



Mangrove biogeomorphology

biophysical interactions in the coastal zone

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index



- mangrove wetlands
- biogeomorphology
- seedling establishment
- sediment dynamics
- act against mangrove loss
- conclusions



mangrove wetlands



mangrove ecosystem services:

- coastal protection
- water quality improvement
- sediment trap
- timber production
- fisheries
- ...



mangrove root systems



characteristic species

mangrove wetlands



latitudinal limit of mangroves



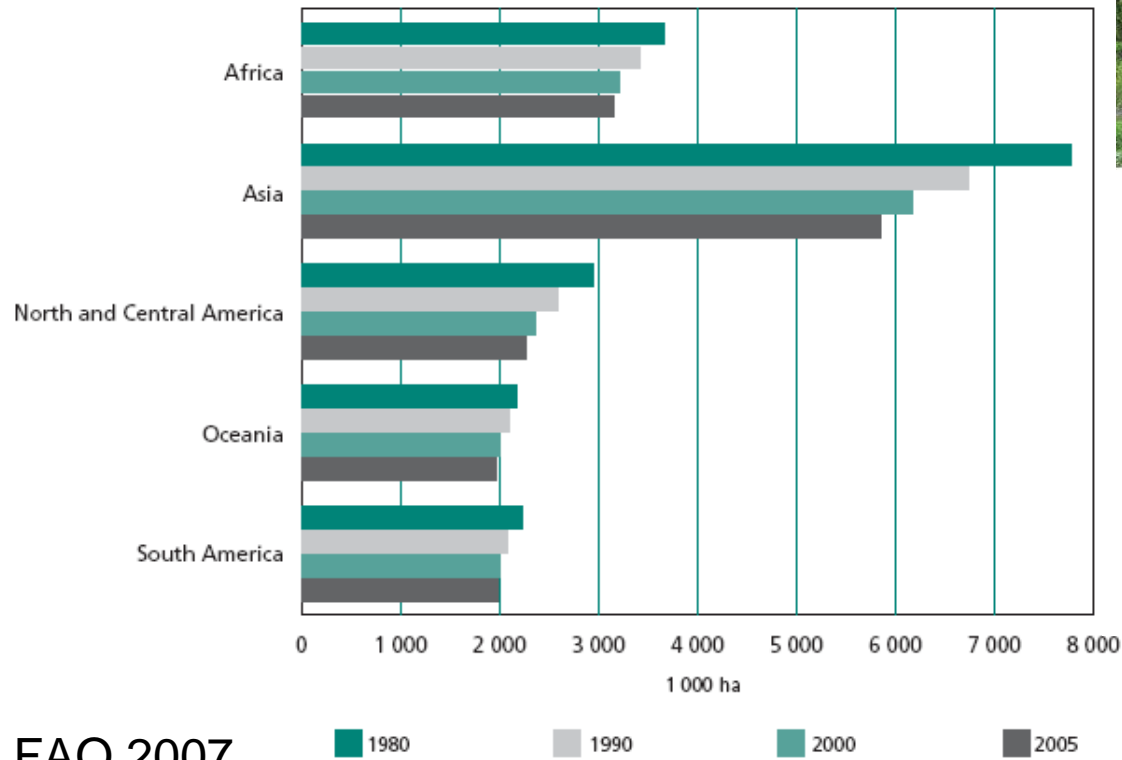
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mangrove wetlands



mangrove destruction

FIGURE 4
Changes in world mangrove area, 1980–2005



FAO 2007

LETTERS

edited by Etsa Kavanagh

A World Without Mangroves?

AT A MEETING OF WORLD MANGROVE EXPERTS HELD LAST YEAR IN Australia, it was unanimously agreed that we face the prospect of a world deprived of the services offered by mangrove ecosystems, perhaps within the next 100 years.

Mangrove forests once covered more than 200,000 km² of sheltered tropical and subtropical coastlines (1). They are disappearing worldwide by 1 to 2% per year, a rate greater than or equal to declines in adjacent coral reefs or tropical rainforests (2–5). Losses are occur-

ing in almost every country that has mangroves, and rates continue to rise more rapidly in developing countries, where >90% of the world's mangroves are located. The veracity and detail of the UN Food and Agriculture Organization data (2) on which these observations are

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Emerging from the embrace of a mangrove tree-lined channel in northern Brazil, these pescadores, like coastal fishers worldwide, know that healthy mangroves mean good fishing and a secure livelihood.

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Mangrove Restoration: Do We Know Enough?

Aaron M. Ellison¹

Abstract

Mangrove restoration projects have been attempted, with mixed results, throughout the world. In this paper, I first examine goals of existing mangrove restoration projects and determine whether these goals are clear and adequate, and whether or not they account for the full range of biological diversity and ecological processes of mangrove ecosystems. Many restored mangrove forests resemble forest plantations rather than truly integrated ecosystems, but mangrove plantations can be a first step toward mangrove rehabilitation. Mangrove restoration projects that involve asso-

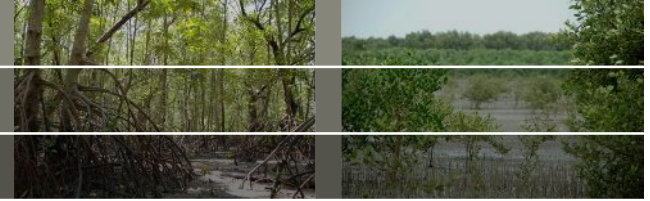
national cooperation, and application of relevant ecological theories will improve the success rate of mangrove restoration projects.

Key words: biological diversity, criteria for success, mangal, mangroves, rehabilitation, restoration.

Introduction

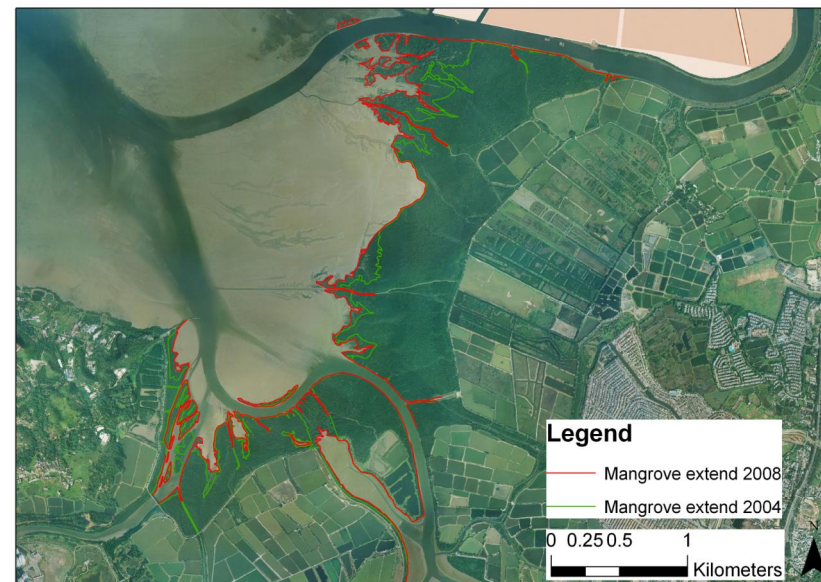
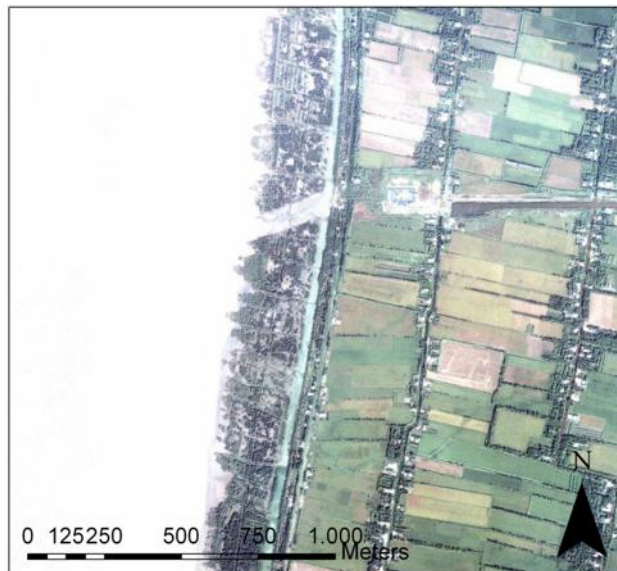
Mangrove ecosystems, or mangal, occur on sheltered tropical coastlines throughout the world (Chapman 1976; Tomlinson 1986). For clarity, I distinguish individual "mangrove" species from the wetland ecosystem "mangal"—of which they are defining features. Mangroves (sensu Tomlinson 1986; Duke 1992) themselves are any one of ~54–70 species in 20–27 genera and 16–19 families of woody, tropical halophytes that are obligate inhabitants of mangal. Occupying ~181,000 km² of these coastlines, mangal occurs in a diversity of geomorphological settings (Twilley 1995), ranging from the vast riverine and estuarine mangrove

