



Assessing Mangrove Carbon Pools in the Zambezi Delta

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Background - USFS

- **USDA Forest Service**
 - U.S. Department of Agriculture
 - Multiple Use Strategy
 - Manages about 80 million hectares of forest and grassland
 - Protected areas (wilderness), forest concessions, recreation areas, tourist destinations, buffer-zones, hunting areas, community mosaics, rangelands
- **USFS International Programs Office**
 - International mandate and USAID collaboration
 - Four Departments: Technical Cooperation, Disaster Management, Policy, Migratory Species
 - Working in 5 continents and over 20 countries in Africa
 - Program support in diverse technical areas



Background

USAID GCC Program + USFS

- **USAID/USFS GCC Mozambique Program**
 - pilot land-use planning strategies as effective and comprehensive measures towards long-term, integrated land-use planning necessary for the implementation of REDD
 - establish Monitoring, Reporting, and Verification (MRV) pilot sites, and develop replicable methodologies for forest inventories and carbon measurement in Mozambique, focusing on forest concessions areas and Private-Public Partnerships
 - develop replicable methodologies and baseline data for determination of the carbon stocks of mangrove forests and associated land uses in the Zambezi Delta region of Mozambique
- **Additional USFS support to Africa Mangrove work on horizon**



USAID/SWAMP Program

Sustainable Wetlands Adaptation and Mitigation Program (SWAMP)

formerly called Tropical wetlands initiative for climate adaptation and mitigation (TWINCAM)



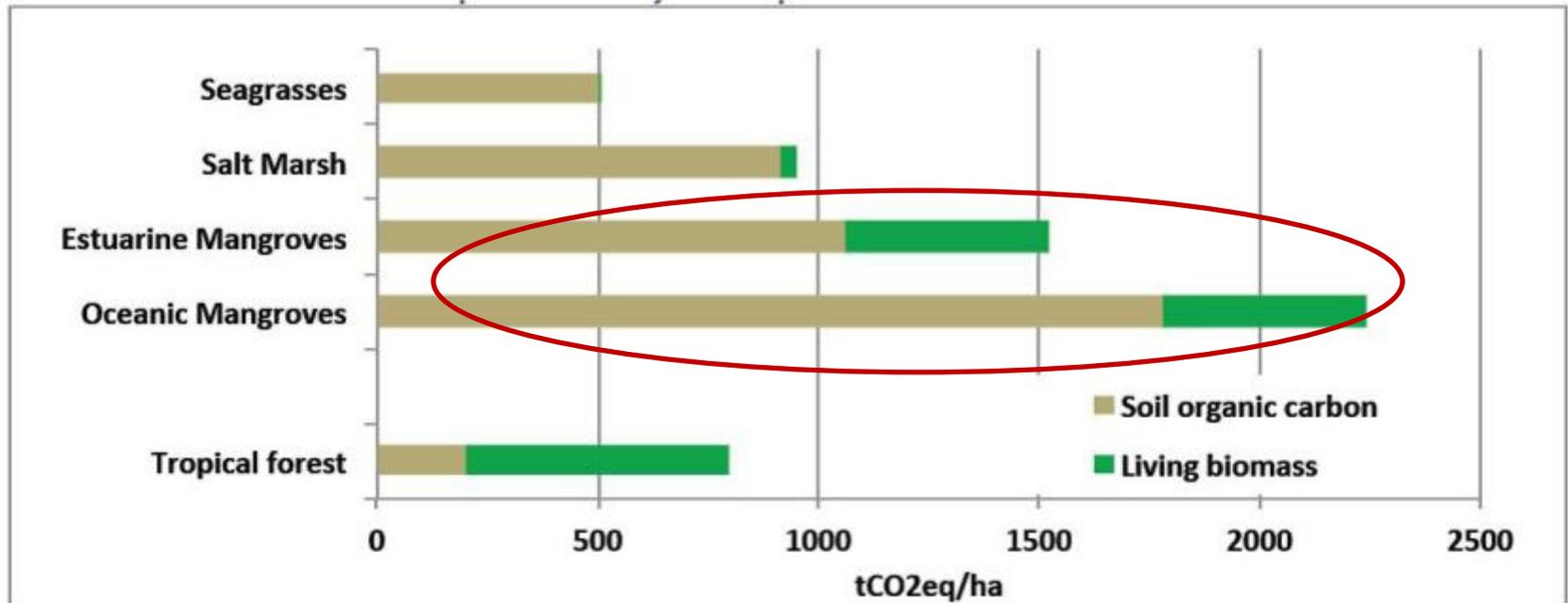
- Partnership with Center for International Forestry Research (CIFOR) and supported by USAID/E3 (GCC-SL)
- Advancing the science and knowledge of MRV and greenhouse gas emissions specific to tropical wetlands
- Creating networks of permanent forest plots and professional staff designed to fill critical knowledge gaps in wetland carbon dynamics.
- Building capacity and outreach of regional academic and research counterparts for scientific inquiry and climate change research





The Carbon Density of Mangroves is Higher than other Marine or Terrestrial Systems

However, there is considerable uncertainty in the estimates of pools and fluxes.

