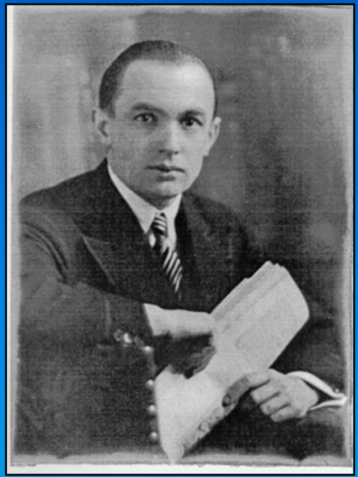
Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team



Prijs Dr. Edouard Delcroix

Farid Dahdouh-Guebas

Vrije Universiteit Brussel

Vrije Universiteit Brussel
VUB-APNA-WE
Pleinlaan 2, B-1050 Brussels
BELGIUM
Tel. +32 2 629.34.22
Fax. +32 2 629.34.13
E-mail : fdahdouh@vub.ac.be

Mangrove ecosystem degradation and its effects on the quality of life of coastal subsistence communities in Third World countries

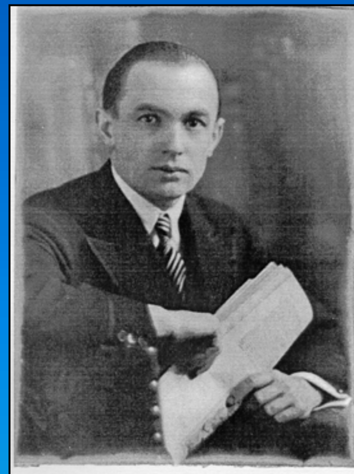
MANGROVE management group

www.vub.ac.be/APNA/research/biocomplexity.html

apna

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team



Prijs Dr. Edouard Delcroix

Farid Dahdouh-Guebas

Vrije Universiteit Brussel
VUB-APNA-WE
Pleinlaan 2, B-1050 Brussels
BELGIUM
Tel. +32 2 629.34.22
Fax. +32 2 629.34.13
E-mail : fdahdouh@vub.ac.be

Mangrove-ecosysteemdegradatie en het effect op de levenskwaliteit van afhankelijke kustgemeenschappen in Derde Wereldlanden

MANGROVE management group

www.vub.ac.be/APNA/research/biocomplexity.html

Vrije Universiteit Brussel

apna

Verwezenlijkingen – Achievements 1995-2005

- *ca.* 40 peer-reviewed publications;
- >20 special publications (not refereed, popularising,…);
- >80 presentations on international conferences (*e.g.* Gordon Research Conference);
- 6 international scientific awards (*e.g.* Laureate Academy of Overseas Sciences; Prize Development Co-operation);
- co-supervision of *ca.* 50 students (incl. 7 current PhD fellows);
- …

Het mangrove-ecosysteem

The mangrove ecosystem

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Salt - Zout

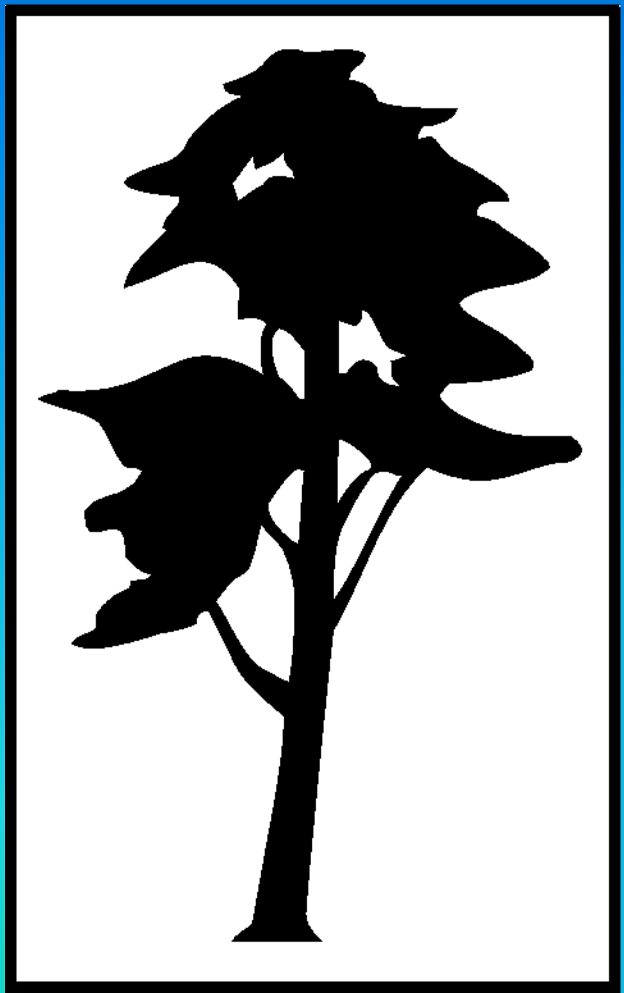
MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Fysiognomie

Gematigd woud



Temperate forest

Mangrovewoud

Mangrove forest

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Luchtwortels - Aerial roots

Photographs by Nico Koedam

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Levendbarendheid - Vivipary

apna

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

Fauna

Photographs by Jeremy Stafford-Deitsch

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Fauna







Photographs by Stefano Cannicci, Marco Vannini, Ricardo Innocenti, Jeremy Stafford-Deitsch and Farid Dahdouh-Guebas

MANGROVE management group

apna

Fauna

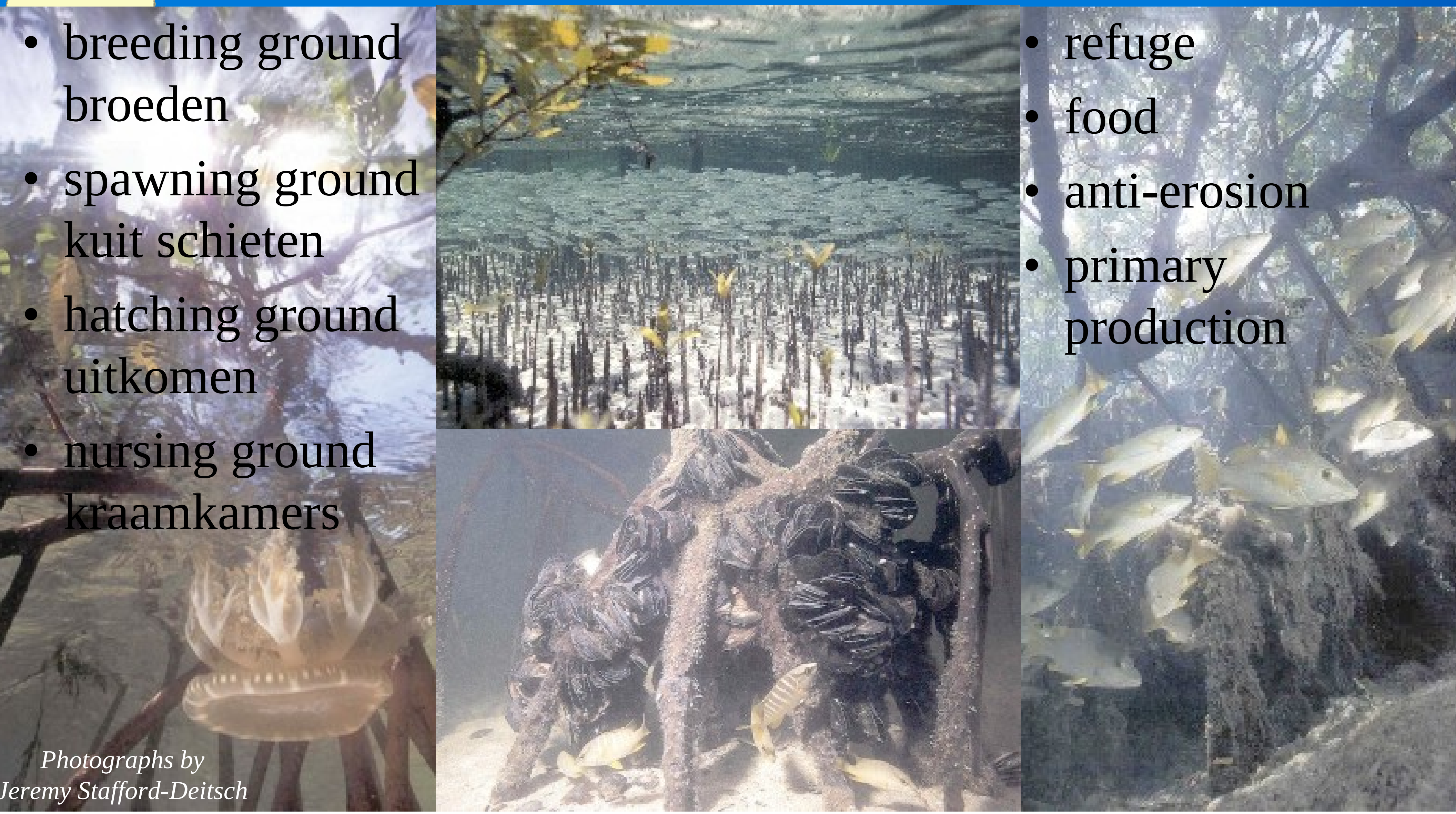
Photographs by Jeremy Stafford-Deitsch

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Mangrove ecosystem functions

- breeding ground
  broeden
- spawning ground
  kuit schieten
- hatching ground
  uitkomen
- nursing ground
  kraamkamers

- refuge
- food
- anti-erosion
- primary production



Photographs by Jeremy Stafford-Deitsch

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

De mangrovemens

The mangrove people

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Mangrove etnobiologie


Jeremy Stafford-Deitsch


Farid Dahdouh-Guebas


Farid Dahdouh-Guebas

MANGROVE management group

apna

Mangrove etnobiologie

Farid Dahdouh-Guebas

Anouk Verheyden

Nico Koedam

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Mangrove etnobiologie

Photographs by Nico Koedam and Farid Dahdouh-Guebas.

Source : Dahdouh-Guebas *et al.*(2000a)

MANGROVE management group

apna

Bedreigingen - Threats

Farid Dahdouh-Guebas

Farid Dahdouh-Guebas

Nico Koedam

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

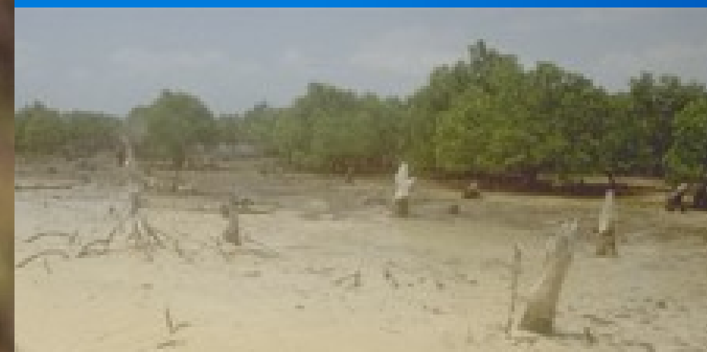
MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Bedreigingen - Threats








Photographs by
Nico Koedam
James G. Kairo
Farid Dahdouh-Guebas
and Jeremy Stafford-Deitsch

SHARI ABEYRATHNE, 10 ANS, ECOLE DE MATARA

« Je suis monté dans un arbre et j'ai vu les autres emportés par la mer. »

CHATHRA ASHAMANI, 10 ANS, ECOLE DE MATARA

*« Mon père, pêcheur,
a perdu son bateau.
Nous n'avons plus d'argent.»*

NAVODI KASUNSARA, 10 ANS, ECOLE DE MATARA

*« La montagne d'eau
a tout balayé,
y compris le bus. »*

NISHANI IROSHIKA, 12 ANS, ECOLE D'IKKADUWA

« Je m'étais réfugiée dans le train. Les wagons de devant ont été emportés. »

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Het wetenschappelijk onderzoek

