K&C Phase 3 – Brief project essentials

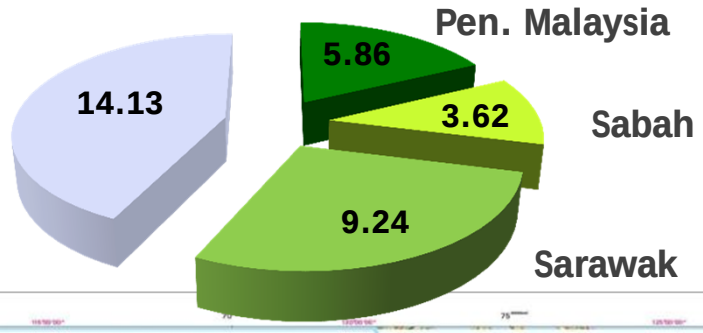
Aboveground Biomass and Carbon Stock Mapping and Changes Monitoring in the Forest of Peninsular Malaysia Using L-Band ALOS Palsar and JERS-1

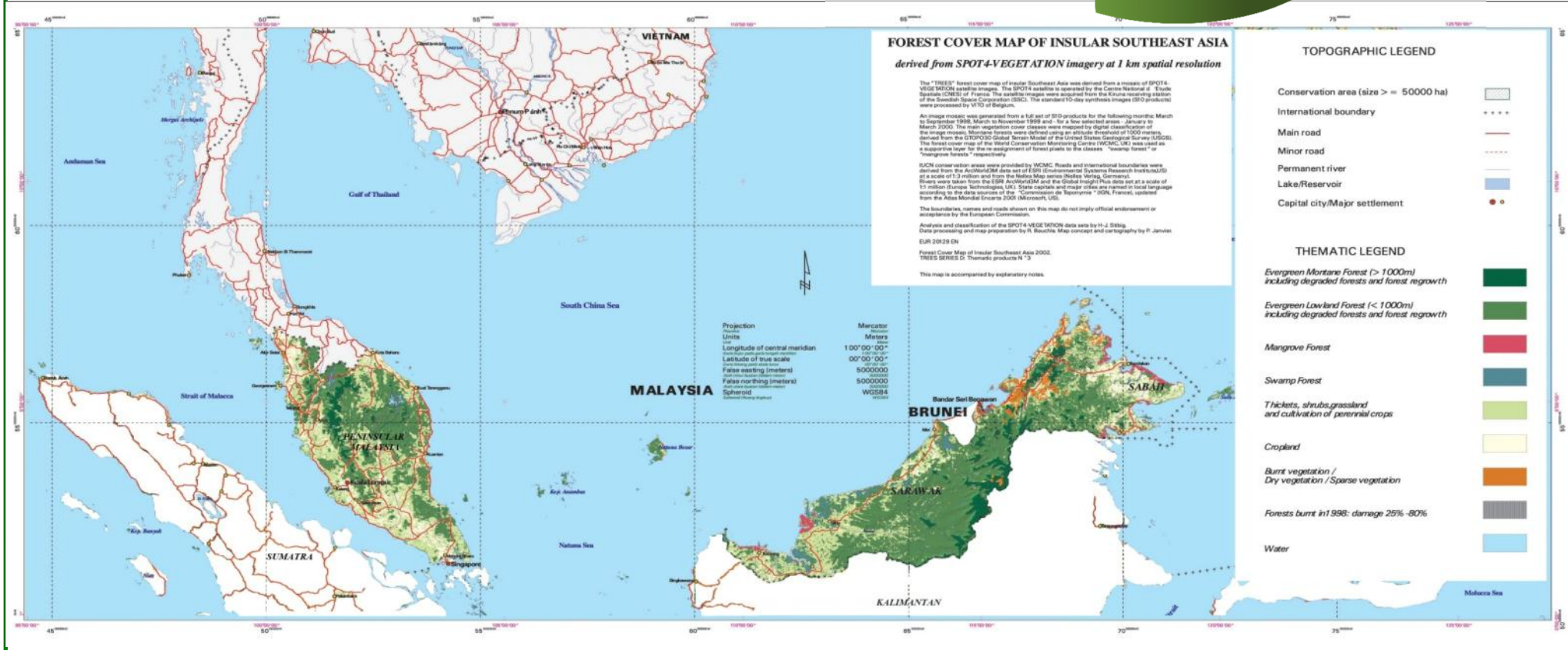
Hamdan Omar & Khali Aziz Hamzah
Forest Research Institute Malaysia (FRIM)

Science Team meeting #17 – Phase 3
JAXA TKSC/RESTEC HQ, March 27-29, 2012

Forest in Malaysia

('000,000 ha)





Distribution and extent of major forest types in Malaysia, 2010 ('000,000 ha)

Region	Land Area	Natural Forests			Total Forested Land	% of Total Land Area
		Dry Inland Forest	Swamp Forest	Mangrove Forest		
Pen. M'sia	13.18	4.58	0.24	0.10	5.86	44.4
Sabah	7.37	3.17	0.12	0.32	3.61	49.0
Sarawak	12.30	7.98	1.12	0.14	9.24	75.1
Malaysia	**32.85**	**15.73**	**1.48**	**0.56**	**17.77**	**54.1**

Sources: *Forestry Department Peninsular Malaysia (2011)*
Sabah Forestry Department (2011)
Forest Department Sarawak (2011)

Permanent Reserved Forest in Malaysia, 2010 ('000,000 ha)

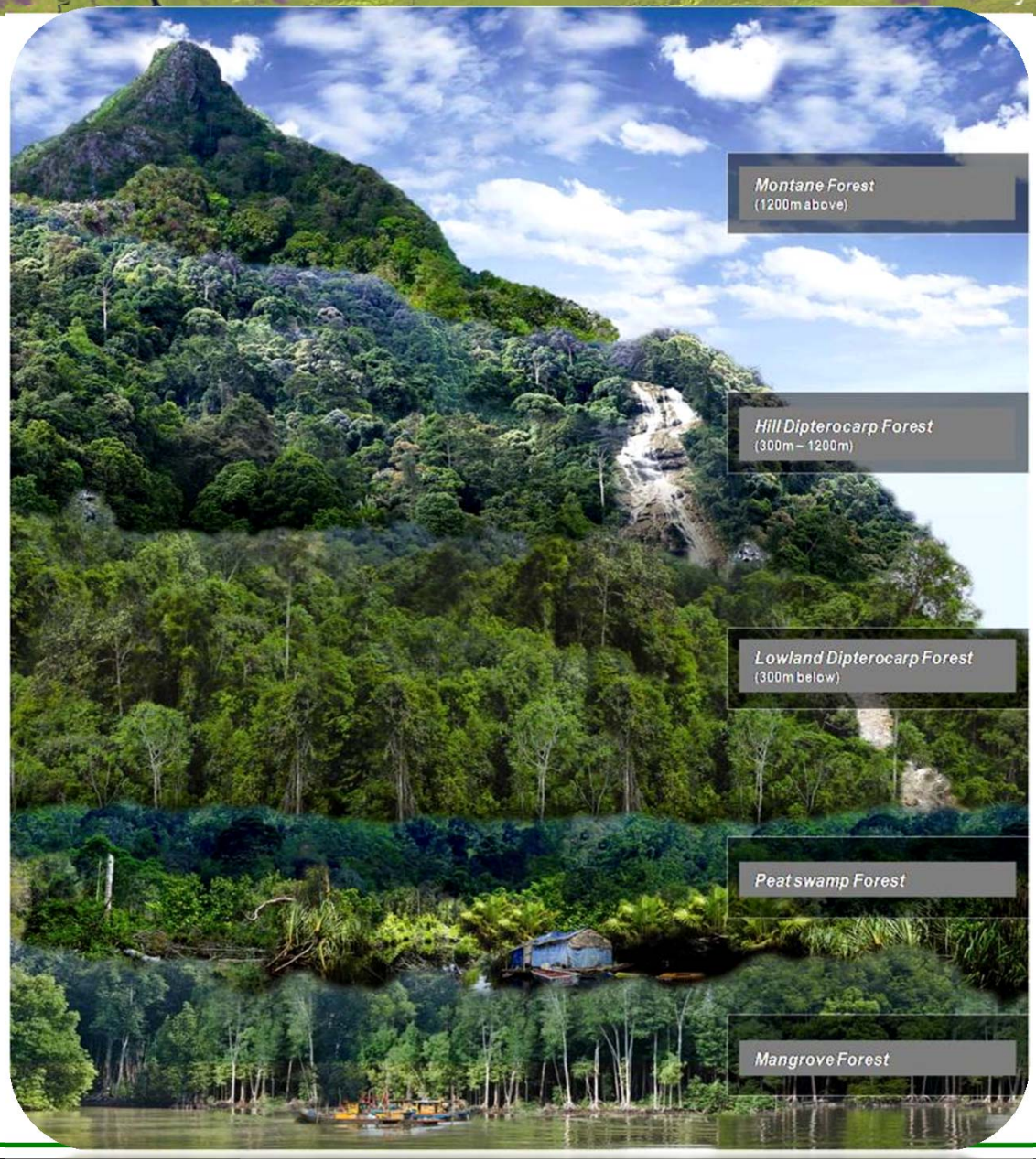
Region	Protection Forest	Production Forest	Total PRFs
Pen. M'sia	1.98	2.82	4.80
Sabah	1.04	2.55	3.59
Sarawak	1.10	5.00	6.10
Malaysia	**4.12**	**10.37**	**14.49**

Sources: *Forestry Department Peninsular Malaysia (2011)*
Sabah Forestry Department (2011)
Forest Department Sarawak (2011)