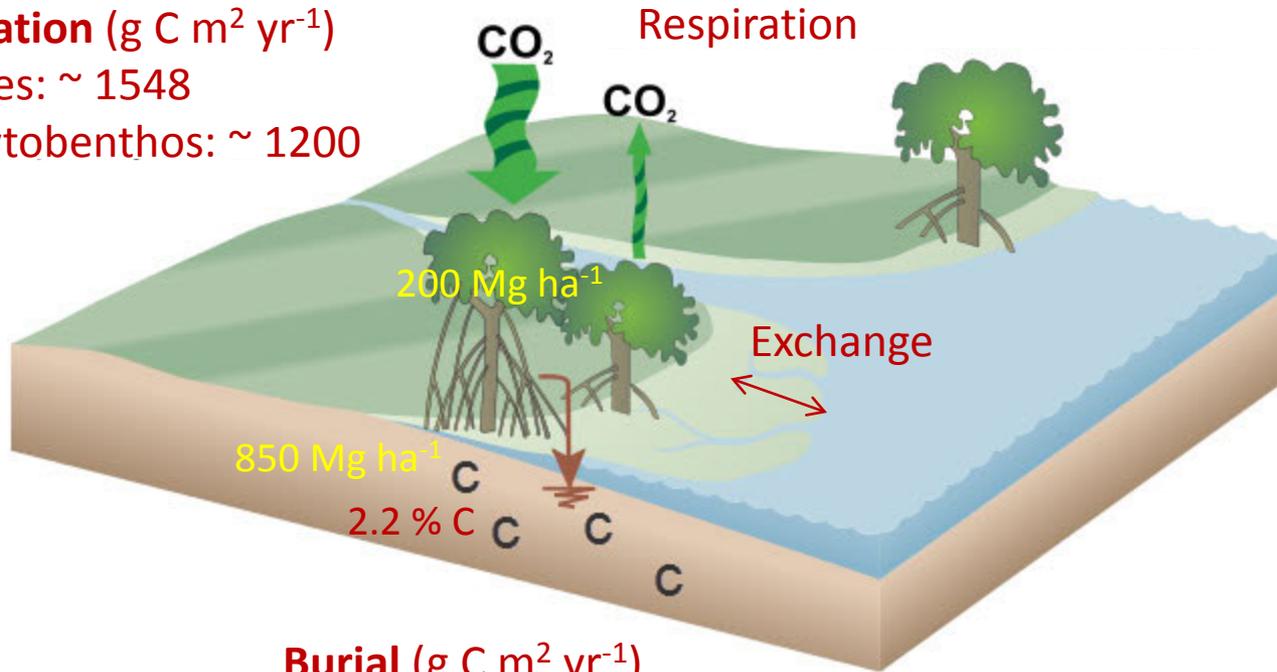


*Data is per unit area, where tCO₂eq/ha is tons of carbon dioxide equivalents per hectare

Source: Murray, Brian, Linwood Pendleton, W. Aaron Jenkins, and Samantha Sifleet. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NIR 11-04

Mangroves – A Carbon-rich Ecosystem

Sequestration ($\text{g C m}^2 \text{ yr}^{-1}$)
Mangroves: ~ 1548
Microphytobenthos: ~ 1200



