Restoration may Increase Carbon Stock of Degraded Mangrove Forests across Cambodia

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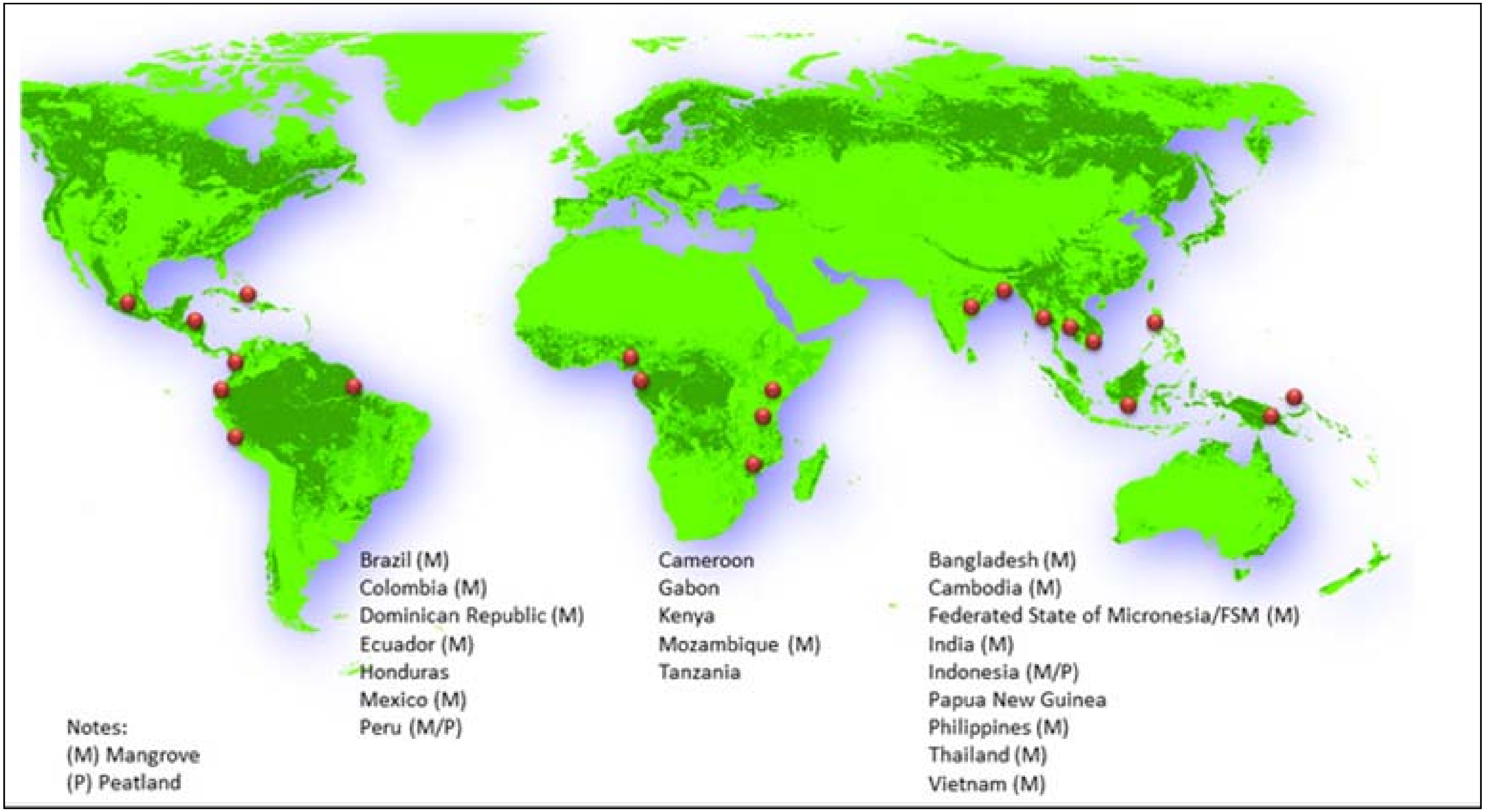
Sustainable Wetlands Adaptation and Mitigation Program (SWAMP)

SWAMP provide management agencies, policy makers, and scientists from Southeast Asia with credible scientific information needed to make sound decisions relating to the role of tropical wetlands in climate change adaptation and mitigation strategies.