Forest in Peninsular Malaysia

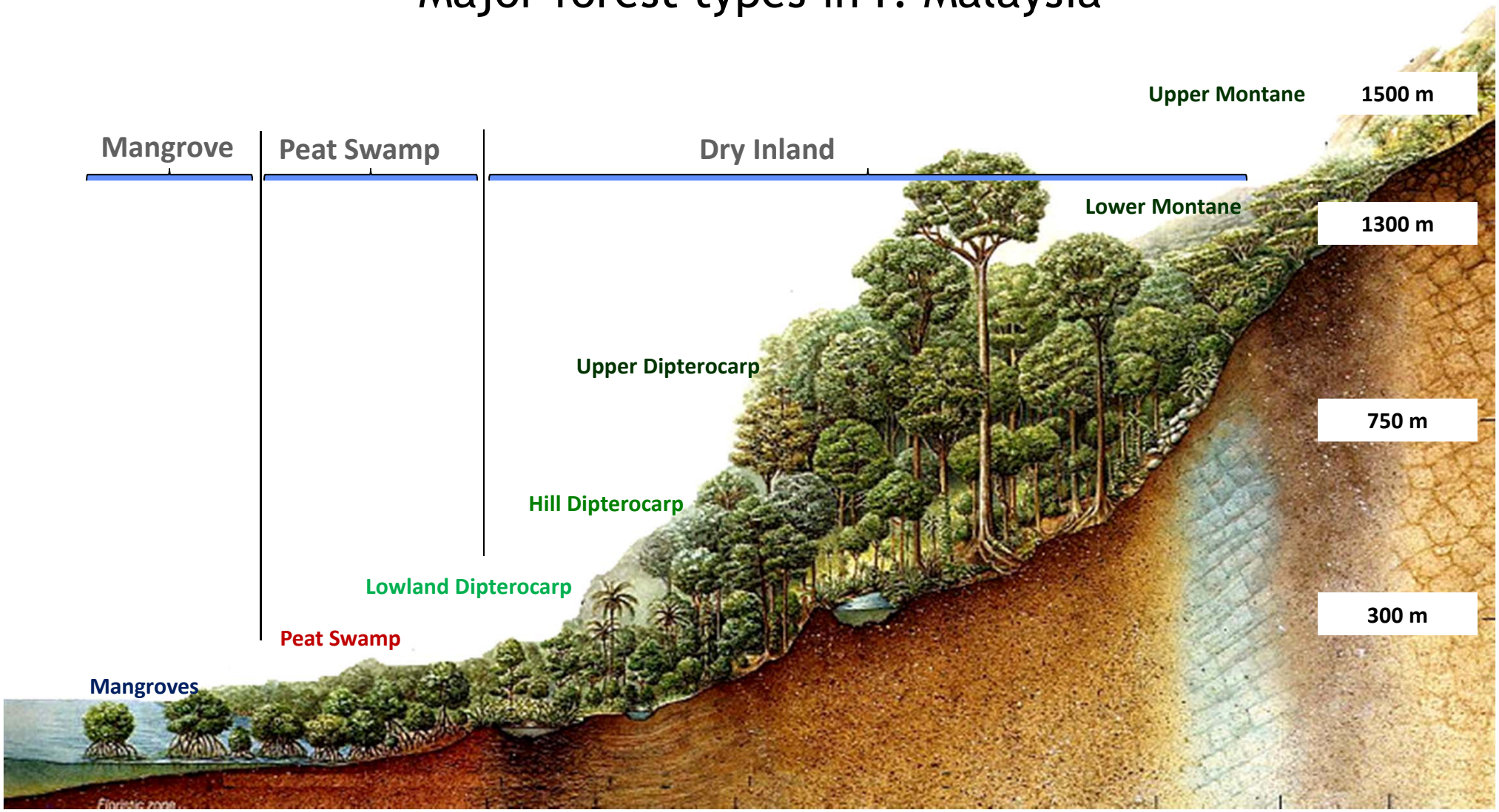
- Malaysia is one of the countries with high percentage of forested land among developing countries.
- Estimated forested land in Peninsular Malaysia (2010) - 5.86 million ha or 44.4% of the total land area.
- Of the total forested land, 4.80 million ha - Permanent Reserved Forests (PRFs) - National Forestry Act 1984.
- PRFs is being managed based on Sustainable Forest Management (SFM) principles and practices.

Major types of forest in Peninsular Malaysia



- Inland forest
- Peat swamp forest
- Mangrove forest

Major forest types in P. Malaysia



Project Summary

TITLE:	Aboveground Biomass and Carbon Stock Mapping and Changes Monitoring in the Forest of Peninsular Malaysia Using L-Band ALOS Palsar and JERS-1
DURATION:	Two years (April 2012 – March 2014)
EXEC. AGENCY:	Malaysian Forestry Research and Development Board, Forest Research Institute Malaysia (FRIM)
LOCATION:	Peninsular Malaysia

Project objectives and schedule

Objectives:

(i) to establish empirical relationship between aboveground biomass and L-Band signals for tropical forest ecosystem,

(ii) to determine aboveground biomass by using L-band SAR data, and

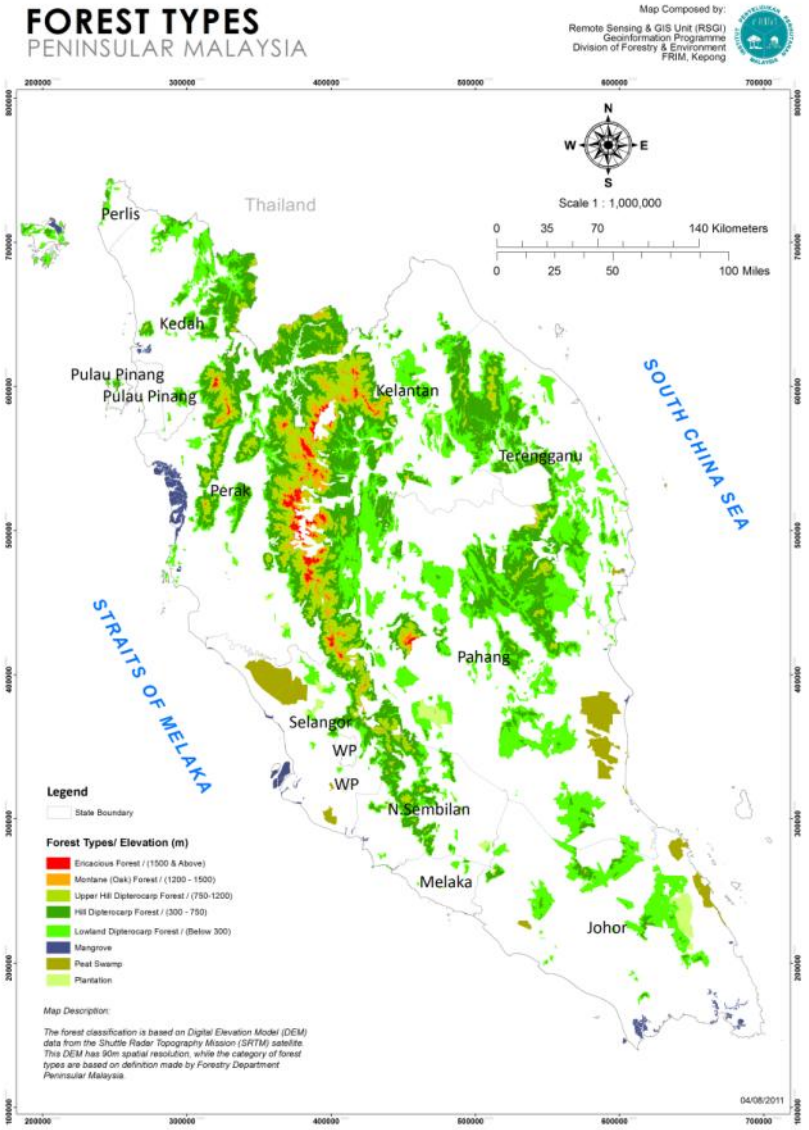
(iii) to map the current status and identify changes of aboveground biomass and carbon stocks in the forest in Peninsular Malaysia.

Deliverables:

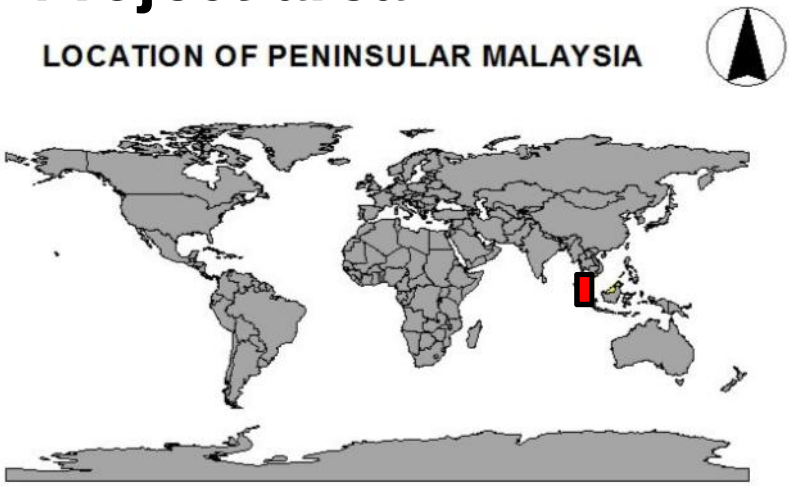
(i) Forest cover in the study area (1995 & 2010)

(ii) Pattern of spatial distribution of above ground biomass & carbon stocks in the forest (1995 & 2010)

(iii) Changes of biomass and carbon stocks from 1995 to 2010.