Burial ($\text{g C m}^2 \text{ yr}^{-1}$)
Sediments: ~ 120

Metrics from: Kristensen et al. 2008

Biomass C Pools

Above-Ground:
Tree Stem + Branches
Understory

Measured

Dead-Wood

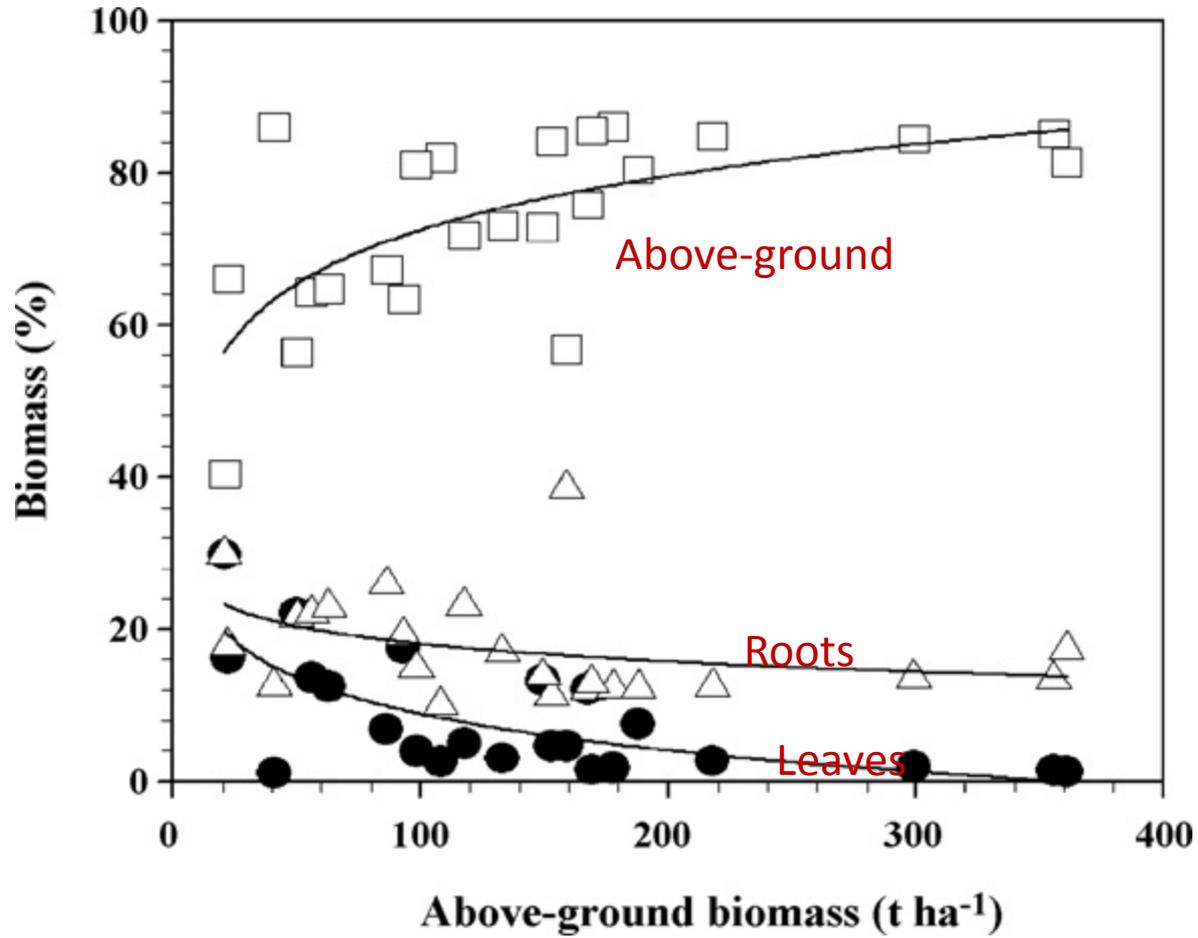
Below-Ground: Roots

Estimated



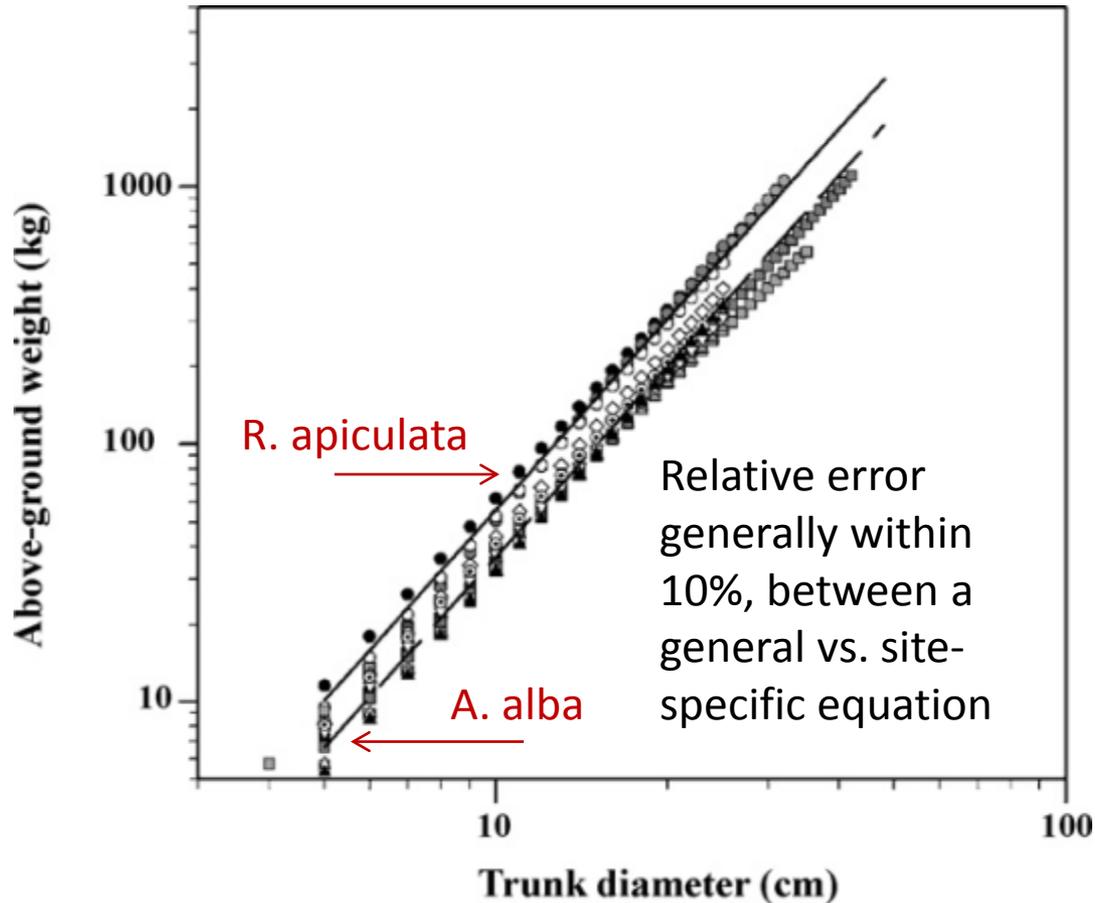
Biomass Allocation

Rhizophera



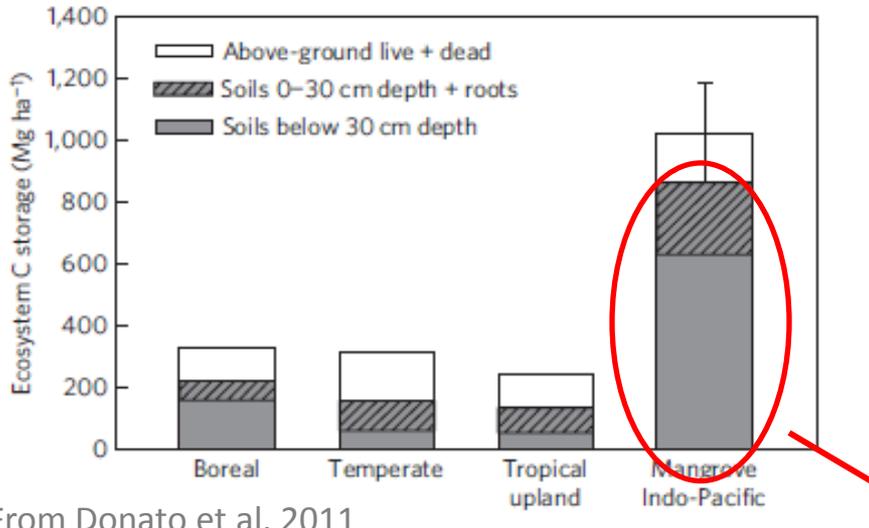
(from Komiyama et al. 2008)

Above-ground Biomass Estimation Dependent on Allometric Equations



(from Komiyama et al. 2008)