mangrove wetlands



worldwide issues

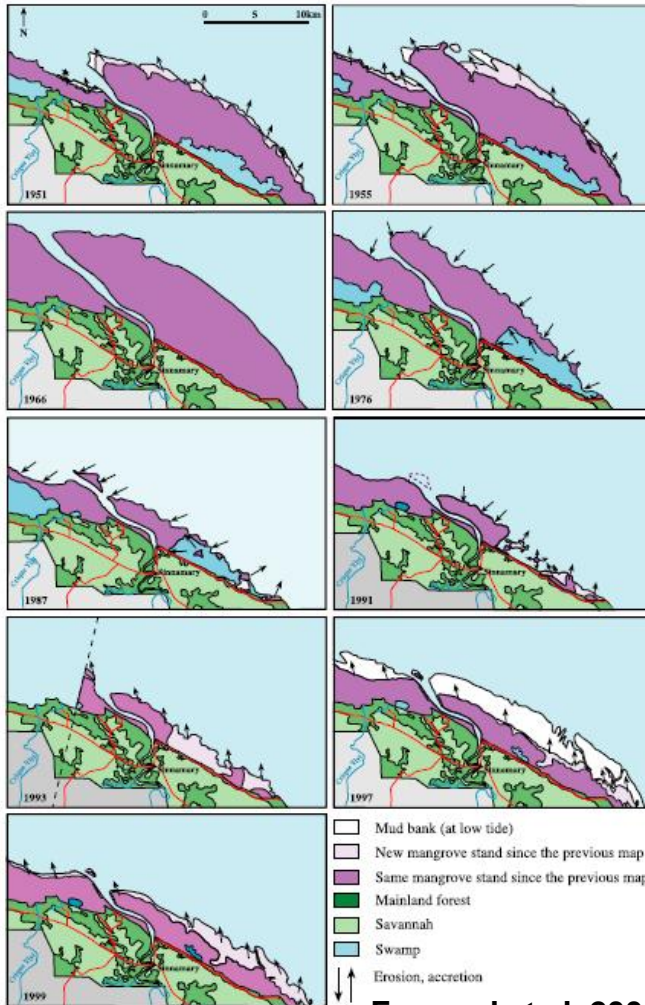
- coastal squeeze and sea level rise
- wetland destruction (aquaculture...)
- anthropogenic influence on sediment budgets
- increase in storminess and coastal erosion
- failure of restoration



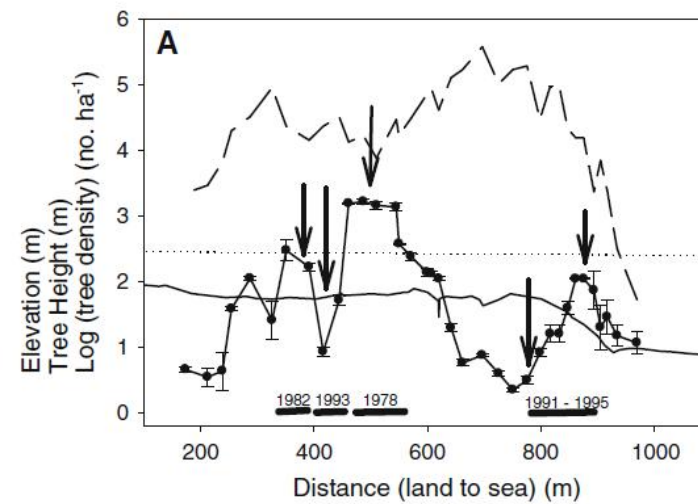
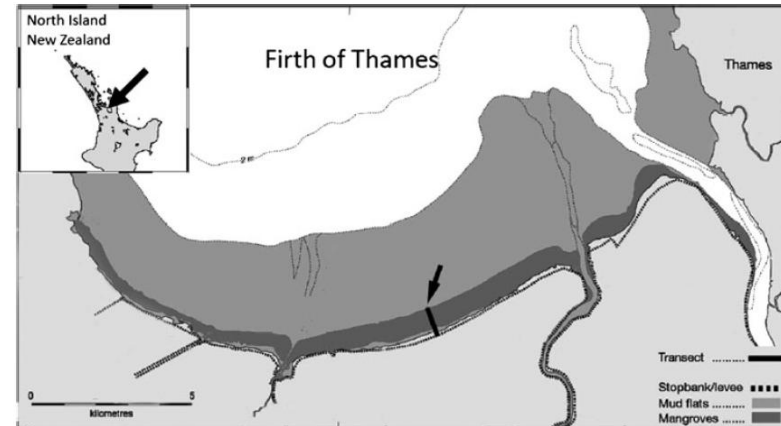
biogeomorphology



natural dynamics



Fromard et al. 2004



Lovelock et al. 2010

biogeomorphology



How mangroves interact with the physical environment?



