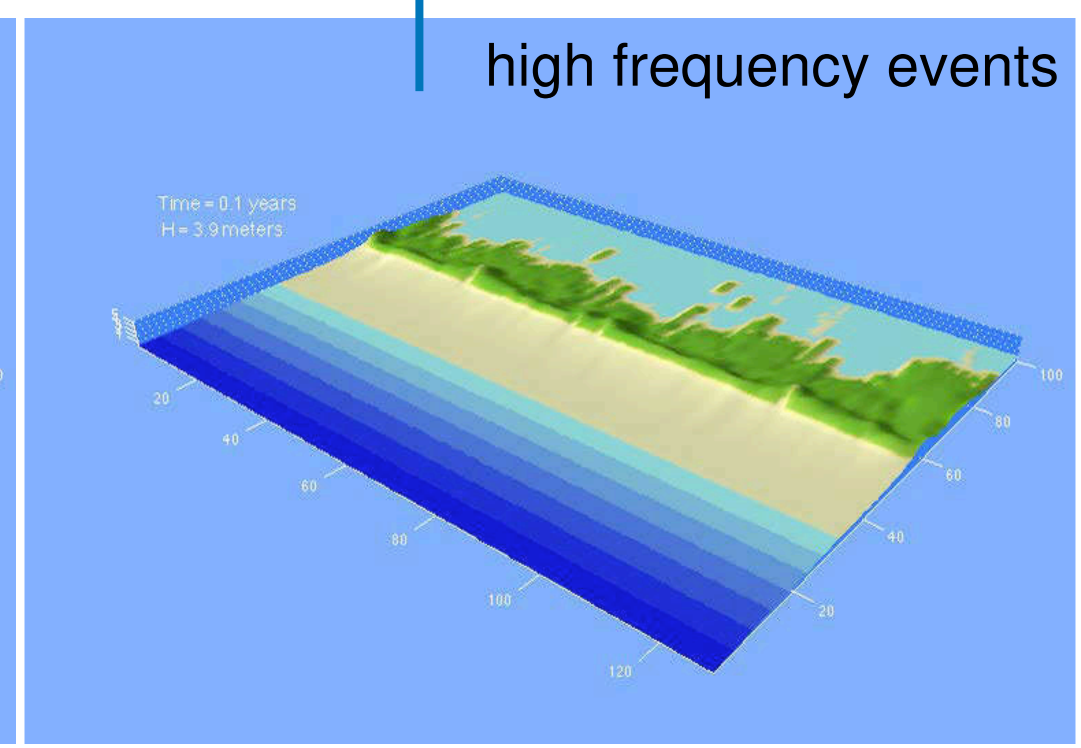
Dynamics of ecosystem engineers: **dune vegetation**

Coastal dunes and barrier islands



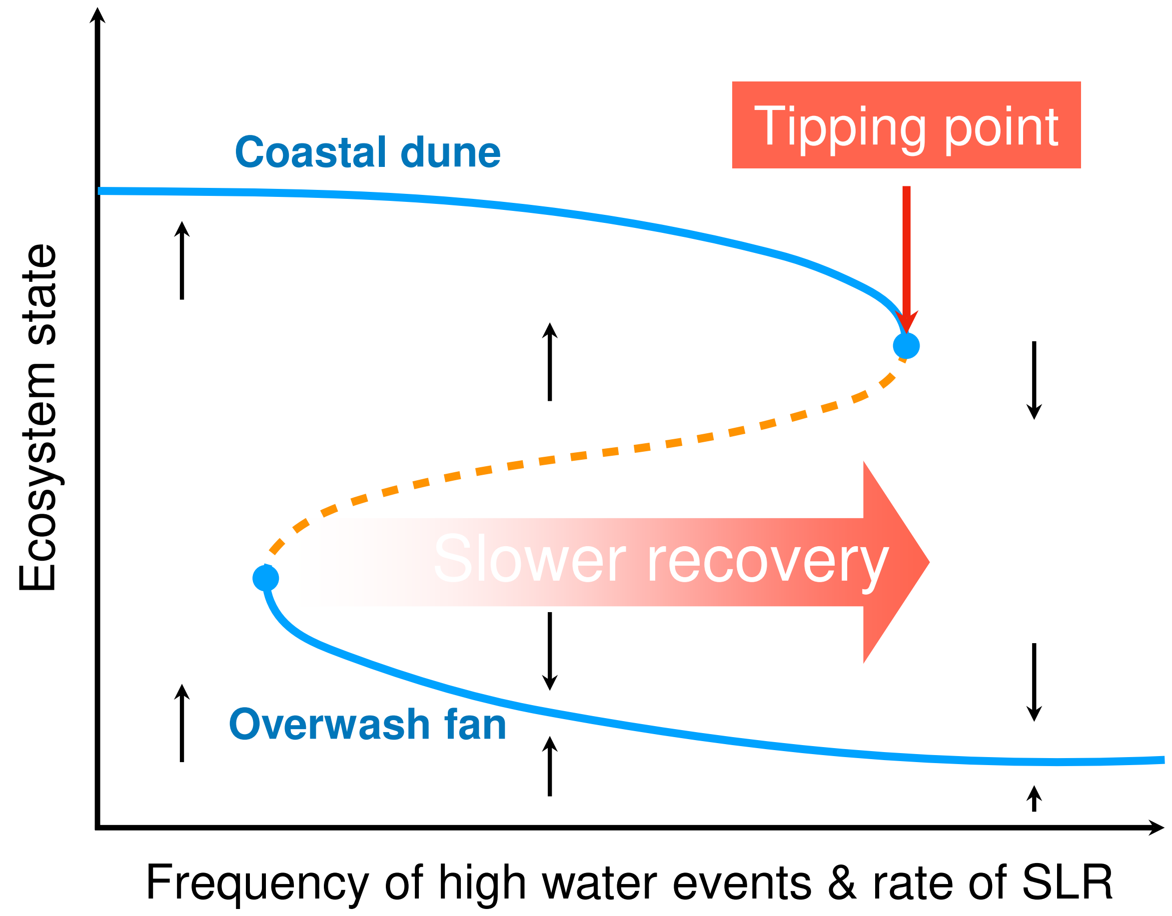
Numerical simulations: *Duran & Moore, Nat. Clim. Change (2015)*