Project area



Forest Cover in Peninsular Malaysia

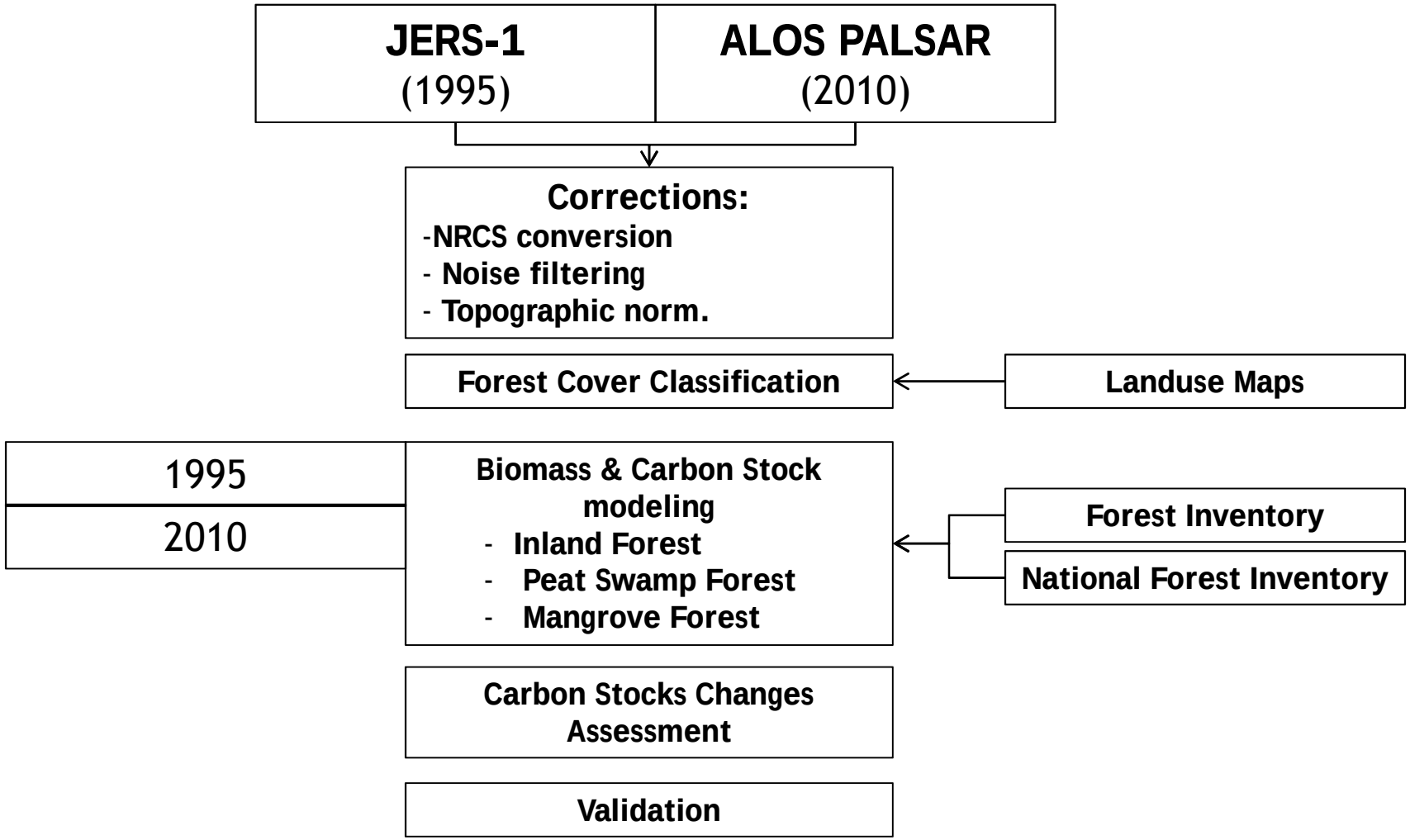
Location of Peninsular Malaysia:

Upper left Latitude/Longitude
6° 30’ 00” / 100° 00’ 00”

Lower right Latitude/Longitude
1° 00’ 00”/ 105° 00’ 00”

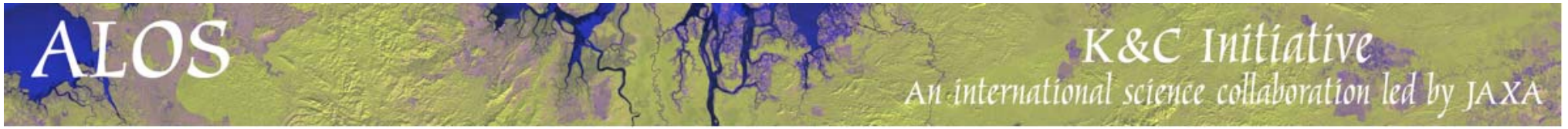
Region	Land Area	Natural Forests			Total Forested Land	% of Total Land Area
		Dry Inland Forest	Swamp Forest	Mangrove Forest		
Pen. M’sia	13.18	4.58	0.24	0.10	5.86	44.4

Methodology



Project milestones

No.	Key-milestone	Date of completion
i	Forest inventory data	Jun 2012 ●
ii	Maps of forest cover in the study area (1995 & 2010)	September 2012 ●
iii	Spatial distribution map of biomass and carbon stock (2010)	March 2013 ●
iv	Spatial distribution map of biomass and carbon stock (1995)	Jun 2013 ●
v	Spatial distribution map of biomass and carbon stock changes over 15 years (1995 - 2010)	Dec 2013 ●
vi	Project report	March 2014 ●



Project Schedule

Japanese Fiscal Year 2012 (April) – 2015 (March)

X : Activities

● : Planned milestone

Project Activities	2012/13												2013/14											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
•Agreement signing & ALOS Palsar + JERS-1 Data collection	X																							
•Secondary data collection	X	X																						
•Ground data collection/Plot Sampling	X	X	●																					
•Ground data analysis	X	X																						
•ALOS Palsar Image pre-processing: · Image Mosaic · Topographic normalization · DN to NRCS (dB) Conversion		X	X																					
•ALOS Palsar Image processing: · Forest classification · Biomass modeling				X	X	●																		
•Mapping of Current AGB & Carbon Stocks (2010)							X	X	X	X	X	●												
•JERS-1 Image pre-processing: · Image Mosaic · Topographic normalization · DN to NRCS (dB) Conversion		X	X																					
•JERS-1Image processing: · Forest classification				X	X	●																		
•Mapping of AGB & Carbon Stocks in 1995										X	X	X	X	X	●									
•Mapping of AGB & Carbon Stocks Changes (1995-2010)																X	X	X	X	X	●			
•Validation and verification																						X	X	
•Project completion report																						X	X	●

Support to JAXA's global forest mapping effort

Tropical rainforest of Malaysia is one of the oldest and most complex ecosystems in the world. Although generally taken to mean the species rich lowland forests, other forest types include mangroves, peat swamps and montane forests are also rich with diverse species.

Forest Research Institute Malaysia (FRIM) will be responsible to **verify** and **validate** these forest cover in Peninsular Malaysia, and assess the response of SAR data on these forests. By using ground truth samples and experts knowledge, the algorithm that will be developed for forest cover mapping by using both ALOS Palsar and JERS-1 SAR products will be validated, specifically for the corresponding region in the study area.

Growth levels, health status, density and quality of each type of the forest will be taken into considerations in sampling processes.

Data will be inventoried on the ground and will be stored in digital shapefile (.shp) for analysis and image pixel sampling. This ground data will be shared together with JAXA scientist on conditions as specified in the project agreement.

Number of sampling plots according to the forest types

Types of forest	Natural Forest			Plantation forest	Total samples
	Dry inland	Swamp forest	Mangrove forest		
No. of Sampling Points	150 (4.5 mil. ha)	35 (0.2 mil. ha)	20 (0.1 mil. ha)	15 0.08 (mil. ha)	**220**