Sustainable Wetlands Adaptation and Mitigation Program (SWAMP)

1. **Quantify greenhouse gas emissions** arising from intact wetland forests and sites that have undergone land cover change
2. **Quantify C stocks** of tropical forested wetlands of the world and associated land uses
3. **Develop ecosystem modeling tools** and remote sensing technology to scale up C measurements
4. **Quantify the role** of tropical wetland systems in climate change adaptation and mitigation
5. **Develop capacity building and outreach activities with associated countries** that will lead to sustainability of local communities, livelihoods and infrastructure

Using SWAMP to assess Carbon pools



SWAMP has been/is being used in 22 different countries

http://www.cifor.org/swamp/

Are all mangroves equal? How does mangrove condition impact the ecosystem services it provides?

Intact


Disturbed


Deforested


Restored

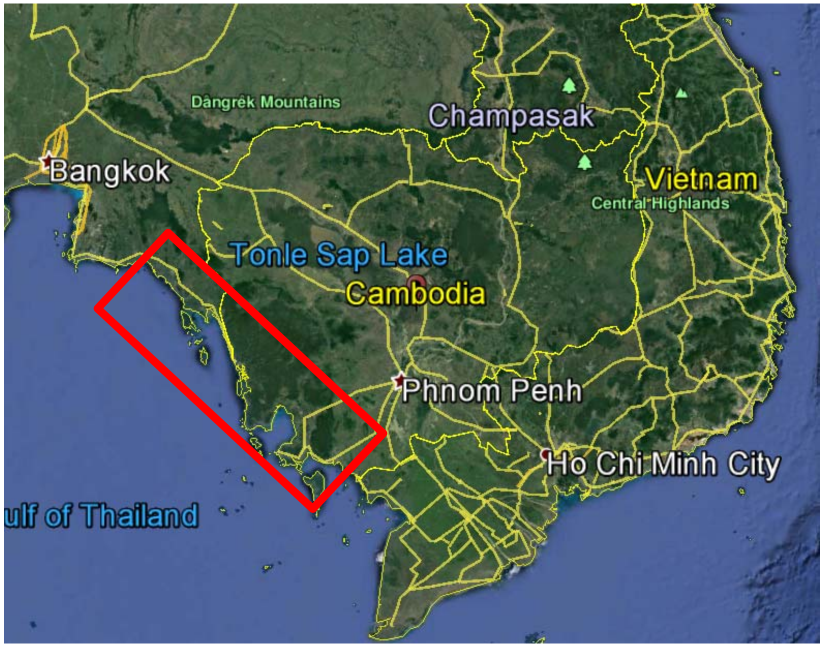

- **In recognition of the valuable services that intact mangrove forests provide, mangrove rehabilitation and restoration are being carried out in many regions to reverse the deleterious consequences of these past conversions.**
- **Unfortunately, it is unclear how effective mangrove rehabilitation projects are at restoring mangrove forests and the many ecosystem services that they provide.**