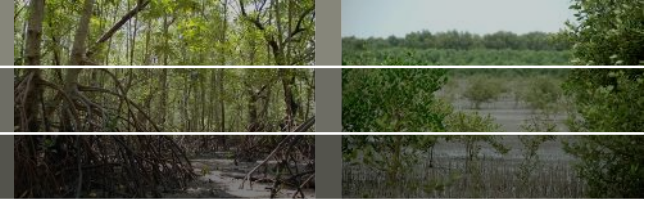
biogeomorphology



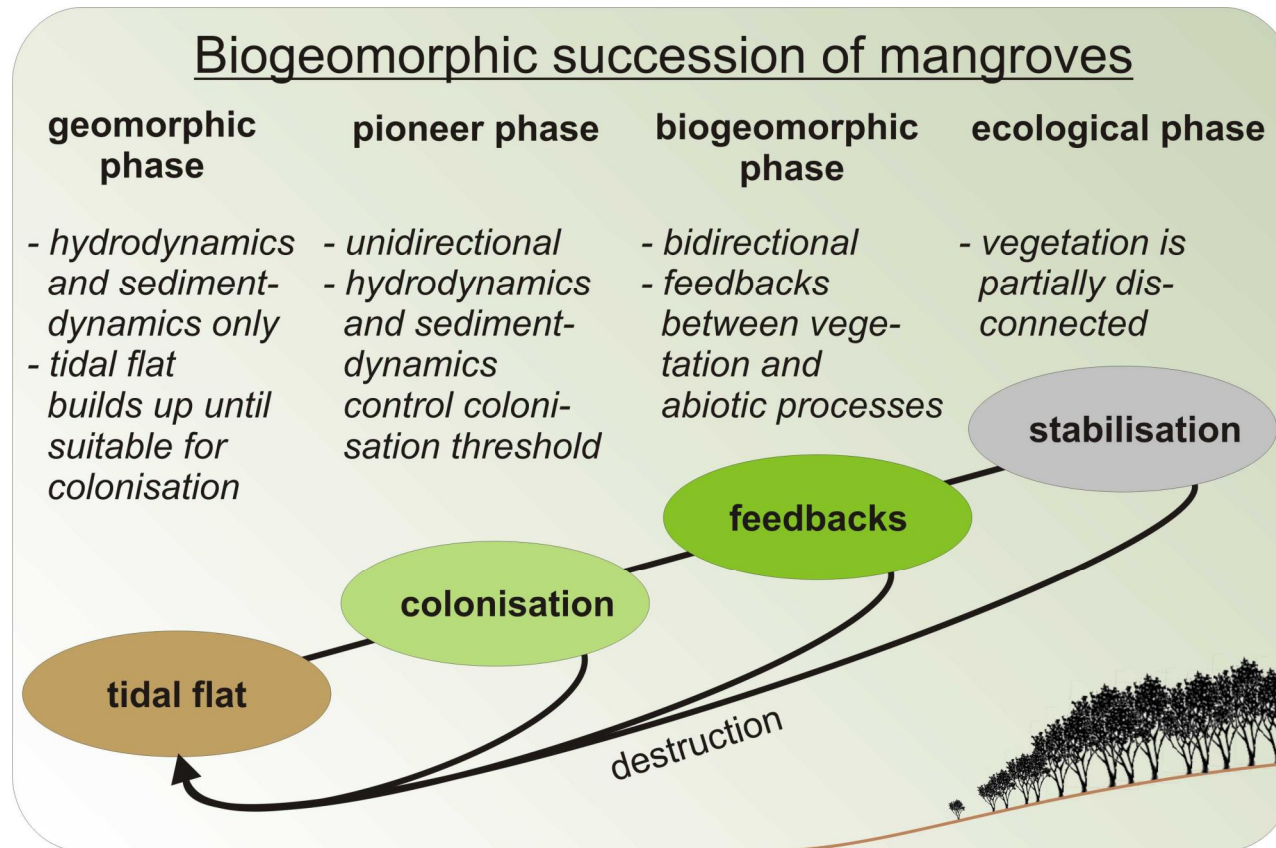
mangrove succession
SE Asia example



biogeomorphology

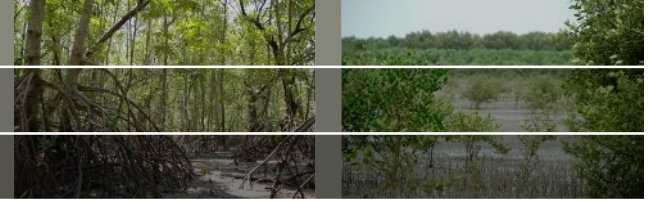


How mangroves interact with the physical environment?

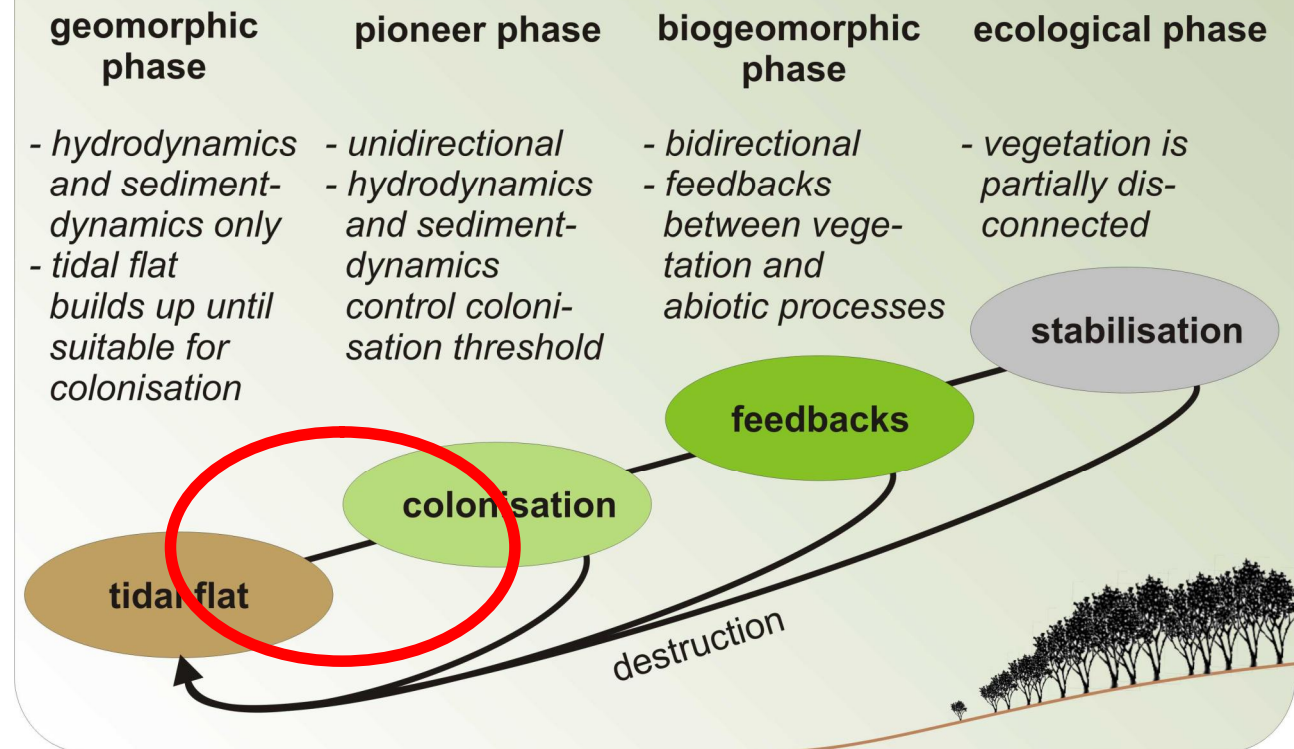


after Corenblit et al. 2007

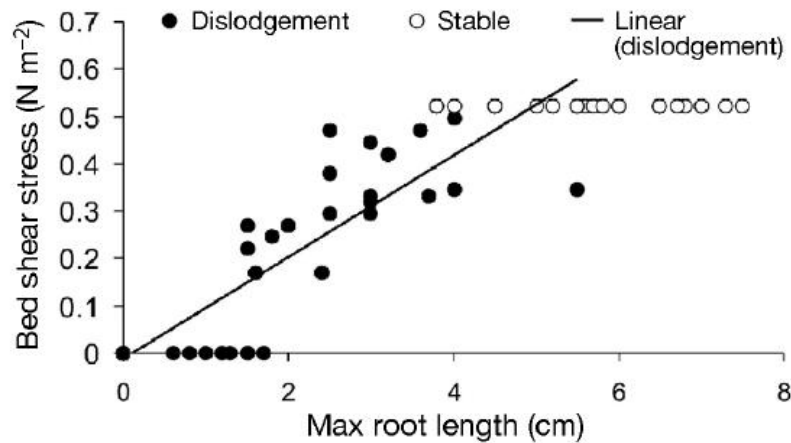
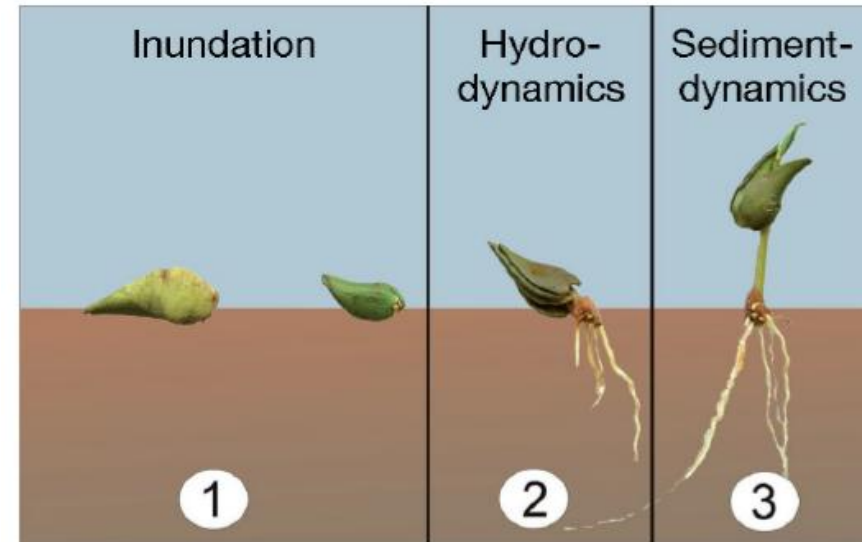
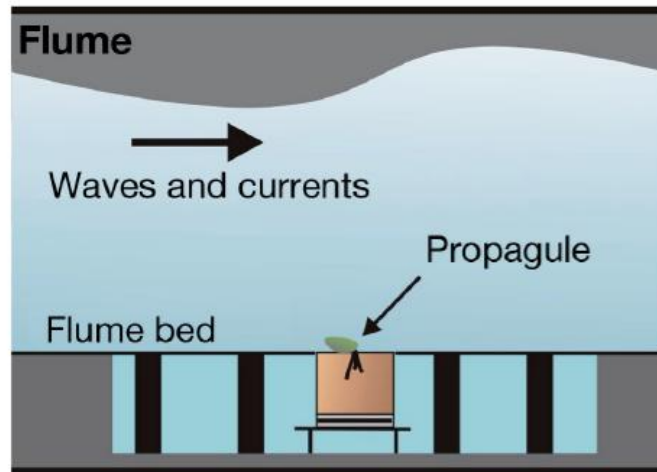
seedling establishment