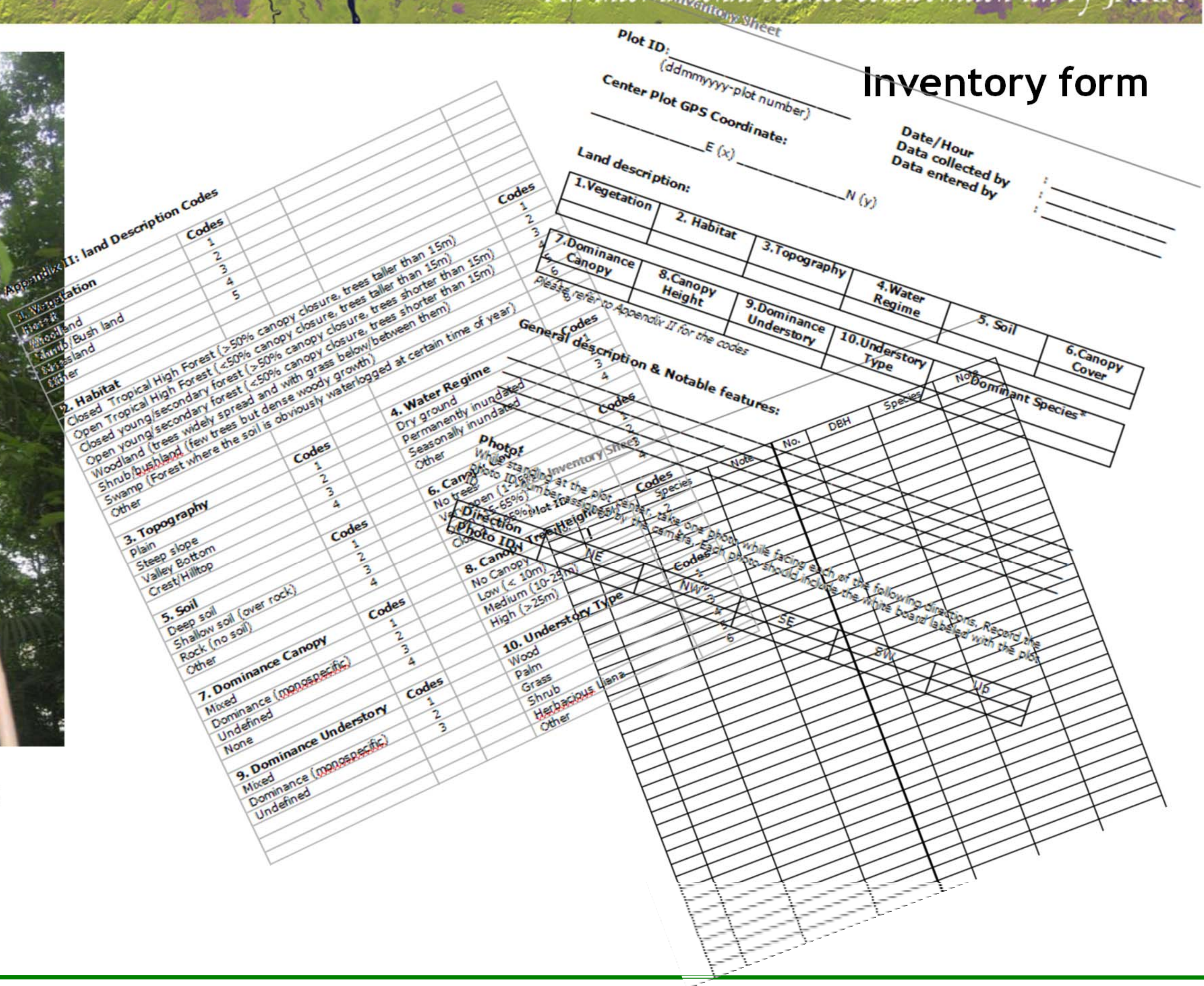
ALOS

K&C Initiative

An international science collaboration led by JAXA

GPS to record plot center coordinate

Inventory form



ALOS

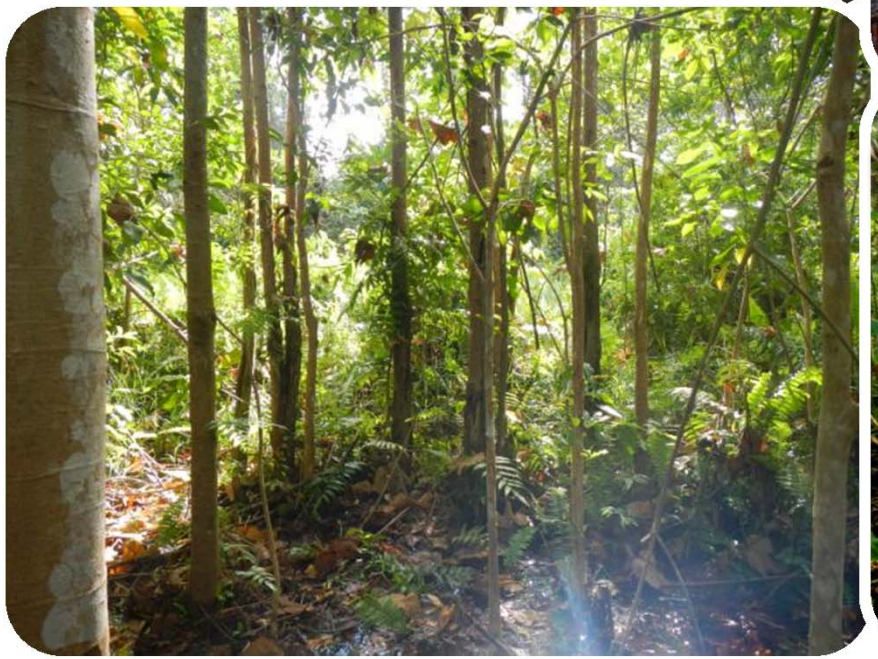
K&C Initiative

An international science collaboration led by JAXA

Inland Forest

Mangrove Forest

Peat Swamp Forest



Biomass Allometric Functions

No.	Source	Allometric functions	Application to type of forest
1	Kato et al. (1978)	$1/H = 1/(2.0*D) + 1/61$ from the values of D and H, the dry mass of stem, branches, and leaves of the tree is estimated $Ms=0.0313*(D^2H)^{0.9733}$ $Mb=0.136*Ms^{1.070}$ $1/Ml=1/(0.124Ms^{0.794})+1/125$	Inland forest including both lowland and hill forest type at Bukit Lagong FR, Sungei Menyala FR, Pasoh FR and Semangkok FR, FRIM's planted forest
2	Niiyama et al. (2010)	$Wr = 0.0254*D^{2.521}$	As above
3	Chave et al. (2005)	$Wt=0.0509*\rho D^2H$ $Wt=\rho*\exp(-1.499+2.148*\ln(D)+0.207*(\ln(D))^2-0.0281*(\ln(D))^{2)}$	Pasoh 50 ha plots and other CTFS plots
4	Istomo (2006)	$Wt = 0.0145 (D^3) - 0.4659* (D^2) + 30.64*(D) - 263.32$ $Wr = 20.1\%$ of Wt	Peat swamp forest
5	Komiyama et al. (2007)	$Wt= 0.251\rho D^{2.46}$ $Wr=0.199\rho^{0.899} D^{2.22}$	Common equation applied to all trees in mangrove forest
6	Ong et al. (2004)	$Log10(Wt)= 2.420 *log10(GBH) -1.832$ $Log10(Wr)= 2.611 *log10(GBH) – 3.454)$	Specific equation *Rhizophora apiculata*

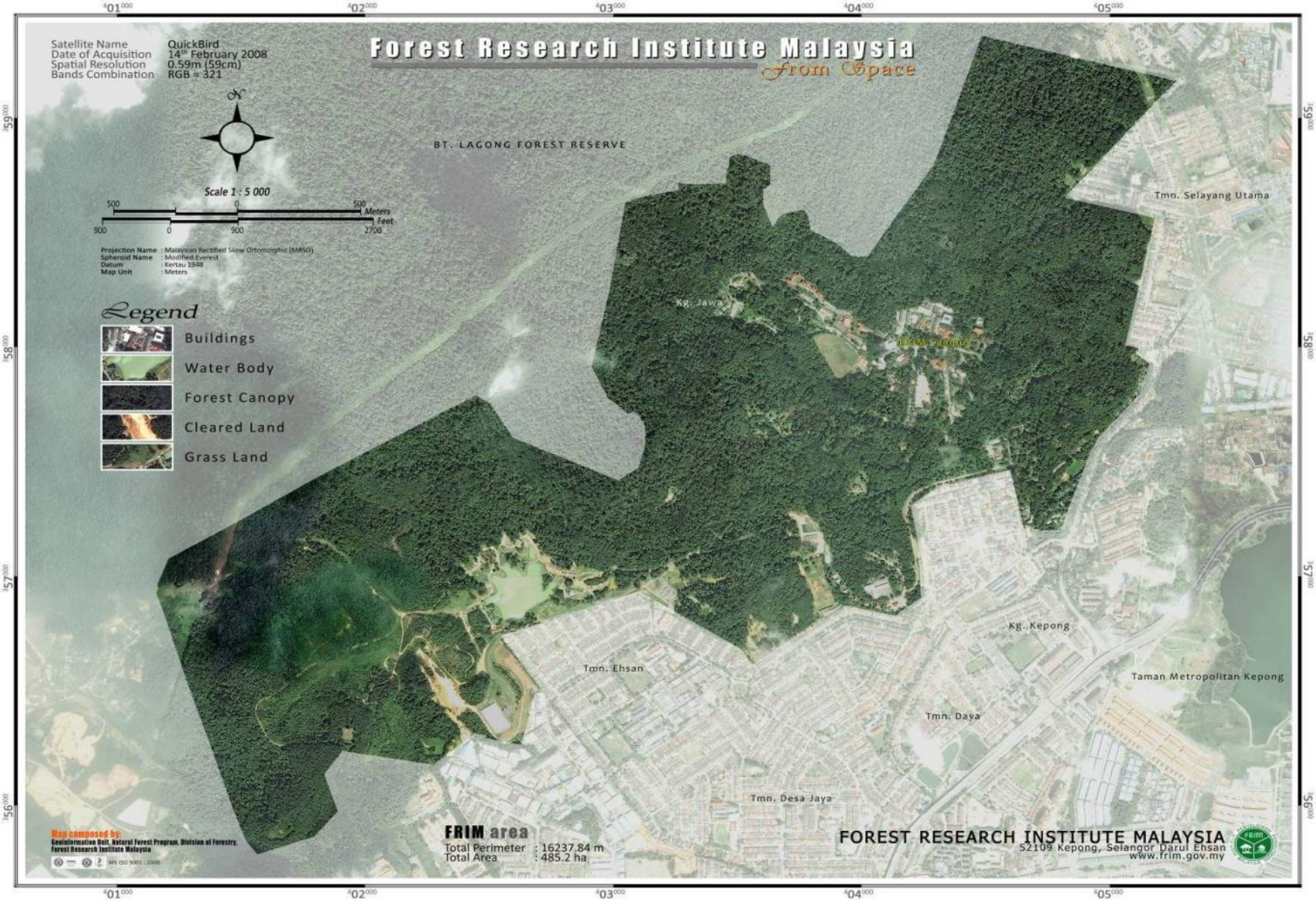
Case Study 1

O Hamdan, H Khali Aziz & K Abd Rahman (2011). Remotely Sensed L-Band SAR Data for Tropical Forest Biomass Estimation. Journal of Tropical Forest Science 23(3): 318–327

ALOS

K&C Initiative

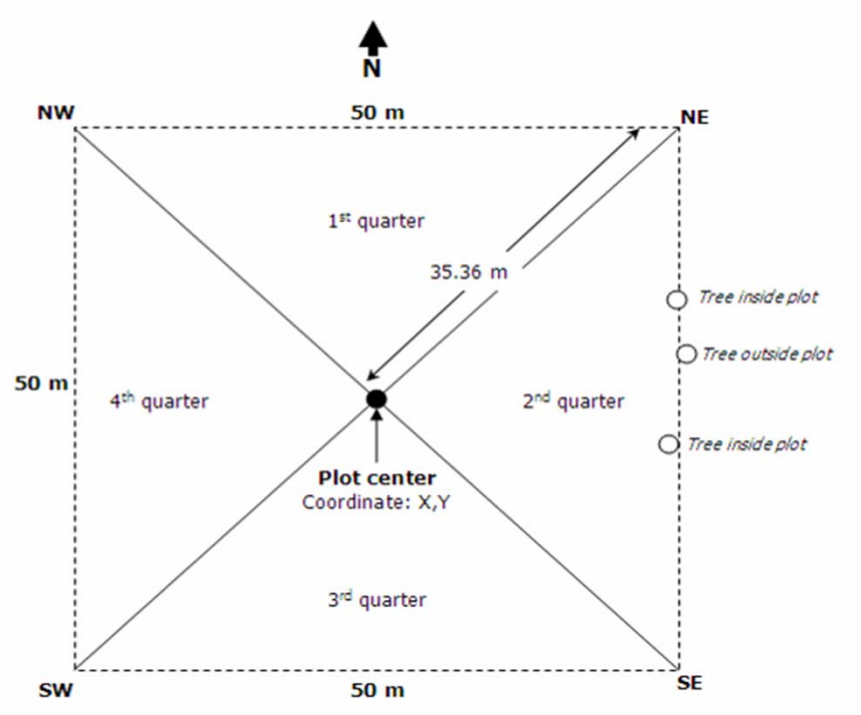
An international science collaboration led by JAXA



Field Inventory Data

Field survey was carried out and more than 30 plots of 50 x 50 m size were established within the study area. The plots covered all forest types and various ages.