The scientific research

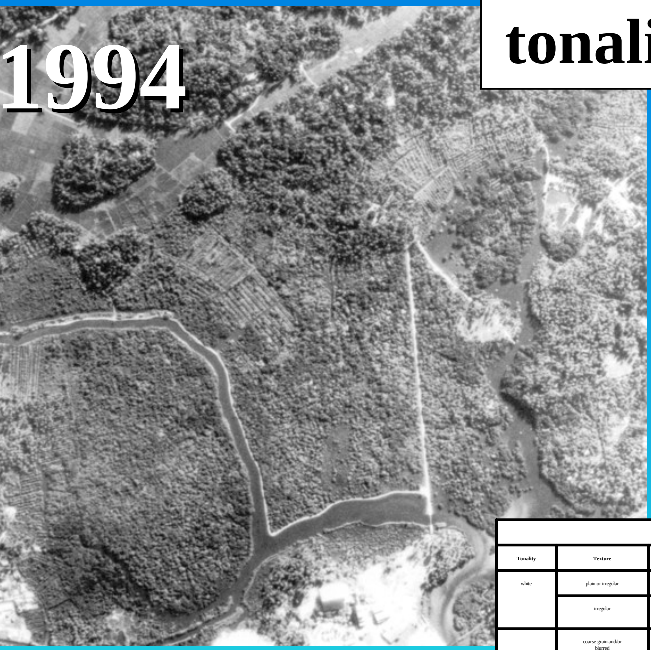
ANGROVE management group

apna

Dynamics : historical aerial photography

tonality + texture + structure + size + shape + shade + position

Identification key



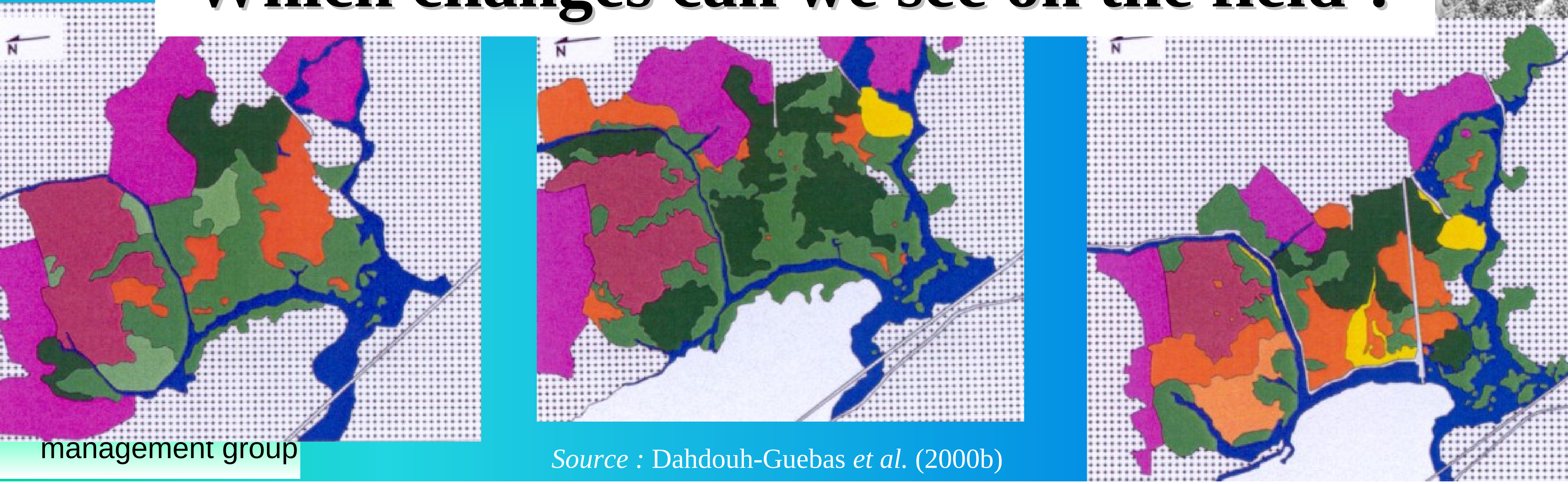
GAZI (04°25'S - 39°30' E)							
Tonality	**Texture**	**Structure**	**Size**	**Shape**	**Shade**	**Position**	**Identification**
white	plain or irregular	plain or irregular	rather large	variable	none	variable	sand
	irregular	irregular	variable	variable	variable	often clearly man-made	infrastructure (tracks, constructions)
	coarse grain and/or blurred	discontinuous canopy	regular	star-shaped crown	light shade	sparse and regular distribution landward	*Cocos nucifera* (coconut)
light grey	coarse grain	discontinuous canopy	very large crowns, often higher than surrounding vegetation	variable	surrounding vegetation may be shaded intermediate to dark	water side	*Avicennia marina*
	fine grain	discontinuous canopy or continuous canopy with crowns hard to distinguish	small-sized crowns	variable	light	landward side	*Avicennia marina*
	variable	often discontinuous canopy	variable, but in case of trees often larger than mangroves	variable	none (herbaceous layer), dark (often for trees) or variable	landward side or outside reach of mangrove vegetation	terrestrial vegetation
dark grey	fine grain and blurred	continuous canopy crowns not separately visible	small-sized crowns, lower than surrounding vegetation	circular canopy	light	landward side or mid-mangrove	*Ceriops tagal*
	coarse grain 'peluche' texture	discontinuous canopy	regular	circular canopy	intermediate to dark	amongst terrestrial vegetation sparse and regular distribution	*Mangifera indica* (mango)
	coarse grain	discontinuous canopy	very large crowns	variable	dark	always at water side large-sized canopy	*Sonneratia alba*
very dark grey or black	fine or coarse grain	continuous canopy with crowns hard to distinguish	often large-sized aggregating crowns	variable	intermediate to dark	often at water side wide spatial range	*Rhizophora mucronata*

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

Dynamics : historical aerial photography

Which changes can we see on the field ?



management group

Source : Dahdouh-Guebas *et al.* (2000b)

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

Terreinwerk - Fieldwork


Helen Defever


Jeremy Stafford-Deitsch

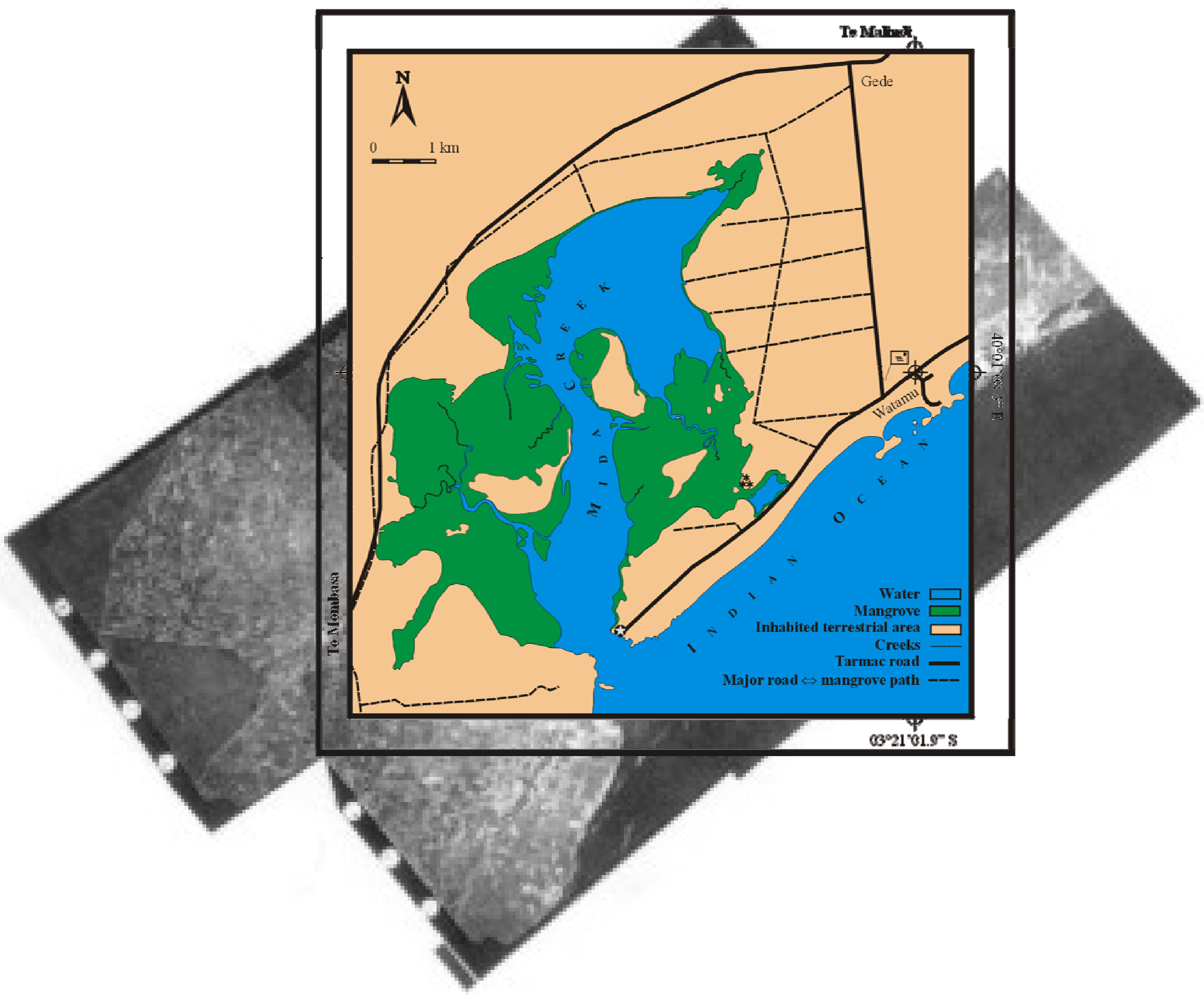

Farid Dahdouh-Guebas


Farid Dahdouh-Guebas


Griet Neukermans

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

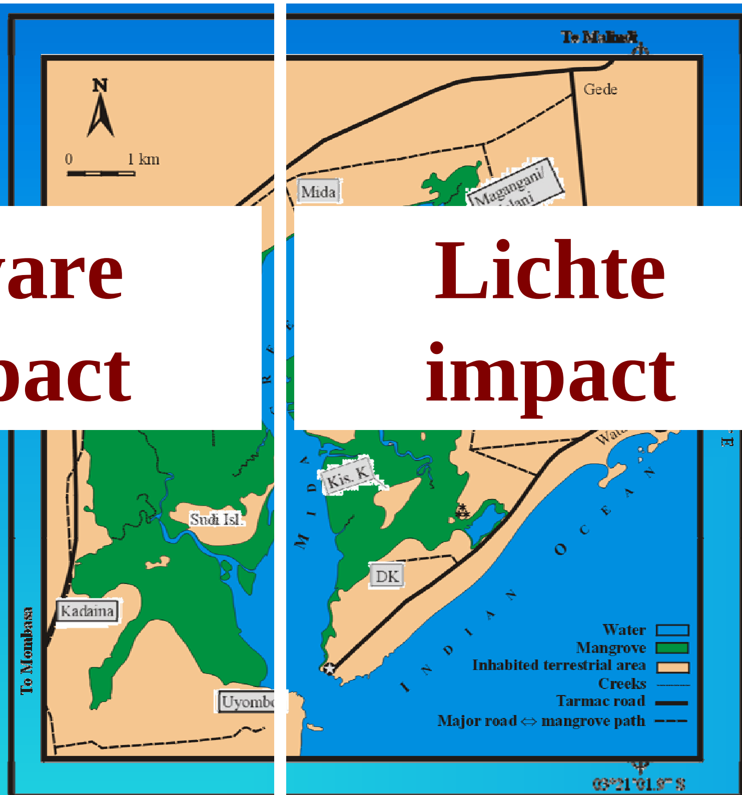
Canopy gap dynamics



MANGROVE management group

apna

Canopy gap dynamics



	Uyombo	Kirepwe
	Zware impact	Lichte impact

	U	K
Diameter class (cm)	> 15	> 15
Stem density (ha^{-1})	234	465
Mean height (m)	10.4	12.1
Basal area ($m^2. ha^{-1}$)	10.87	19.40

- most exploited area exhibits lack of (preferred) long straight stems

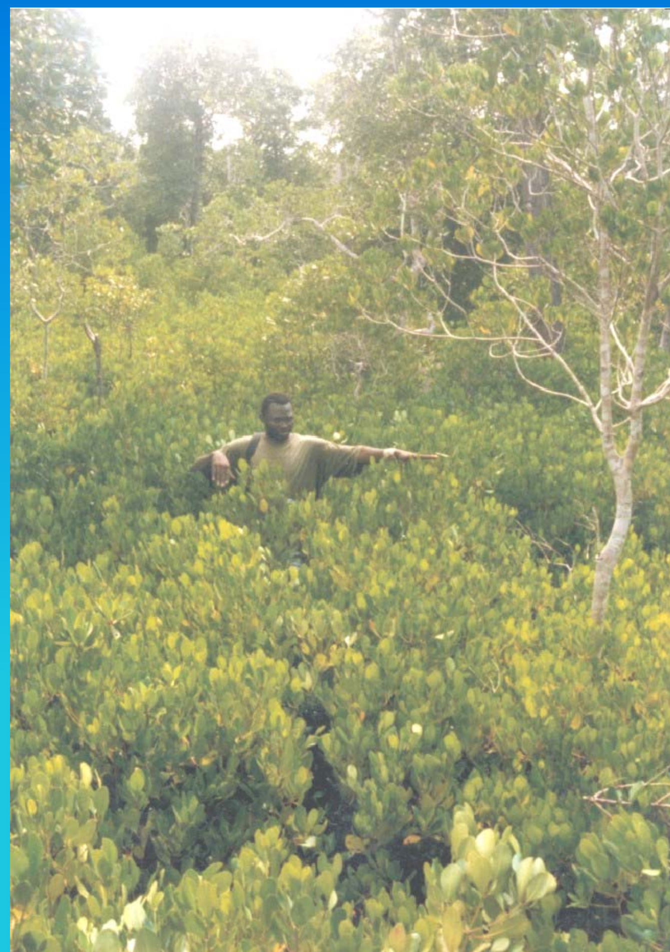
Source : Dahdouh-Guebas *et al.* (2000), Kairo *et al.*(2002)

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Canopy gap dynamics

Stem density (ha^{-1})	**U**	**K**
R. mucronata ADULT trees	433	545
C. tagal ADULT trees	899	400

ADULT TREES :
U : *C. tag* > *R. muc*
K : *R. muc* > *C. tag*



Stem density (ha^{-1})	**U**	**K**
R. mucronata RC-III trees	461	145
C. tagal RC-III trees	768	728

YOUNG TREES :
U : *C. tag* > *R. muc*
K : *C. tag* > *R. muc*

what people cut is what they prefer, but is not necessarily what regenerates

MANGROVE management group

Source : Kairo *et al.* (2002)

