Experiences with RapidEye satellite imagery for REDD+ in Indonesia

Prof. Dr. Florian Siegert

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Remote sensing related objectives in ForCLIME

- collect activity data
- estimation of emission factors
- support REDD+ demonstration activities
- develop methods fort forest carbon mapping and monitoring
- validation of remote sensing products
- design of field surveys and collection of forest inventory data
- capacity building

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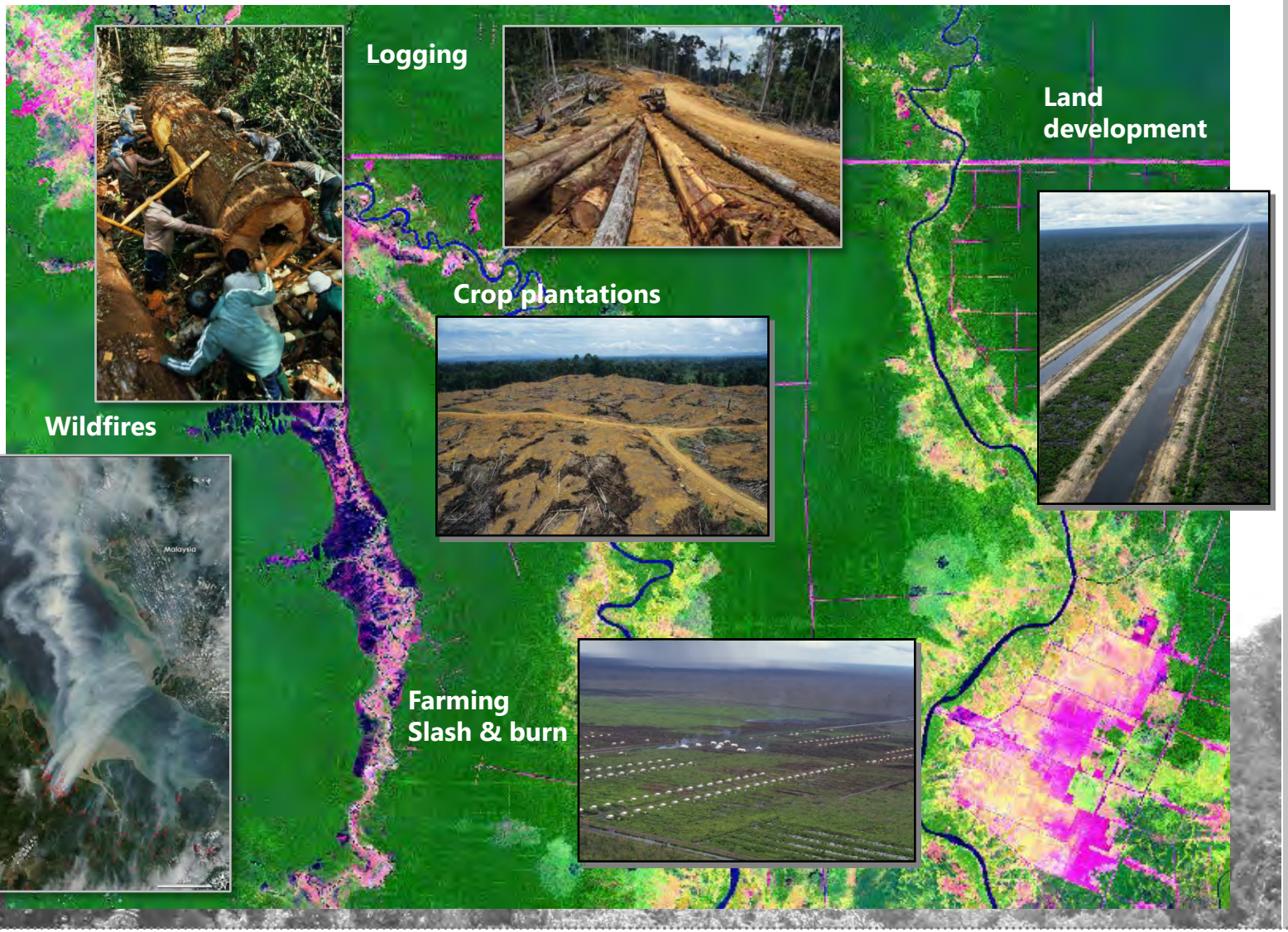
Drivers of deforestation in Indonesia



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Selected mulitspectral satellite sensors suitable for REDD+ MRV

Resolution and coverage	Mission	Number of bands	Spatial Resolution	Swath Width	Revisit time
Very high resolution Small spatial coverage	WorldView-2	9 bands	PAN: 0,46 m MS: 1,84 m	16,4 km	1-6 days
	Ikonos-2	5 bands	Pan :1m MS: 4 m	11 km	
	GeoEye	5 bands	PAN: 0,41 m MS: 1,65 m	15.2 km	
	QuickBird	5 bands	PAN: 0,61 m MS: 2,44 m	16,5 km	
	Pleiades	5 bands	PAN: 0.5 m MS: 2 m	20 km	
High resolution Moderate spatial coverage	RapidEye	5 bands	6.5 m	78 km	daily
	SPOT 5 / 6	4 bands	Pan: 5 m (2.5) MS: 10 m	60 km	2-3 days
Moderate resolution Large spatial coverage	Landsat	7 bands	PAN: 15 m, MS: 30 m	185 km	16 days