All the trees with the size of dbh of more than five centimetre (≥ 5 cm) were inventoried.

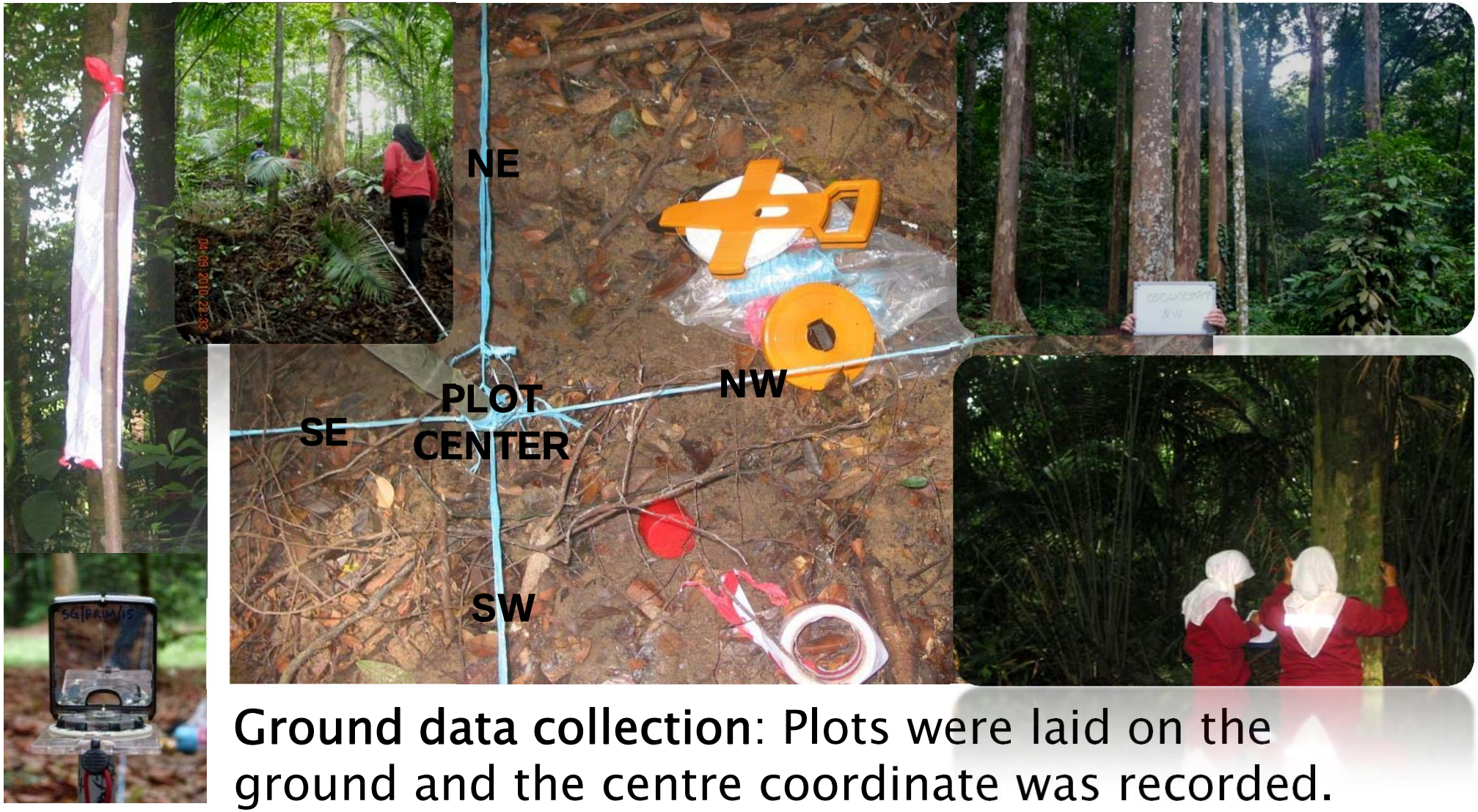


Design of the plots that were distributed and laid on the ground in the study area.

ALOS

K&C Initiative

An international science collaboration led by JAXA



Ground data collection: Plots were laid on the ground and the centre coordinate was recorded.

Dominant types of standing trees that are found in the study area. Most of the trees are above 25 m height and reach up to 45 m.

High biomass & carbon concentration

Medium biomass & carbon concentration

Low biomass & carbon concentration

Biomass Allometry

Biomass equations to calculate AGB were based on Kato et al. (1978). The allometric function of trees applied in the calculation of standing biomass can be expressed as

$$1/H = 1/(2.0*D)+1/61$$

From the values of D and H, the dry mass values of stem, branches and leaves of the tree are estimated.

$$Ms = 0.0313*(D2H)0.9733$$
$$Mb = 0.136*Ms1.070$$
$$1/Ml = 1/(0.124Ms0.794)+1/125$$

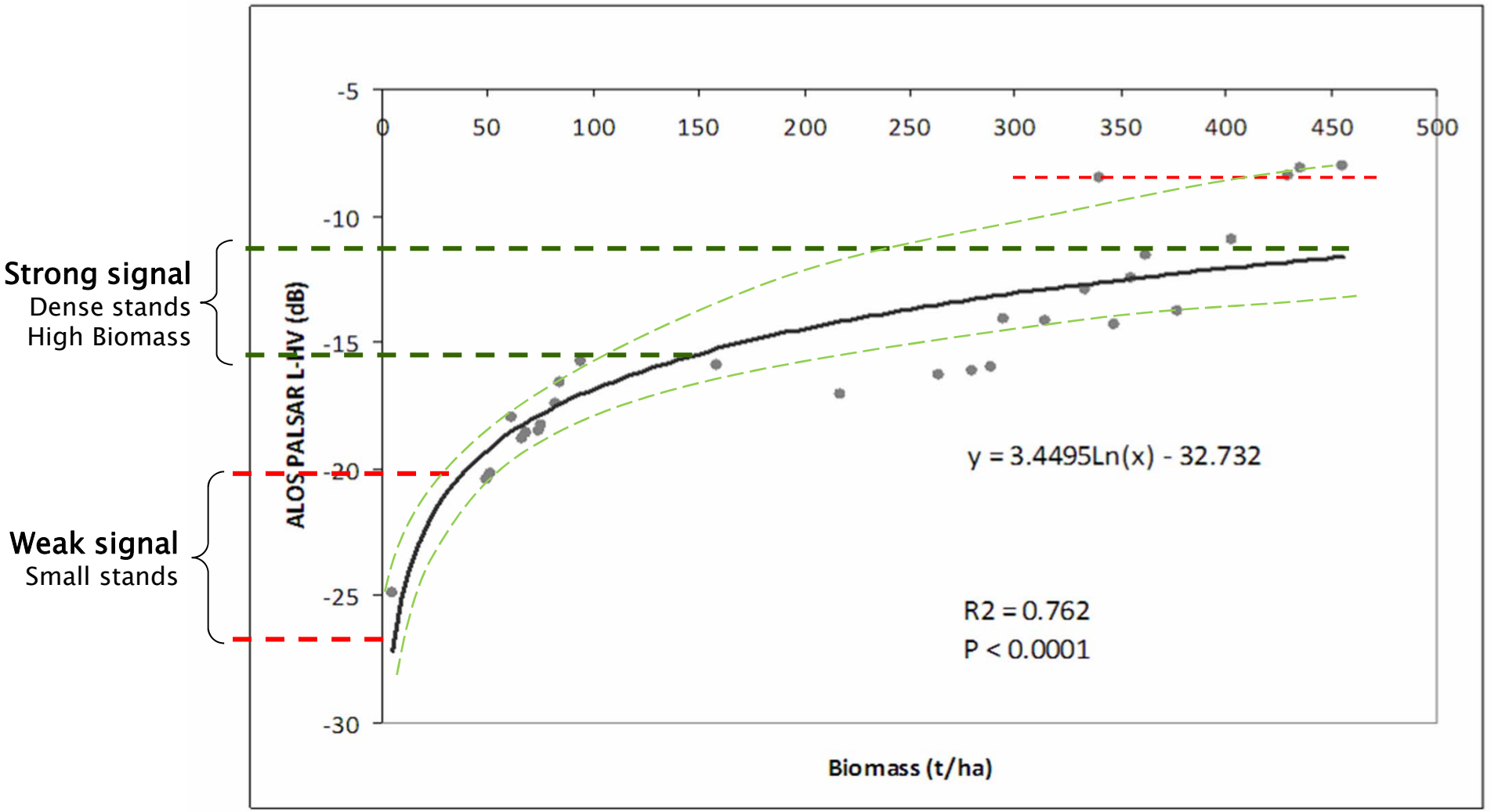
where;

H = total tree height

D = stem diameter at breast height (dbh)

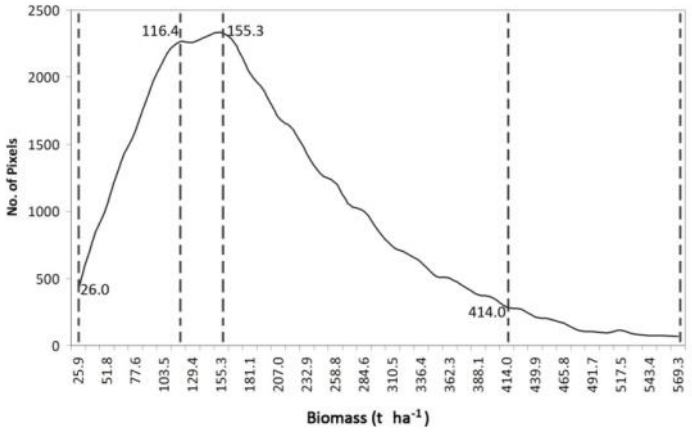
Ms, Mb and Ml denote the dry mass of stem, branches and leaves respectively.