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

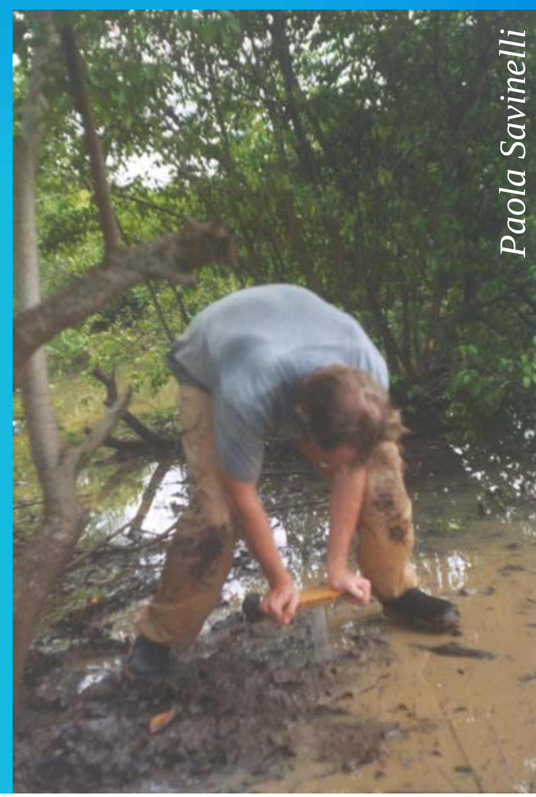
Biotische en abiotische milieufactoren

- salinity
- pH
- temperature
- relative humidity
- sulphides
- redox potential

- soil cores
- texture, organisms
- TOC, TN, C:N, $\delta^{13}C$
- crabs, snails, soil fauna


Farid Dahdouh-Guebas

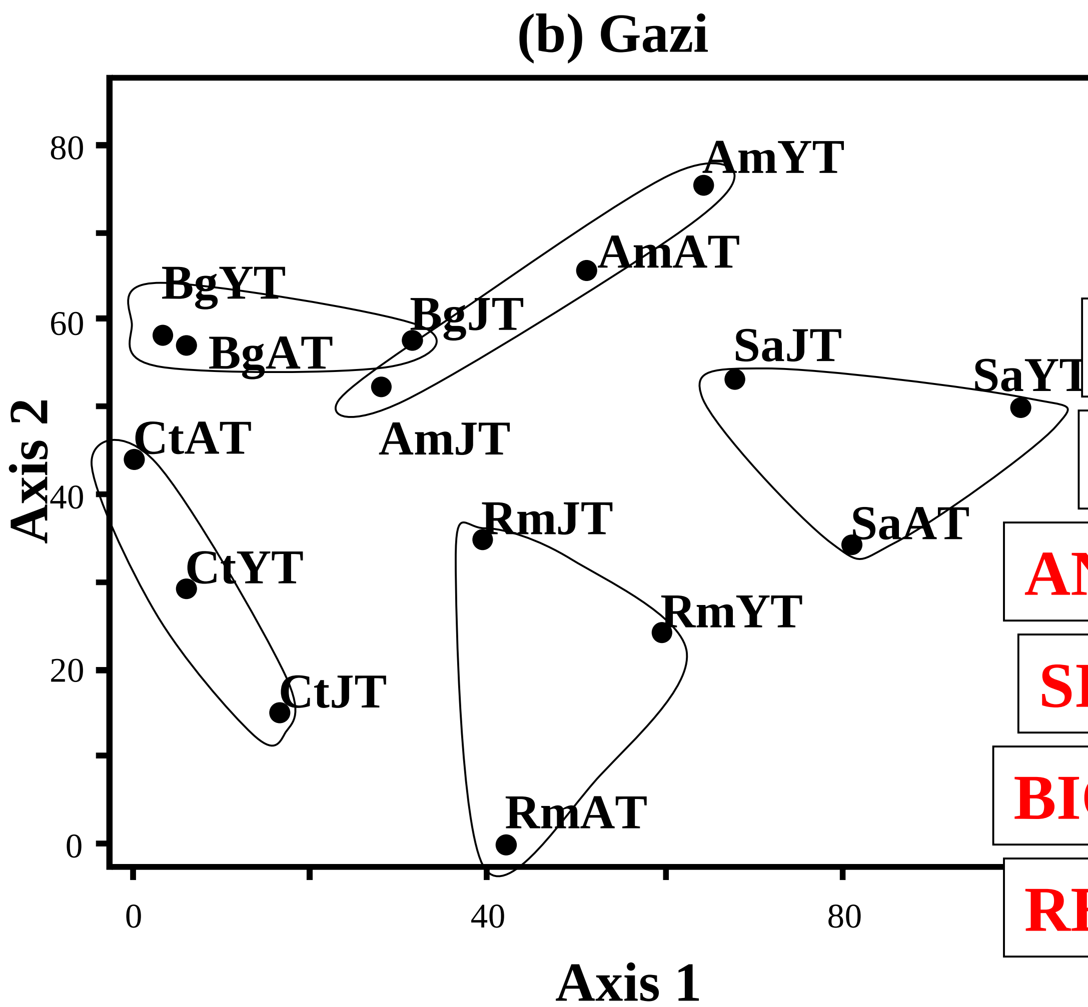

Nico Koedam


Paola Savinelli


Griet Neukermans

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Analytische methoden

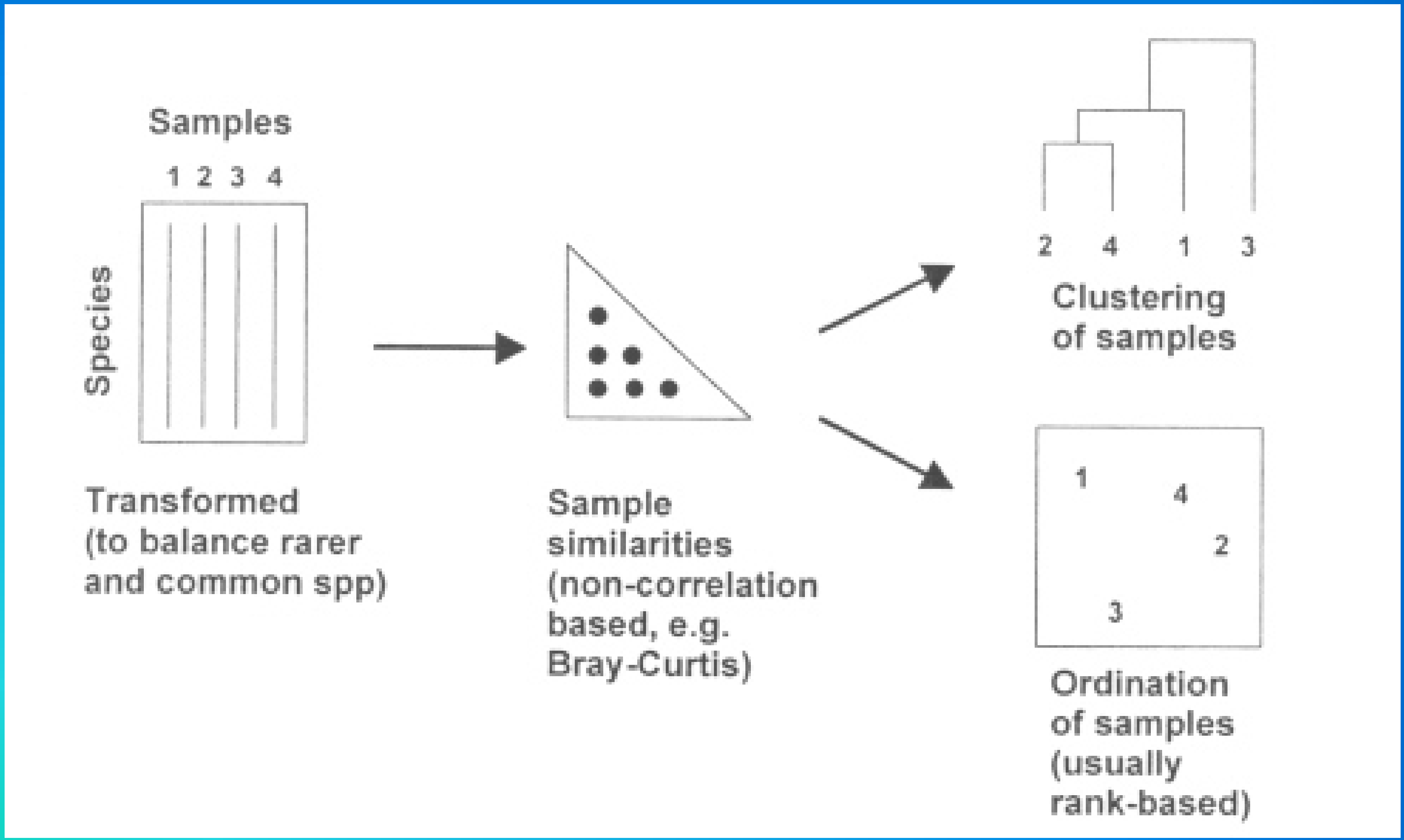


- CA
- PCA
- DCA
- CCA
- DCCA
- NMDS
- ANOSIM
- SIMPER
- BIO-ENV
- RELATE

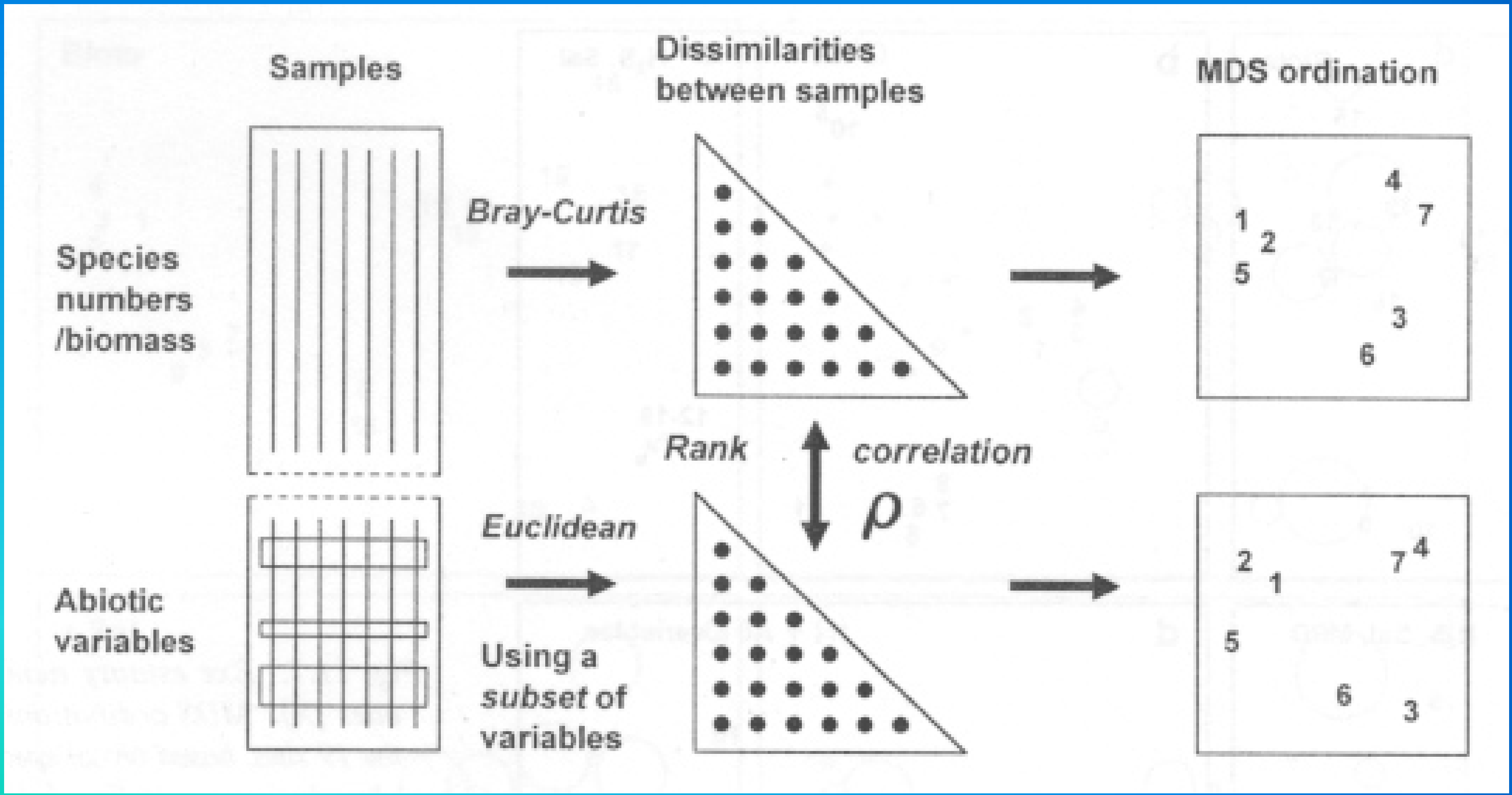
	sp. A AT	sp. A YT	sp. A JT	…
Plot 1	3	2	0	…
Plot 2	3	0	0	…
Plot 3	5	1	2	…
…	…	…	…	…

	env. var. 1	env. var. 2	env. var. 3	…
Plot 1	23	5.62	88	…
Plot 2	30	4.69	85	…
Plot 3	41	5.83	92	…
…	…	…	…	…