Biogeomorphic succession of mangroves



seedling establishment

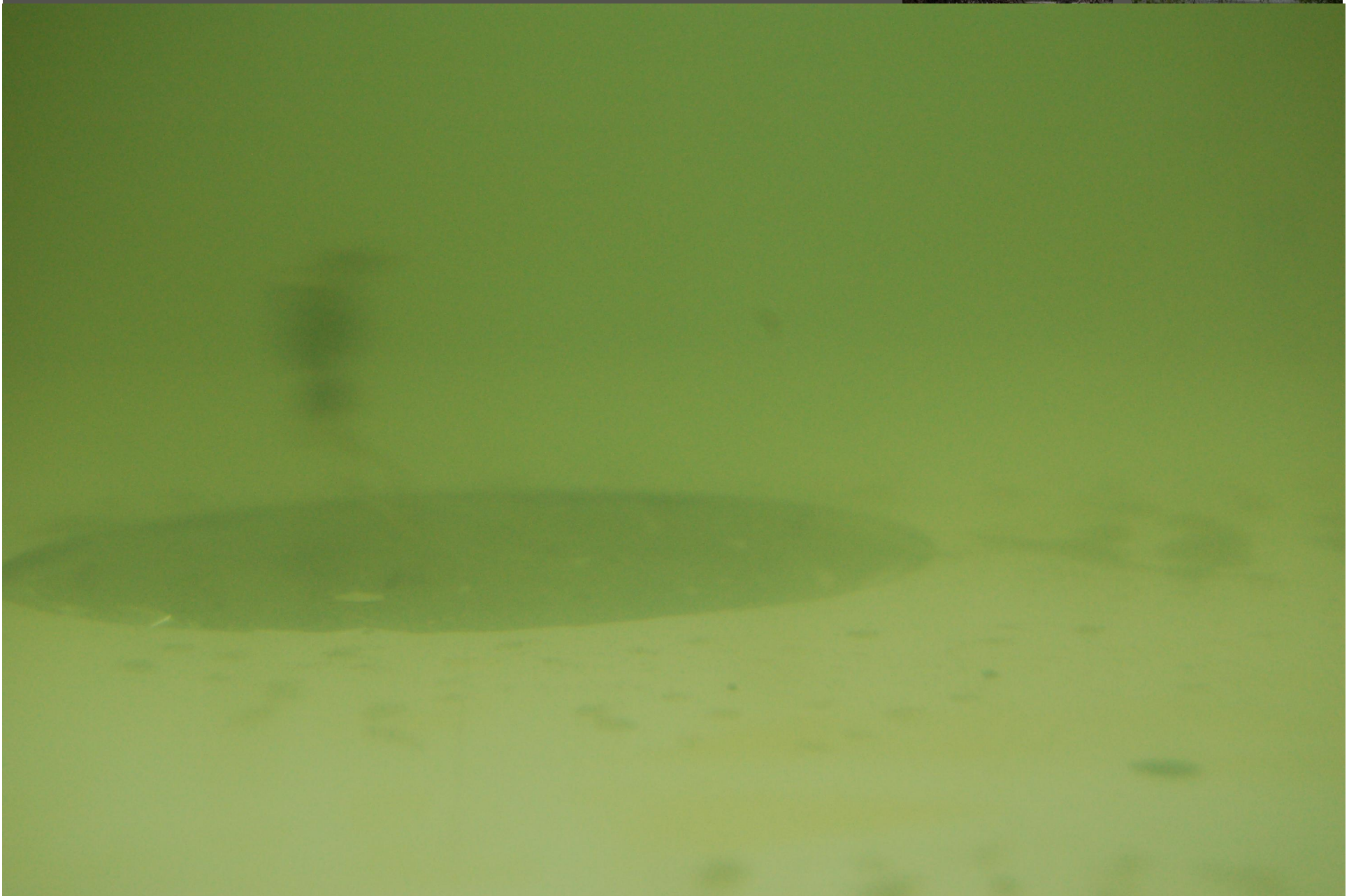
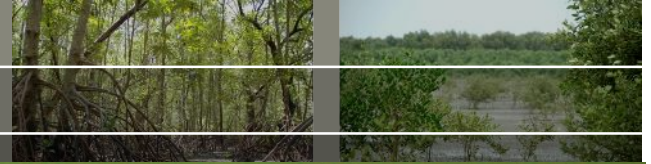


anchorage of *Avicennia* propagules, first days:

- buoyant propagules need to strand
- drag forces by waves pull out seedlings
- erosion excavates seedlings

Balke et al. 2011 Mar. Ecol. Progr. Ser.

