Coastal Protection & Mangrove Restoration of Pulau Tekong, Singapore

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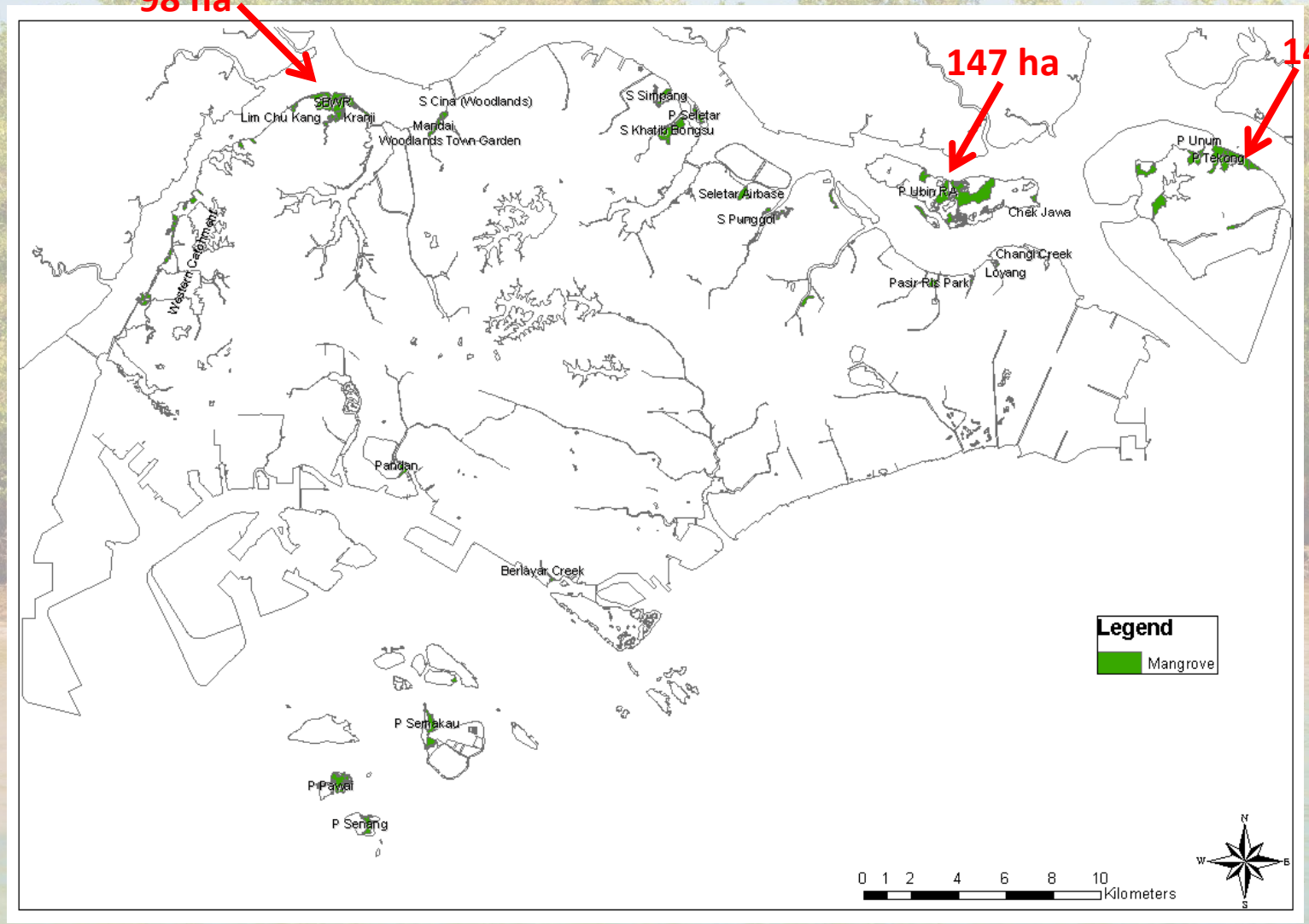
Content

- Mangrove Forests in Singapore
- Mangrove Restoration Project

Mangrove Forests in Singapore

- 200 years ago → approx 7500 ha
- 2013 → approx 735 ha
- Singapore's current mangroves → 1% of total land space

