



Plants as ecosystem engineers in coastal landscapes

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Abstract

Coastal ecosystems are often characterized by their vegetation. This vegetation provides a wide spectrum of valuable ecosystem services. However, increased disturbance and stress is threatening the stability of such ecosystems. It is therefore important to understand what mechanisms vegetation exert to influence their environment and how these mechanisms affect coastal ecosystems via landscape formation. In this colloquium landscape formation mechanisms are discussed via two sub-categories: the mechanisms that vegetation directly impose on the landscape and indirect effects on the landscape via mechanisms and processes on vegetation development and succession. In extension it is discussed how the mechanisms are affected when vegetation degrades and disappears. Ultimately these mechanisms are then taken into consideration for how coastal ecosystems can be conserved or restored. First this presentation discussed small-scale physical effects that emerge in the environment from the presence of vegetation. Then mechanisms behind distribution patterns are addressed providing causes for the emergence of spatial patterns in landscape formation. Thirdly it is discussed how vegetation composition and accompanying life-history traits affect landscape formation processes. Finally interaction between vegetation and other organisms and their effect on spatial patterns are examined. Next it was established how vegetation affect soil composition, provide shielding and induce self-facilitating feedback mechanisms, making the environment more habitable for other vegetation. These feedback loops are consecutively used to explain processes that occur once vegetation degrades. Examples are shown of how negative feedback loops change existing ecosystems and allow other ecosystems to encroach on the original ecosystem. In the end methods are discussed which can help reduce disturbance and reintroduce the positive feedback mechanisms that stabilize coastal ecosystems.



Vegetation in coastal landscapes

- Foundation species
- Identity ecosystem

Vegetation in coastal ecosystems

Nutrient Cycling
+
Water Purification

+ Tourism
+ Biodiversity

Carbon Storage

Flood protection



Coastal ecosystems under pressure

- Resource extraction
- Landscape modification
- Eutrophication
- Acidification
- Climate change
- Sea-level rise





How does vegetation cope with this external harassment?

- Role of coastal vegetation
- Processes underlying the role of vegetation in coastal areas.
- Implementation of vegetation processes in conservation / restoration efforts.

How does vegetation influence the formation of coastal ecosystems?



What mechanisms/processes drive vegetated landscape formation?



What mechanisms/processes drive vegetation development and succession in coastal ecosystems?

How does vegetation influence the formation of coastal ecosystems?



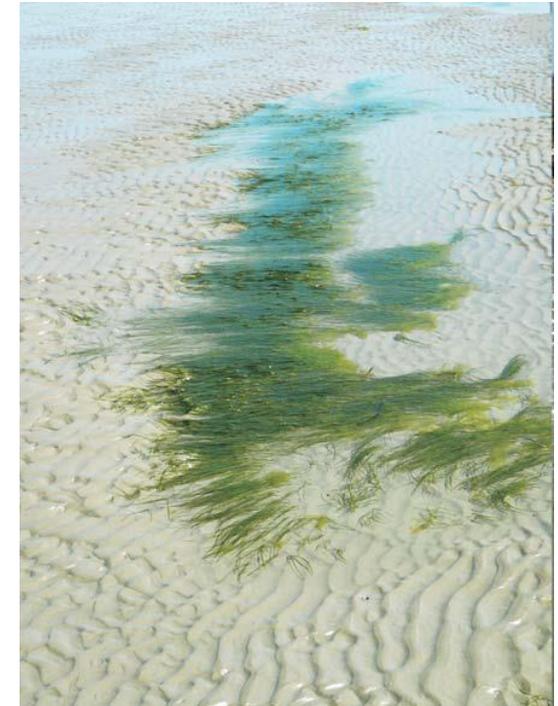
What processes/mechanisms take place in coastal ecosystems when vegetation is lost?



What requirements need to be met to restore/conservate vegetation in coastal ecosystems?