seedling establishment

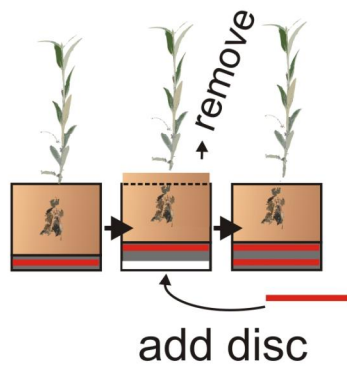


seedling establishment

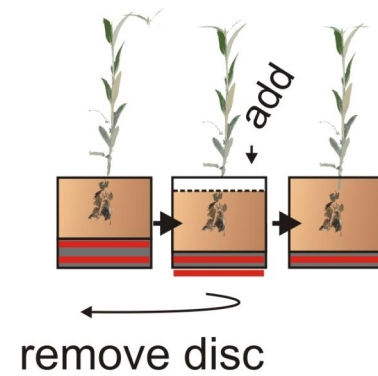


c) cumulative treatments

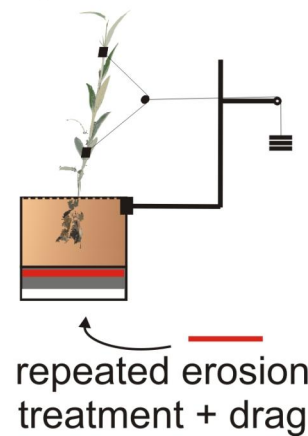
erosion treatment



accretion treatment

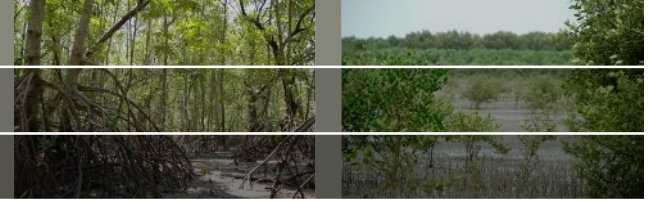


critical erosion
at harvest

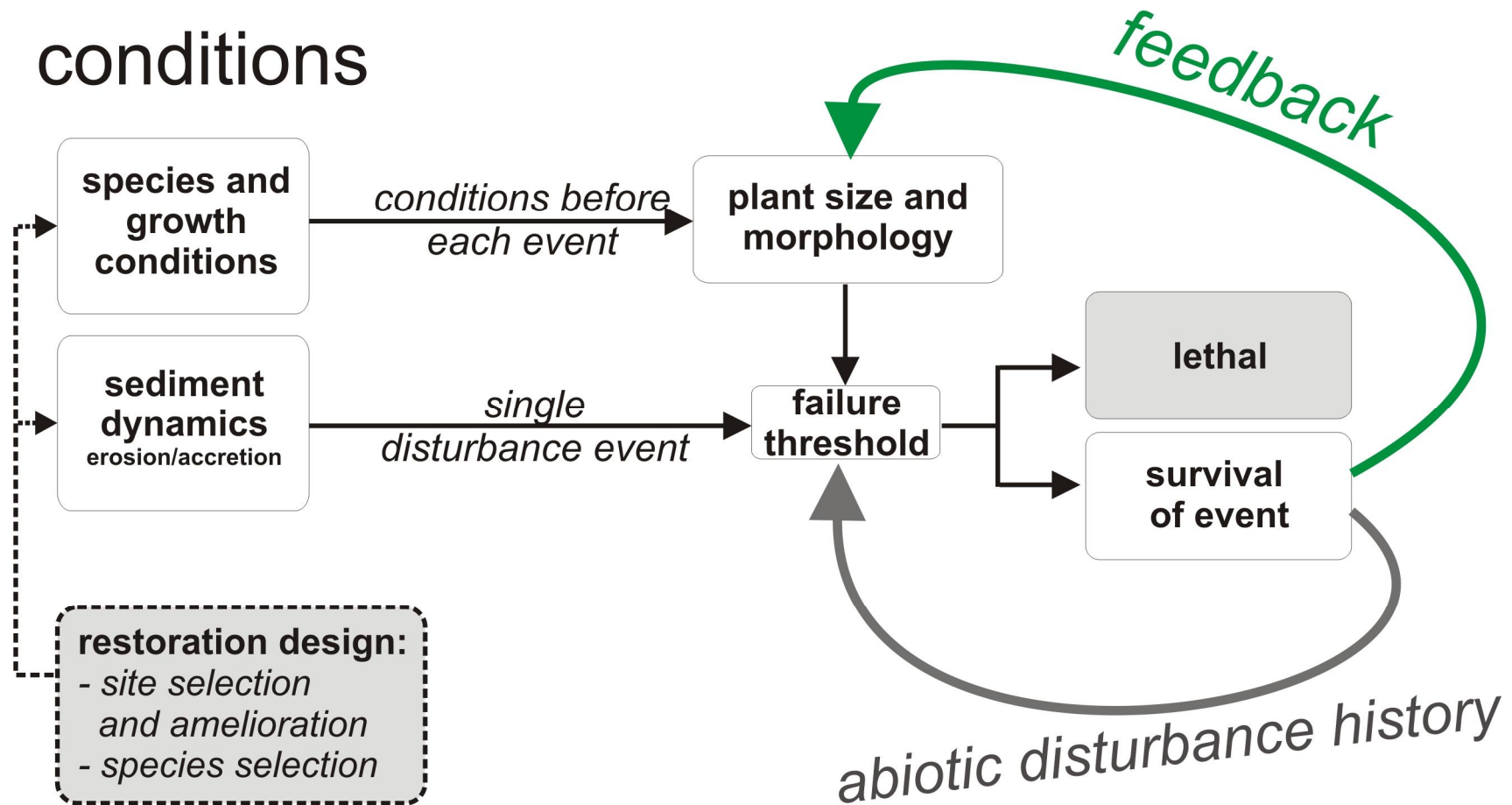


Balke et al. submitted

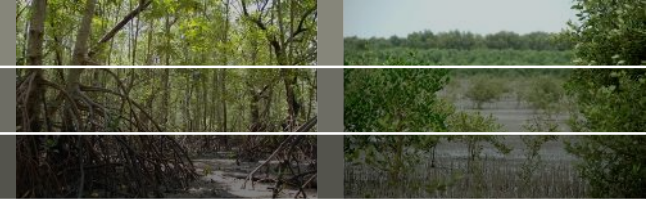
seedling establishment



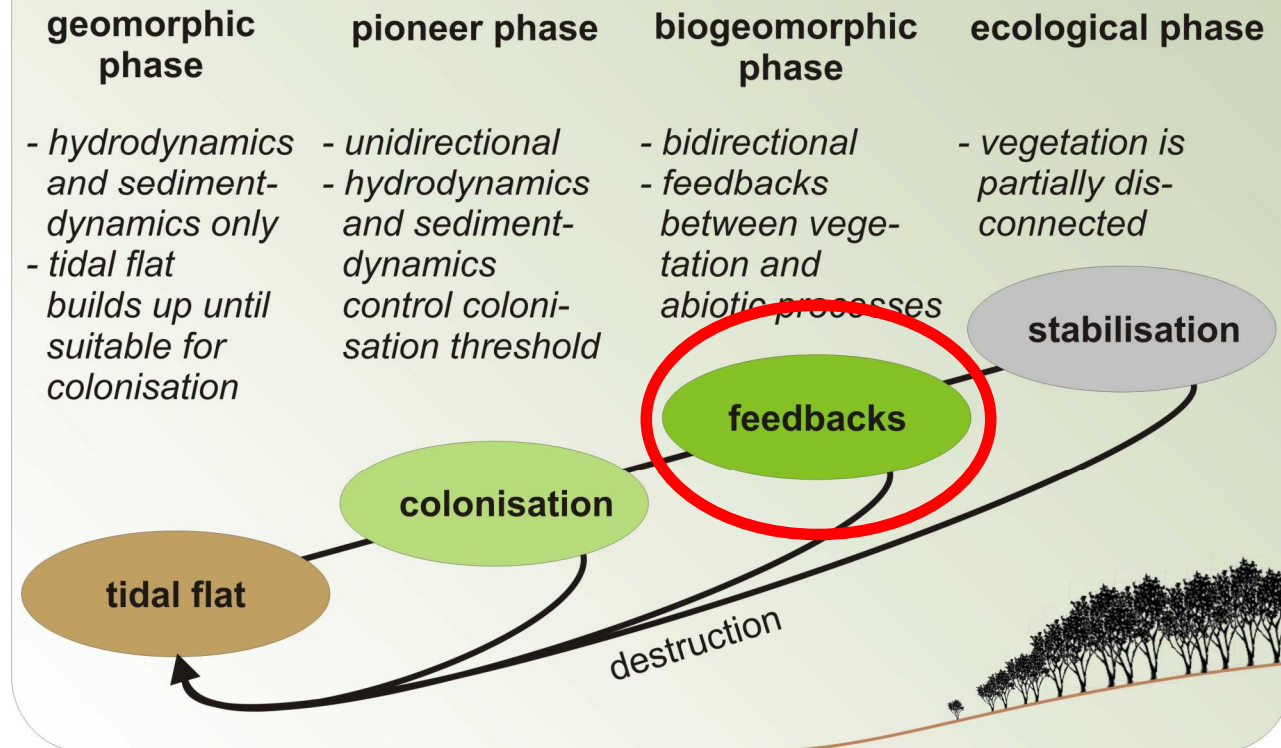
conditions



sediment dynamics



Biogeomorphic succession of mangroves



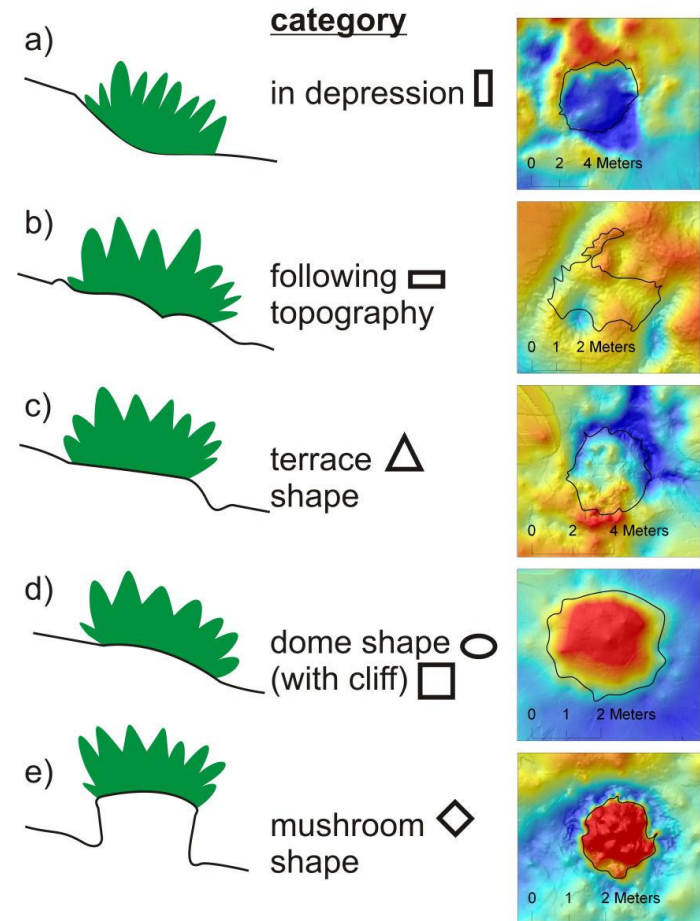
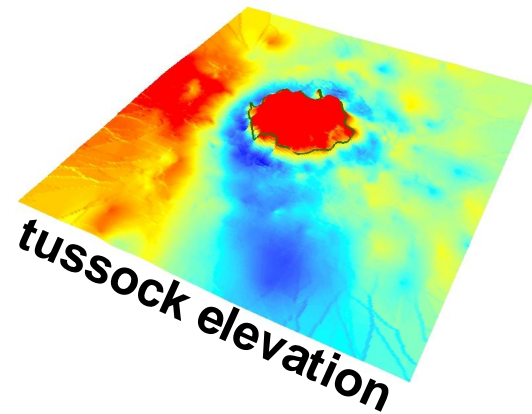
sediment dynamics