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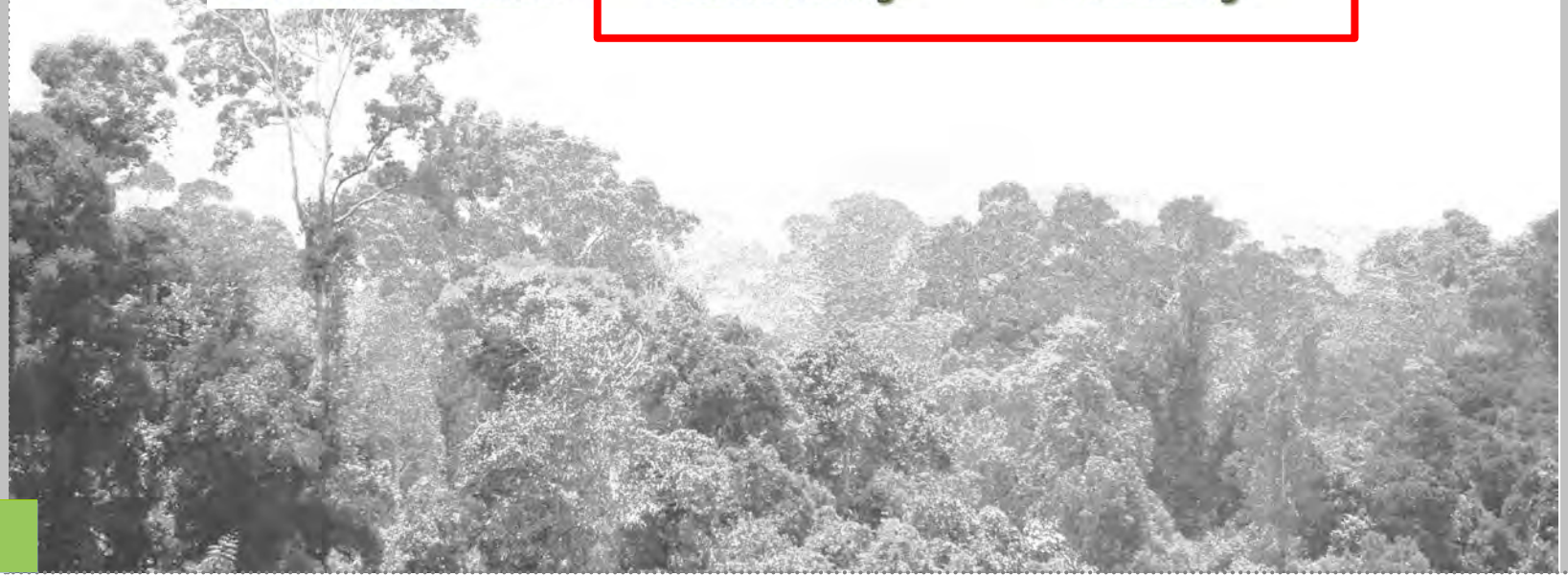
MRV - Measurement Reporting and Verification

Historical Forest Cover & Carbon Stock

Current Forest Benchmarking

Future Forest Monitoring



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Rapideye – multi temporal, high-resolution satellite imagery

- 5 satellites
- 3000 km per satellite & orbit
- 77km swath (Nadir)

- 5 m pixel size (ortho rectified)
- 5.000.000km^2 per day

Illustration der 5 Satelliten im Orbit

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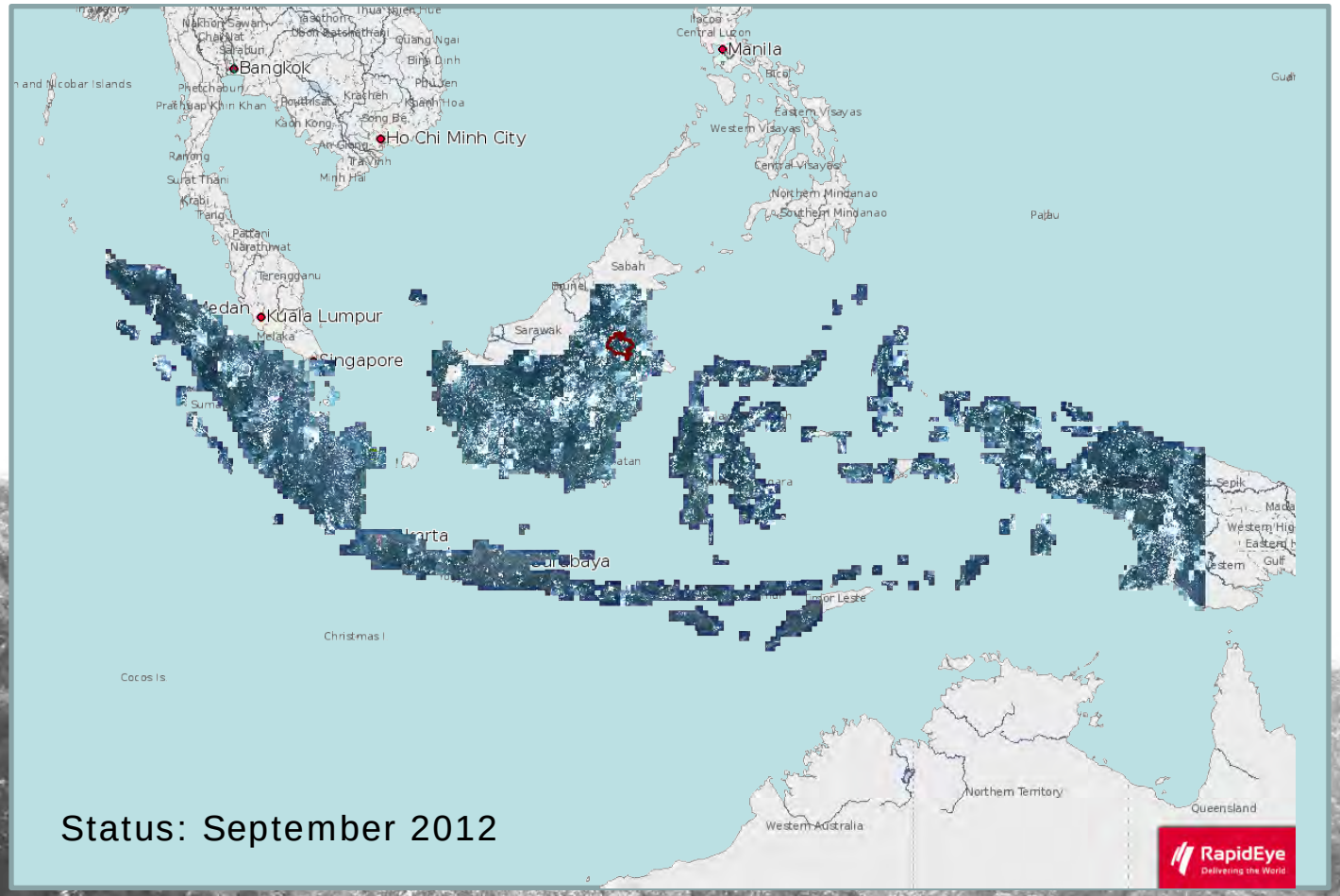
RapidEye – current coverage of Indonesia