The Soil is the Major Carbon Pool in Mangroves



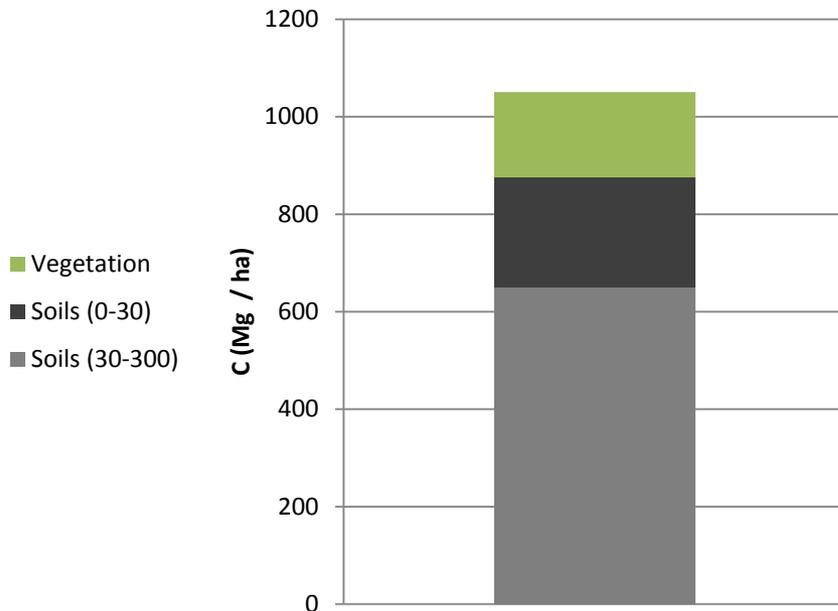
From Donato et al. 2011



Mozambique



Assessment of Ecosystem Level C Pools



- Biomass – AG
 - Confirm allometric eqns.
 - Compute by species, adjust for density
- Biomass – BG
 - Better equations needed
- Soil
 - Prioritize assessment of soil (0-200 cm)

After: Donato et al. 2011



Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests

J. Boone Kauffman
Daniel C. Donato



Harmonization of mangrove C inventory will facilitate regional and larger-scale assessments

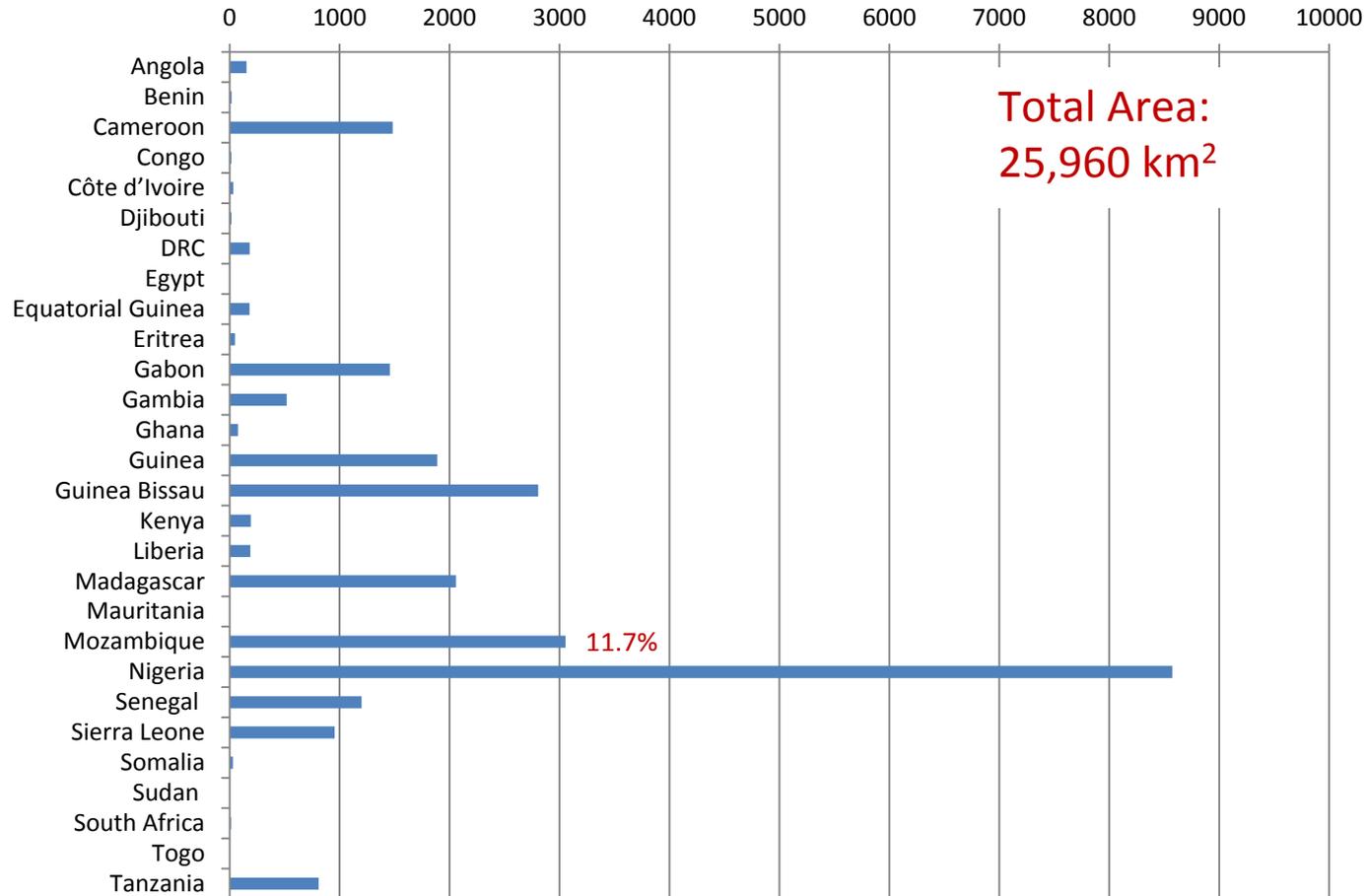
These protocols are currently being evaluated for the first time in Africa in the Zambezi River Delta Mangrove Carbon Assessment Project

Available at:
<http://www.cifor.org/online-library/browse/view-publication/publication/3749.html>



Mangrove Area in Africa

(km²)



(from Fatoyinbo & Sinard 2013)