Analytische methoden

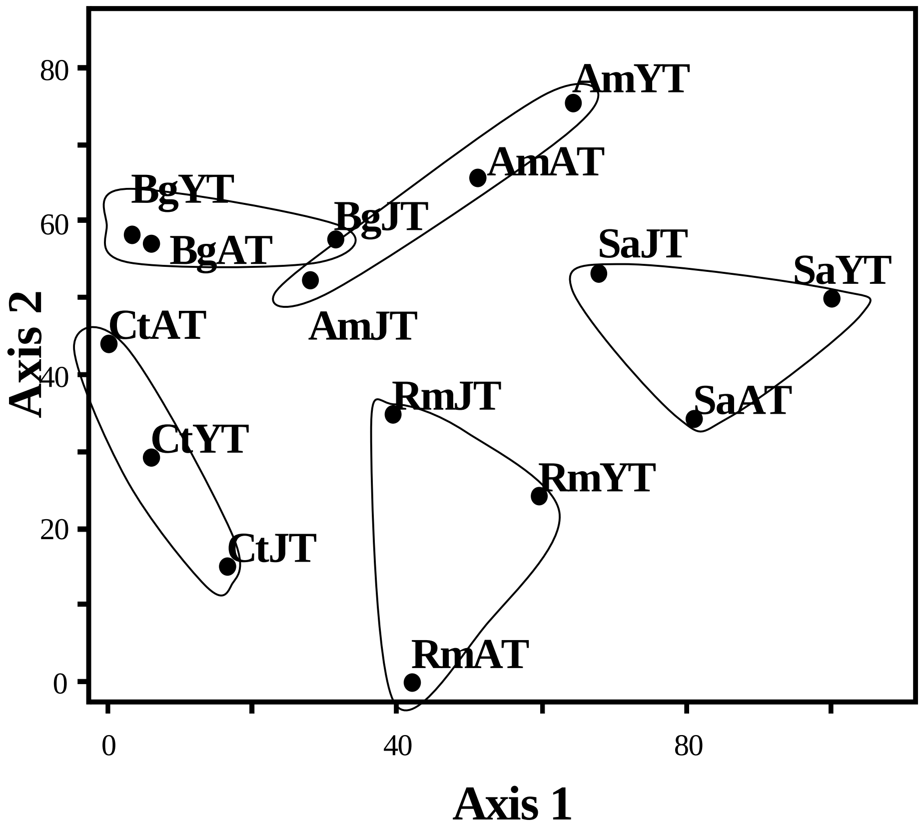


Analytische methoden

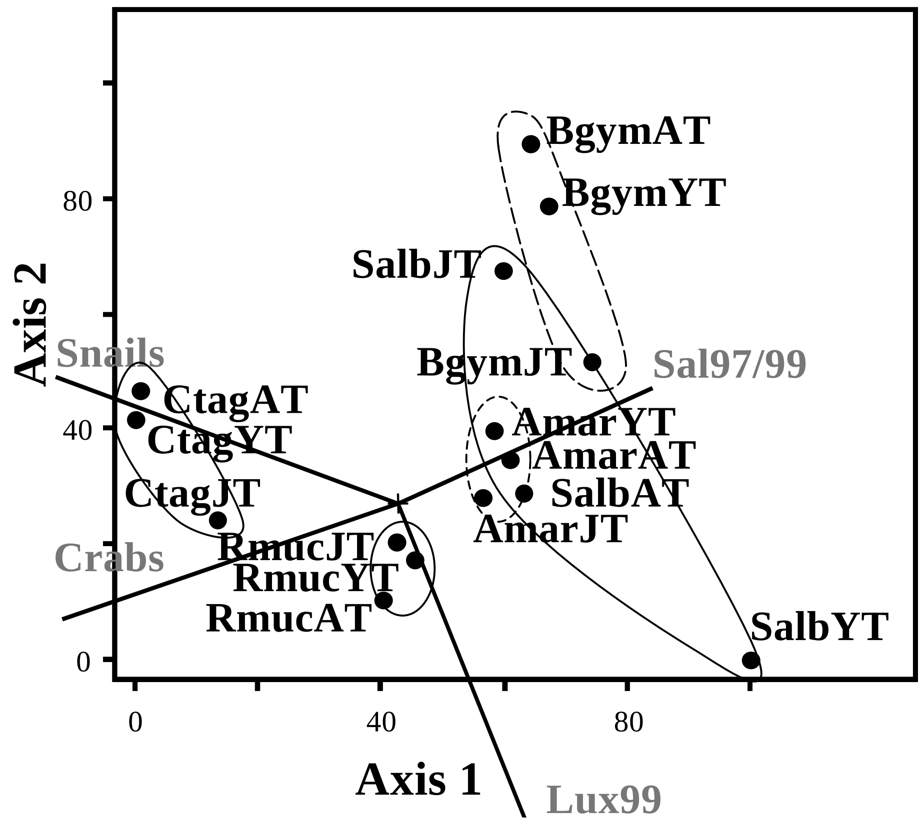


Analytische methoden

Detrended Correspondence Analysis

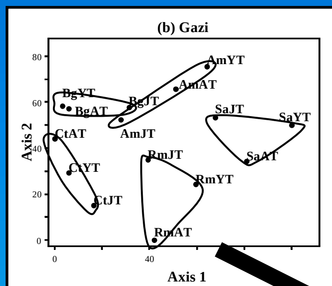


Canonical Correspondence Analysis



Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Retrospection-Prediction



		PRESENT - HEDEN			
		Actual distribution of trees in the field			
		AT=YT=JT	AT=YT≠JT	...	AT≠YT≠JT
PAST-VERLEDEN	Static forest	…	…	…	…
	Dynamic forest	…			…

FUTURE - TOEKOMST

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Retrospection-Prediction

	Actual distribution of trees in the field				
	AT=YT=JT	AT=YT≠JT	AT=JT≠YT	AT≠YT=JT	AT≠YT≠JT
Static forest	rejuvenating (*e.g.* Gazi, Mida, Pambala)	rejuvenating	…	…	declining change (shifting)
Dynamic forest	declining (shifting) (*e.g.* Galle)	…	…	…	rejuvenating (*e.g.* Galle)

MANGROVE management group

apna

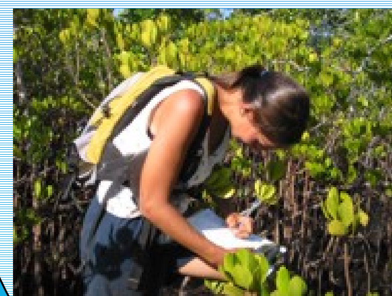
Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporal mangrove dynamics : how and why ?

Retrospective methods

remote sensing

ground-truth



dendro-chronology

interviews

historic archives

soil coring

MANGROVE management group

Photographs by Farid Dahdouh-Guebas, Griet Neukermans & Anouk Verheyden

apna

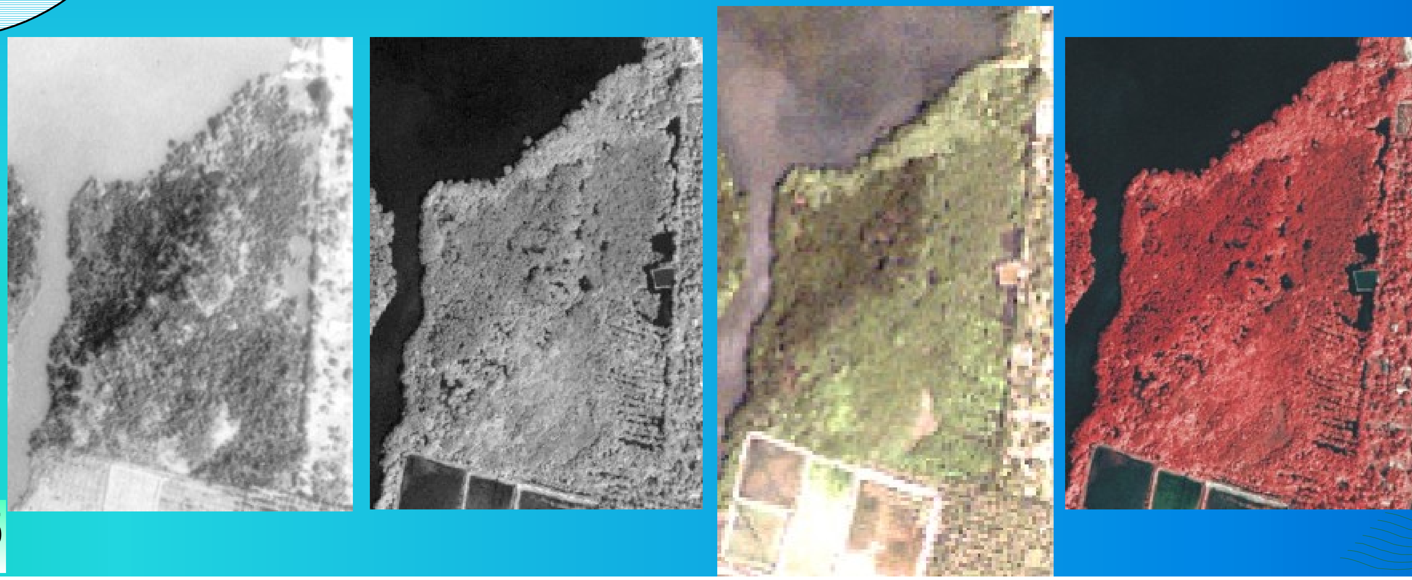
Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporele mangrovedynamiek : hoe en waarom ?

remote sensing

Retrospectieve methoden

- Historische luchtfotografie
- Multispectrale zeer hoge resolutie satellietbeelden (Ikonos, Quickbird)



MANGROVE management group

apna

Spatio-temporele mangrovedynamiek : hoe en waarom ?

ground-truth

Griet Neukermans

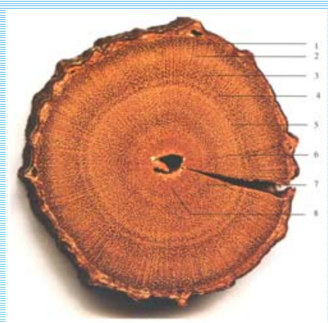
Retrospectieve methoden

- Tereinwerk op fauna, flora, landschap, milieufactoren,…
- Interacties tussen planten en dieren (positief, negatief, gedragsstudies)
- Impact-studies (bv. impact van garnaalkwekerijen)

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporele mangrovedynamiek : hoe en waarom ?

dendro-chronology



Anouk Verheyden

Retrospectieve methoden

- Dendrochronologie
- Houtanatomie
- Ringvorming
- Relatie met milieu

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporele mangrovedynamiek : hoe en waarom ?

interviews

Retrospectieve methoden

- Ethnobiologie / ethnoecologie
- Traditionele interacties tussen mensen, dieren en omgeving
- Percepties van mensen

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporele mangrovedynamiek : hoe en waarom ?

historic archives

Retrospectieve methoden

- manuscripten, dagboeken, logboeken, tekeningen, schilderijen en kartografie
- voormalige maritieme koloniale mogendheden (bv. Vereenigde Oostindische Compagnie)

van Keulen, 1753

apna

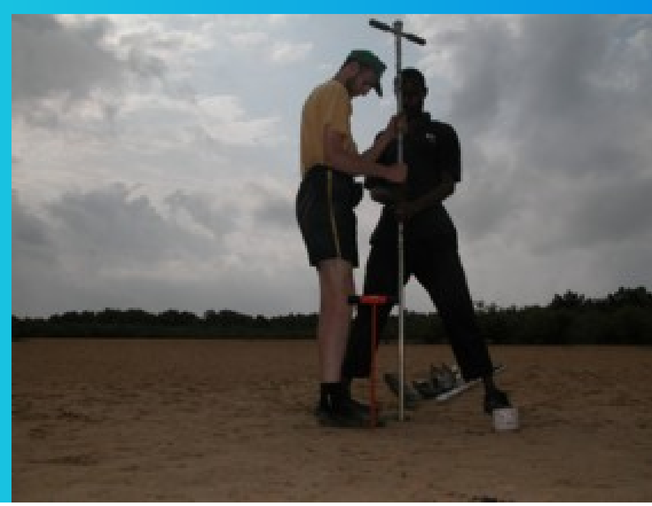
Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Spatio-temporele mangrovedynamiek : hoe en waarom ?

soil coring

Retrospectieve methoden

- Metersdiepe bodemboringen
- Stratigrafie, leeftijd, oorsprong, organismen, stuifmeel



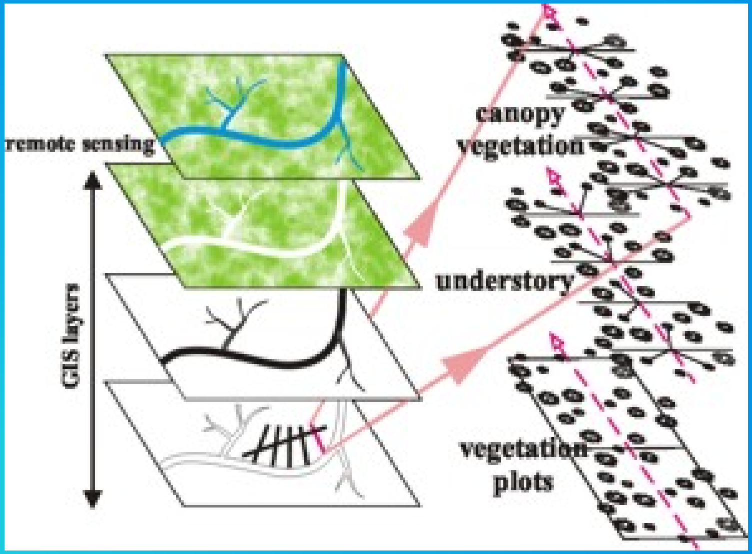
MANGROVE management group

Spatio-temporal mangrove dynamics : how and why ?