Mangrove forests in Singapore



List of mangrove flora species

No.	Species	Family	Conservation Status*
1.	*Acanthus ilicifolius*	Acanthaceae	-
2.	*Acanthus ebracteatus*	Acanthaceae	Vulnerable
3.	*Acanthus volubilis*	Acanthaceae	Vulnerable
4.	*Acrostichum aureum*	Ceratopteridaceae	-
5.	*Acrostichum speciosum*	Ceratopteridaceae	-
6.	*Aegiceras corniculatum*	Myrsinaceae	Endangered
7.	*Avicennia alba*	Acanthaceae	-
8.	*Avicennia marina*	Acanthaceae	Critically Endangered
9.	*Avicennia officinalis*	Acanthaceae	-
10.	*Avicennia rumphiana*	Acanthaceae	-
11.	*Brownlowia tersa*	Malvaceae	Endangered
12.	*Brownlowia argentata*	Malvaceae	Nationally Extinct IUCN Global Data Deficient
13.	*Bruguiera cylindrica*	Rhizophoraceae	-
14.	*Bruguiera gymnorhiza*	Rhizophoraceae	-
15.	*Bruguiera parviflora*	Rhizophoraceae	Endangered
16.	*Bruguiera hainesii*	Rhizophoraceae	Critically Endangered; IUCN Global Critically Endangered
17.	*Bruguiera sexangula*	Rhizophoraceae	Critically Endangered
18.	*Ceriops zippeliana*	Rhizophoraceae	Endangered
19.	*Ceriops tagal*	Rhizophoraceae	Vulnerable
20.	*Dolichandrone spathacea*	Bignoniaceae	Critically Endangered
21.	*Excoecaria agallocha*	Euphorbiaceae	-
22.	*Heritiera littoralis*	Malvaceae	Endangered
23.	*Kandelia candel*	Rhizophoraceae	Critically Endangered
24.	*Lumnitzera littorea*	Combretaceae	Endangered
25.	*Lumnitzera racemosa*	Combretaceae	Endangered
26.	*Nypa fruticans*	Arecaceae	Vulnerable
27.	*Pemphis acidula*	Lythraceae	Critically Endangered
28.	*Rhizophora apiculata*	Rhizophoraceae	-
29.	*Rhizophora murconata*	Rhizophoraceae	-
30.	*Rhizophora stylosa*	Rhizophoraceae	Vulnerable
31.	*Scyphiphora hydrophyllacea*	Rubiaceae	-
32.	*Sonneratia alba*	Lythraceae	-
33.	*Sonneratia caseolaris*	Lythraceae	Critically Endangered
34.	*Sonneratia ovata*	Lythraceae	Critically Endangered
35.	*Xylocarpus granatum*	Meliaceae	-
36.	*Xylocarpus moluccensis*	Meliaceae	Endangered

Source: J.W. H. Yong (SUTD), K. S. Koh (NParks), S. F. Yang (NParks)

Notable mention

- Extinction only 1 species: *Brownlowia argentata*
- Addition of *Rhizophora x lamarckii*

Source: Joseph Lai & K. S. Koh (NParks)

Notable mention

- Addition of 7 *Bruguiera hainesii* + 4 existing = 11

Source: K. S. Koh (NParks)

Conservation Efforts of Mangroves

- Semakau Landfill
- Mangrove Restoration in Pulau Tekong

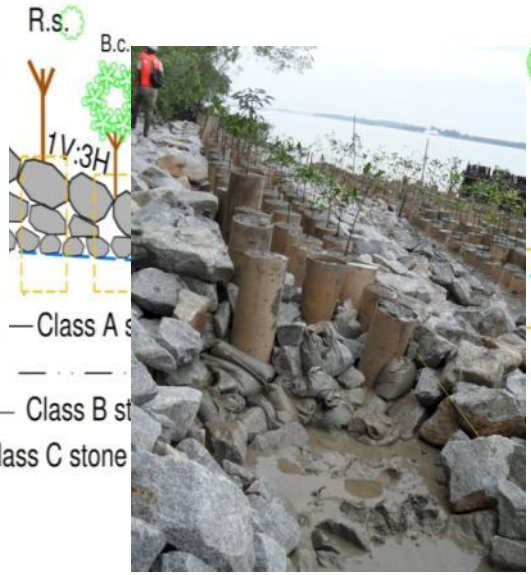
Mangrove Restoration in Pulau Tekong

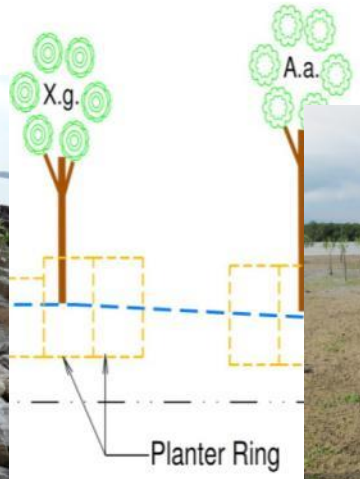
- Severe erosion of the coastline
- Land loss