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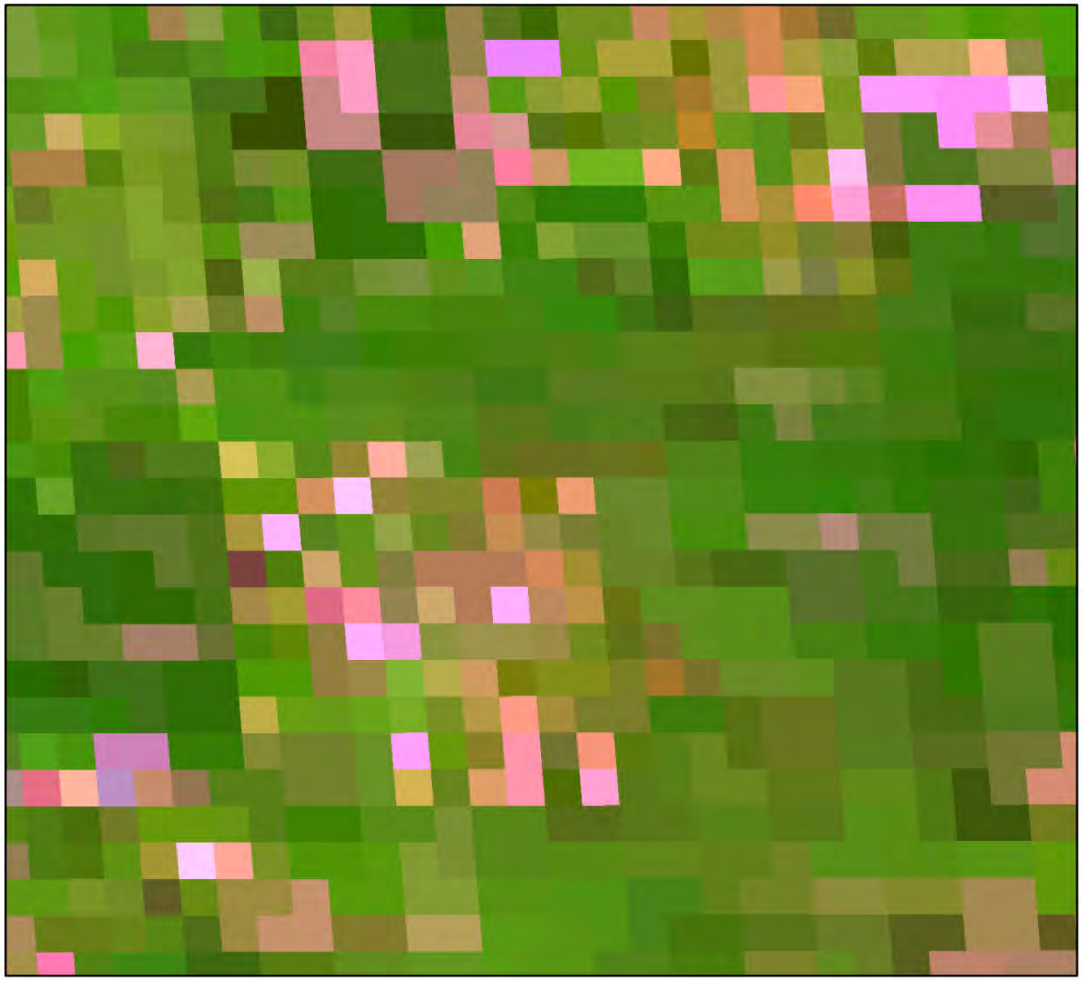
Forest benchmarking
Spatial resolution of satellite imagery