Objectives

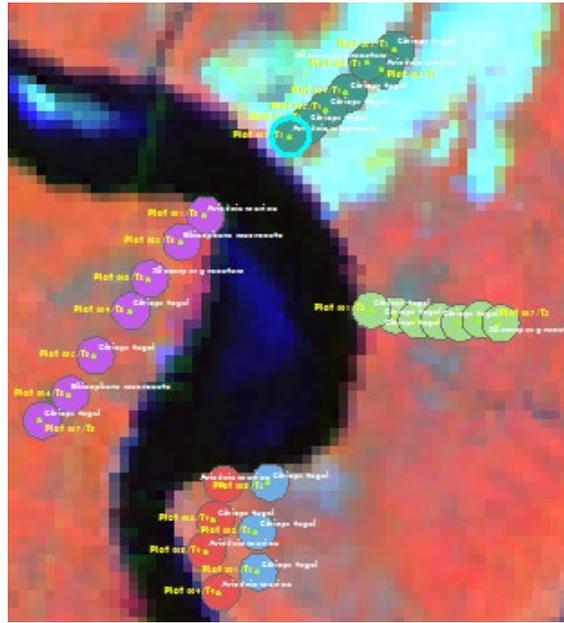
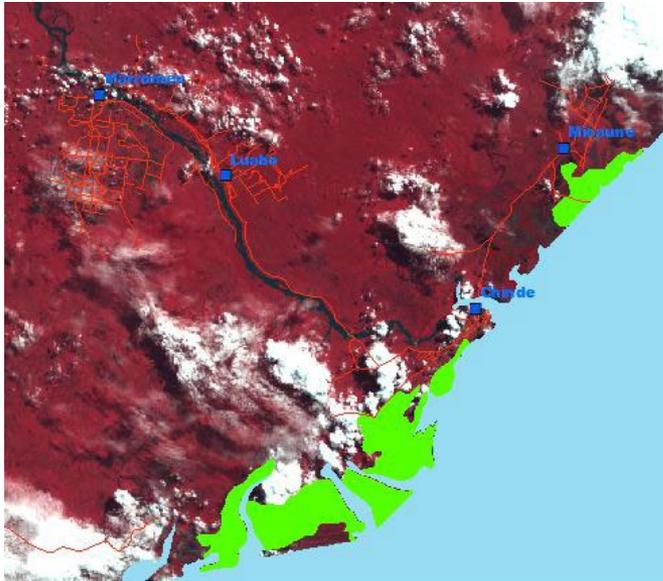
- Provide an estimate of the mangrove carbon pools within the Zambezi Delta as a baseline for REDD+
- Consider issues associated with quantifying C pools in mangroves within the Zambezi Delta at two scales:
 - Site → measurements of ecosystem C pools
 - Landscape → data & tools
- Provide context for considering approaches for the WIO region
 - Challenge – Quantify C pools with sufficient accuracy and at spatially-relevant scales for REDD+





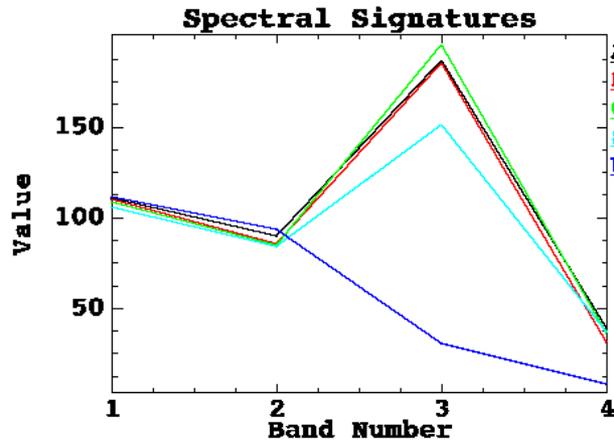
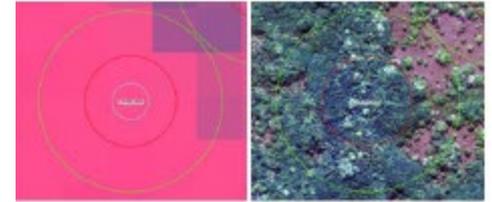
Our Challenge

Develop an inventory approach(s) that provides an acceptable level of accuracy for estimating the C content of mangroves and that serves as a foundation for monitoring change in the carbon pools.

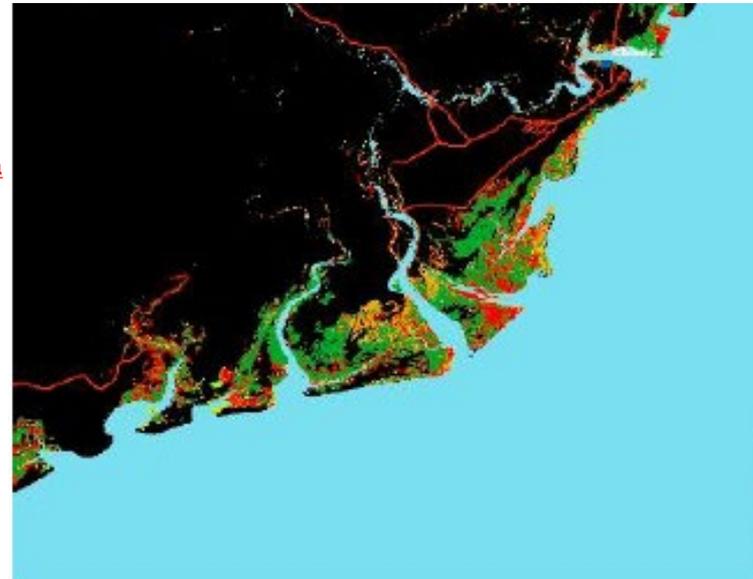


Mangrove Type Mapping

J. Rafael - Mozambique Center of Remote Sensing and Cartography (CENACARTA)



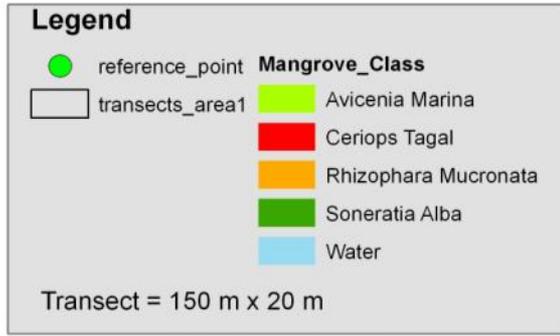
Avicennia Marina
Rhizophara Mucronata
Ceriops Tagal
Soneratia Alba
Water