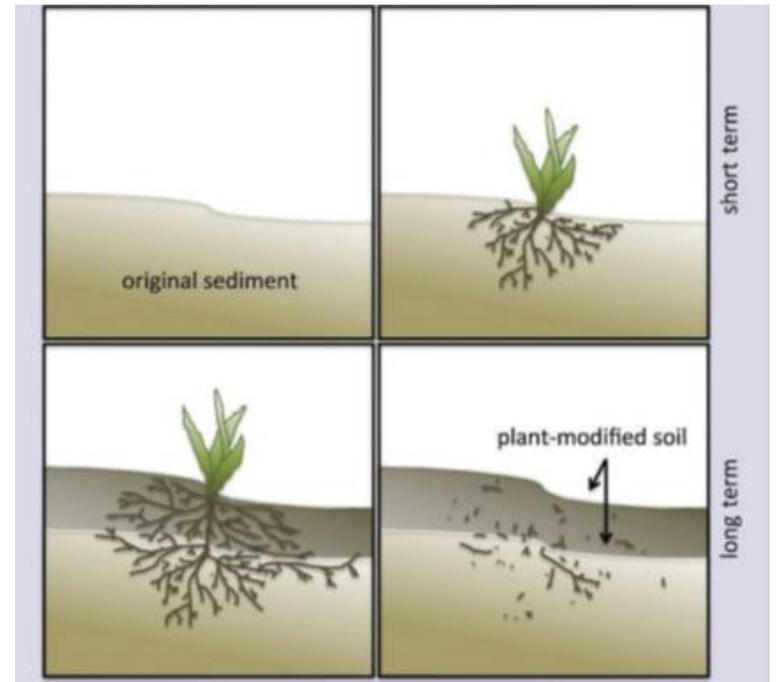
Physical impact of vegetation^{1,2}

- Flow pattern changes
- Reduced erosion
- Increased sediment deposition



Physical impact of vegetation²

- Sediment stability



Landscape formation mechanisms

Spatial impact of vegetation³

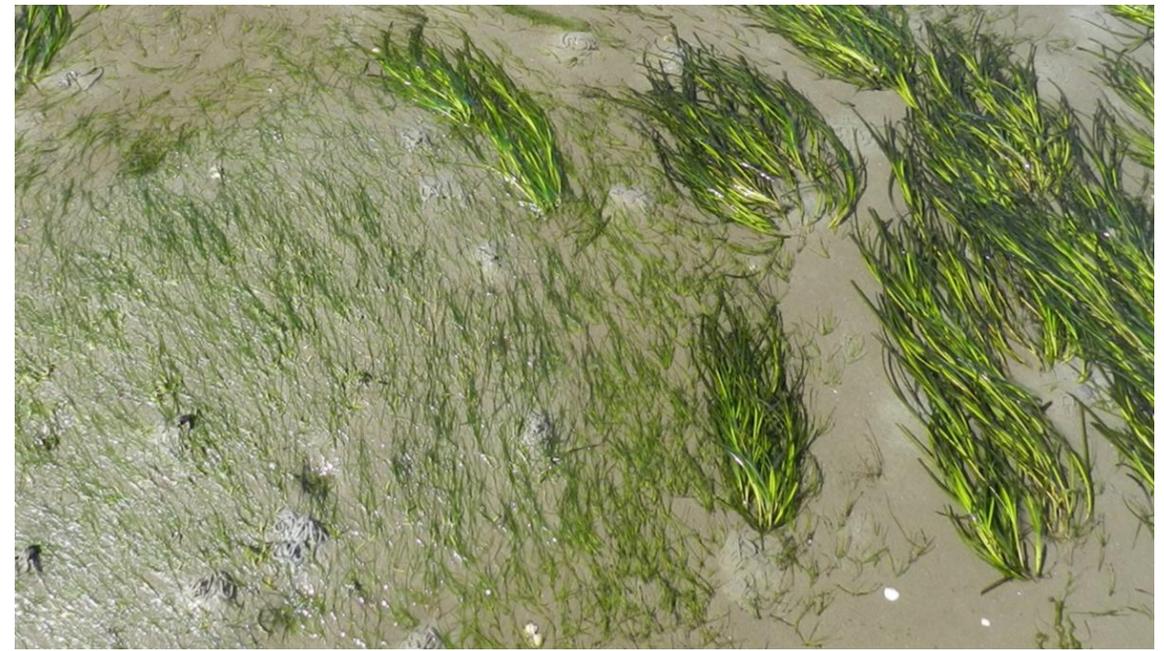
- Vegetation propagation
- Seed germination