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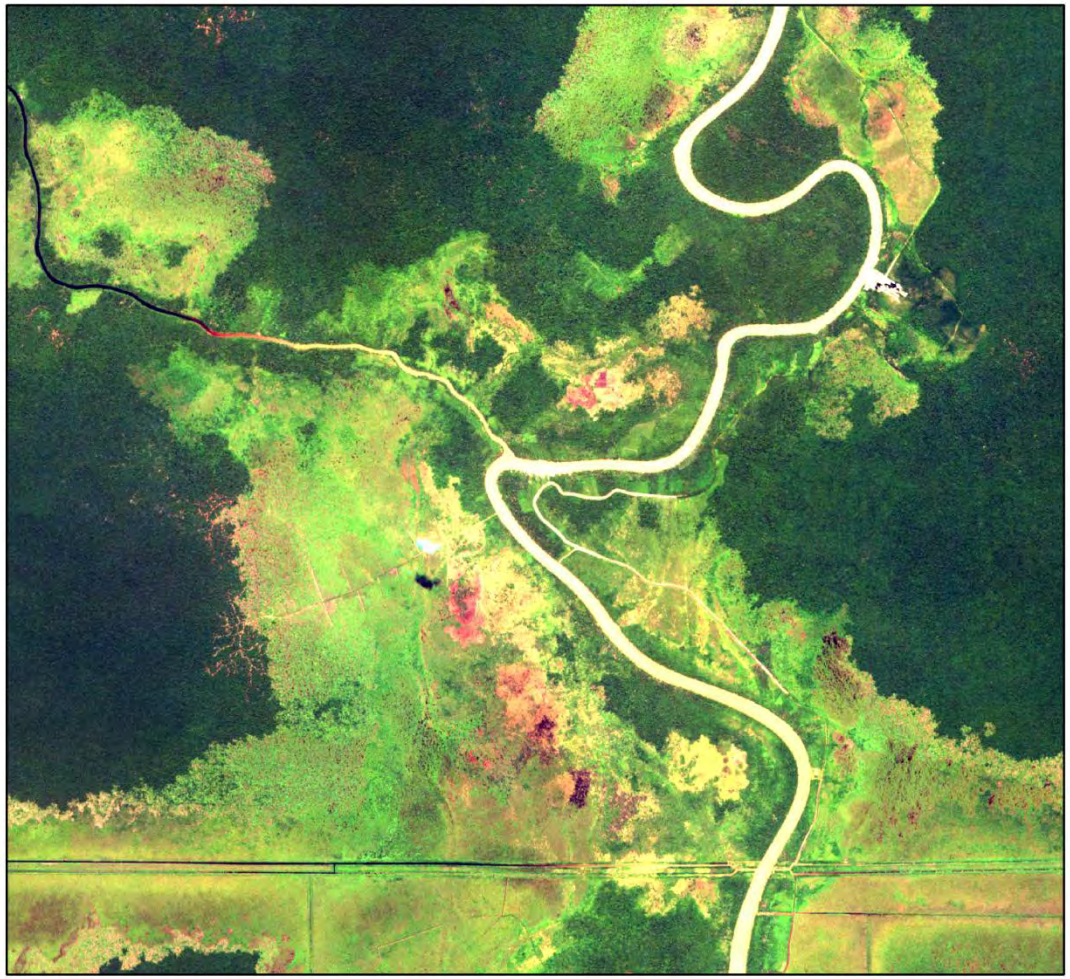
Forest benchmarking
Spatial resolution of satellite imagery



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Forest benchmarking
Spatial resolution of satellite imagery

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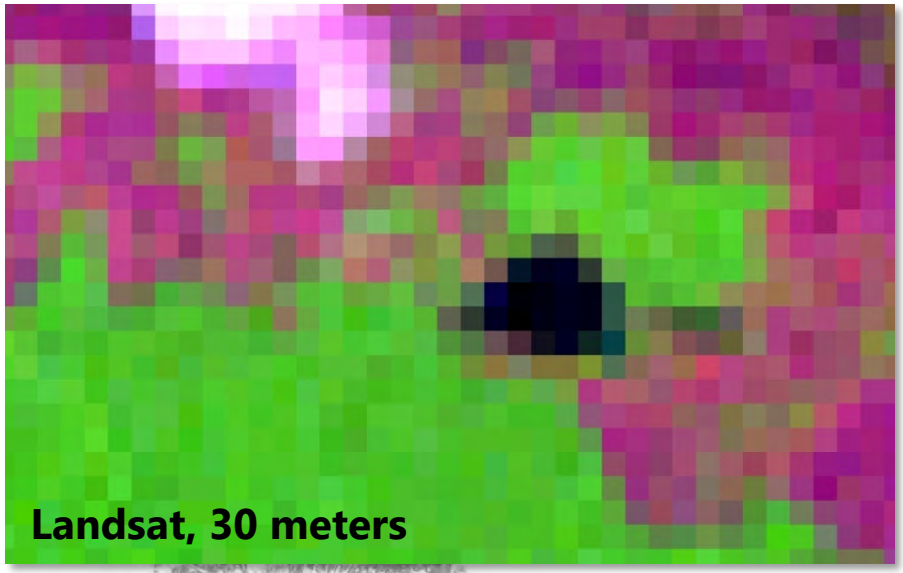
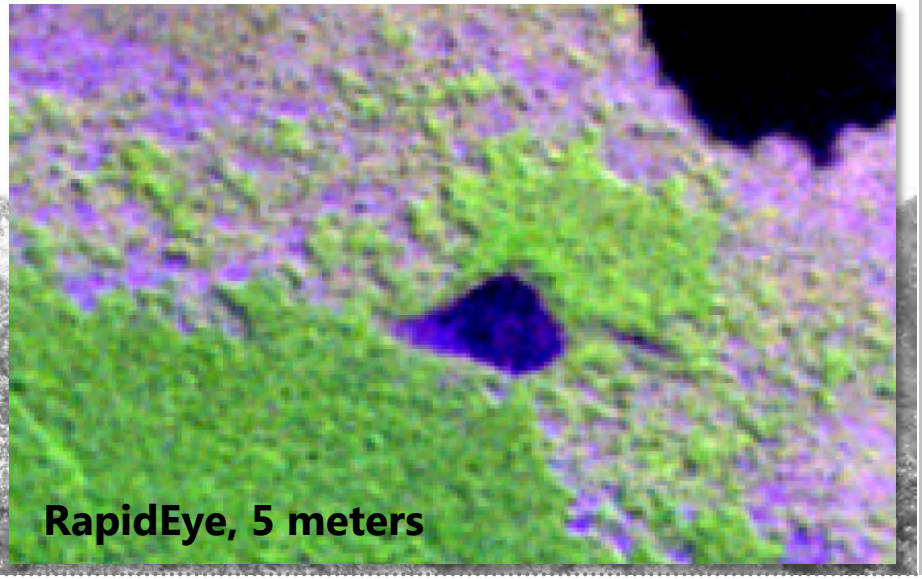
Comparion Rapideye & Landsat
Forest fragmentation





