Mangrove biogeomorphology
biophysical interactions in the coastal zone

thorsten.balke@deltares.nl
• 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
latitudinal limit of mangroves
mangrove wetlands

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 where the services offered by mangrove ecosystems, probably within the next 20 years, are severely and potentially irreversibly diminished. This is due to a number of factors:

- Mangrove destruction
- Mangrove degradation
- Mangrove disturbance

Mangrove destruction

Mangrove destruction is often caused by human activities such as land clearing for agriculture, aquaculture, and urban development. The FAO estimates that over 25% of the world's mangrove forests have been lost due to these activities.

Mangrove degradation

Mangrove degradation occurs when natural processes such as sedimentation, sea-level rise, and climate change impact the health of mangrove ecosystems. This can lead to a decline in mangrove biomass and biodiversity.

Mangrove disturbance

Mangrove disturbance refers to the impact of natural disasters such as storms, tsunamis, and wildfires on mangrove ecosystems. These events can cause significant damage to mangrove forests and disrupt the services they provide.

Mangrove Restoration: Do We Know Enough?

Aaron M. Ellison

Abstract

Mangrove restoration projects have been attempted, with mixed results, throughout the world. This paper reviews the history of mangrove restoration efforts and examines the potential for success. A successful approach to mangrove restoration is one that is based on a deep understanding of the ecological processes that drive mangrove growth and functioning. This understanding can be achieved through a combination of scientific research and traditional knowledge.

Mangrove ecosystems provide a range of benefits, including coastal protection, carbon sequestration, and habitat for a wide range of marine species. These benefits are threatened by climate change and human activities, making restoration efforts even more important.

Mangrove restoration is a complex and challenging task, but with careful planning and implementation, it is possible to restore mangrove ecosystems and the services they provide.

References

- World Mangrove Atlas 2014
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
How mangroves interact with the physical environment?
biogeomorphology

mangrove succession

SE Asia example
How mangroves interact with the physical environment?

Biogeomorphic succession of mangroves

**geomorphic phase**
- hydrodynamics and sediment-dynamics only
- tidal flat builds up until suitable for colonisation

**pioneer phase**
- unidirectional
  - hydrodynamics and sediment-dynamics control colonisation threshold

**biogeomorphic phase**
- bidirectional
  - feedbacks between vegetation and abiotic processes

**ecological phase**
- vegetation is partially disconnected

**Stabilisation**

**Tidal flat**

**Colonisation**

**Feedbacks**

**Destruction**

*after Corenblit et al. 2007*
Biogeomorphic succession of mangroves

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**feedbacks**

**stabilisation**

**colonisation**

**tidal flat**

**destruction**
achorage of *Avicennia* propagules, first days:

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

seedling establishment
seedling establishment

a) experimental tank
   reservoir

b)

c) cumulative treatments
   
   erosion treatment
   accretion treatment
   
   add disc
   remove disc
   add disc
   remove disc
   repeated erosion treatment + drag

Balke et al. submitted
seedling establishment

conditions

species and growth conditions

sediment dynamics
erosion/accretion

conditions before each event

plant size and morphology

failure threshold

lethal

survival of event

feedback

restoration design:
- site selection and amelioration
- species selection

abiotic disturbance history

Balke et al. submitted
Biogeomorphic succession of mangroves

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**Feedbacks**
- stabilisation

**Colonisation**

**Tidal flat**

**Destruction**
Biogeomorphic feedbacks?

*Spartina tussock*

Balke et al. 2012 Geomorphology
Floodplain example

http://news.lternet.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

Balke et al. submitted
act against mangrove loss

understand impact of sea level rise

Mangrove sediment accretion vs. sea level rise:
- Equilibrium
- Drowning!

Cahoon et al. 2003
Healthy mangroves can keep up

Hurricane Mitch
1998, Honduras

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.

Cahoon et al. 2003
Destruction of mangroves increases vulnerability to sea-level rise
Act against mangrove loss

Restoration

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

Philippines:

10ha plantation
90% dead within 1 year
2008 ScienceNow

Ellison 2000
act against mangrove loss

restoration

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
• …

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 + 6 months, November 1991 and (C) Time Zero + 12 months, January 1992, beginning of mangrove occurred. All vegetation derived from volunteer mangrove propagules.
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