Analysis

- remote sensing
- ground-truth
- dendro-chronology
- interviews
- historic archives
- soil coring

GIS



- beschrijving
- kwantificing
- impact evaluatie
- voorspelling
- fundamenteel onderzoek

Spatio-temporal mangrove dynamics : how and why ?

Output

beschrijving	• soortenrijkdom, biodiversiteit, biocomplexiteit; • typologie en dynamiek van de vegetatiestructuur;
kwantificing	• silvimetrie; • quantificatie van verandering;
impact evaluatie	• menselijke exploitatie, regeneratieve beperkingen; • herbebossing, monitoring van restauratiesucces;
voorspelling	• digitale terrein modellering, propaguleverspreiding; • veerkracht, voorspelling van assemblagetransities;
fundamenteel onderzoek	• vegetatiedynamiek en ecologische stabiliteit; • processen en synergieën in propagule verspreiding.

Spatio-temporele mangrovedynamiek : hoe & waarom?

Concrete vraagstellingen

- Kan een mangrovebos degraderen en toch zijn functies behouden ?
- Welk ander vegetatietype kan de mangrove functioneel vervangen ?
- Hoe snel ontwikkeld of herstelt een mangrovewoud zich ?
- Welke flora, fauna, milieufactoren en –processen karakteriseren een functioneel mangrovewoud ?
- Welke continue en stochastische evenementen vormen een mangrovewoud ?
- Hoe stabiel is een dynamisch (mangrove)ecosysteem ?
- Onder welk scenario kan een mangrovewoud zich handhaven en onder welk scenario verdwijnt het ?

Concrete questions

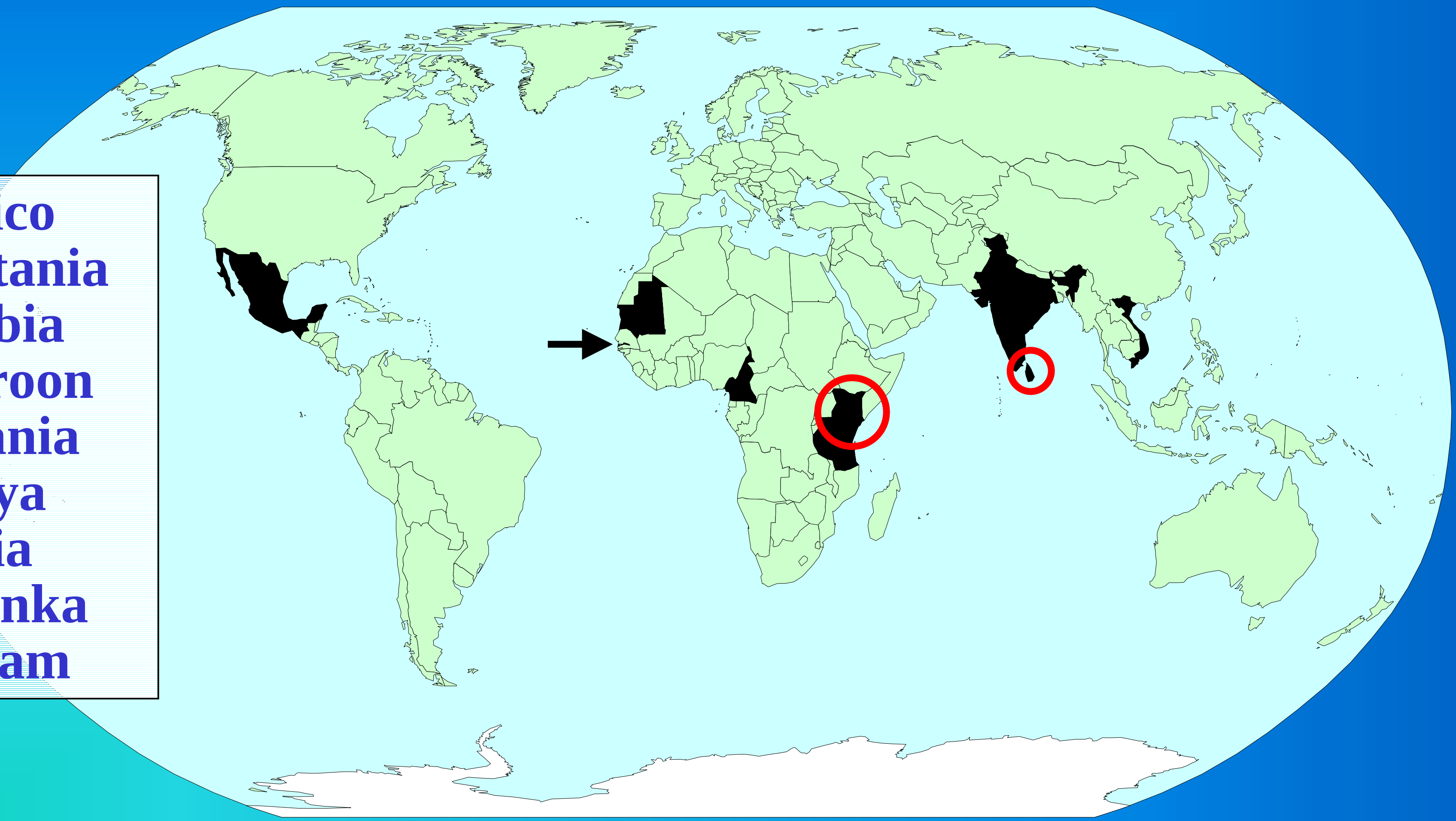
- Can a mangrove forest degrade and still keep its functions ?
- Which other vegetation type can functionally replace the mangrove ?
- How fast does a mangrove forest develop or rehabilitate ?
- Which flora, fauna, environmental factors and –processes characterise a functional mangrove forest ?
- Which continuous and stochastic events shape a mangrove forest ?
- How stable is a dynamic (mangrove) ecosystem ?
- Under which scenario can a mangrove forest resist and under which scenario does it disappear ?

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

Studiesites

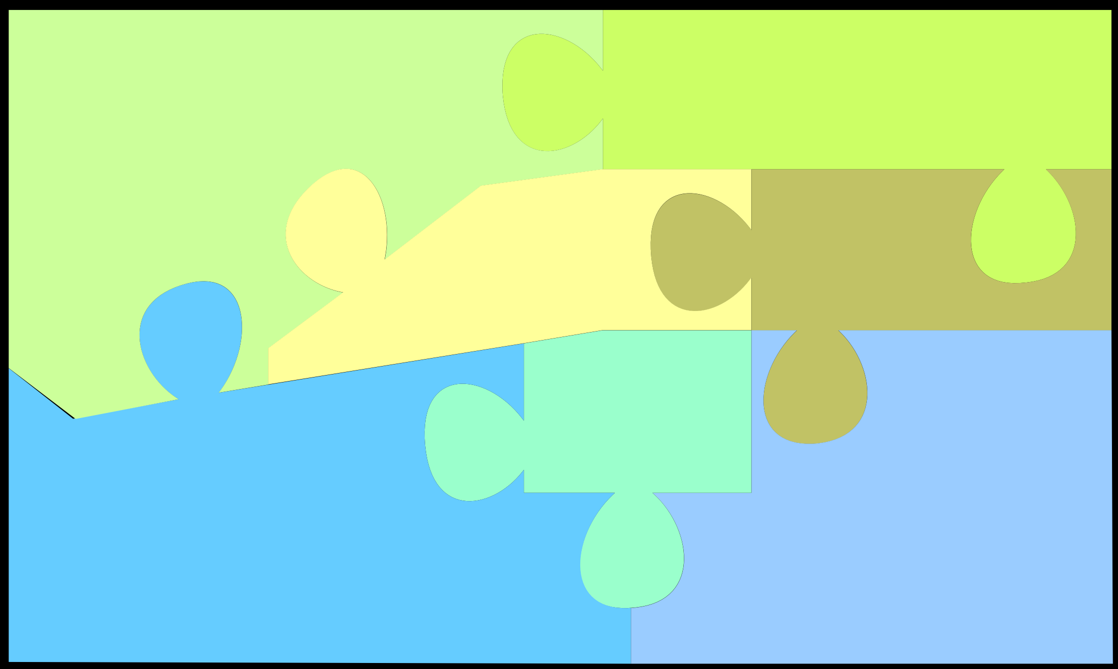
Mexico
Mauretania
Gambia
Cameroon
Tanzania
Kenya
India
Sri Lanka
Vietnam



MANGROVE management group

apna

Een geïntegreerde case-study



An integrated case-study

ıbstrates depend on binding at
ıis site, there are probably
dditional substrate recognition
tes. Another contribution to
ıbstrate selection is made by
caffold proteins, e.g. AKAP79,
hich target the phosphatase to
euronal synapses or other
ellular sites. Calcineurin also
elegates work to protein
hosphatase 1 (PP1) through a
hosphatase cascade, in which
ephosphorylation of the PP1
ıtagonists DARPP-32 or
hibitor-1 by calcineurin relieves
ıeir inhibitory effect on PP1, and
lows PP1 to act on its own
eferred substrates.

hat are its inhibitors?
yclosporin A (CsA) and FK506
nd tightly to the abundant
tracellular proteins cyclophilin A
nd FKBP12, respectively, and
e resulting ligand–protein
omplex binds to calcineurin and
npedes access of protein
ıbstrates to the active site.
ockade of a biological process
y CsA and independently by
K506 is diagnostic for
alcineurin involvement. Other
hibitors that find frequent
xperimental use are the
utoinhibitory peptide from
alcineurin and fragments of the
gulatory proteins
SCR1/MCIP/calcipressin/Rcn1p,
abin1/cain, and AKAP79.

oes it have any medical
levance? Calcineurin signalling
prominent in transplant
jection and autoimmune
sease, where the inhibitors CsA
nd FK506 are used clinically, and
being studied for its
ontribution to myocardial
ypertrophy and to virulence in
ıngal pathogens.

here can I find out more?

ramburu, J., Rao, A., and Klee, C.B. (2000). Calcineurin: from structure to function. Curr. Top. Cell. Regul. 36, 237–295.
usnak, F., and Mertz, P. (2000). Calcineurin: form and function. Physiol. Rev. 80, 1483–1521.

e CBR Institute for Biomedical
esearch and Department of Pathology,
arvard Medical School, Boston,
assachusetts 02115, USA.
mail: hogan@cbr.med.harvard.edu

Essay

How effective were mangroves as a defence against the recent tsunami?

Whether or not mangroves function as buffers against tsunamis is the subject of in-depth research, the importance of which has been neglected or underestimated before the recent killer tsunami struck. Our preliminary post-tsunami surveys of Sri Lankan mangrove sites with different degrees of degradation indicate that human activity exacerbated the damage inflicted on the coastal zone by the tsunami.

F. Dahdouh-Guebas[1*], L.P. Jayatissa[3*], D. Di Nitto[1], J.O. Bosire[4], D. Lo Seen[5] and N. Koedam[2] (* = equal contribution)

Mangrove forests have iconic status as natural ecosystems that provide services to humans. They function as breeding, spawning, hatching and nursing grounds for marine and pelagic species, and are important in the daily livelihood of local human subsistence communities. Mangrove representatives such as *Rhizophora* spp. also function as a physical barrier against tidal and ocean influences by means of their large above-ground aerial root systems and standing crop. Like many habitats, mangrove forests have been degraded and destroyed by humans, and their loss is a source of global concern. In the second half of the 20th century, 50% of the world's mangrove forests have been destroyed, and current annual loss rates vary from 1 to 20% [1]. Ironically, the great human tragedy of the recent December 26th tsunami may provide the stimulus for a better understanding of what mangrove forests can and cannot do for human well-being.

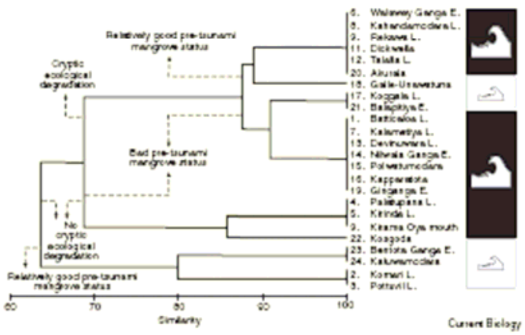


Figure 1. Dendrogram generated by a cluster analysis of the 24 mangrove sites investigated, indicating their characteristics and the impact of the tsunami (big wave, severely impacted; small wave, little impacted).

The 'mangrove status' is a combination of pre-tsunami aerial extent of the front mangrove and pre-tsunami mangrove destruction (see text). The tsunami had only a small impact on lagoons that show no cryptic ecological degradation (sites 2, 3, 23 and 24) or that are protected by the distance from the shore and by frontal *Rhizophora* spp. fringes (sites 17, 18 and 21). The lagoons are numbered clockwise from East to West, to emphasize that damage was not linked to geographic position in view of tsunami wave energy. A map overview of all lagoons can be found in Jayatissa *et al.* [18], with the exception of Batticaloa, Komari and Potuvil, which are located at the easternmost extremity of the island. L, Lagoon; E, Estuary.