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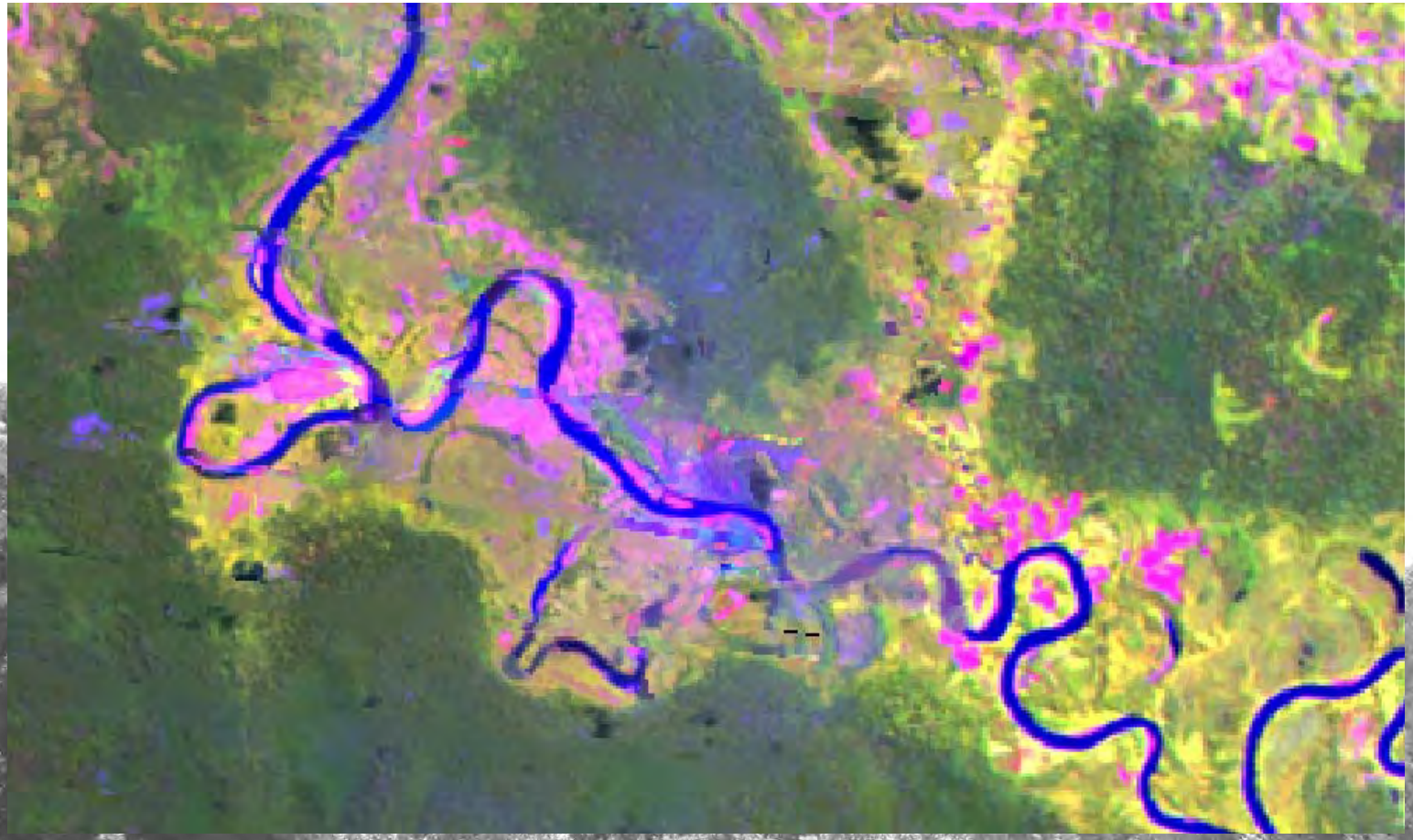
Forest benchmark mapping
Forest fragmentation