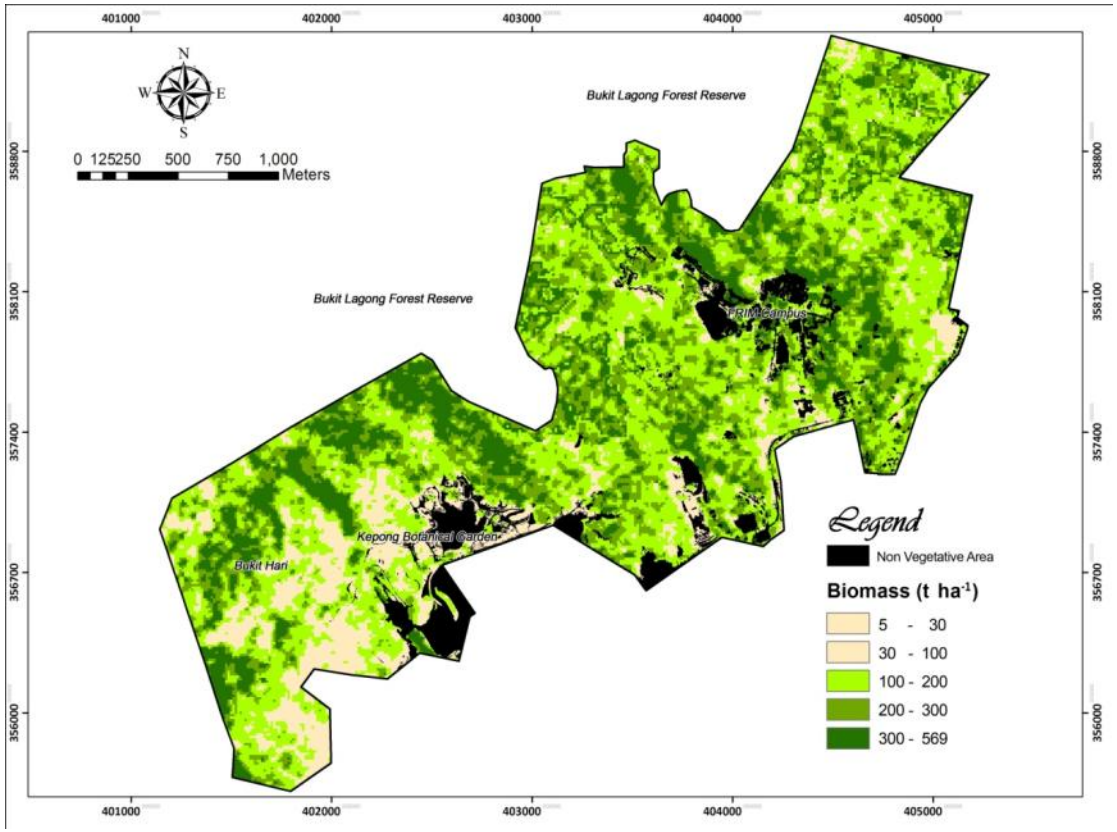
Relationship between biomass and L-Band ALOS PALSAR signal



Range:
12.95 -284.65 t C

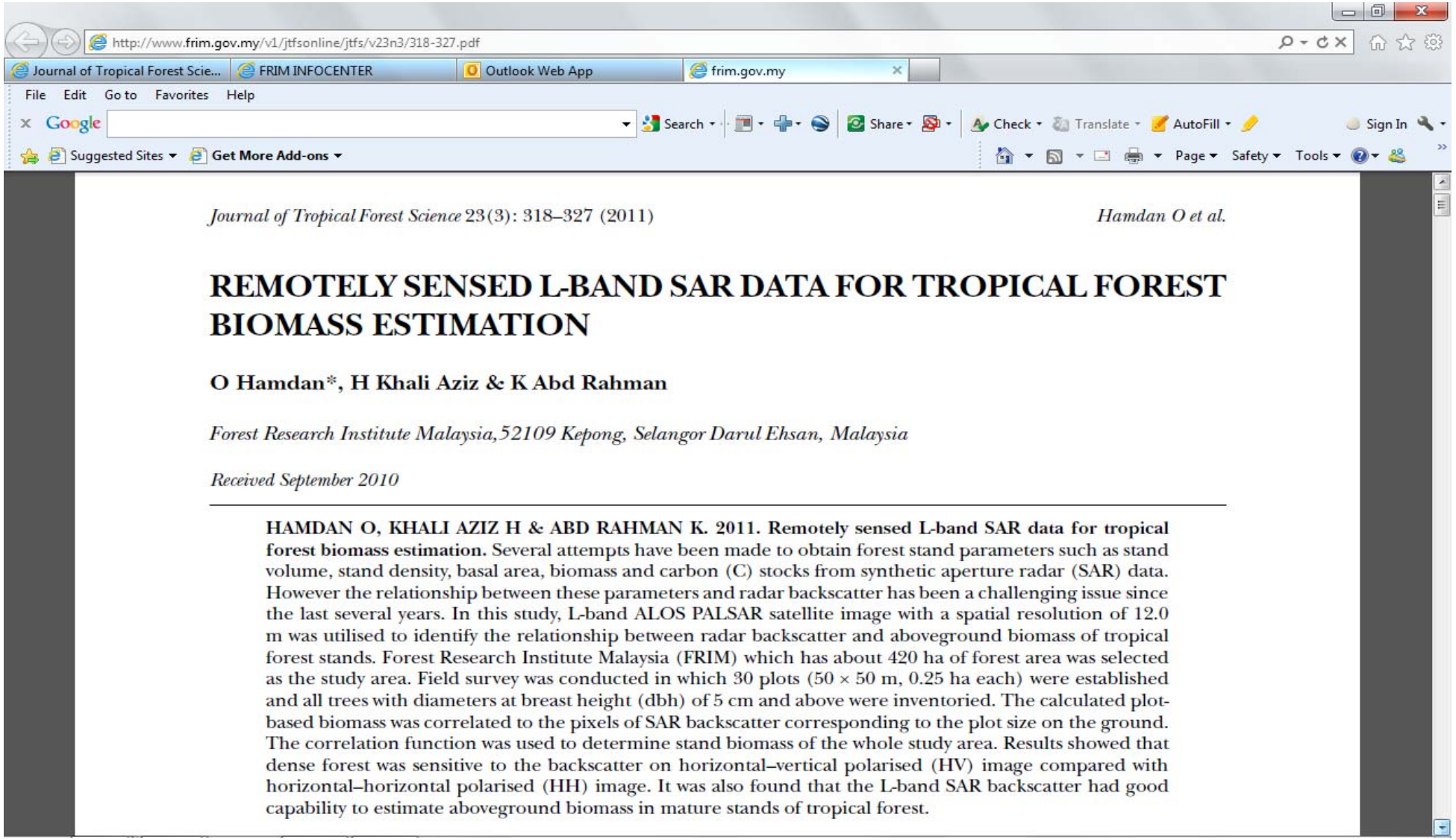
Total C stocks:
56,874.9 t C





Category	Biomass (t ha^{-1})	Carbon Stocks (t ha^{-1})	Coverage (%)
Small, growing stands	26 – 116	13–58	28.2
Mixed small & mature stands	130 – 155	65 – 77.5	16.9
Mature, dense stands	168 – 414	84 – 207	51.1
Mature & very dense stands	427 – 569	213.5 – 284.5	3.9

http://www.frim.gov.my/v1/jtfsonline/jtfs/v23n3/318-327.pdf



http://www.frim.gov.my/v1/jtfsonline/jtfs/v23n3/318-327.pdf

Journal of Tropical Forest Scie... | FRIM INFOCENTER | Outlook Web App | frim.gov.my

File Edit Go to Favorites Help

Google Search Share Check Translate AutoFill Sign In

Suggested Sites Get More Add-ons Page Safety Tools

Journal of Tropical Forest Science 23(3): 318–327 (2011)