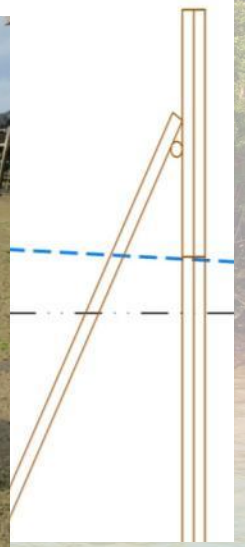
Guiding Principals

- ‘Green’ engineering
- Biotic and abiotic factors
- Assisted regeneration

Final Design







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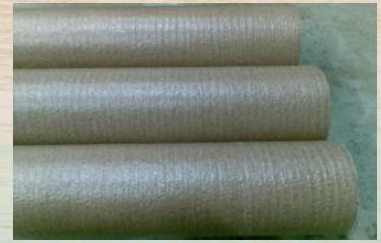
Use of Biodegradables

Agricultural Waste

Plastic Waste

R3PLAS Technology

Seeding bags



Planter rings

Mud filling bags

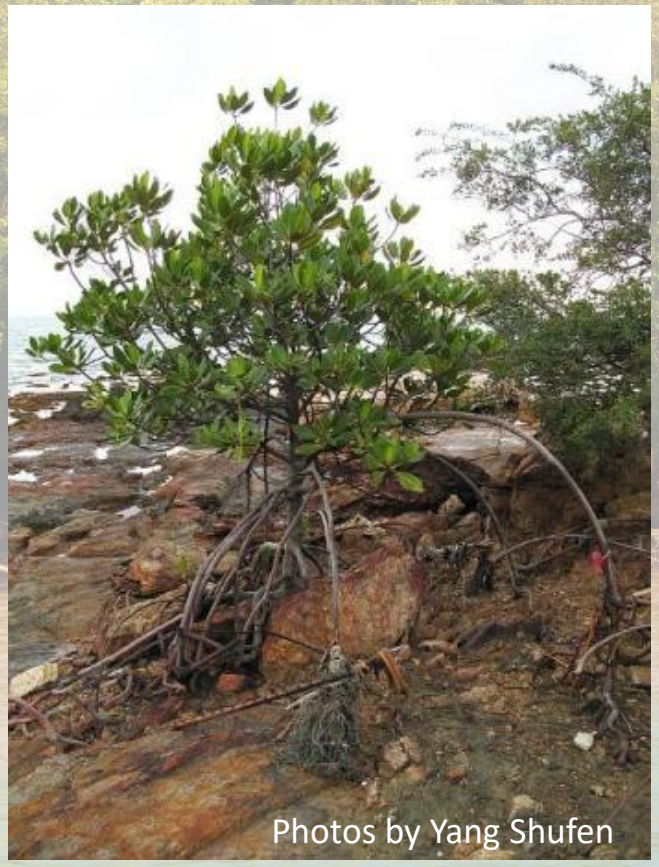
Winrigo (S) Pte Ltd

Factors influencing choice of mangroves

- Wave Energies
- Depth, Duration and frequency of Inundation
- Salinity
- Sediment Composition and stability

Mangrove Species Planted

Ideal Mangrove species: *Rhizophora stylosa*



Photos by Yang Shufen

Mangrove Species Planted

Mangrove Species	
Avicennia alba	*Rhizophora mucronata*
Bruguiera cylindrica	***Rhizophora stylosa***
Bruguiera gymnorhiza	*Sonneratia alba*
Bruguiera sexangula	*Sonneratia caseolaris*
Ceriops tagal	*Sonneratia ovata*
Lumnitzera littorea	*Xylocarpus granatum*
Rhizophora apiculata	*Xylocarpus rumphii*
Bruguiera hainesii	*Kandelia candel*
Bruguiera parviflora	