Landscape formation mechanisms

Spatial impact of vegetation ^{1,4}

- Vegetation expansion



Landscape formation mechanisms

Spatial impact of vegetation⁶

- Landscape patterns





Spatial impact of vegetation⁷

Interspecific interactions with
grazers

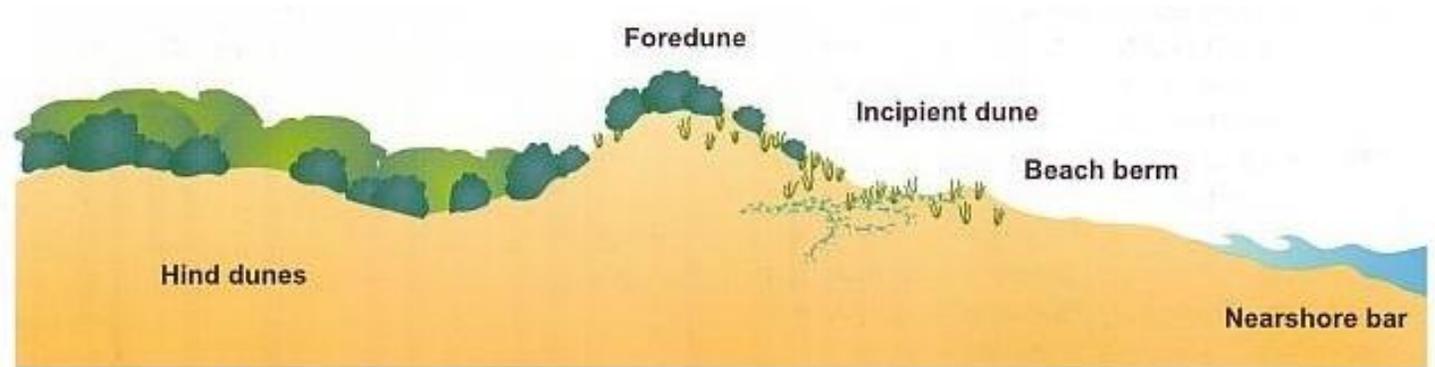
Vegetation composition and landscape formation⁸

- Plant traits affect geomorphology
- Life history traits > Plant characteristics



Vegetation development and succession

- Vegetation develop landscape
- Vegetation part of landscape
- Interactions within vegetation