REMOTELY SENSED L-BAND SAR DATA FOR TROPICAL FOREST BIOMASS ESTIMATION

O Hamdan*, H Khali Aziz & K Abd Rahman

Forest Research Institute Malaysia, 52109 Kepong, Selangor Darul Ehsan, Malaysia

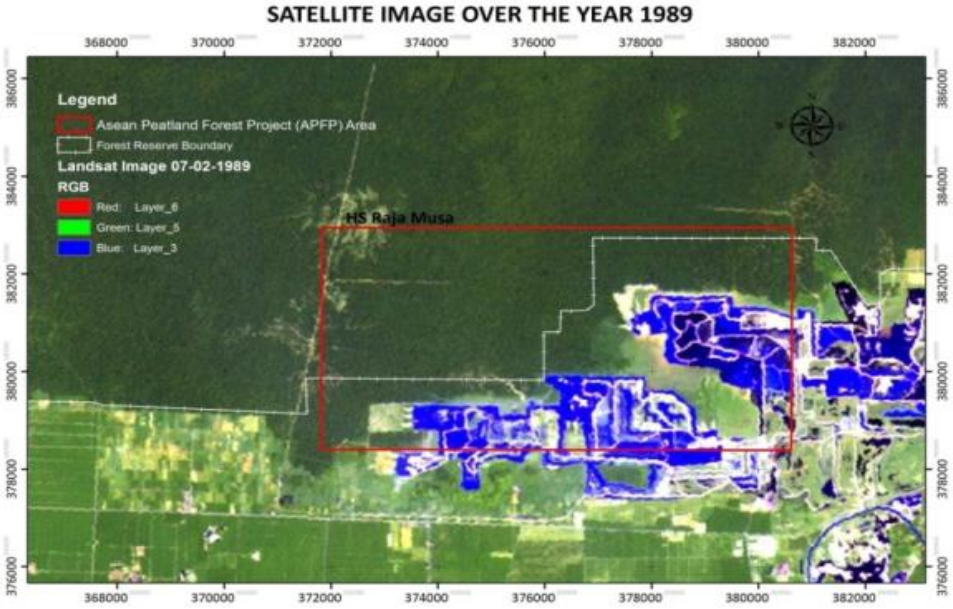
Received September 2010

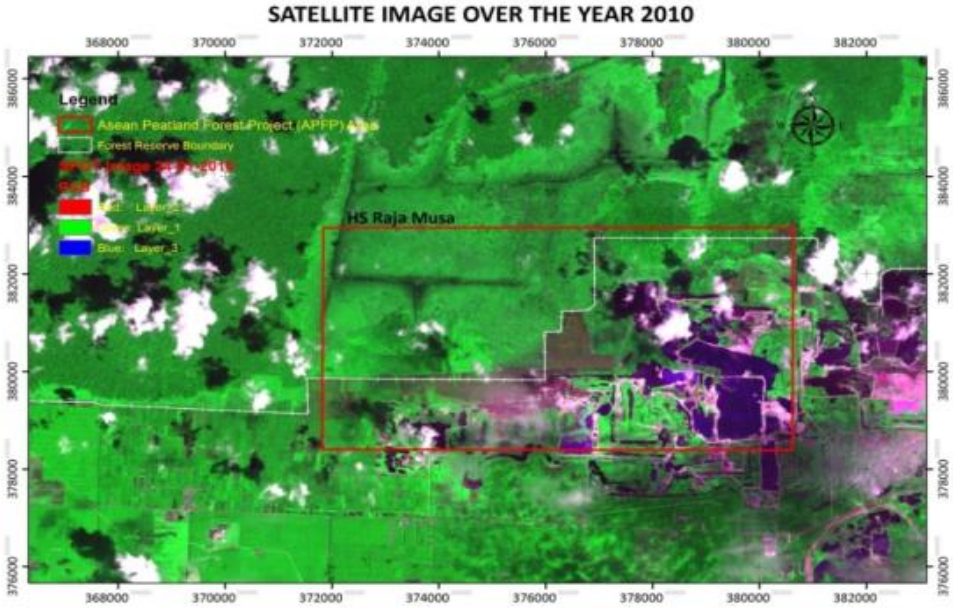
HAMDAN O, KHALI AZIZ H & ABD RAHMAN K. 2011. Remotely sensed L-band SAR data for tropical forest biomass estimation. Several attempts have been made to obtain forest stand parameters such as stand volume, stand density, basal area, biomass and carbon (C) stocks from synthetic aperture radar (SAR) data. However the relationship between these parameters and radar backscatter has been a challenging issue since the last several years. In this study, L-band ALOS PALSAR satellite image with a spatial resolution of 12.0 m was utilised to identify the relationship between radar backscatter and aboveground biomass of tropical forest stands. Forest Research Institute Malaysia (FRIM) which has about 420 ha of forest area was selected as the study area. Field survey was conducted in which 30 plots (50 × 50 m, 0.25 ha each) were established and all trees with diameters at breast height (dbh) of 5 cm and above were inventoried. The calculated plot-based biomass was correlated to the pixels of SAR backscatter corresponding to the plot size on the ground. The correlation function was used to determine stand biomass of the whole study area. Results showed that dense forest was sensitive to the backscatter on horizontal–vertical polarised (HV) image compared with horizontal–horizontal polarised (HH) image. It was also found that the L-band SAR backscatter had good capability to estimate aboveground biomass in mature stands of tropical forest.

Case Study 2

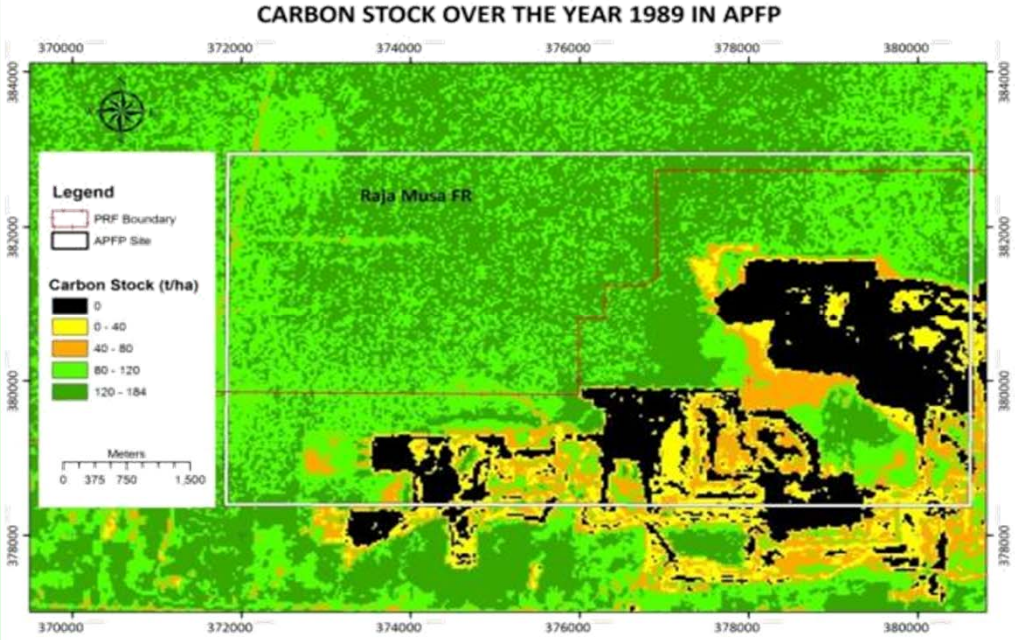
Hamdan O, Ismail P & Azian M. (2012). Assessment of carbon stock changes in demonstration site of Asean Peatland Forest Project (APFP) at Raja Musa Forest Reserve. Project Report, Forestry Department Peninsular Malaysia. 39pp.

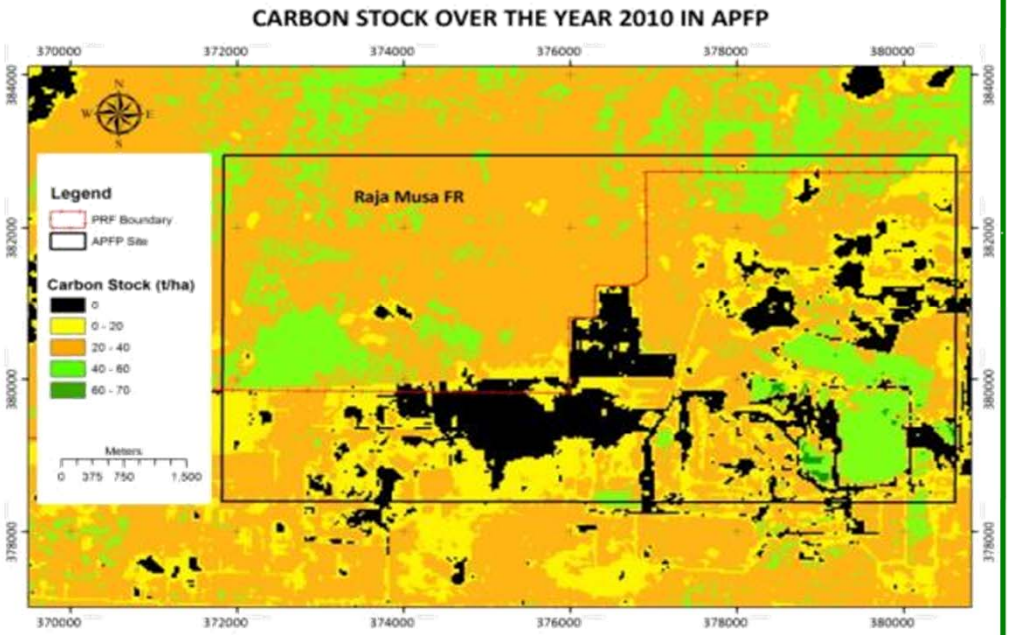
Satellite images over the years 1989 and 2010