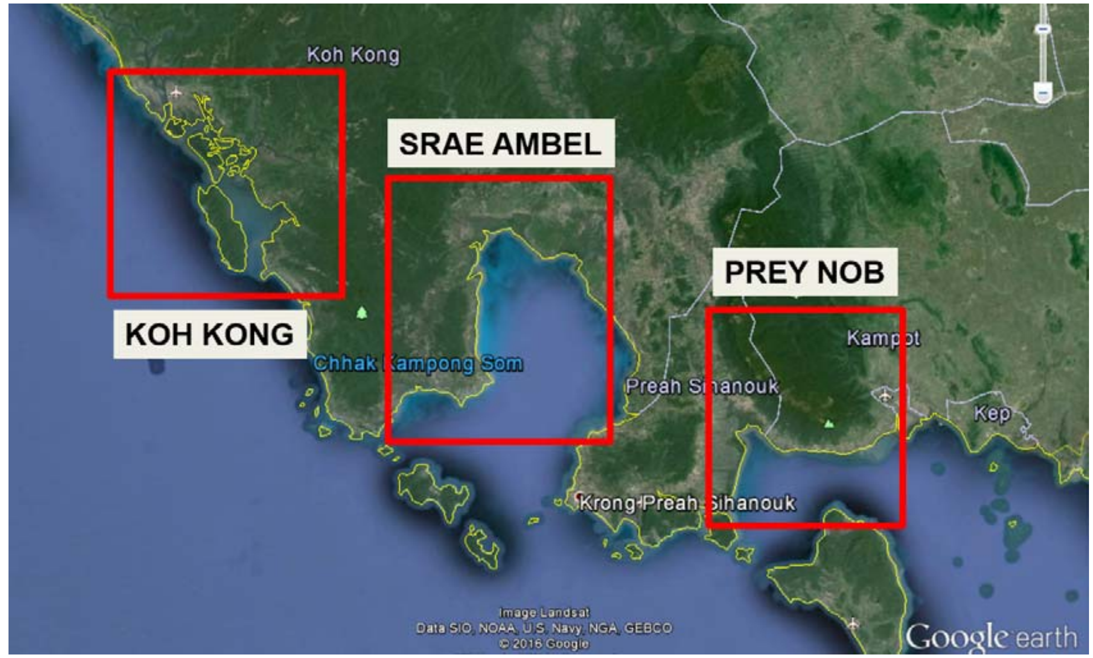
OBJECTIVES

- **Estimation of ecosystem carbon stock of mangrove forests across Cambodia**

- **How ecosystem carbon stock of mangrove forest change with different land-use type (intact, disturbed, deforested and restored) ?**

STUDY AREA





Mangrove areas in Cambodia (FAO, 2011)

Province	Area (ha)
Koh Kong	63,700
Kampot (Prey Nob)	13,500
Sihanouk Preah (Srae Ambel)	7,900

The conversion of mangroves into shrimp farms, salt farms and charcoal has adversely impacted coastal ecosystem productivity (Rizvi 2011).

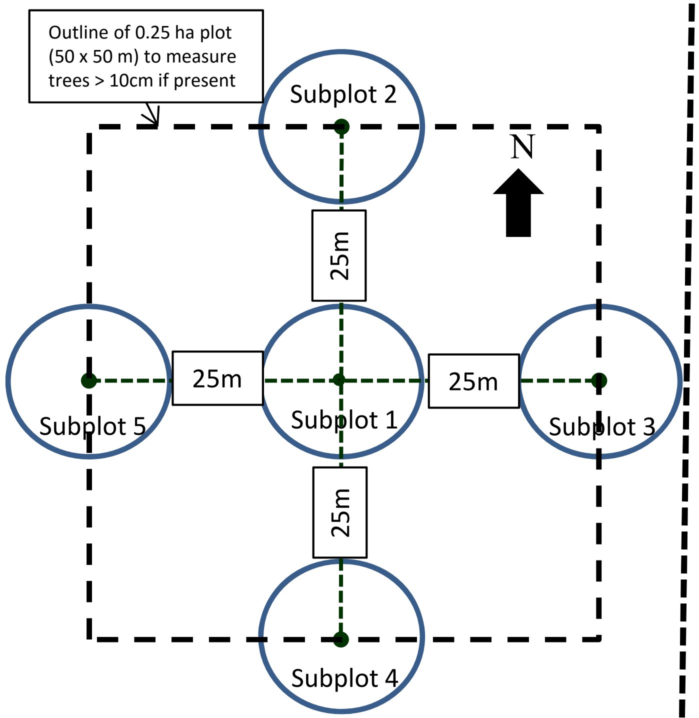
SAMPLING

- We sampled a total of 46 plots across Cambodia (Intact, disturbed and reforested mangrove forests)
  - Koh Kong (27 plots)
  - Prey Nob (7 plots)
  - Srea Ambel (12 plots)