* Native stock

** All species planted, grown from local stock

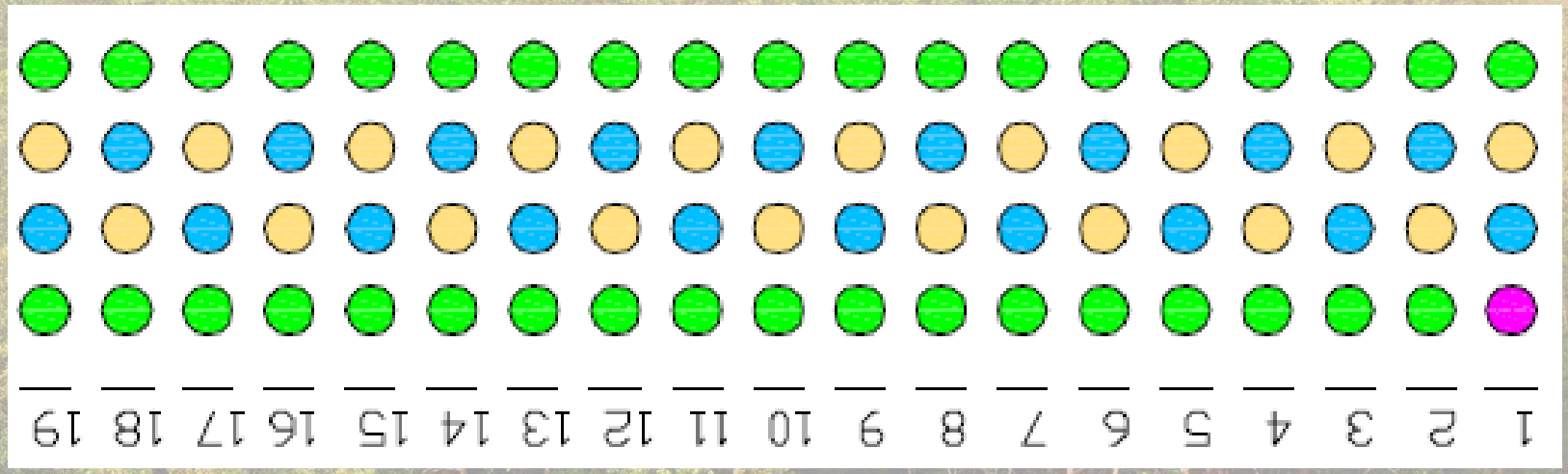
Propagule Propagation

Acclimatising before Planting

Surbana Consultancy

Completed Works

Methodology for Sapling Survival Assessment



Coastal Protection Configuration

Methodology for Sapling Survival Assessment