Comparison of Landsat and Rapideye satellite imagery for benchmark mapping



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Forest benchmark mapping
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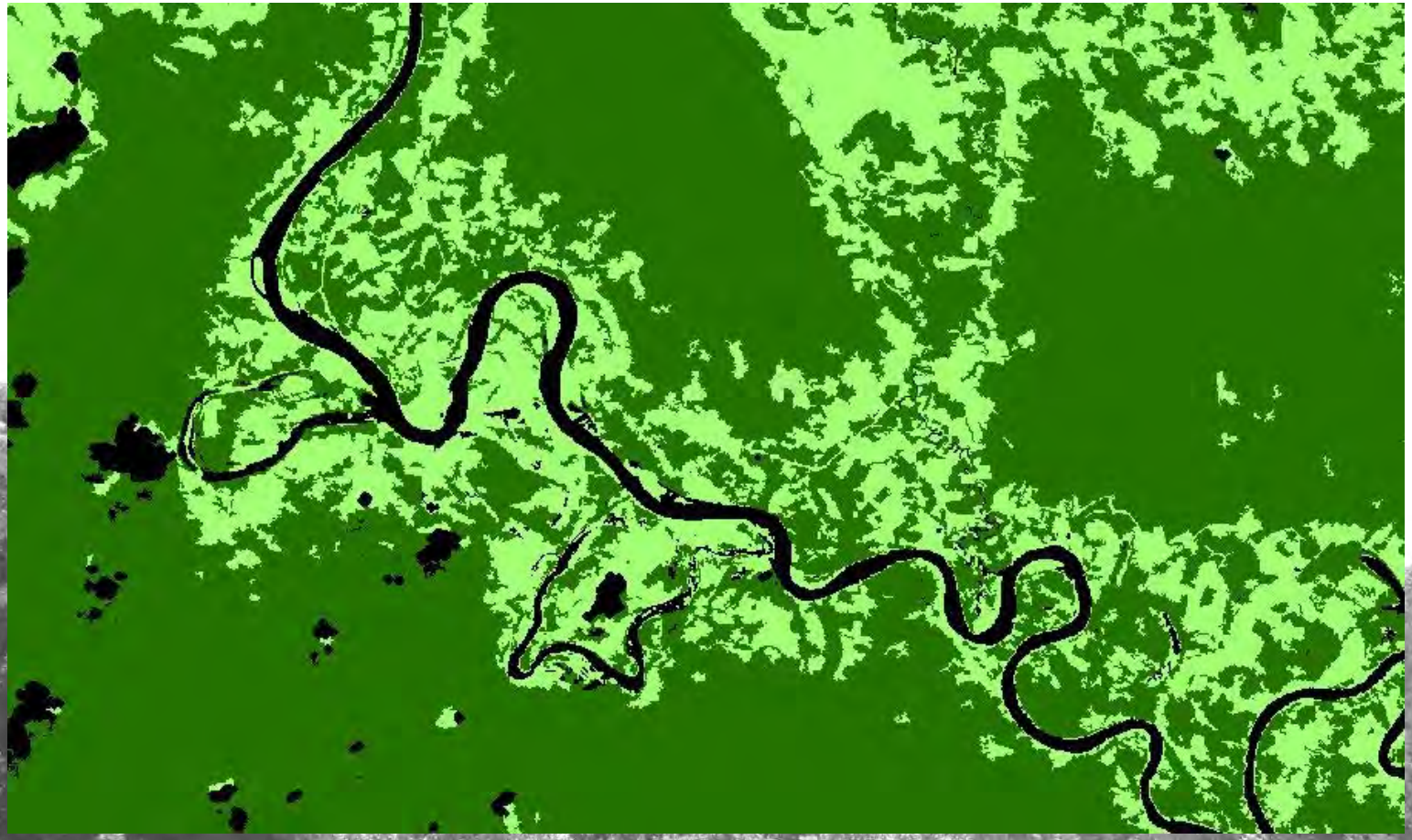

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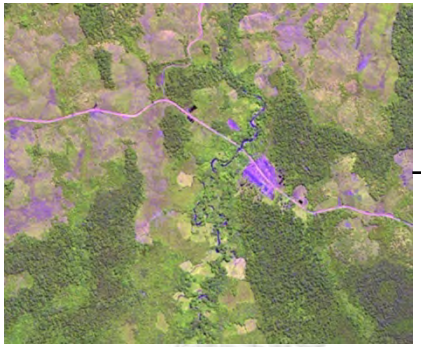
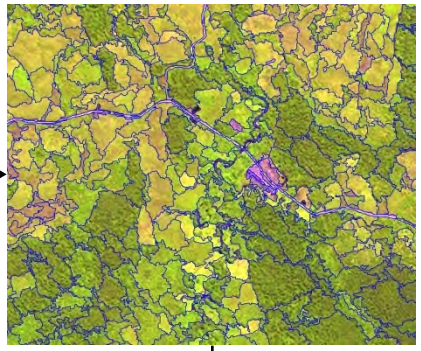
Forest benchmarking
From Images to Information