- We sampled a total of 22 soil cores from deforested land (Shrimp pond, abandoend pond, salt pans and deforested area) across Cambodia
  - Koh Kong (5 soil cores)
  - Prey Nob (7 soil cores)
  - Srae Ambel (10 soil cores)

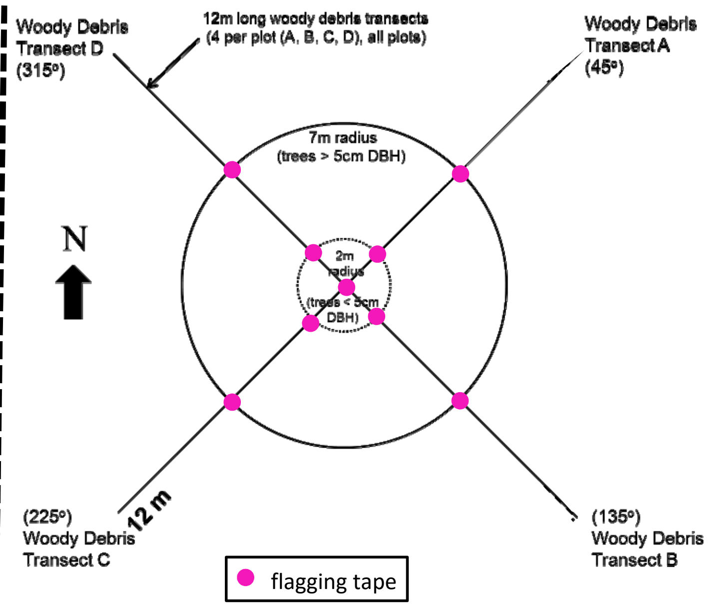
METHODOLOGY

- Data were collected using Sustainable Wetland Adaptation and Mitigation Program (SWAMP) protocol.