Vrije Universiteit Brussel

How effective were mangroves as a defence against the recent tsunami?

Farid Dahdouh-Guebas, Loku P. Jayatissa, Diana Di Nitto, Jared O. Bosire, Danny Lo Seen & Nico Koedam

MANGROVE management group

Journal highlight in *Current Biology* 15(12), 21 June 2005

apna

Systematics and Biodiversity 2 (2): 113–119
DOI: 10.1017/S1477200004001422 Printed in the United Kingdom
Issued 25 January 2005

**Farid Dahdouh-Guebas[1,*]
Elly Van Hiel[1],
Jonathan C.-W. Chan[2], Loku
Pulukkuttige Jayatissa[3] &
Nico Koedam[1]**
[1] (Biocomplexity Research Team), Laboratory of General Botany and Nature Management, Mangrove Management Group, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium
Email: fdahdouh@vub.ac.be
[2] Department of Electronics and Information Processing, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium
[3] Department of Botany, University of Ruhuna, Matara, Sri Lanka

submitted June 2003
accepted April 2004

Qualitative distinction of congeneric and introgressive mangrove species in mixed patchy forest assemblages using high spatial resolution remotely sensed imagery (IKONOS)

Abstract This paper is a preliminary report of the ability of IKONOS multispectral satellite imagery with a very high spatial resolution of 1 metre to distinguish two mangrove species in Sri Lanka belonging to the same genus (*Rhizophora apiculata* and *R. mucronata*). Not only is this an advancement for the monitoring of forests, it is even more important considering their patchy nature in Sri Lankan mangroves (in contrast to classically zoned forests). Apart from congeneric distinction, introgressive species (*Acrostichum aureum*) can also be detected from IKONOS imagery, which is important in the early warning for cryptic ecological changes that may affect mangrove species composition (both floral and faunal) and functioning. The results tabulate the usage of various image composites, transformations and classifications, and indicate the danger of too much detail in remote sensing, and the need to apply an optimum resolution. We also highlight that the highest resolutions (as in pansharpened multispectral composites) remain invaluable for visual ecological investigations, which are not at all outdated by new digital satellite images of (sub)metre spatial resolution and their possibility for computer-aided analysis.

Key words mangrove, remote sensing, resolution, introgression, IKONOS, *Acrostichum*, *Rhizophora*, Sri Lanka

Introduction

The assessment of the condition of the Earth's surface and atmosphere is primarily based on air- and space-borne imagery and ground truth. Until the launch of the IKONOS sensor (24 September 1999), remote sensing-based research on the current status of, and the changes in, biodiversity and ecosystems was limited to delineation of large, homogeneous assemblages, or to recognition of higher taxonomic levels, either because of the spatial, or the spectral, resolution of the imagery (Dahdouh-Guebas, 2002). On one hand globally available multispectral satellite imagery had a spatial resolution of 10 m to 30 m, too coarse to distinguish individual trees. On the other hand, aerial photography had a very good spatial resolution (20–30 cm), but it was not multispectral. There are, however, some recent evaluations of the usefulness of the compact air-borne spectrographic imager (CASI) and of its applications (Mumby *et al.*, 1997, 1998; Green *et al.*, 1998), but this type of multispectral imagery is not globally available, and is very expensive to acquire (Mumby *et al.*, 1999). With the first commercial high-resolution satellite imagery from IKONOS, the first attempt was made to combine a very high spatial resolution (panchromatic: 1 m; multispectral: 4 m) with a good spectral resolution (panchromatic: 0.45–0.90 μm; blue: 0.45–0.53 μm; green: 0.52–0.61 μm; red: 0.64–0.72 μm; near-infra-red: 0.77–0.88 μm) on a global scale. In addition, IKONOS has a very high temporal resolution (*ca.* 2.9 day revisit time for data with the above qualities) and a high radiometric resolution (11 bit quantization). This paper deals with the 'taxonomic (or floristic) resolution', which we define as '*the taxonomic level to which biological identification can be performed using a remotely sensed image*'. This may be applied and extrapolated to a range between the distinction of large biomes or land-cover classes on global and regional scales on one hand, and ecosystems, assemblages, genera or even species and individuals on local scales on the other hand.

Here, we report, first, the invaluable distinction of congeneric species that contribute to complex mixed assemblages

* Corresponding author

Vrije Universiteit Brussel

Qualitative distinction of congeneric and introgressive mangrove species in mixed patchy forest assemblages using high spatial resolution remotely sensed imagery (IKONOS)

**Farid Dahdouh-Guebas,
Elly Van Hiel, Jonathan C.-W. Chan,
Loku P. Jayatissa & N. Koedam**

MANGROVE management group

Systematics and Biodiversity **2(2): 113-119**

apna

Vrije Universiteit Brussel

Transitions in ancient inland freshwater resource management in Sri Lanka affect biota and human populations in and around coastal lagoons.

**Farid Dahdouh-Guebas, Sanath Hettiarachchi,
Danny Lo Seen, Okke Batelaan,
Loku Pulukkuttige Jayatissa & Nico Koedam**

MANGROVE management group

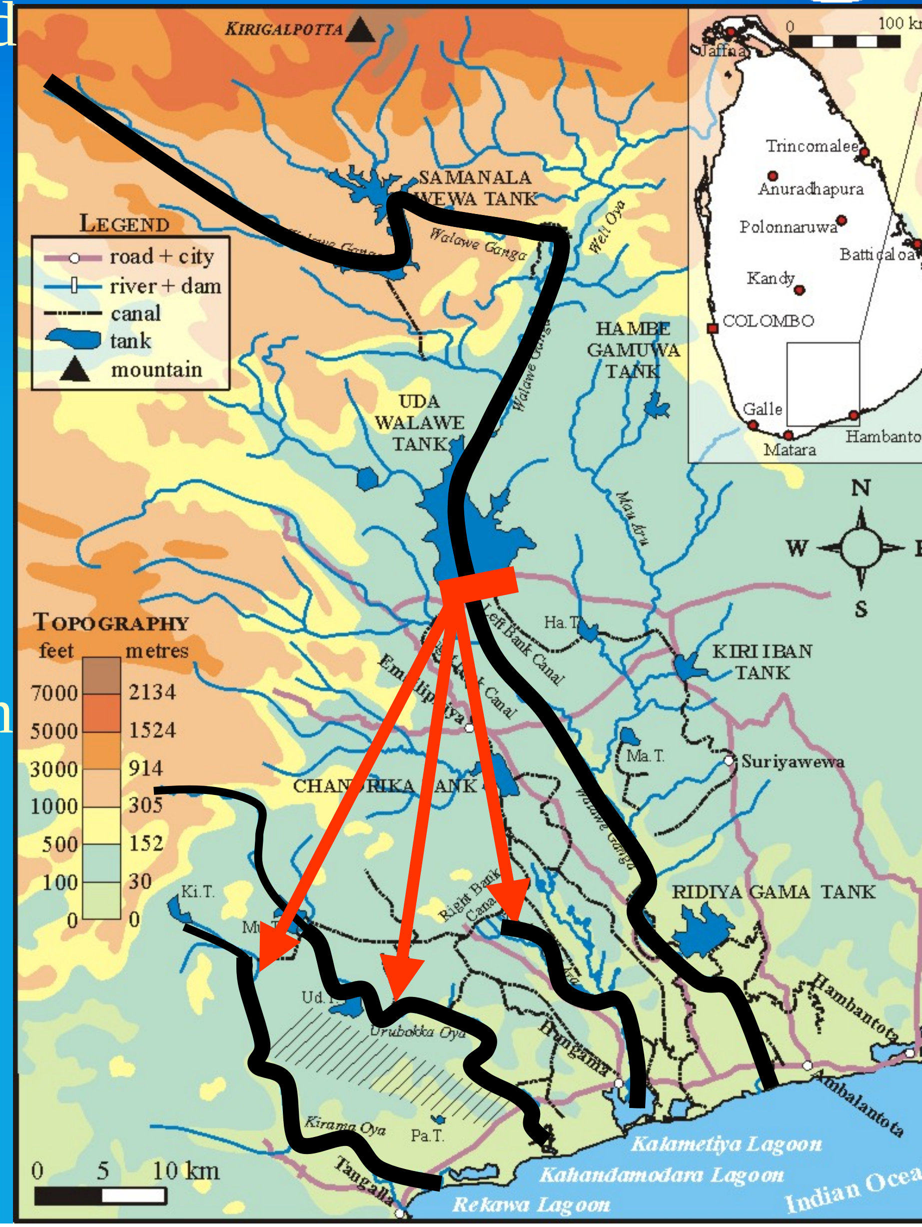
Cover paper of *Current Biology* 15(6), 29 March 2005

apna

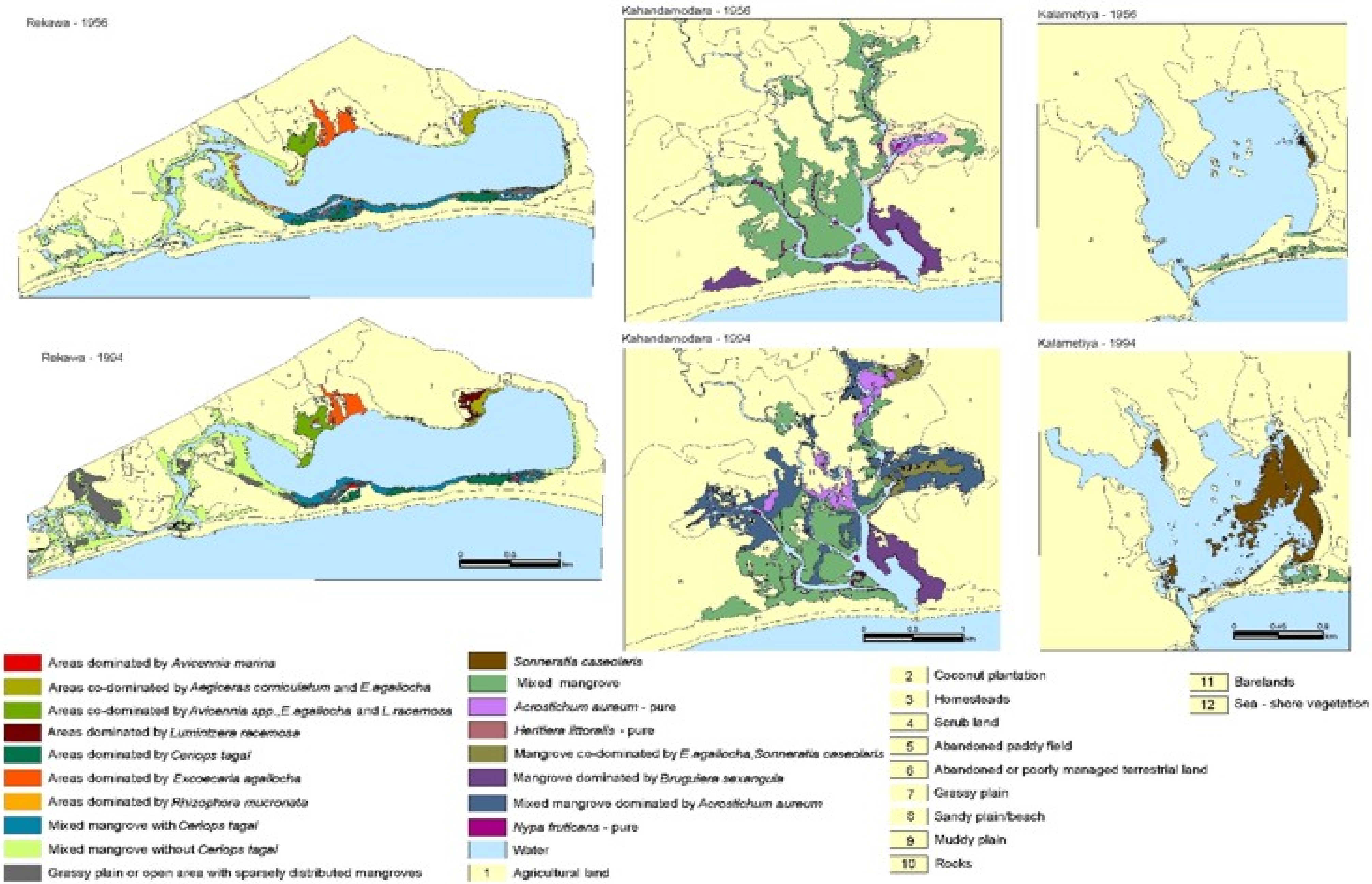
Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Problem situation

- lake-sized water reservoirs sustained highly developed ancient irrigation cultures in Sri Lanka for millenia;
- contemporary hydrological projects increasingly divert entire river systems for freshwater management;
- 1967 : Udawalawa project
- diversion of water to agricultural lands (paddy fields)
- increased nutient inflow and sedimentation
- siltation of the lagoon mouth
- hydrological, sedimentological and salinity changes converted the brackish lagoon into a freshwater body