Atmospheric correction
Orthorectification

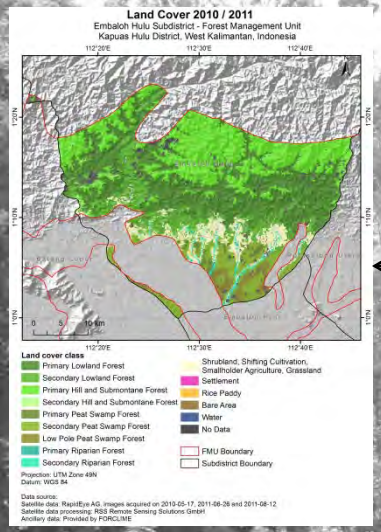
Segmentation



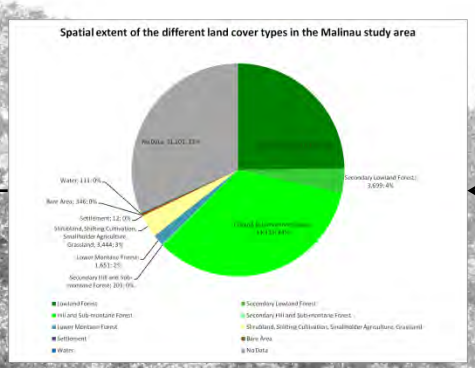


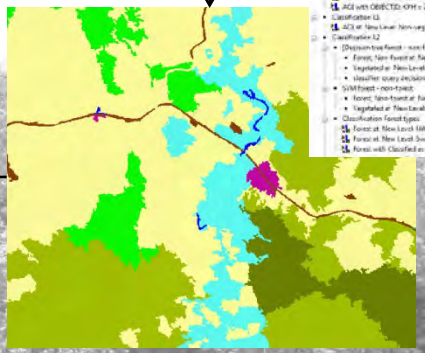
Map production

Classification



Spatial analysis





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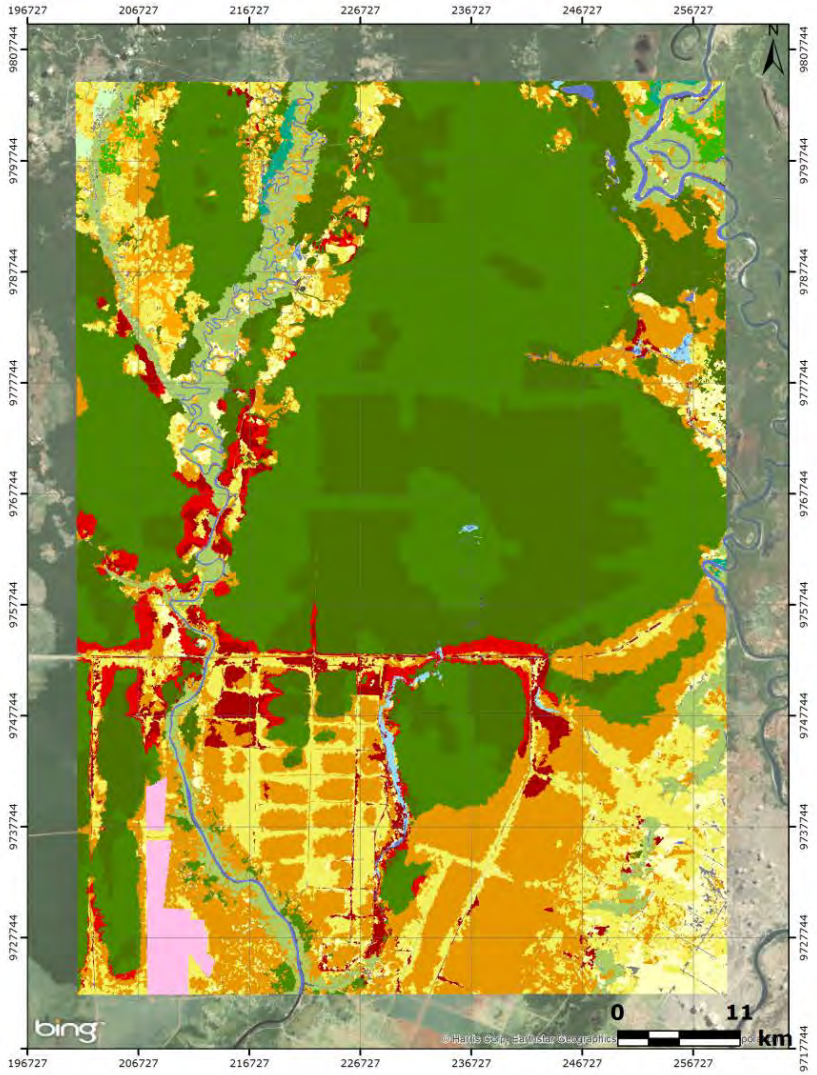
Land Cover map based on RapidEye imagery

Mapping scale: 1:25.000



RapidEye Landcover classificiaton 2010
Mawas, Central Kalimantan, Indonesia

Legend

- Burned Forest
- Burned Non-Forest Vegetation
- Peat Swamp Forest (primary)
- Peat Swamp Forest (secondary)
- Freshwater Swamp Forest (secondary)
- Dipterocarp Forest (secondary)
- Riparian Forest (secondary)/ Agroforestry
- Heath Forest (secondary)
- Bush/ Shrubs/ Regrowth
- Bush/ Shrubs/ Regrowth (Swamp)
- Grassland/ Fern/ Agriculture
- Sparse Vegetation/ Regrowth
- Plantation - Oil Palm
- Non-Vegetated
- Settlement
- Water
- Wetland

Minimum mapping unit: 0.5 ha

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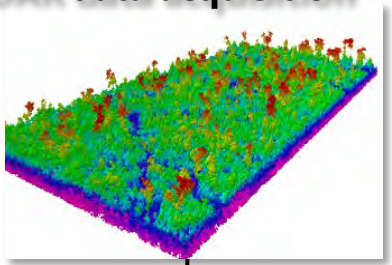
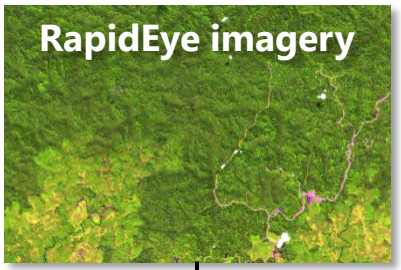
Assessment of AGB & carbon stock

Field inventory

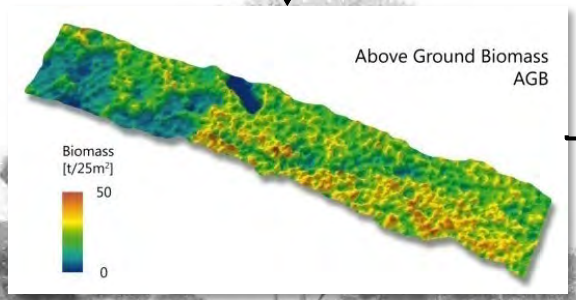
LiDAR data acquisition





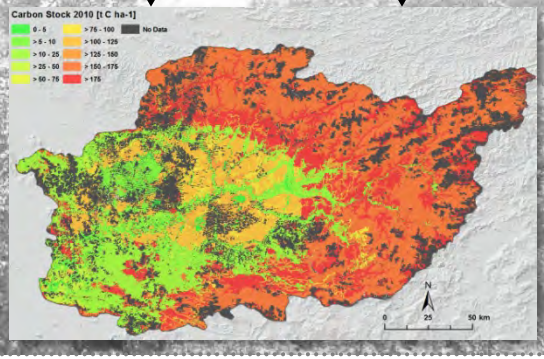
Modeling

Land cover classification



Upscaling

Stratification



Carbon stock map

Photo: F. Siegert

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Forest Inventories, plot sampling