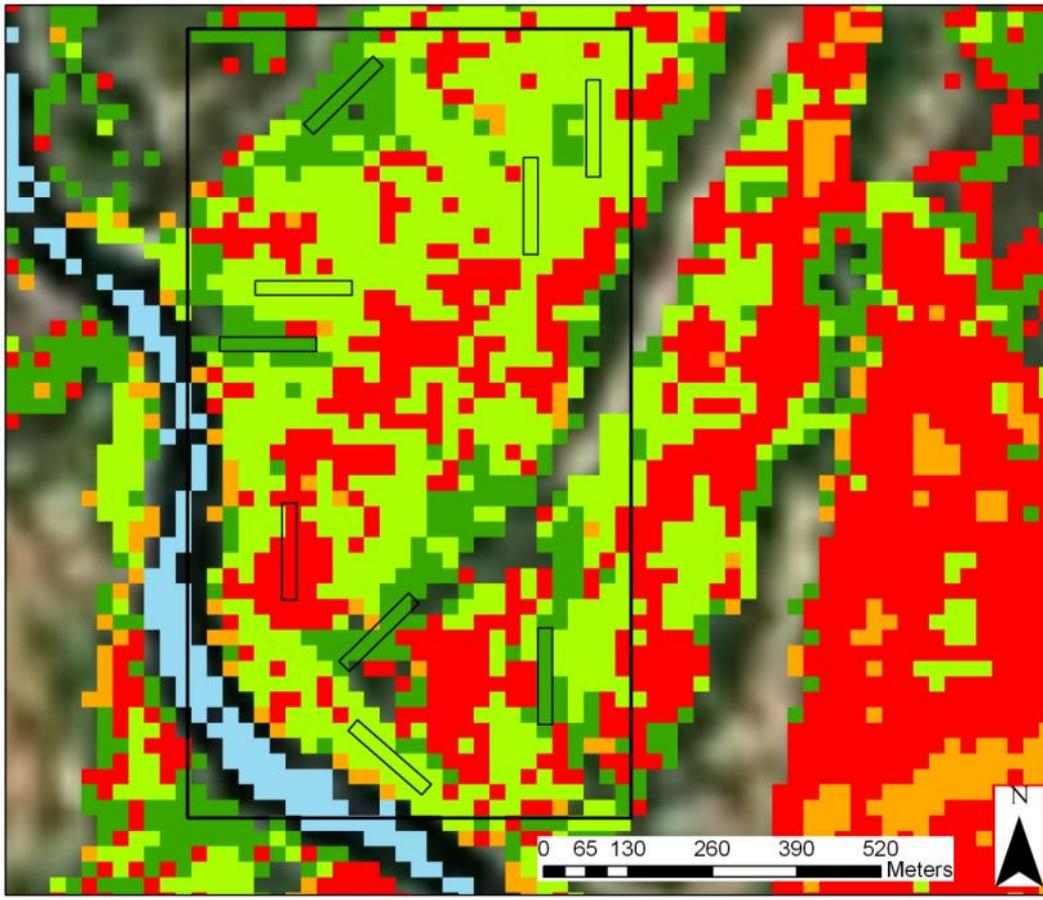
Mangrove Dominant Species
 Avicennia Marina
 Ceriops Tagal
 Rhizophara Mucronata
 Soneratia Alba
 Water

Mozambique





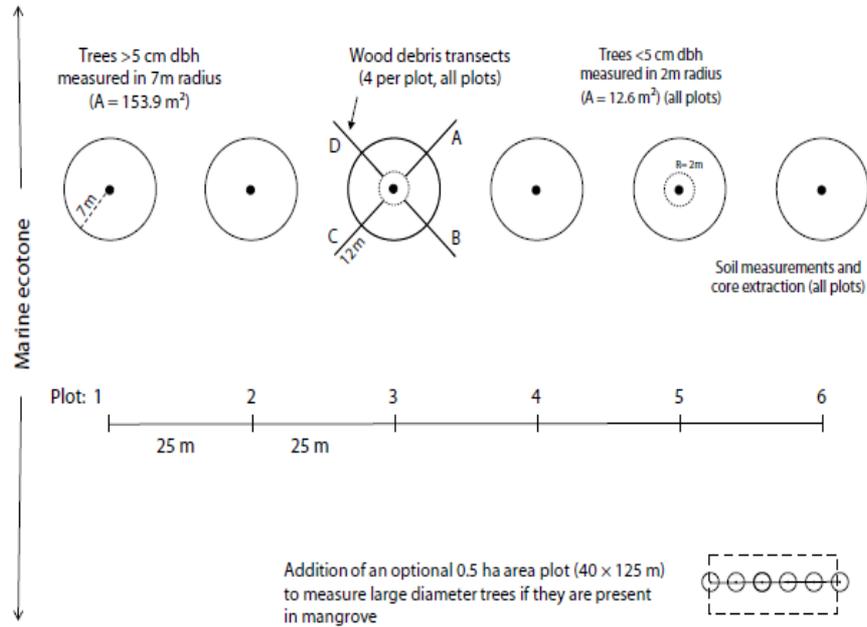
Allocation of Sample Plots Among Mangrove Types





Zambezi Delta Base Camp 2012





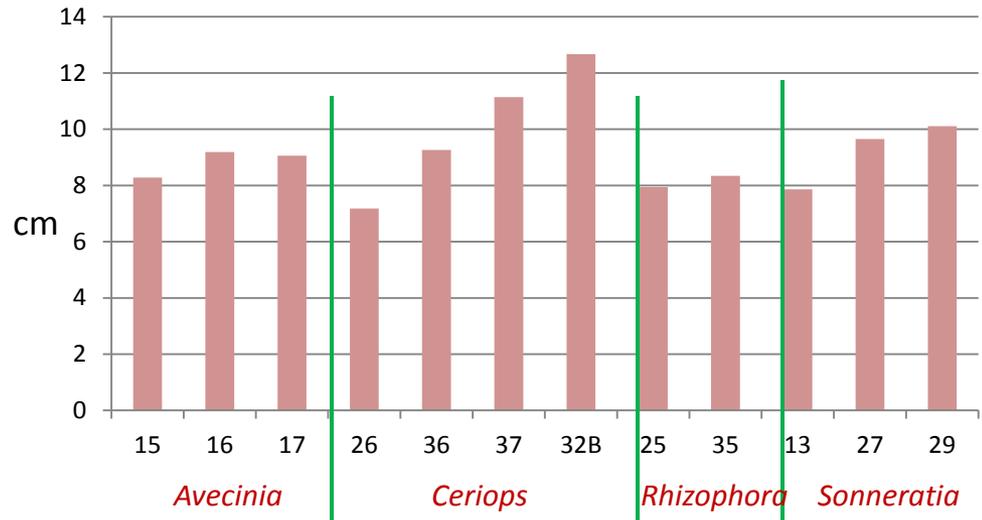
(From: Kaufman & Donato 2012)