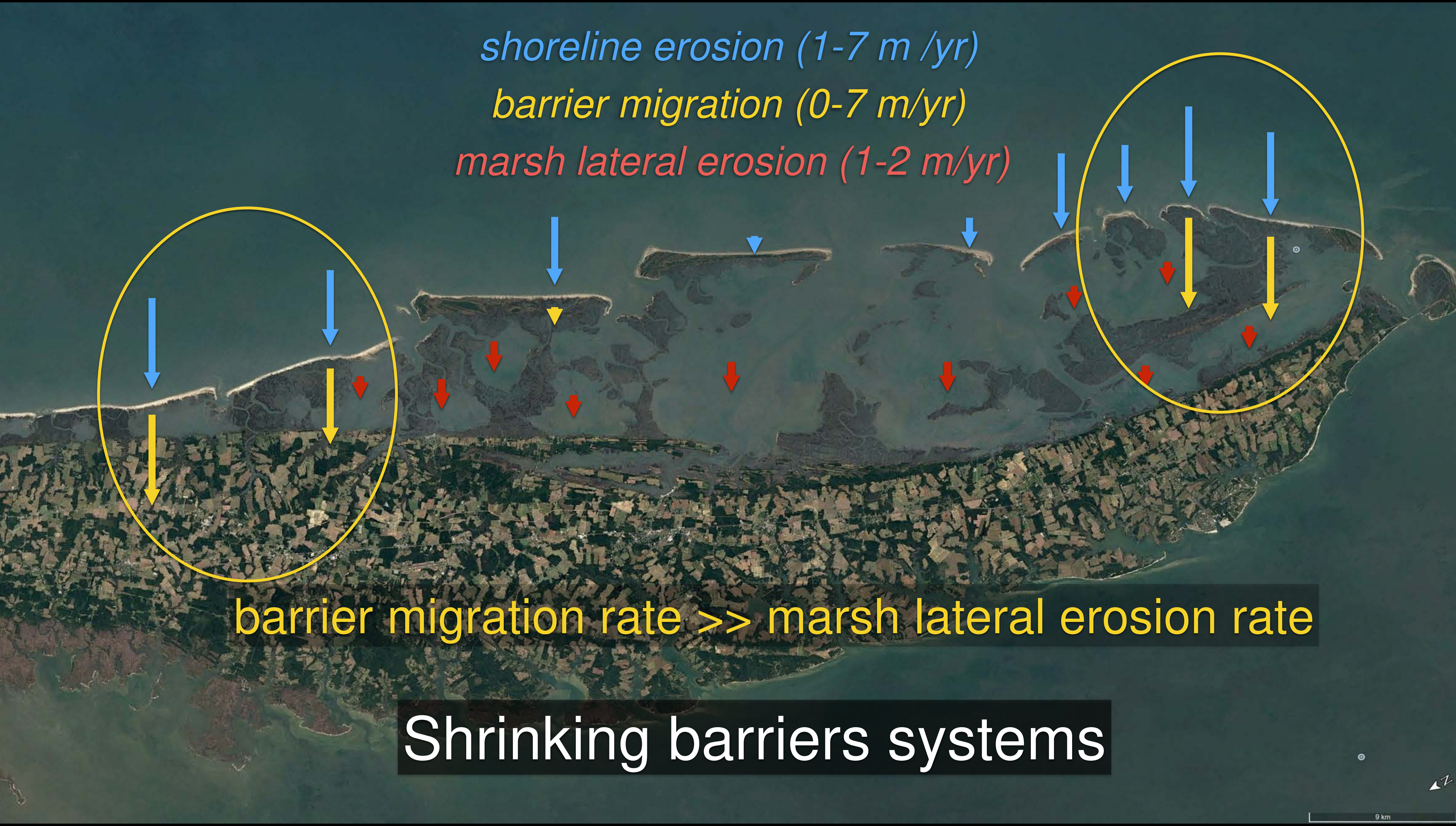
Dynamics of ecosystem engineers: **dune vegetation**

Coastal dunes and barrier islands



Lower dunes → more overwashes → higher migration rates

Virginia Barrier Islands



Thank you