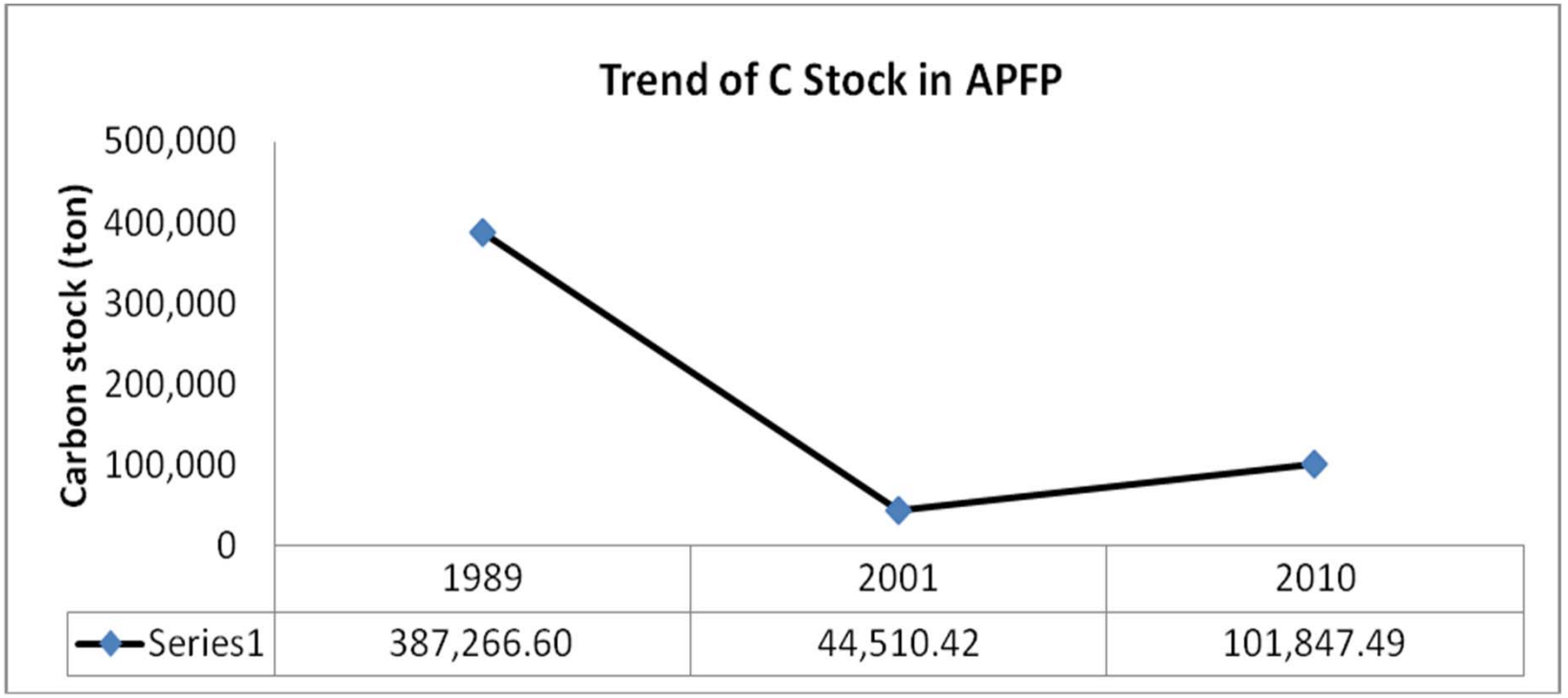


Spatial distribution maps of C stock over the years 1989 and 2010

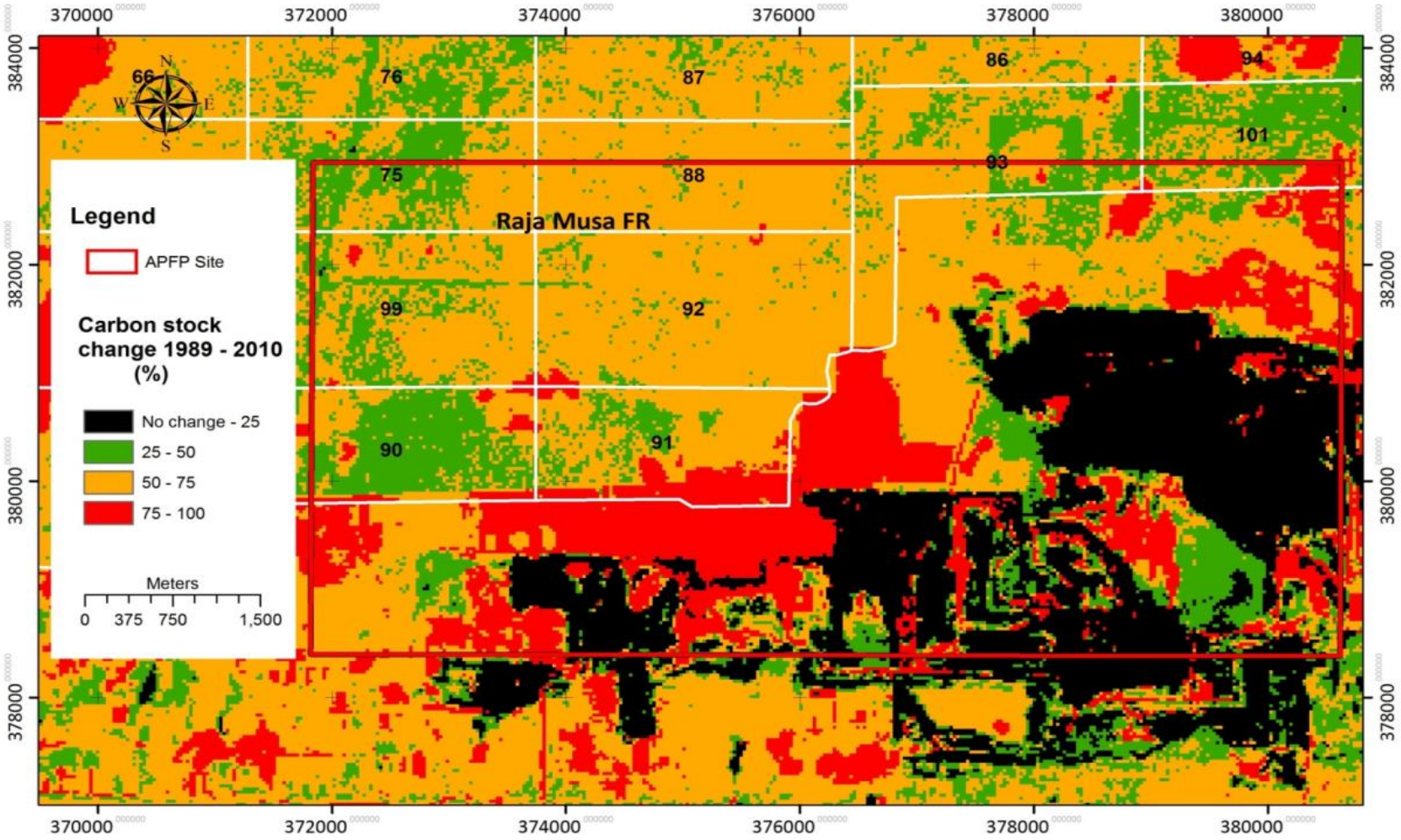




Source: Assessment of carbon stock changes in demonstration site of Asean Peatland Forest Project (APFP) at Raja Musa Forest Reserve. Submitted to Forestry Department Peninsular Malaysia. 39pp.


Trend of C Stock in APFP
Carbon stock (ton)
500,000
400,000
300,000
200,000
100,000
0
1989
2001
2010
Series1
387,266.60
44,510.42
101,847.49

SPATIAL FRACTION OF CARBON STOCK CHANGES (1989 - 2010)



Carbon Stocks – Inland forest

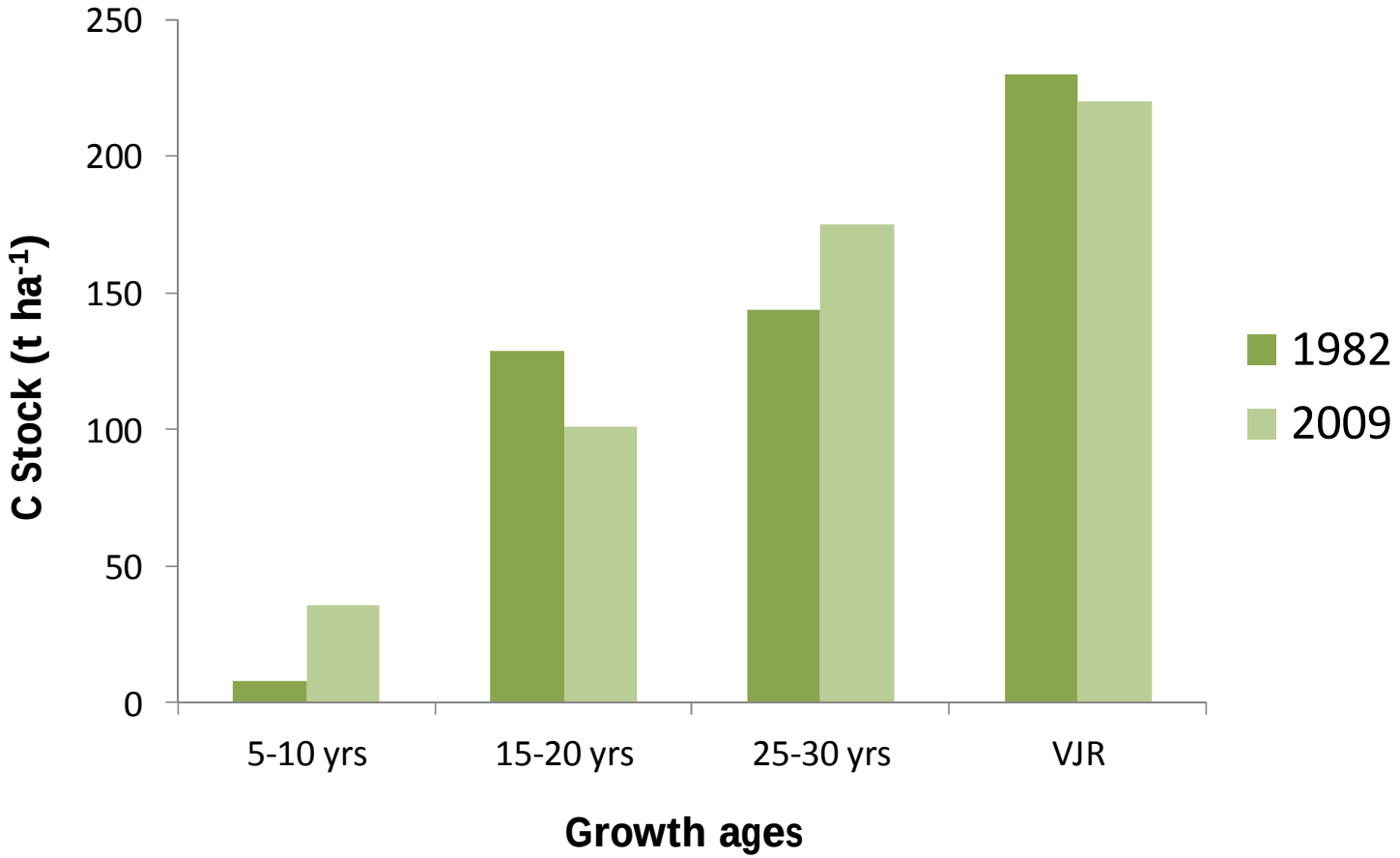
	Forest	Carbon stocks (t/ha)	Reference
P. Malaysia	Lowland dipterocarp Pasoh FR	155 (Primary forest) 138 (Secondary forest)	Okuda, *et al* (2003)
	Inland Air Hitam FR	104-111	Ismriah & Ahmad Fadli (2007)
Sarawak	Mixed dipterocarp	140-202	Brown (1997)
	Secondary forest- 10-14 yrs	16	Chai (1997)
	Lambir, FR	245-250	Feeley et al (2007)
Sabah	Lowland dipterocarp	32-324	Foody *et al* (2001)

Changes in Carbon Stocks - PSF

	1972	1983	2005
PSF	88.75	107	110-225
*Logged PSF	61.8	89	
Degraded PSF	54.7	135	

- *Johor and Selangor PSF
- Unit: t/ha

Carbon Stocks – Mangrove, Matang FR



Thank you

Terima kasih

ありがとうございます

Obrigado

Salamat sa iyo

Merci beaucoup

Danke schön

Su-bhaay