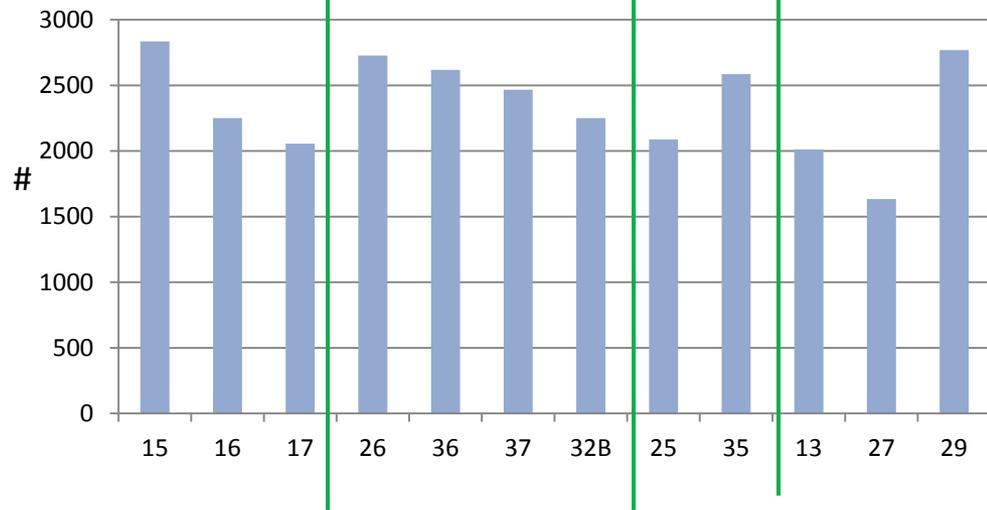
Stand Characteristics



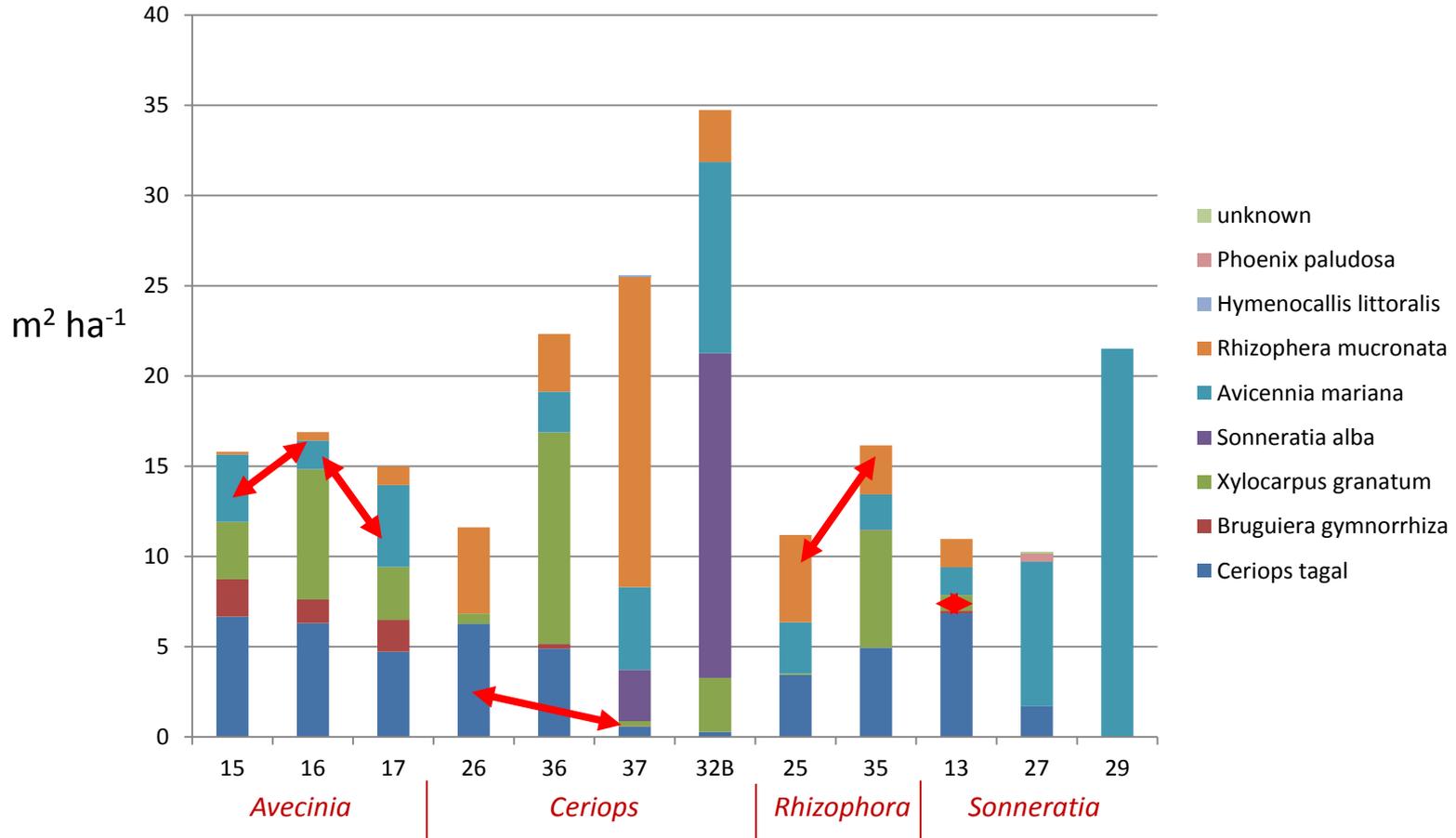
Average Tree (>5 cm) Diameter



Stocking - Trees (> 5 cm) ha⁻¹

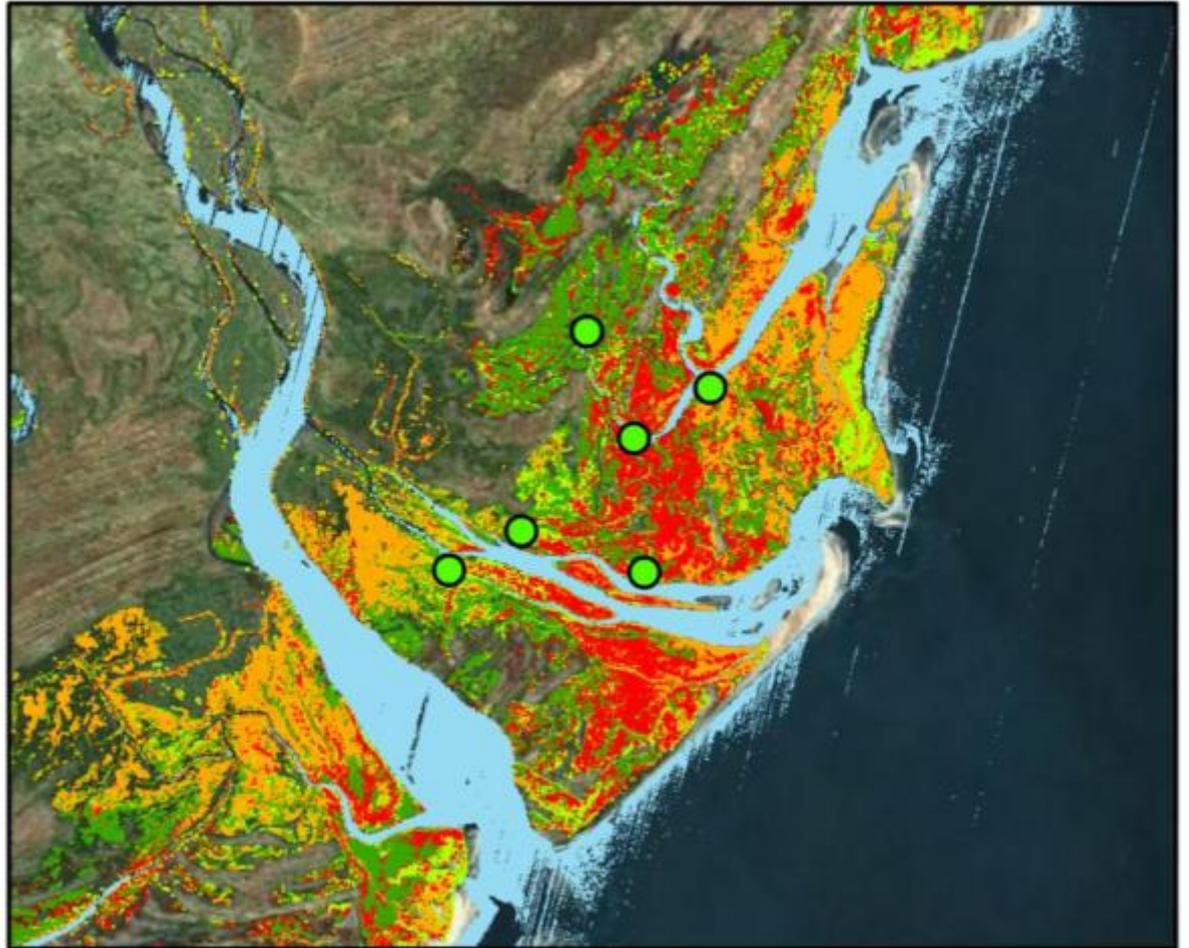
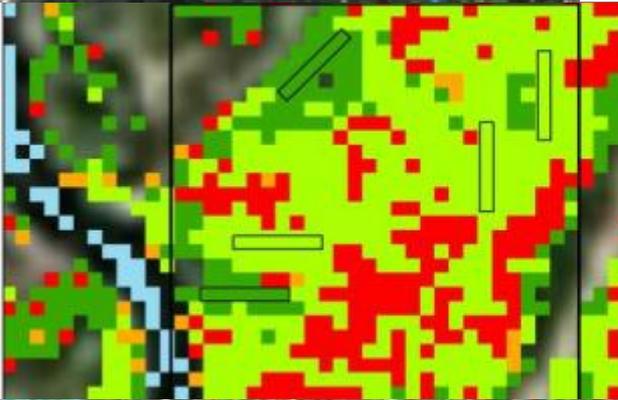


Mangrove Basal Area by Species – Trees > 5 cm



Aggregation at the Landscape Scale

Mangrove C Pool =
 Σ Cover types (Above-ground + Below-ground)



Issues Looking Forward

- Characterizing the main sources of variation in C pools
 - Obtaining sufficient replication to characterize the Zambezi Delta.
 - Validating functional relationships among biomass estimates
- Refining the use of remote sensing data as a basis to stratify mangrove carbon pool assessments;
- Access & logistics for field sampling;



Issues Looking Forward cont.

- Evaluating applications of remote sensing data to estimate biomass;
- Rates of deforestation and conversion?
- Rates of sequestration and efflux?
 - Role of mangroves vs. phytobenthos, etc.
 - Rate of net sequestration?
- Carbon sequestration rates following recovery or restoration?



Critical Ingredients to Assessing Mangrove Carbon Pools

- Effective partnerships
 - The WWF-USAID/FS – UEM Zambezi Mangrove Carbon Project is an excellent example
- Enhanced local capacity
- Information exchange
 - Ex. WIO Mangrove and Carbon Assessment Regional Workshop 29-31 Oct. 2012, Maputo