A

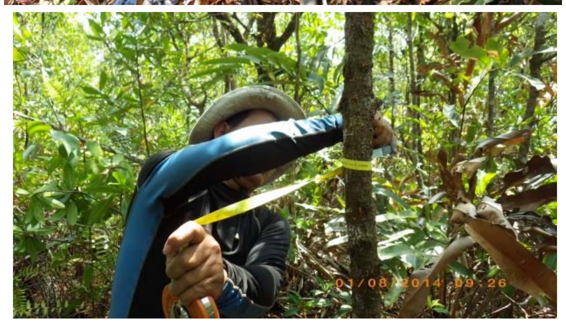
Plot layout



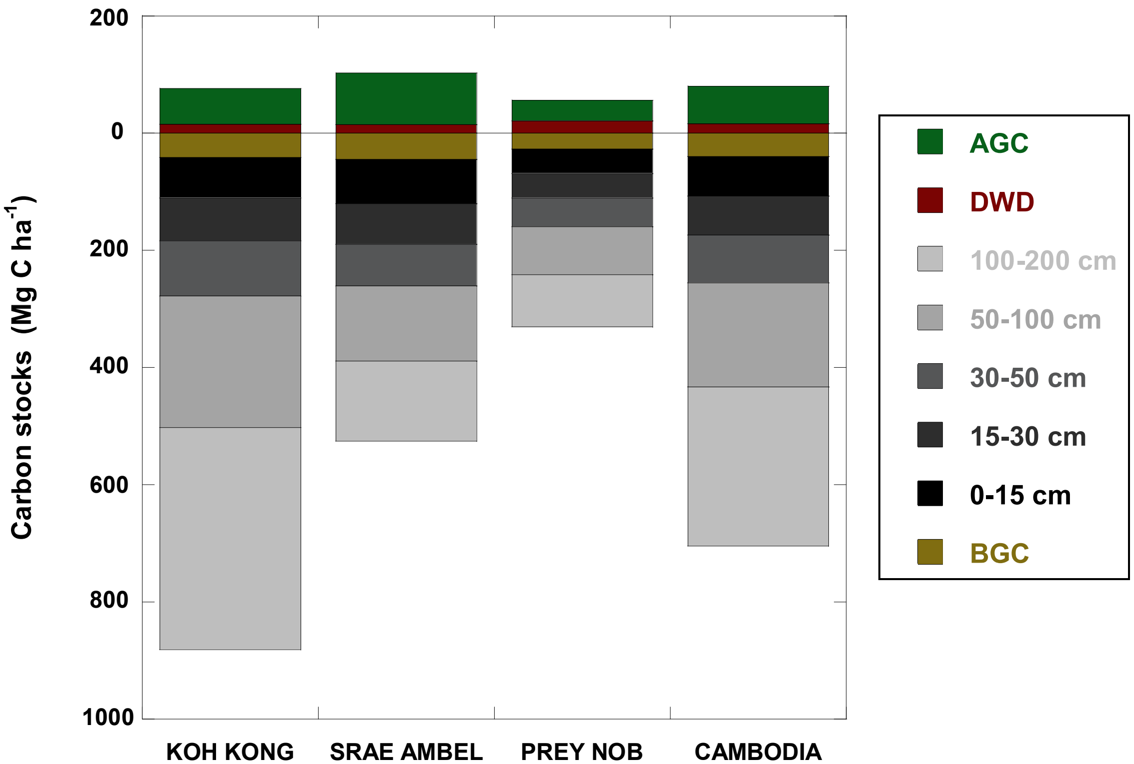
B

Subplot layout

CAPACITY BUILDING



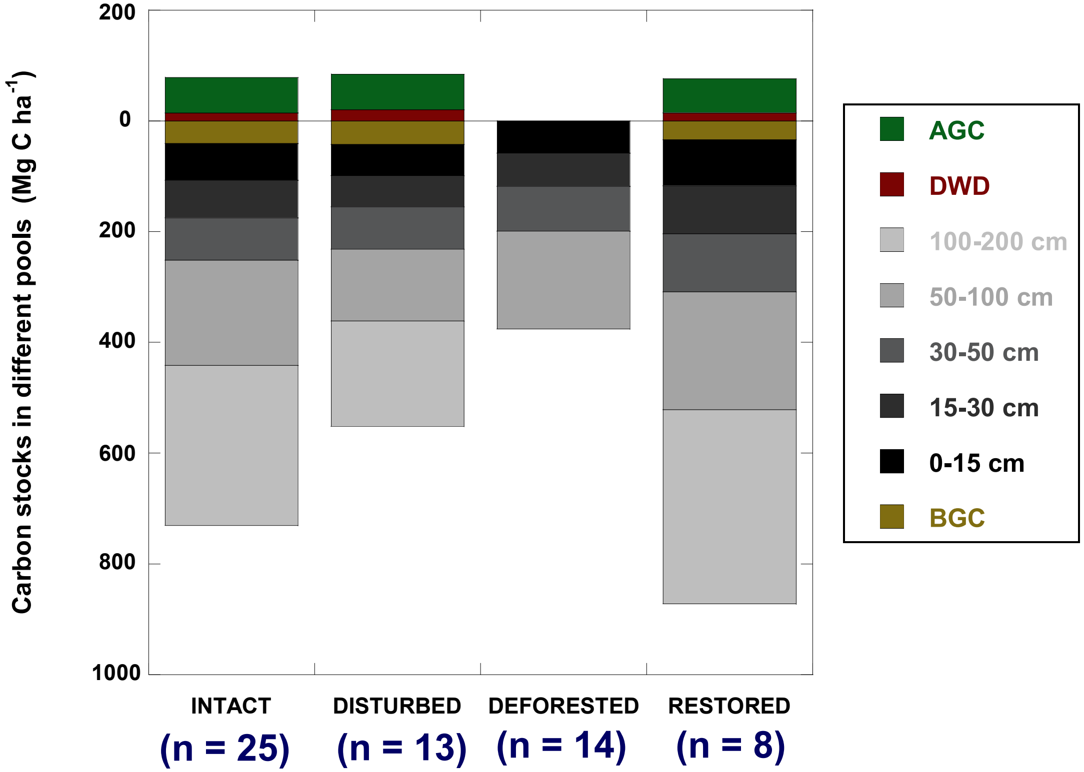