Soil development by vegetation⁶

Landscape changes -> Soil composition changes

Soil composition vital for vegetation



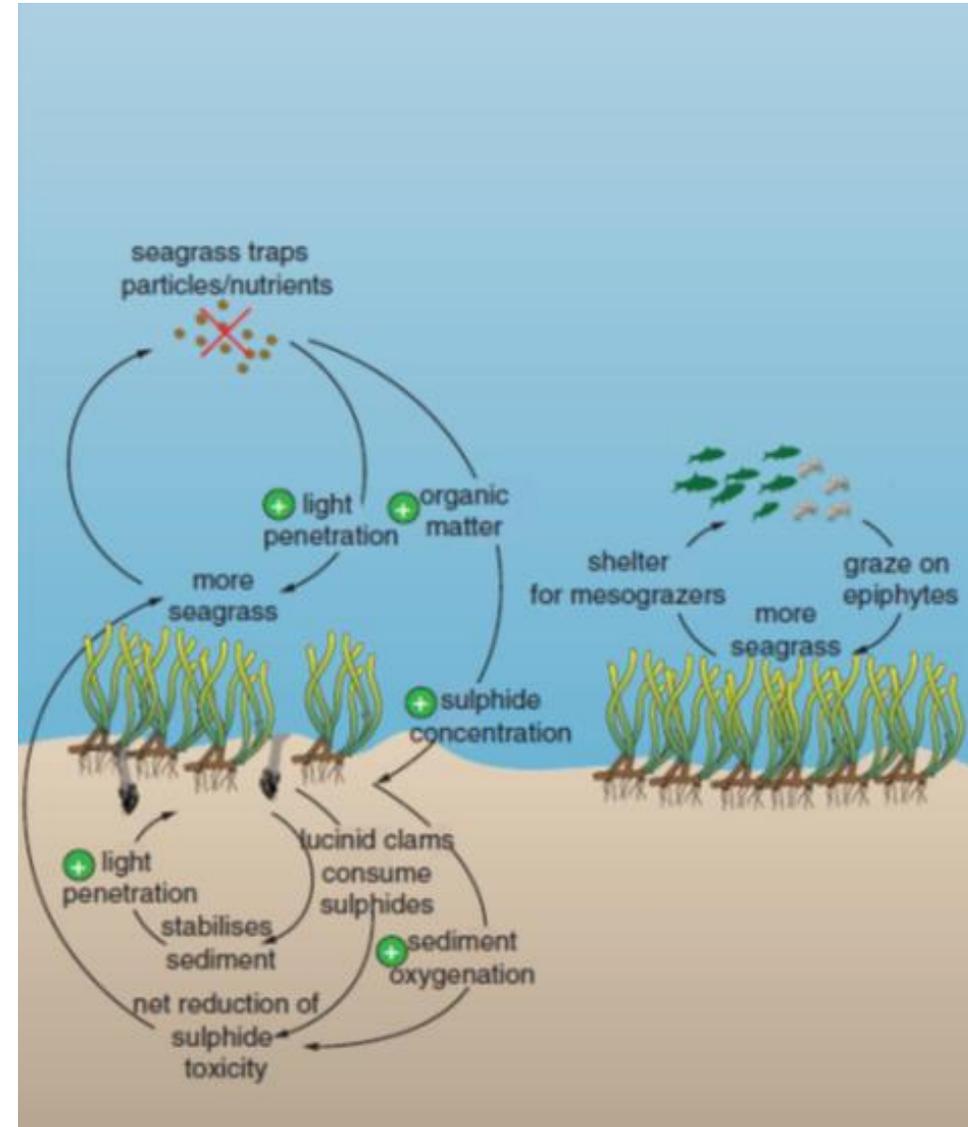
Vegetation shielding⁹

- Reduce direct hydro/aerodynamic stress
