Vegetation structure at Zhanjiang Mangrove National Nature Reserve (ZMNNR), P.R. China: comparison between original and non-original trees using ground-truth, remote sensing and GIS techniques

J.S. Durango-Cordero[1], B. Satyanarayana[1,2], J. Zhang[3], J. Wang[4], M. Chen[3], X. Fanghong[3], J.C.W. Chan[5], L. Kangying[3], J. Bogaert[6], N. Koedam[1] & F. Dahdouh-Guebas[1,2]

[1] Laboratory of Plant Biology and Nature Management. Mangrove Management Group. Vrije Universiteit Brussel-VUB. Pleinlaan 2. B-1050 Brussels. Belgium
[2] Laboratory of Systems Ecology and Resource Management. Département de Biologie des Organismes. Faculté des Sciences. Université Libre de Bruxelles-ULB. B-1050 Brussels. Belgium
[3] Administration Bureau of Zhanjiang Mangrove National Nature Reserve (ZMNNR). Huguang township. Mazhang District. Zhanjiang City. 524088 Guangdong Province. P.R. China
[4] Guangdong Ocean University (GDOU). Xiashan District. Zhanjiang City. 524025 Guangdong Province. P.R. China
[5] Department of Geography. Vrije Universiteit Brussel-VUB. Pleinlaan 2. B-1050 Brussels. Belgium
[6] Biodiversity and Landscape Unit. Université de Liège. Gembloux Agro Bio Tech. Passage des Déportés 2. B-5030 Gembloux. Belgium

Introduction

The present study was conducted to help future genetic studies in different mangrove populations at Leizhou Peninsula (China).

The mangrove plantation schemes were carried out in 1990s. but with no record on its exact position. So going through the past records is tedious and time consuming.

General objective

To create and test the methodology for distinguishing *Original* trees (before planting schemes) from *Non-Original* trees. i.e. planted trees or trees that have naturally established after interaction between planted and non-planted trees (for instance through pollination).

Fig. 1: Original and non-original mangrove stands

Specific objectives

1. Can we identify original mangrove patches? If so. what are the trees constituting original mangrove populations? An approach based on time-series satellite data and ground inventory.
2. To compare vegetation structure between original and non-original mangrove patches.
3. To identify the mangrove cover change.

Methodology

1. Satellite data:
   - Corona (mono-band) declassified images of 1967 and 1971
   - Landsat 2000 image
   - GeoEye-1 (multi-spectral) 2009 image

2. ArcGIS 9.3.1: On-screen digitization for the mangrove areas overlapped between 1967 and 2009.

3. Ground-truth: 5x5m plots from 1967 vegetative (Om) areas and the remaining (2009) (Nom) forest (Fig. 2).
   - In each plot. the tree structural parameters such as density (ind. ha^{-1}). basal area (m^2. ha^{-1}). height (m). and Complexity Index (CI). were estimated.

4. Statistical analyses: PRIMER v.6 for Bray-Curtis similarity and Non-metric Multidimensional Scaling plots.

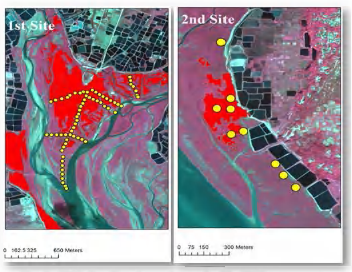


Fig. 2: 2009 GeoEye-1 overlapped with 1967 mangrove layer from 1967.

1967 Original forest — Non-Original forest in 2009 — Sample plots

Results and Discussion

- In total. 76 plots were investigated (Fig. 2).
- *Aegiceras corniculatum* is the dominant species (42%). followed by *Bruguiera gymnorrhiza* (17%). *Rhizophora stylosa* (16%). *Kandelia candel* (5%). and *Sonneratia apetala* (3%) in the vicinity.
- *S. apetala* was planted by ZMNNR officials and hence not considered for data analysis. in terms of original and non-original trees separation.
- While a strong association was observed between *Avicennia marina* and *A. corniculatum; R. stylosa* formed ure stands.
- Looking at the higher variance among *A. corniculatum* and *R. stylosa.* we divided them into two categories each –
  - Tall *A. corniculatum* (mean height. 2.08m)
  - Small *A. corniculatum* (mean height. 1.7m)
  - Tall *R. stylosa* (mean height. 3.9m)
  - Small *R. stylosa* (mean height. 2.1m)
- Among others. tree height. basal area and density were found important for discriminating the *Original* and *Non-Original* mangrove stands.