Ecosystem Carbon stock in Cambodia

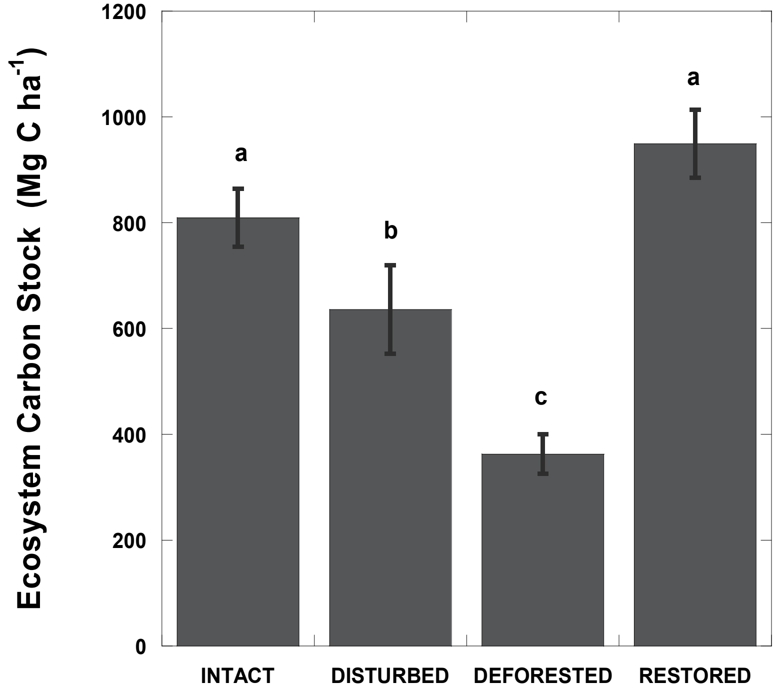


Ecosystem carbon stock of Cambodia (n = 46)

784.7 ± 42 Mg C ha^{-1} (range 386.3 to 1501.1)