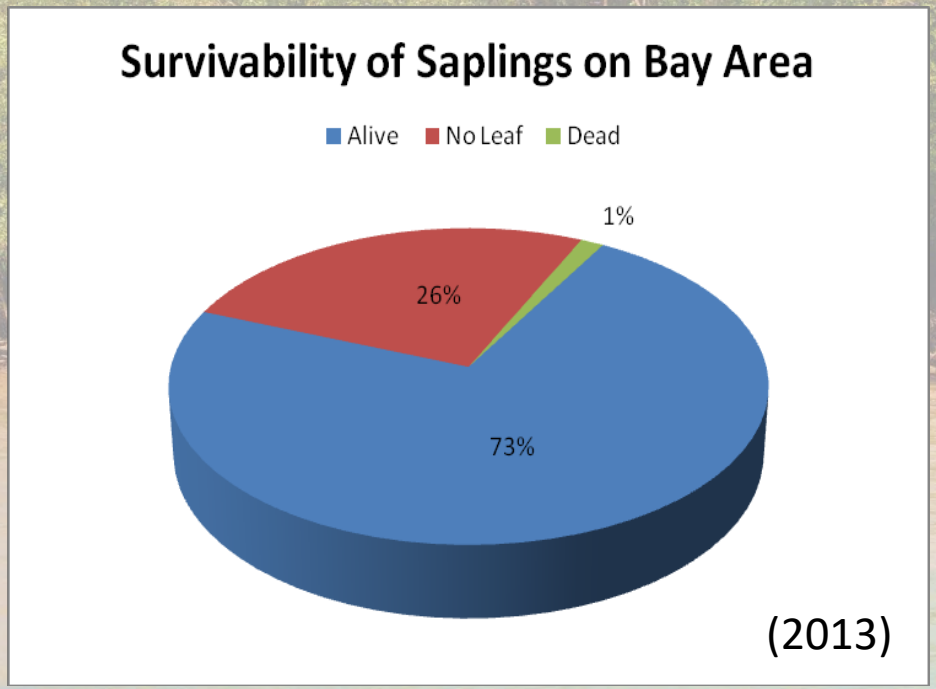
Classification

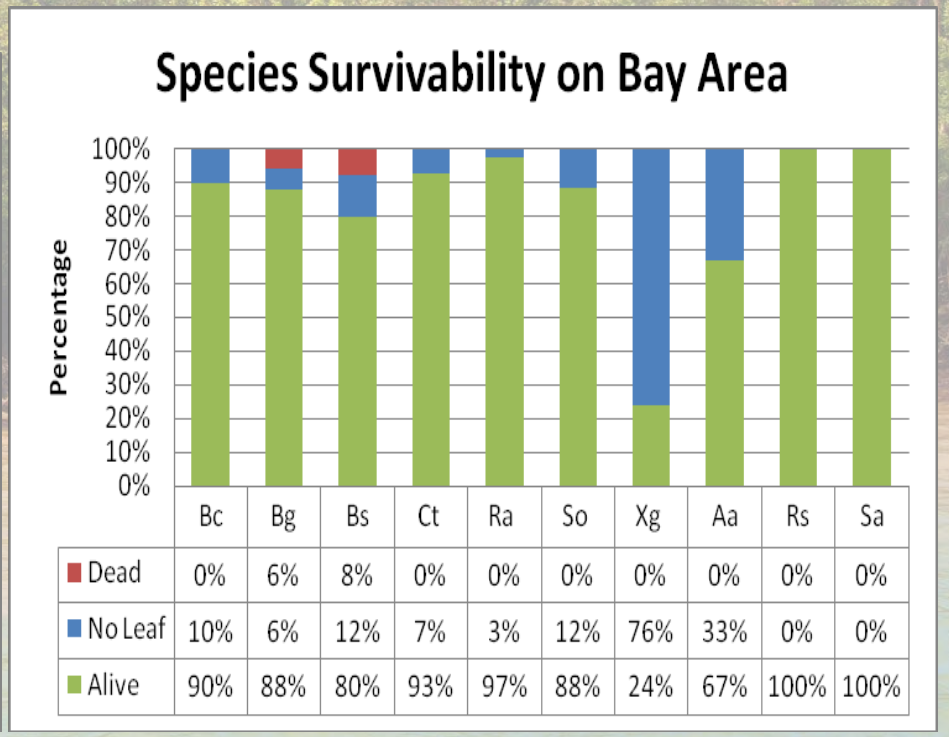
Classification	Symbol	Characteristics
Alive	√	Leaves present
No Leaf	O	Leaf absent Shoot may be present or absent Stem is green and sturdy
Dead	X	Leaf absent Shoot absent Stem is brittle and/or already decaying

Results for Sapling Survivability

Bay Area:

- 355 planted; 355 monitored



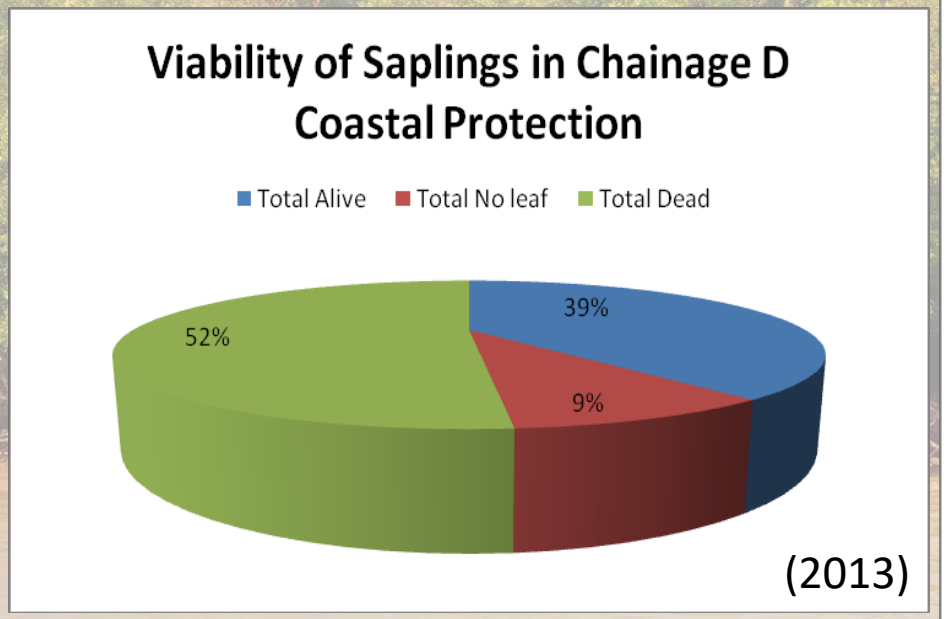


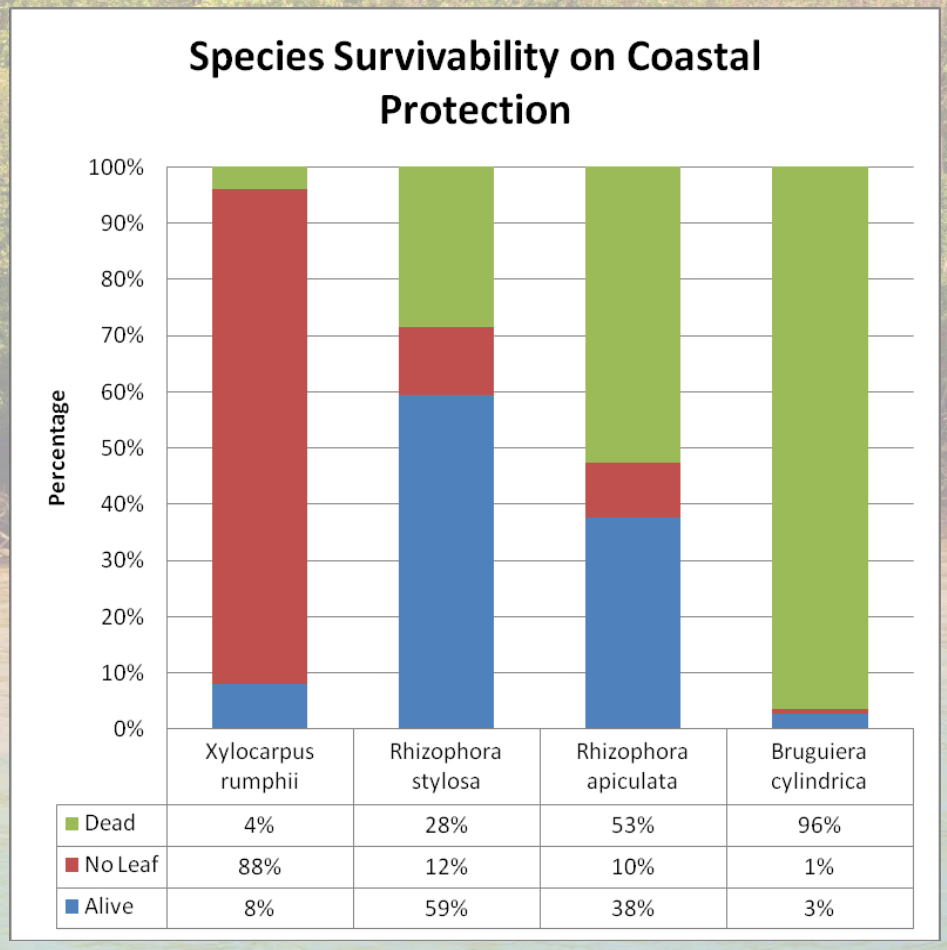
	Bc	Bg	Bs	Ct	Ra	So	Xg	Aa	Rs	Sa
Dead	0%	6%	8%	0%	0%	0%	0%	0%	0%	0%
No Leaf	10%	6%	12%	7%	3%	12%	76%	33%	0%	0%
Alive	90%	88%	80%	93%	97%	88%	24%	67%	100%	100%

Results for Sapling Survivability

Coastal Protection:

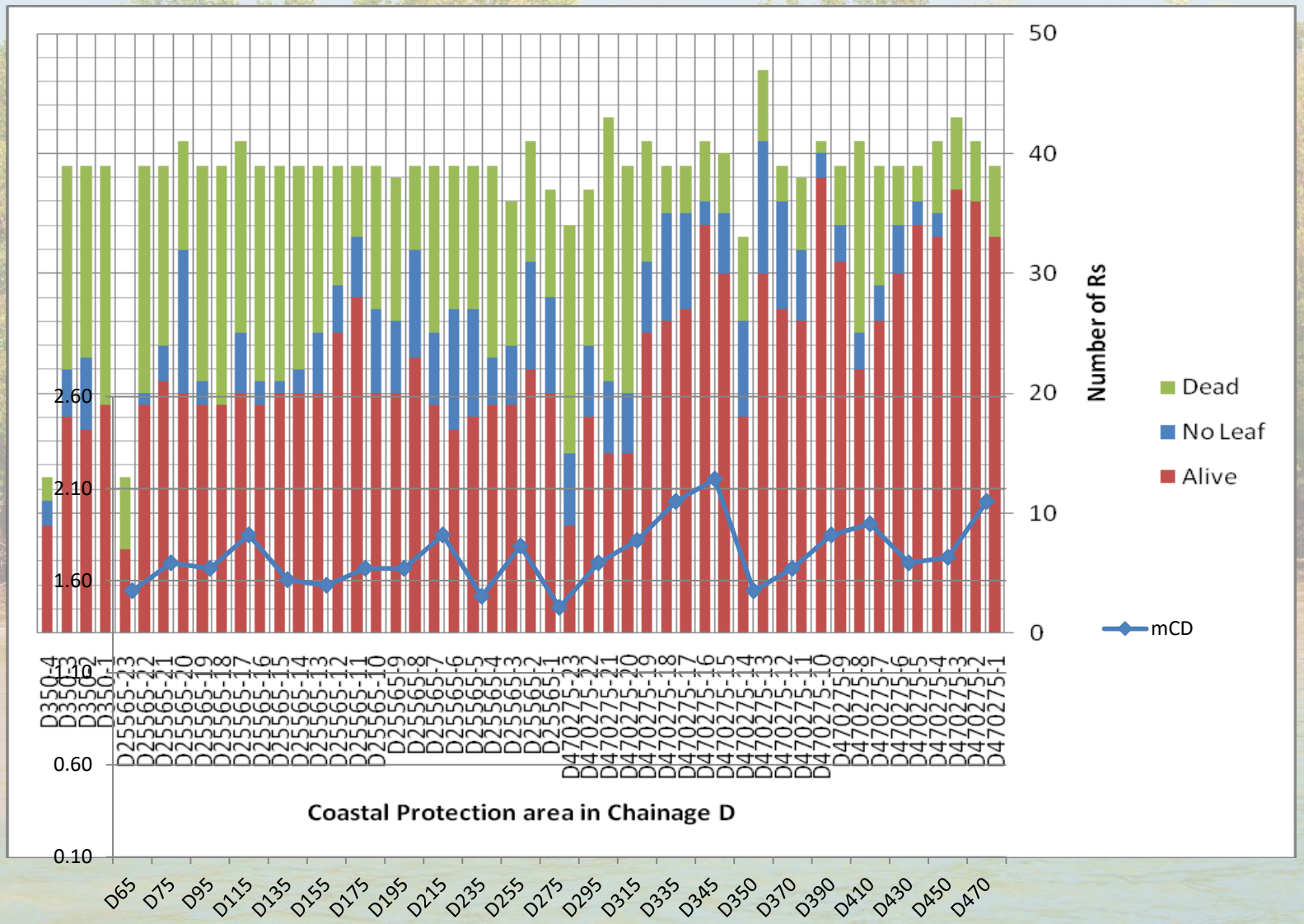
- 3968 planted; 3908 monitored





	Xylocarpus rumphii	Rhizophora stylosa	Rhizophora apiculata	Bruguiera cylindrica
Dead	4%	28%	53%	96%
No Leaf	88%	12%	10%	1%
Alive	8%	59%	38%	3%

Survivability distribution of *Rhizophora stylosa* on Coastal Protection



Sapling Survival

- Sapling Survival is dependent on:
  - Species
  - Salinity
  - Substratum
  - Inundation level & frequency
  - Hydrodynamic (Currents)

Conclusion

- ‘Green’ engineering
- Biotic and abiotic factors
- Assisted regeneration required?

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