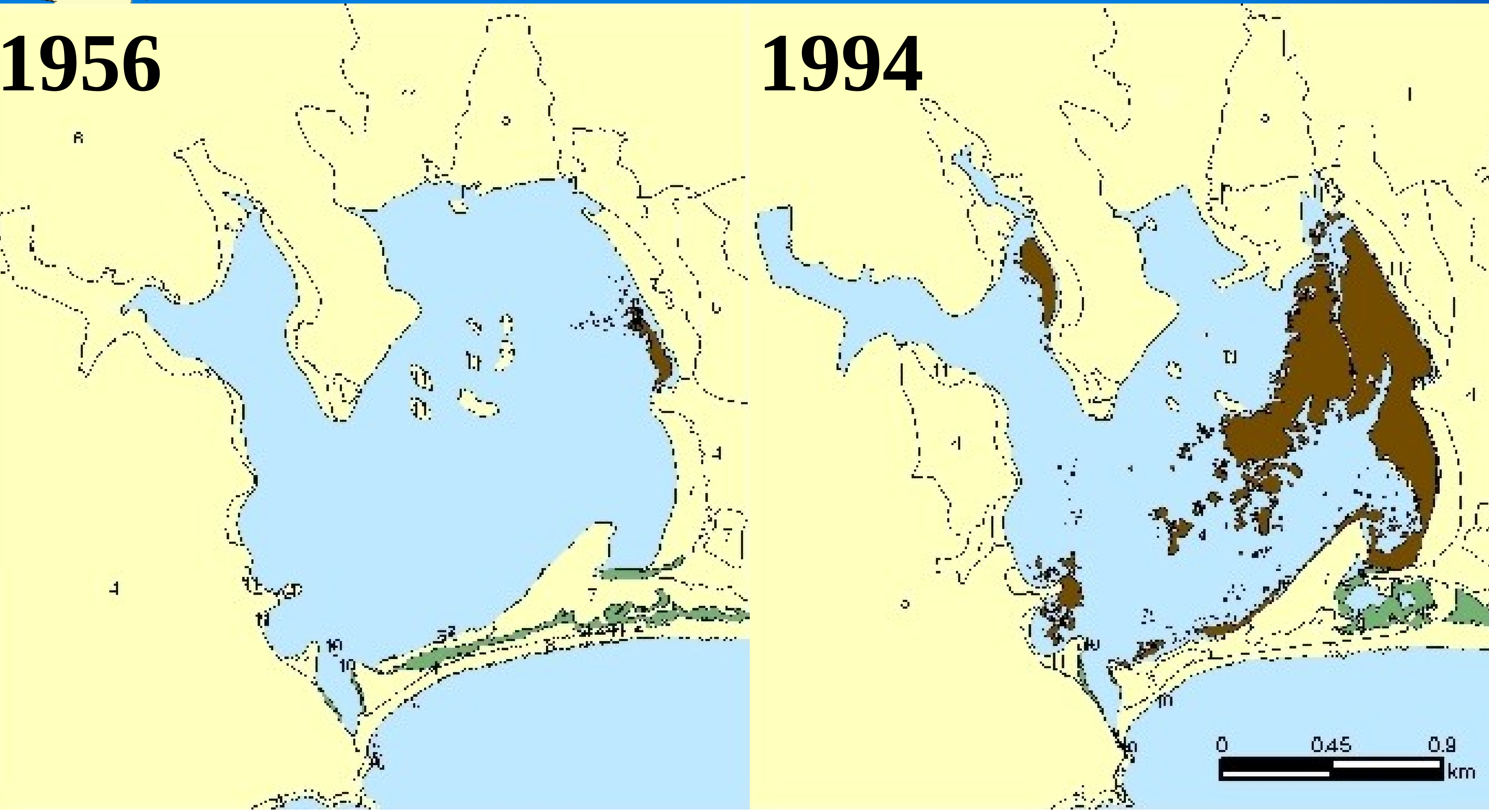
MANGROVE management group



Rekawa - 1956
Kahandamodara - 1956
Kalametiya - 1956
Rekawa - 1994
Kahandamodara - 1994
Kalametiya - 1994
Areas dominated by Avicennia marina
Areas co-dominated by Aegiceras corniculatum and E.agallocha
Areas co-dominated by Avicennia spp., E.agallocha and L.racemosa
Areas dominated by Lumnitzera racemosa
Areas dominated by Ceriops tagal
Areas dominated by Excoecaria agallocha
Areas dominated by Rhizophora mucronata
Mixed mangrove with Ceriops tagal
Mixed mangrove without Ceriops tagal
Grassy plain or open area with sparsely distributed mangroves
Sonneratia caseolaris
Mixed mangrove
Acrostichum aureum - pure
Heritiera littoralis - pure
Mangrove co-dominated by E.agallocha, Sonneratia caseolaris
Mangrove dominated by Bruguiera sexangula
Mixed mangrove dominated by Acrostichum aureum
Nypa fruticans - pure
Water
1 Agricultural land
2 Coconut plantation
3 Homesteads
4 Scrub land
5 Abandoned paddy field
6 Abandoned or poorly managed terrestrial land
7 Grassy plain
8 Sandy plain/beach
9 Muddy plain
10 Rocks
11 Barelands
12 Sea - shore vegetation

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Close-up of Kalametiya Lagoon

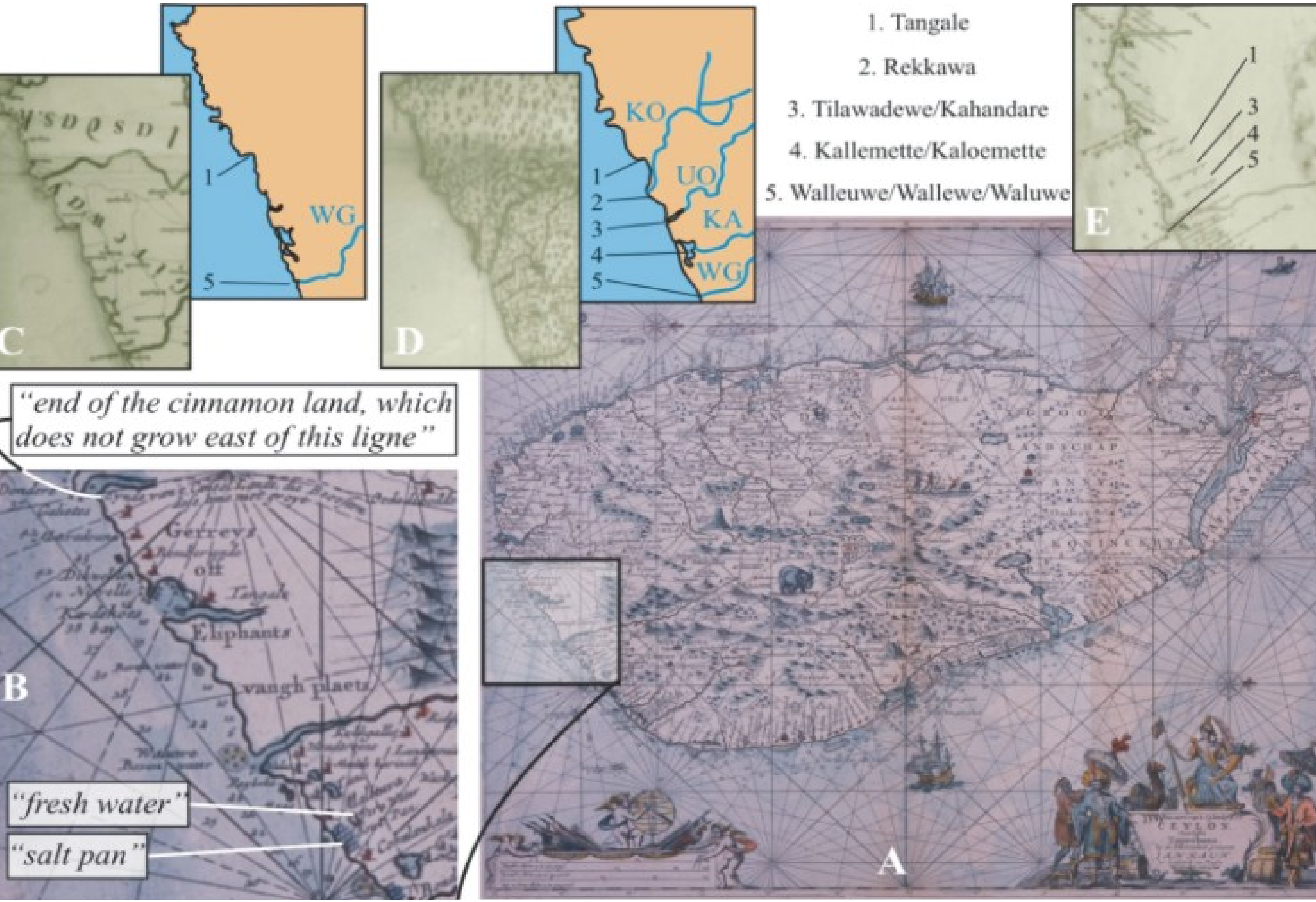


Observed ecologic changes

Are the changes due to transitions in inland water management?

- has local anthropogenic impact decreased ? No !
- was there an artificial re-afforestation program ? No !
- is there a natural dynamism ? Yes but no !

  - mangroves may display strong spatio-temporal dynamics;
  - relative increase of this magnitude have never been reported;
  - mangrove canopy turnover takes hundreds of years under natural conditions (Chen & Twilley, 1998; Sherman *et al*., 2000);


1. Tangale
2. Rekkawa
3. Tilawadewe/Kahandare
4. Kallemette/Kaloemette
5. Walleuwe/Wallewe/Waluwe
C
D
E
KO
UO
KA
WG
1
2
3
4
5
"end of the cinnamon land, which does not grow east of this ligne"
Gerrevs
off
Tangale
Eliphants
vangh plaets
"fresh water"
"salt pan"
B
A

Calculated hydrologic changes

Are the changes due to transitions in inland water management ? Hydrological evidence :

$$Q_W(t_0) - Q_W(t_1) \approx E_{UWS} + \sum_{i=1}^{3} RF_i$$

Qw = the discharge of the main river before (t_0) and after (t_1) dam construction;
E_{UWS} = evapotranspiration large water reservoirs and irrigation scheme (UWS);
RFi is the return flow from the UWS to the three rivers feeding the lagoons;

$$RF_i = \left\lfloor ID_{UWS} - \left(IS \times ET_{paddy}\right)\right\rfloor \times EPRF_i$$

ID_{UWS} = irrigation demand of the irrigation scheme;
IS = irrigation surface;
ET_{paddy} = evapotranspiration for rice fields;
EPRFi = estimated proportion of return flow from irrigation scheme to river *i*.

Reported socio-economic changes

Is there socio-economic evidence ?

Questionnaire survey :

- period of living in association with the lagoon
- occupation
- source of water used for subsistence needs
- involvement in lagoon fisheries, fishermen demography
- fisheries catch (species, quantity)
- other uses of the lagoon
- fauna and flora in the lagoon ecosystem
- lagoon mouth dynamics
- identity and age
- sources of family income

Source : Dahdouh-Guebas (ed.) (2002)

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Reported socio-economic changes

Is there socio-economic evidence ?

BEFORE changed hydrography	PRESENT situation
lagoon water **not used** for drinking, bathing or washing	lagoon water **used** for bathing and washing
people collected **crystallized salt** from the lagoon for cooking	**no crystallization** of salt, even during severe droughts
seasonal shellfish catch was in **1000s** of individuals per unit effort	seasonal shellfish catch is in a **few** individuals per day
shellfish sale was in volumes of **basketfuls**	if sold, shellfish priced **by number**
commercially important fish were mainly **marine/brackish/coastal** water species	**freshwater** fish species with no commercial value caught in lagoon fisheries
>25 families were involved in lagoon fisheries for a living	**only 6** families involved in lagoon fisheries for personal consumption

Observed ecologic changes

Are all plants in the mangrove environment true mangrove species ?

Vulnerable mangrove species	Resistant mangrove species	Mangrove associates
• typical of mature stands • stenotopic (salt) • valuable • vulnerable • functional	• pioneering species, less typical of mature stands • eurytopic (fresh) • less valuable • disturbance resistant • how functional ?	• terrestrial • introgressive • invasive
Rhizophoraceae	*Avicennia, Excoecaria*	*Acrostichum*

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Observed ecologic changes

Is the mangrove expansion good ? No !

!!! Cryptic ecological degradation !!!

Lagoon	Mangrove Species/assemblage	Area in 1956	Area in 1994 (ha) and areal change with respect to 1956 (%)
Rekawa	A.spp+E.aga+A.cor	12.9	38.2 (+196.1 %)
	Mixed mangroves	90.3	94.3 (+4.4 %)
	All mangroves	103.2	132.5 (+28.4 %)
Kahandamodara	*Acrostichum aureum*	44.2	70.2 (+58.8 %)
	Mixed mangroves	89.3	95.3 (+6.7 %)
	All mangroves	133.5	165.5 (+24.0 %)
Kalametiya	*Sonneratia caseolaris*	4.5	139.0 (+2988.9 %)
	Mixed mangroves	19.5	17.0 (-12.8 %)
	All mangroves	24.0	156.0 (+550.0 %)

Socio-ecologic functionality

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Are there novel socio-economic consequences ?

- Yes, Mangrove apple juice, jam and ice cream
- But do they outbalance the functions lost ?
  - fuelwood, timber and non-timber products;
  - ecological key role;
  - fisheries;
  - physical barrier against ocean influences.