- Protect shore-vegetation



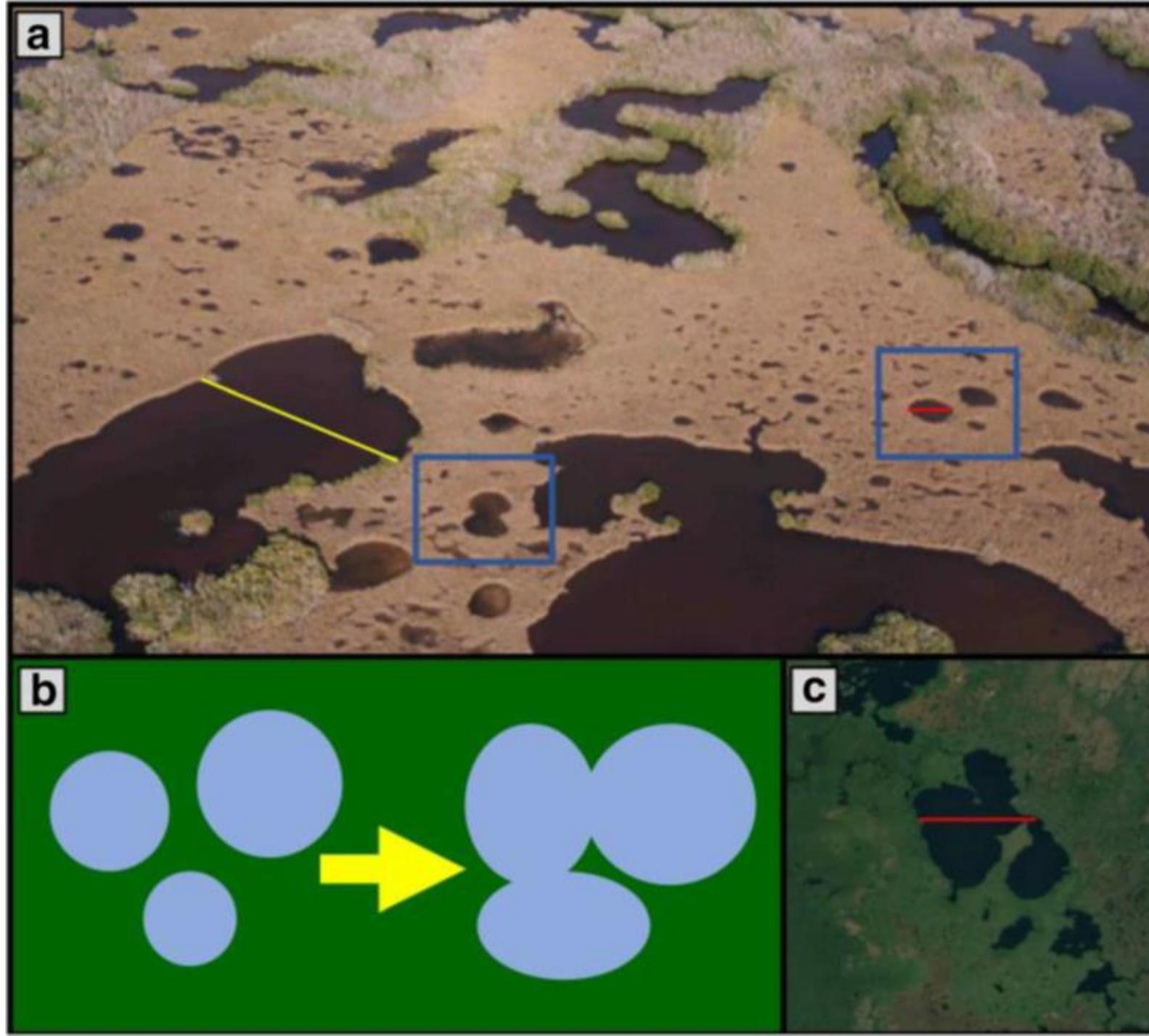
Intraspecific feedback mechanisms¹⁰

- Ameliorate environment
- Harbor protecting organisms



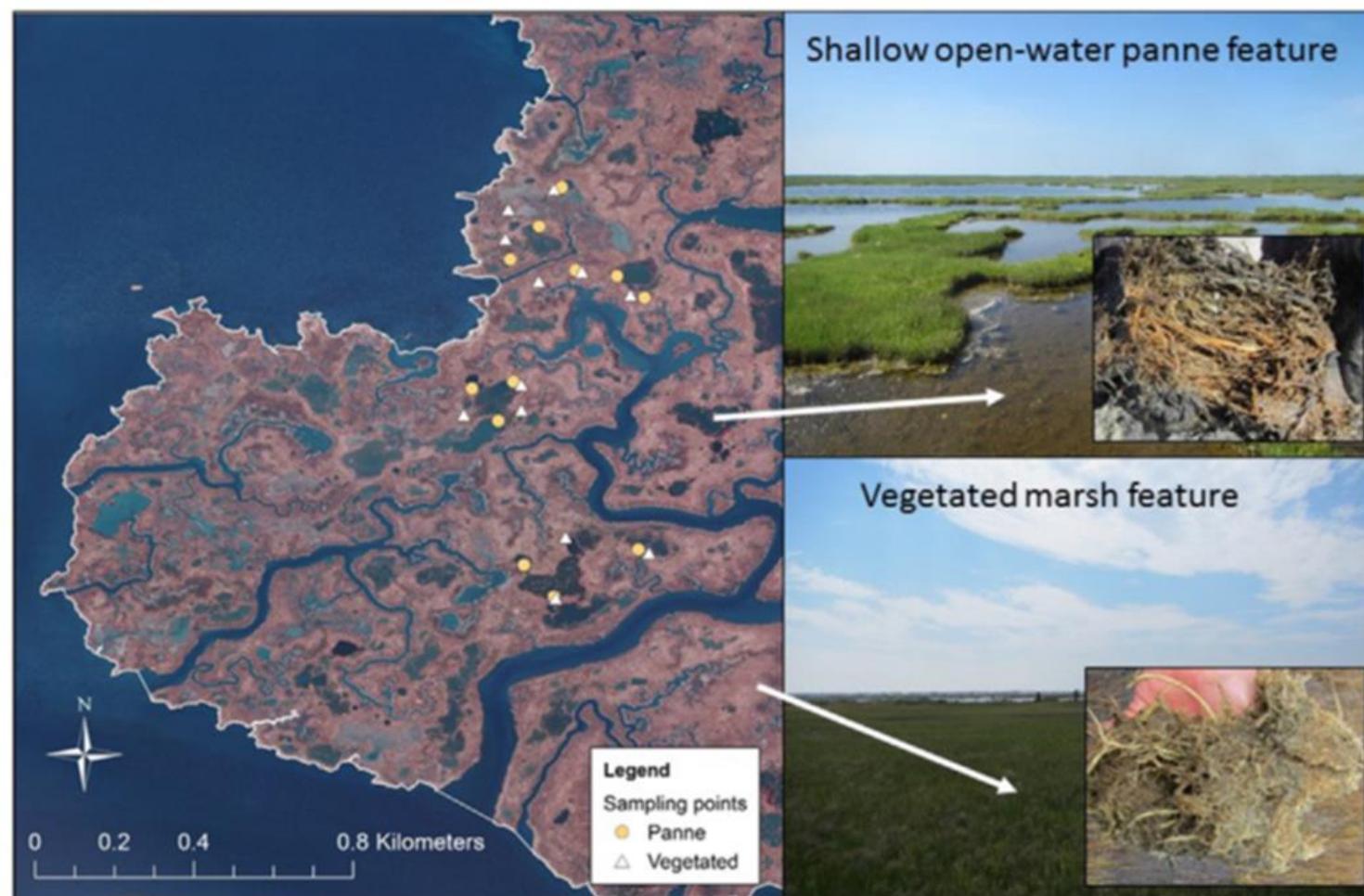
Ecosystem changes after vegetation loss¹¹