Biogeomorphic feedbacks?

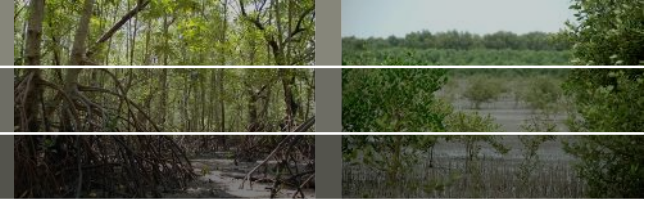


Spartina tussock



Balke et al. 2012 Geomorphology

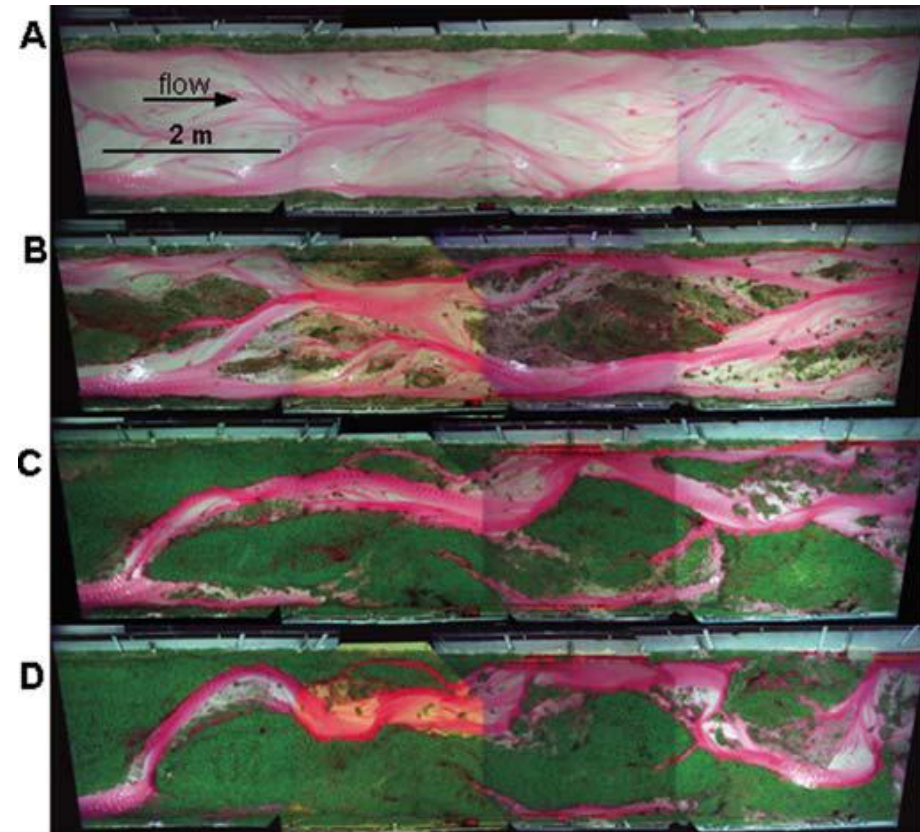
sediment dynamics



Floodplain example

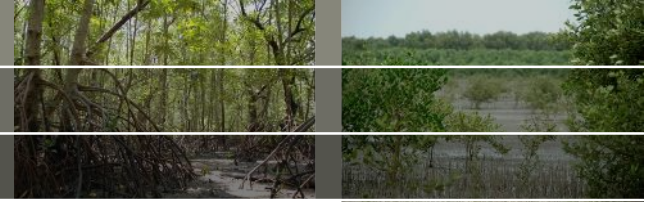


<http://news.1ternet.edu/article226.html>

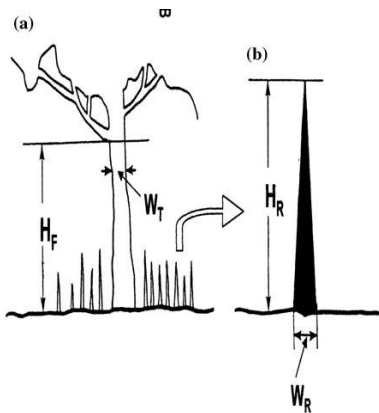
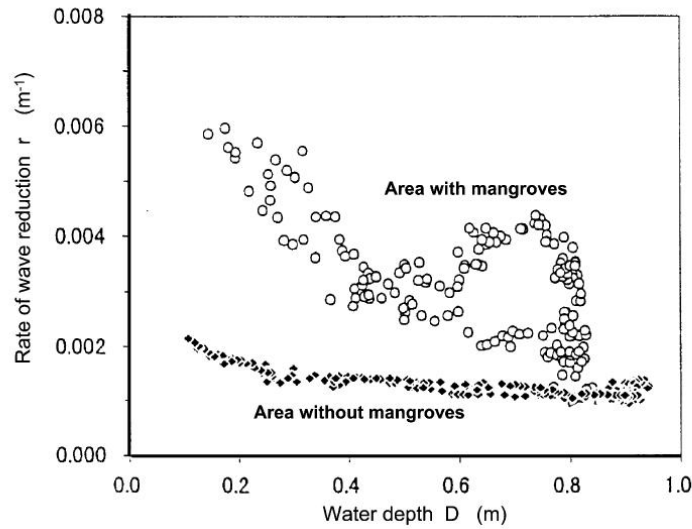


Tal and Paola 2007

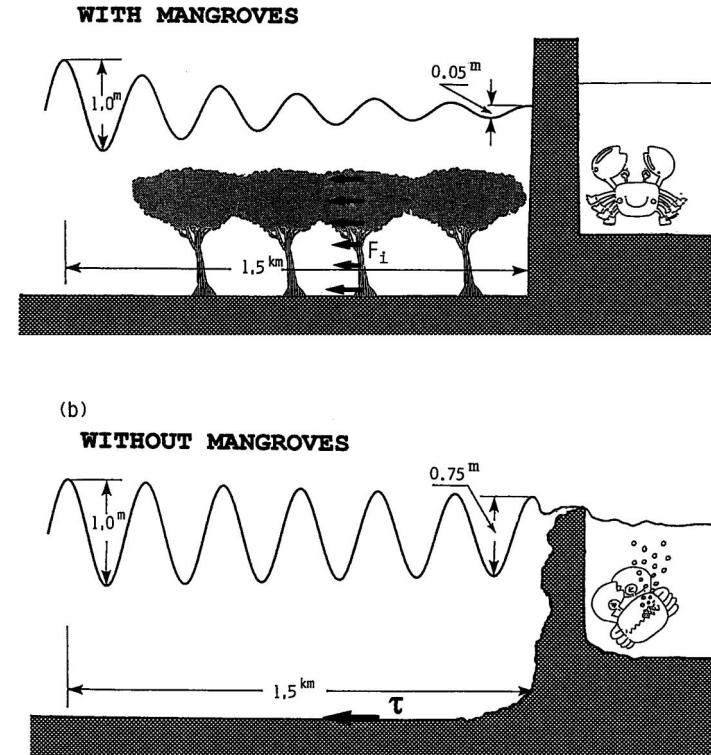
sediment dynamics



wave attenuation of mangroves:



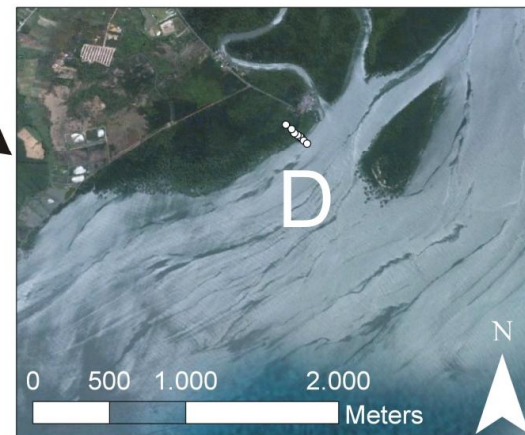
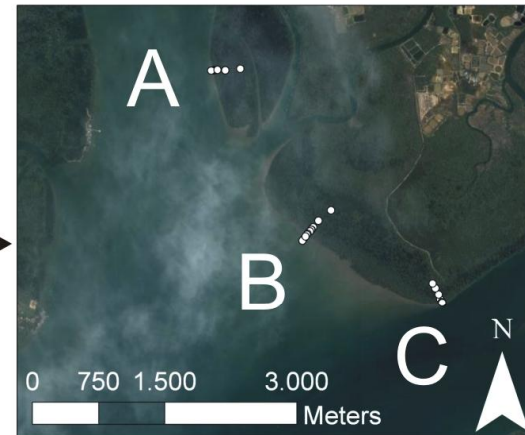
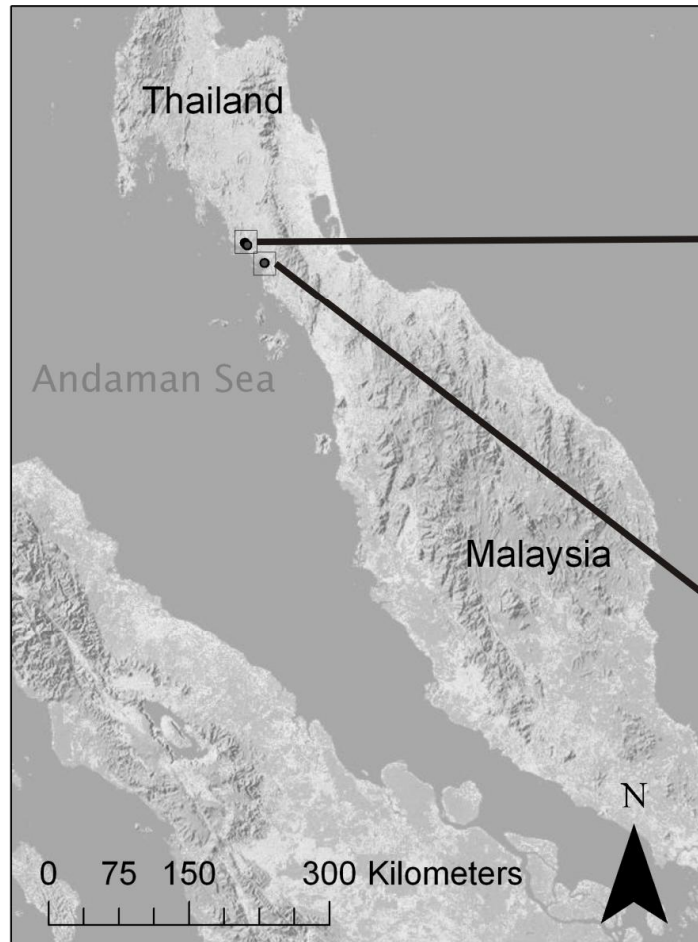
Mazda et al. 2006



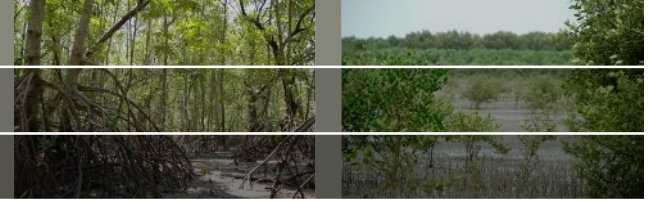
Mazda et al. 1997

20% per 100m if dense enough

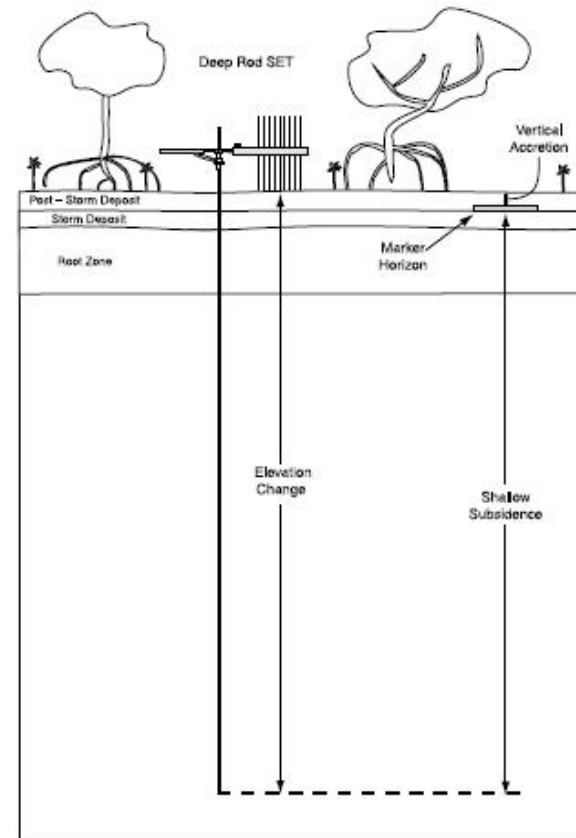
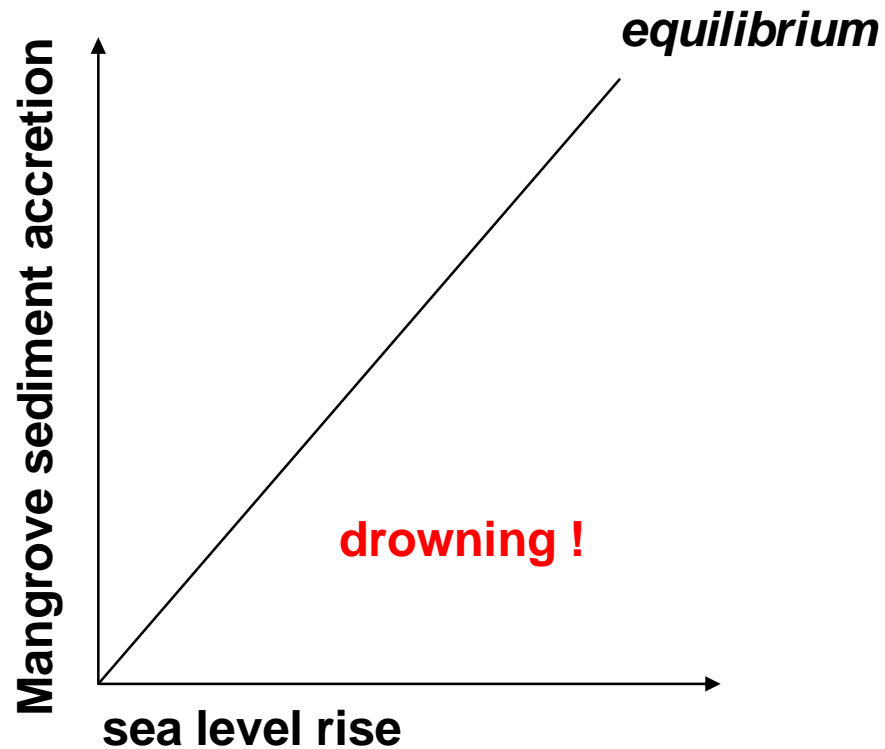
sediment dynamics