Ecosystem Carbon stock in different land use type

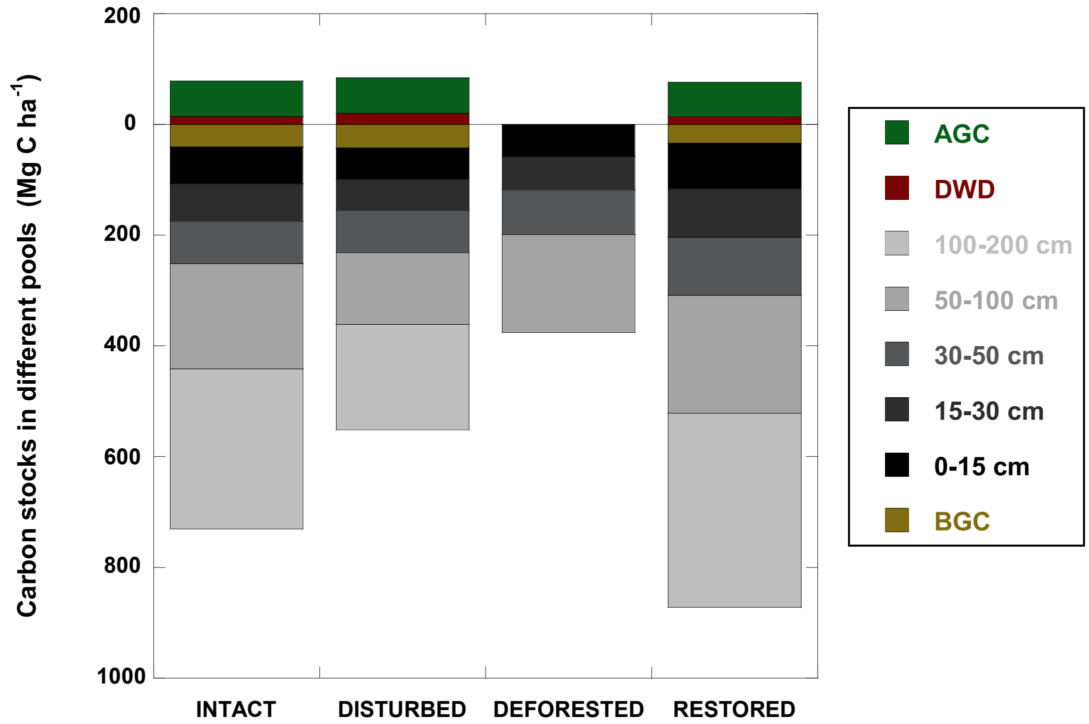




Restored mangroves (Age 24 yr; *Rhizophora* sp. dominant)

- **Higher ecosystem carbon stock (949 ± 64 Mg C ha^{-1})**
- **Might be due to higher fine root biomass productivity, which increases soil carbon content and leads to higher C stocks.**
- **Osland et al. (2012)**
- **Planted Mangroves (35 yrs) Can Gio Mangrove Biosphere (889 ± 111 Mg C ha^{-1}) (Nam et al. 2016)**

Ecosystem Carbon stock in different land use type



- **Conversion of intact to disturbed forest resulted in a loss of 253 Mg C ha^{-1} (~30%)**
- **Conversion of intact to deforested forests (shrimp ponds/salt pans) resulted in a loss of 517 Mg C ha^{-1} (~60%)**

Conclusion

Rehabilitation of mangroves in Cambodia appears to restore the carbon stocks of degraded mangroves. However, conservation of intact mangroves should still be prioritized as an effective tool to maintain mangrove C stocks and their ability to sequester and bury C.

ACKNOWLEDGEMENT

Royal Government of Cambodia
Ministry of Environment (MoE)
Ministry of Agriculture, Forestry and Fisheries (MAFF)
Royal University of Phnom Penh (RUPP)
Royal University of Agriculture in Cambodia (RUA)
USAID Cambodia
USAID LEAD program
USAID Washington
US Forest Service

USAID FROM THE AMERICAN PEOPLE

Soil characteristics in different land use type

C %	0 - 15	15 - 30	30 - 50	50 - 100	100 - 200
Intact	12.9 ± 1.0	11.7 ± 0.9	9.3 ± 1.0	7.8 ± 0.9	4.9 ± 0.6
Disturbed	12.2 ± 2.0	10.1 ± 1.7	8.4 ± 0.9	5.0 ± 0.8	3.2 ± 0.6
Deforested	13.0 ± 2.6	11.5 ± 2.0	8.1 ± 1.7	7.9 ± 1.7	
Restored	13.9 ± 1.9	15.4 ± 1.8	14.0 ± 1.6	12.5 ± 1.5	7.6 ± 1.4

Bulk density	0 - 15	15 - 30	30 - 50	50 - 100	100 - 200
Intact	0.40 ± 0.03	0.47 ± 0.04	0.52 ± 0.05	0.63 ± 0.06	0.72 ± 0.04
Disturbed	0.40 ± 0.04	0.44 ± 0.04	0.47 ± 0.02	0.65 ± 0.06	0.76 ± 0.08
Deforested	0.54 ± 0.11	0.55 ± 0.11	0.65 ± 0.09	0.64 ± 0.09	
Restored	0.48 ± 0.06	0.43 ± 0.05	0.41 ± 0.04	0.45 ± 0.05	0.67 ± 0.07