Geomorphic changes



Soil degradation after vegetation loss¹²

- Soil composition change
- Soil capability change

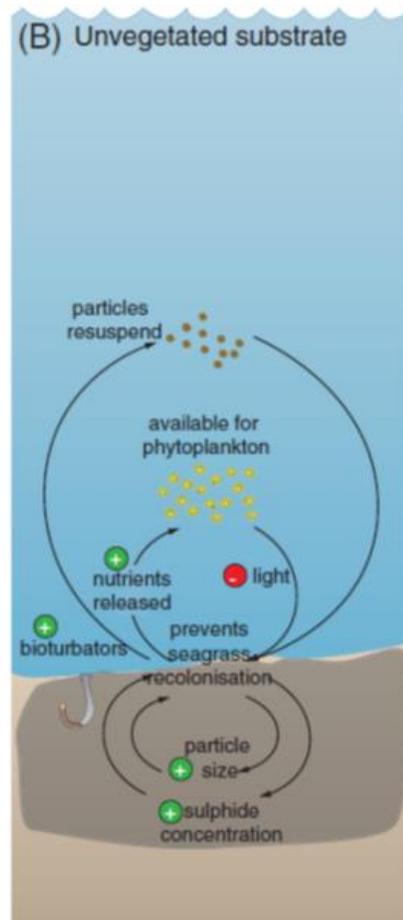


Coastal ecosystems after vegetation loss⁹

- Physical protection loss
- Soil stability loss



Ecological community changes¹⁰



Physical properties change -> community changes
Other ecosystem forms encroach

Ecological community changes¹¹



Physical properties change ->
community changes

Other ecosystem forms encroach

Vegetation requirements for conservation/restoration¹³

- Vegetation production very resilient but biodiversity not
- Ecosystem functions preserved via feedback mechanisms

Identifying
threatened
areas¹⁴

- When is vegetation declining?

Decrease disturbance

- Remove structures hindering water/air flow
- Reduce salinity



Accommodate
vegetation growth^{2,14}

- Artificial sediment deposition
- Re-introduce native vegetation

Vegetation effects on landscape



Vegetation affect abiotic context of landscape



Life-history traits central for landscape development



Feedback mechanisms determine the stability of the ecosystem



Loss of vegetation reshapes coastal landscape



Vegetation resilient but not all-solving

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