Similarity between *Original* and *Non-Original* sites/forest types :

Fig. 3a: *Mean height (m)* *Group average*

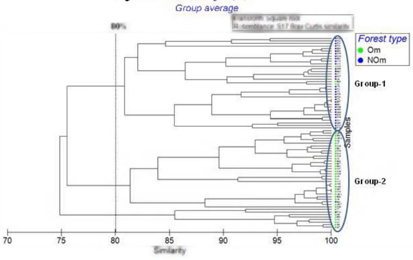


Fig. 3b: *Basal Area (m^2.ha^{-1})* *Group average*

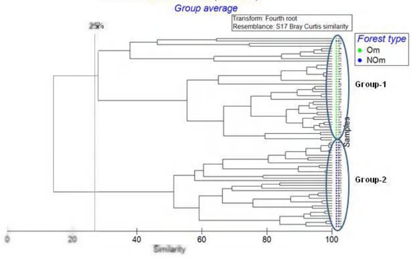
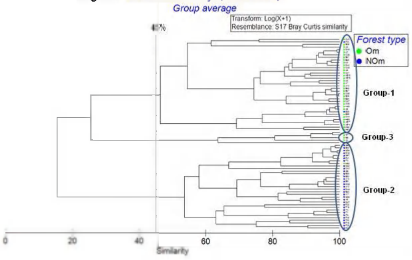


Fig. 3c: *Absolute Density (# ind. ha^{-1})* *Group average*



- Based on tree height and basal area estimates. it was possible to demarcate 2 groups clearly separating the original from non-original trees (Fig. 3a-b).
- In the case of density (Fig. 3c). the 3rd group is the result of estimates (from the area what we believe as old forest) less than that of original type.

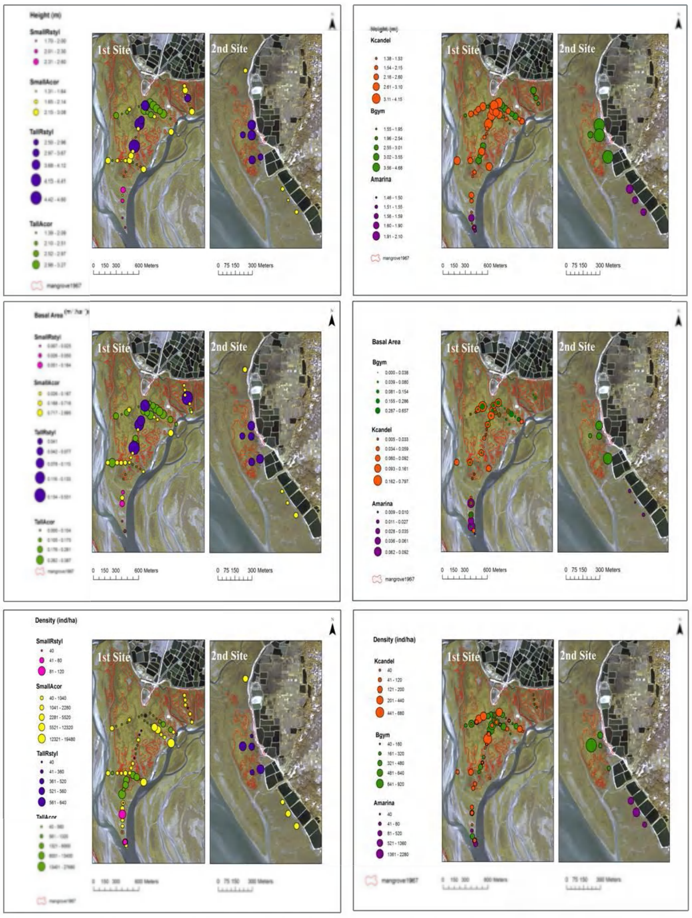


Fig. 4: Spatial distribution of mangroves (SmallRstyl = Small *R. stylosa;* TallRstyl = Tall *R. stylosa;* SmallAcor = Small *A. corniculatum;* TallAcor = Tall *A. corniculatum;* Bgym= *B. gymnorrhiza.* Kcan = *K. candel;* Amarina = *A. marina*)

- The species' distributional patterns (Fig. 4) have indicated that Om areas are in a state of maturity (total density. 1.868-9.327 ind. ha^{-1} & total basal area. 0.83-1.252 m^2 ha^{-1}). and representing the characteristics of less disturbed forest.
- Similarly. high Complexity Index values were obtained from Om stands.
- In addition. the sequential satellite imageries (1967-1971-2000-2009) revealed an increase of 347% of mangrove cover between 1967 and 2009.

Year	1967	1971	2000	2009
Area (ha)	235.76	231.43*	594.37	818.19
Change (%)	-	-1.84	+252.11	+347.04

Conclusions

- The results suggest that the methodology is straight forward for distinguishing Om stands from Nom stands. whereby dominant or bimodal species are categorized by their differences in height.
- There is a considerable difference in species composition from Om areas to Nom areas as well as from the 1st site to the 2nd site.
- In general. heights are larger in Om areas. lower in Nom areas. Basal areas are high in Om areas and lower in Nom areas. Densities are also high as moving from Om areas to Nom areas. however. less clearer than the other parameters tested.

Acknowledgements

The present work was conducted with the help of F.R.S.-F.N.R.S. Scientific Project on Gaoqiao mangroves under the jurisdiction of ZMNNR. China. Authors are grateful to the continued collaboration between VUB. ULB and Guangdong Ocean University.