act against mangrove loss



understand impact of sea level rise

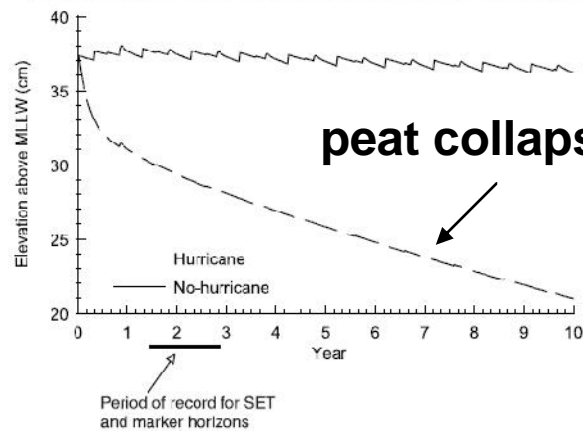


Cahoon et al. 2003

act against mangrove loss



Healthy mangroves can keep up



peat collapse after hurricane

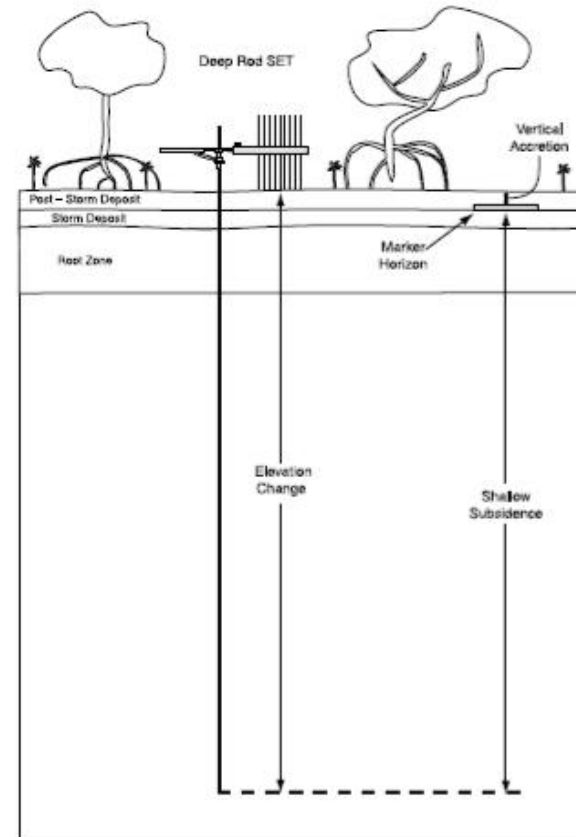
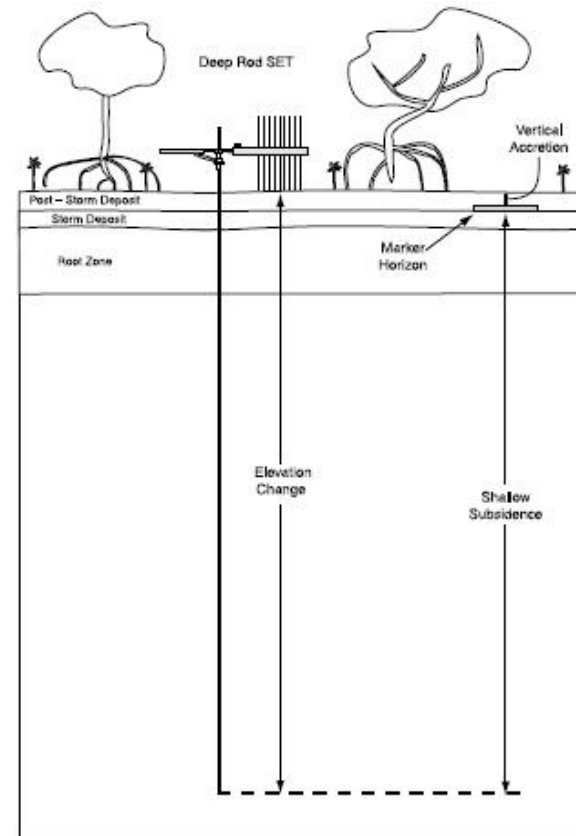


Fig. 7 Simulated change in sediment elevation relative to mean low low water (MLLW) in the high impact basin mangrove forest beginning in October 1998 with (dashed line) and without (solid line) Hurricane Mitch impacts.

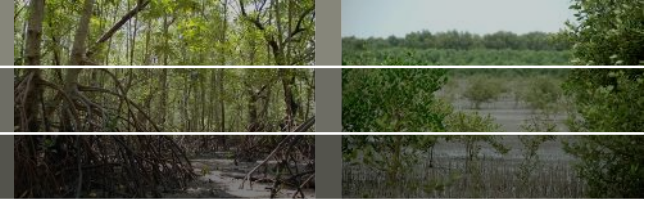
act against mangrove loss



**Destruction of mangroves
increases vulnerability to
sea-level rise**



act against mangrove loss



restoration



Photo: S. Samson

Phillipines:

10ha plantation
90% dead within
1 year

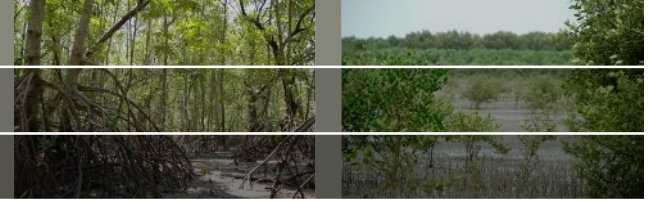
2008 ScienceNow

negative example:

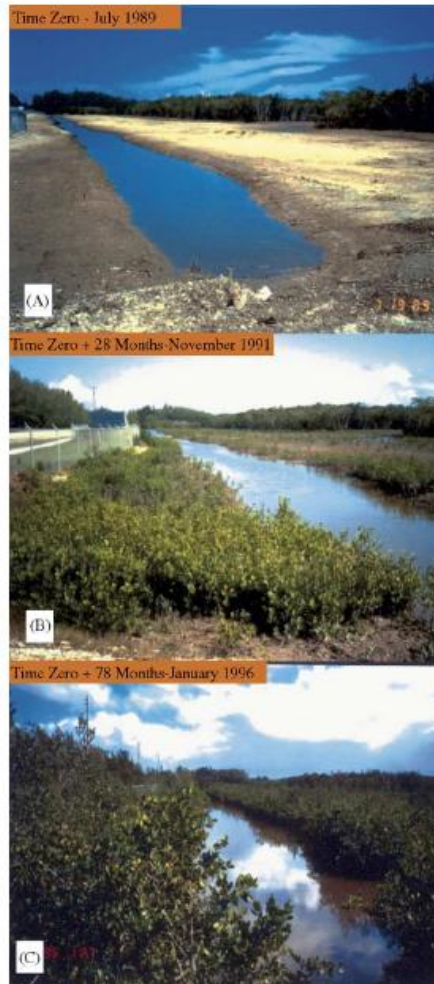
- planting of one non-pioneer species (often *Rhizophora*, Red mangrove)
- no previous assessment of hydrological conditions
- expensive: nursery, planting
- no evaluation of project success

Ellison 2000

act against mangrove loss



restoration



Lewis 2005

Fig. 6. Time series photographs of a hydrologic mangrove restoration project at West Lake Park, Hollywood, FL, USA (A) Time Zero, July 1989, (B) Time Zero + 28 months, November 1991 and (C) Time Zero + 78 months, January 1996. No planting of mangroves occurred. All vegetation derived from volunteer mangrove propagules.

positive example:

- restore hydrology
- create suitable elevation in tidal regime
- let mangroves colonize by themselves
- monitor development and evaluate

socio-economic aspects:

- community involvement
- sustainable use
- ...

conclusions



- mangroves are bio-geomorphic ecosystems with close link to their physical environment
- natural vs. anthropogenic dynamics
- healthy mangroves can help to protect against sea level rise interact with sediment dynamics
- ecological restoration: assess local conditions first