Farid Dahdouh-Guebas

MANGROVE management group

apna

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Barrièrefunctie van mangroven

- 26 December 2004 : tsunamiramp in Indische Oceaan :
- mangroven kunnen een fysische bescherming bieden tegen getijde-golfslag, zeeniveaustijging, cyclonen, tsunamis, overvloedige regenval (vb. El-Niño) en rivierafstroming;
- hebben mangroven deze functie vervuld tijdens de tsunami ?
- ‘crime scene investigation’ van een natuurlijk experiment;
- probleem : bestaande mangroven zijn zelden ongerept;
- menselijke impact op mangroven : omzetting naar garnaalkwekerijen, toeristische resorts,…
- preliminaire vergelijking van pre-tsunami toestand van het woud en schade door de tsunami;

MANGROVE management group

apna

Barrièrefunctie van mangroven

26 December 2004 : tsunamiramp in Indische Oceaan :

A. pre-tsunami oppervlakte van de frontale mangroven (voorste 500m, een conservatieve band die mogelijk bescherming biedt tegen een tsunami);
B. de hoeveelheid mangroven vernietigd vóór de tsunami;
C. de ‘natuurlijkheid’ van de mangrove, in functie van ontbossing en cryptische ecologische degradatie;
D. tsunamischade aan de voorste mangroven; en
E. tsunamischade aan levens en eigendommen in het achterliggende mangrovewoud en in de kustzone achter de mangroven.

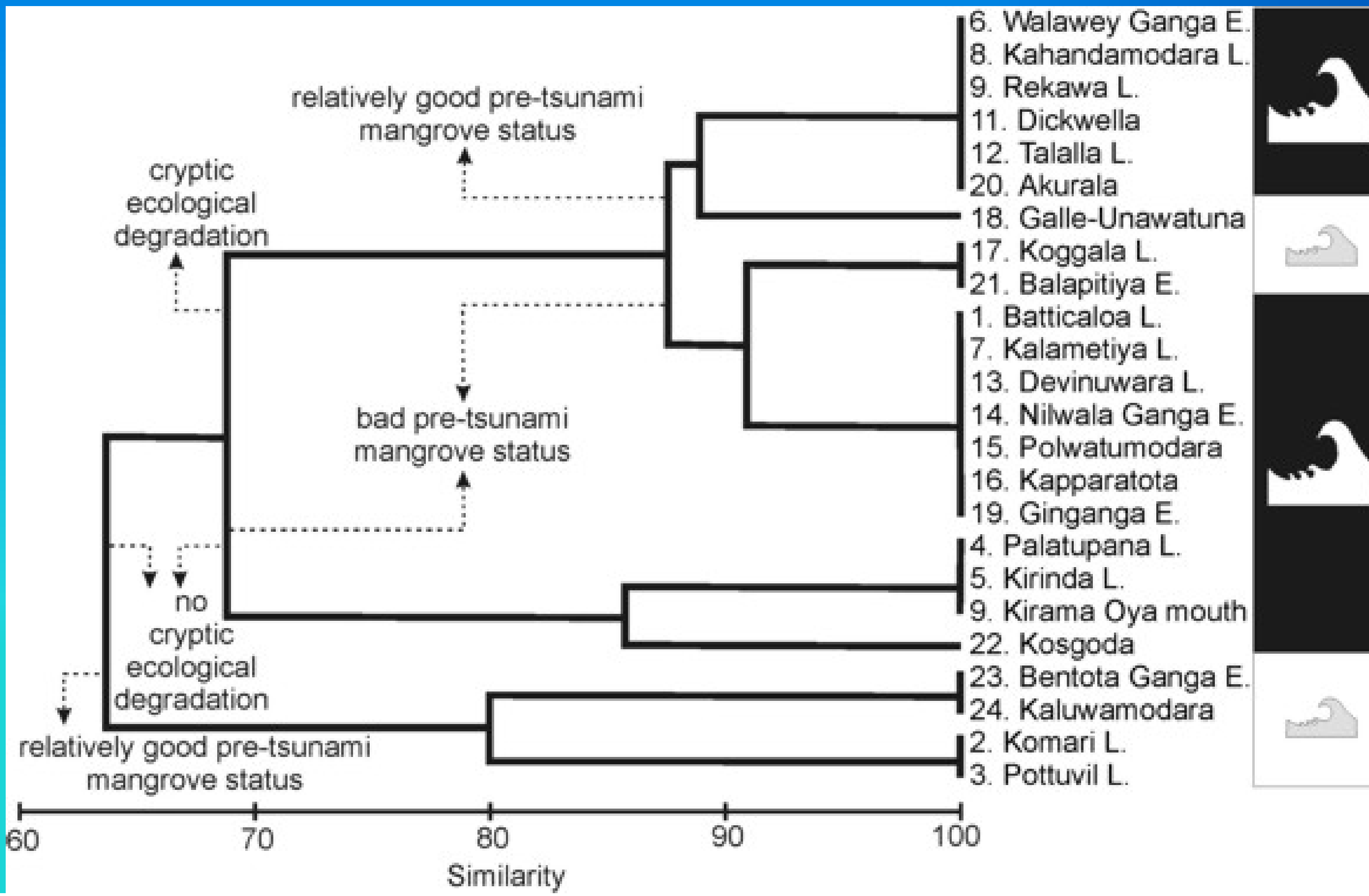
Combinatie van deze karakteristieken in pre-tsunami mangrove status (A+B), aanwezigheid van cryptische ecologische degradatie (C), en tsunamischade (D+E) :

Spatio-temporal dynamics : how and why ?
Biocomplexity Research Team

Barrièrefunctie van mangroven

Clusteranalyse (groep-gemiddelde) op basis van Bray-Curtis similariteit :

Source : Dahdouh-Guebas *et al.* (2005c)



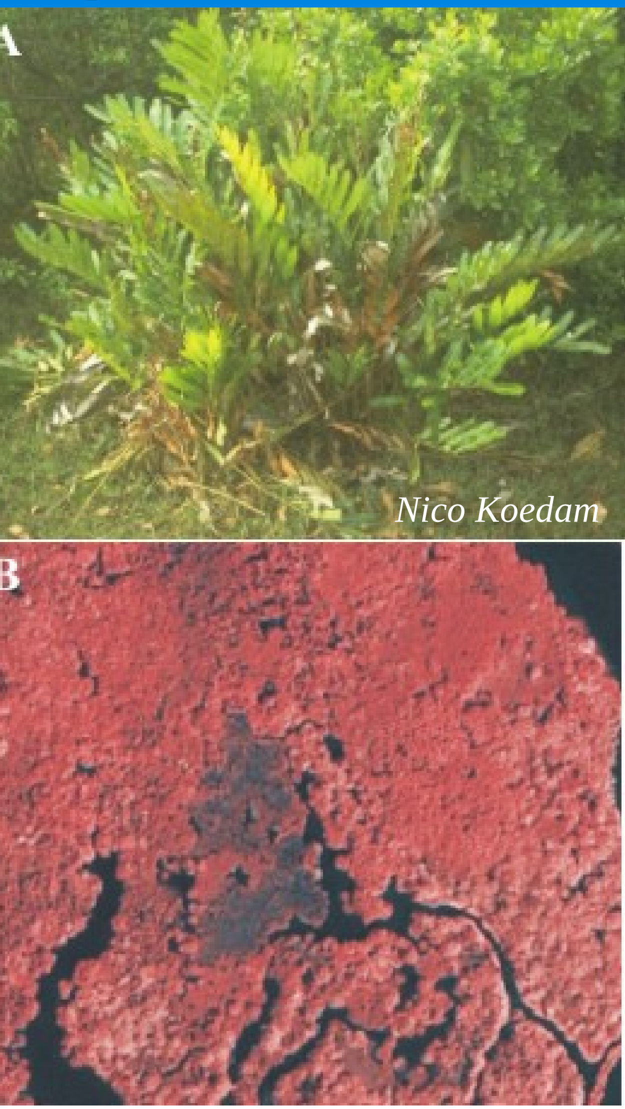
MANGROVE management group

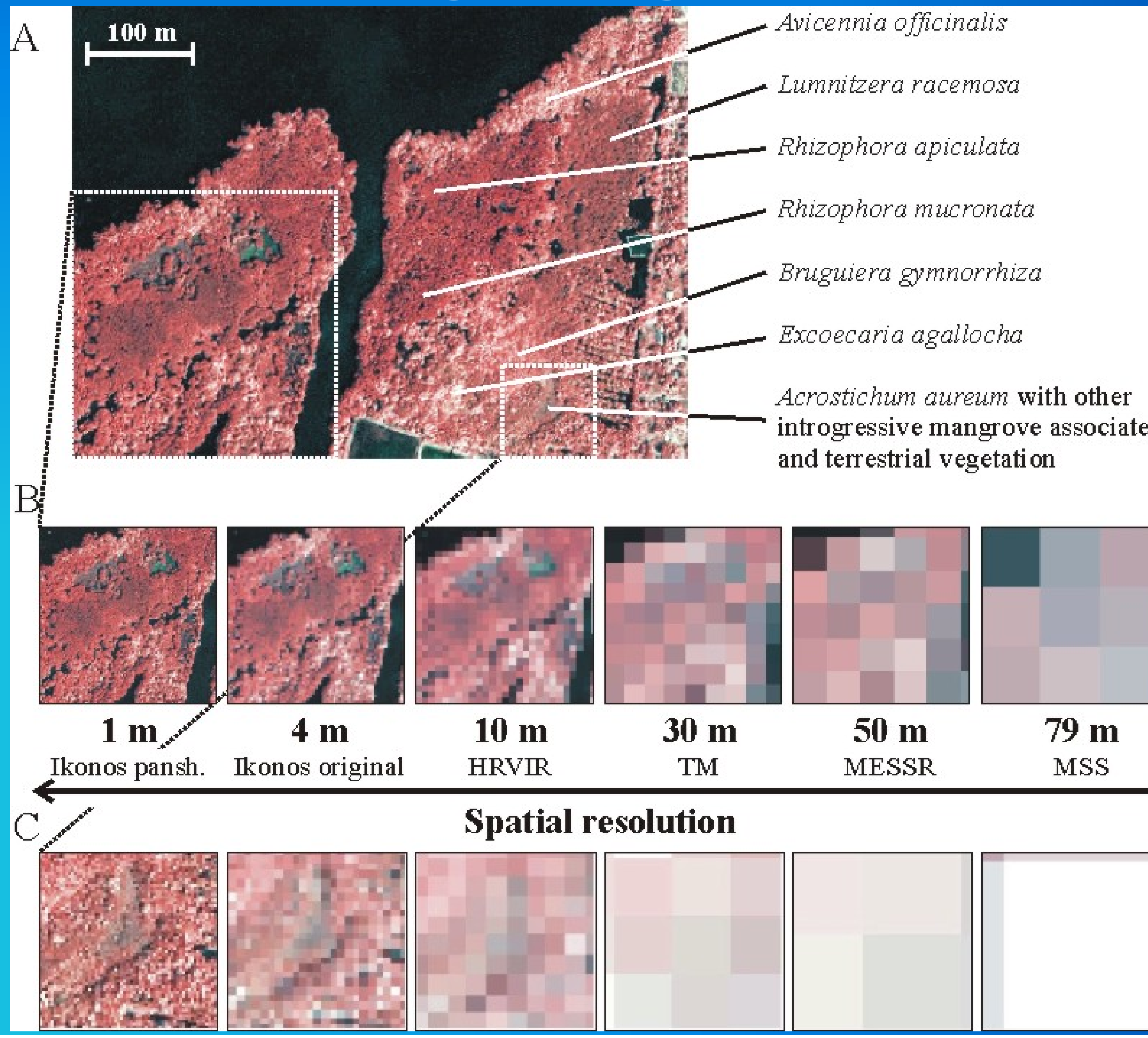
Barrièrefunctie van mangroven

Photographs by Loku P. Jayatissa

Noodzaak voor…

- Waarschuwingssysteem voor mangrovedegradatie;





Noodzaak voor…

- Waarschuwingssysteem voor mangrovedegradatie;

- Voortgezet onderzoek naar barrièrefunctie (worteltypes, vegetatie-formaties, kustmorfologische condities…)

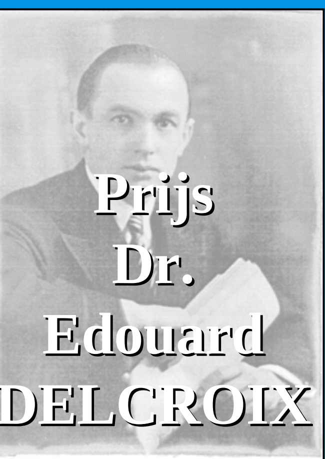
- Inzicht in spatio-temporele dynamiek van mangroven, zowel natuurlijk als anthropogeen;

- Veerkracht, responstijd, functionaliteit, stabiliteit van mangroven in natuurlijke situaties, onder menselijke beïnvloeding, bij chronische veranderingen en bij stochastische natuurrampen.

Spatio-temporal dynamics : how and why ?

Biocomplexity Research Team

Contact details



Farid DAHDOUH-GUEBAS
Vrije Universiteit Brussel
Biocomplexity Research Team
c/o Laboratory of General Botany and Nature Management (VUB-APNA-WE)
Pleinlaan 2, B-1050 Brussel

Tel. +32 2 629.34.22 **Fax. +32 2 629.34.13**

E-mail : fdahdouh@vub.ac.be

URL :
www.vub.ac.be/APNA/research/biocomplexity.html
www.vub.ac.be/APNA/staff/FDG/fdg.html

MANGROVE management group

apna