Design of field sampling campaigns
Collection of

- **Forest type & tree species**
- **dbh > 5 cm**
- **biomass per ha**
- **carbon per ha**

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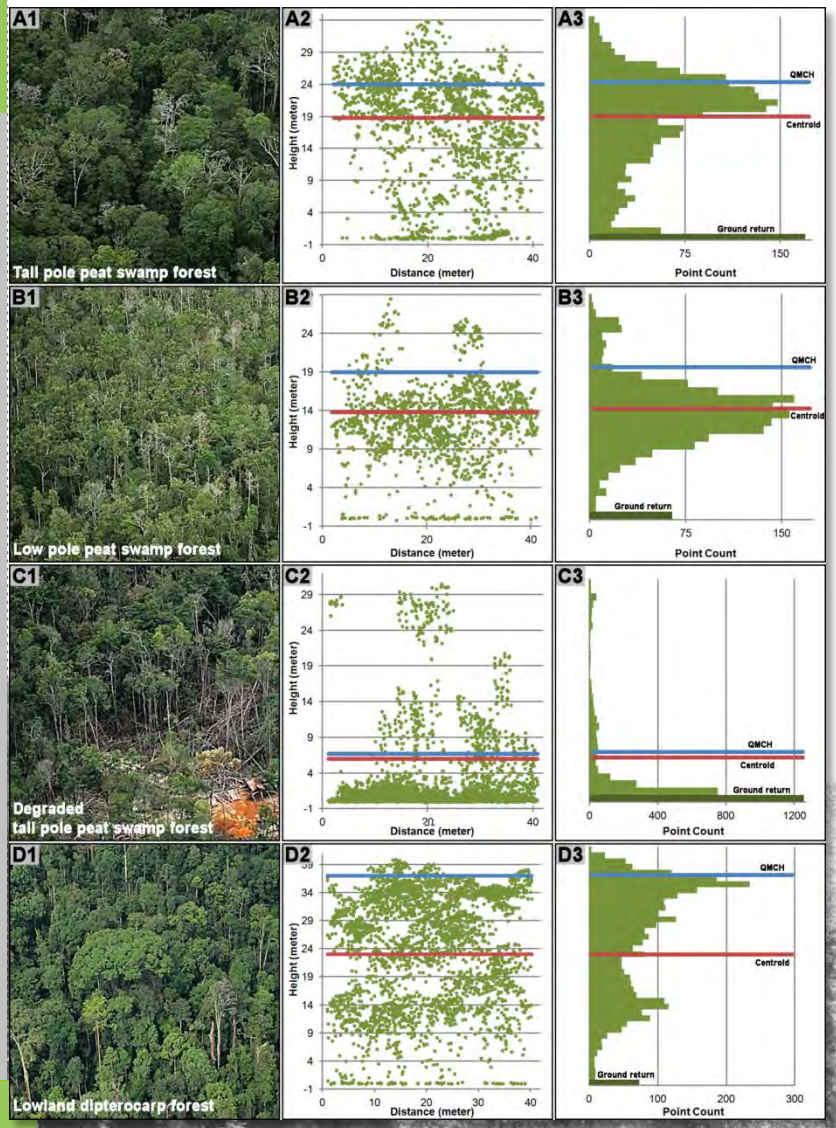
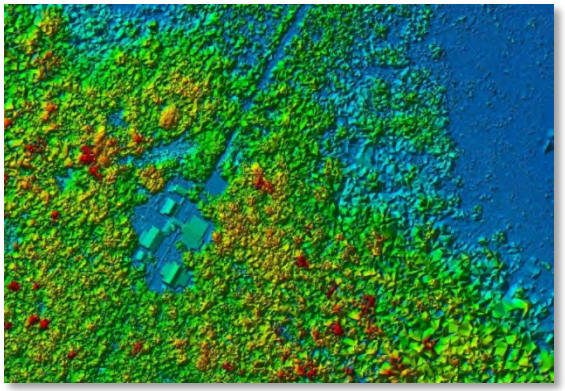
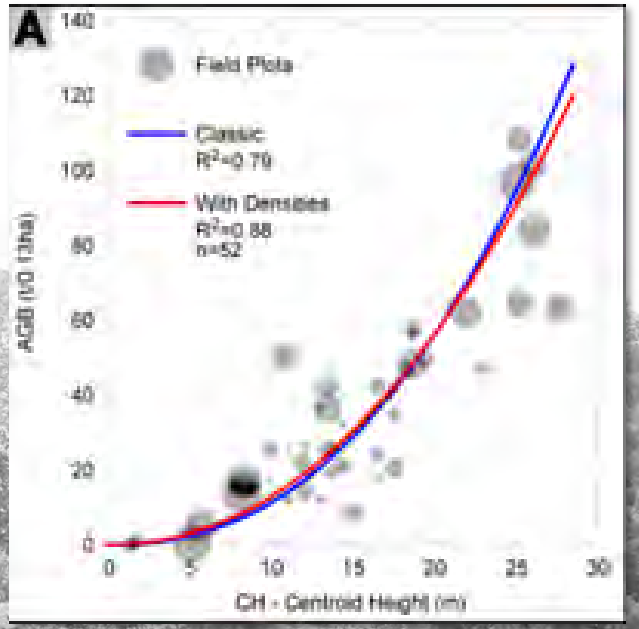
AGB Biomass estimation

LIDAR - Light Detection and Ranging







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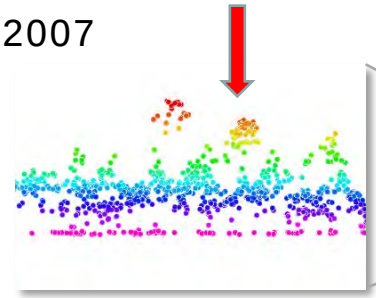
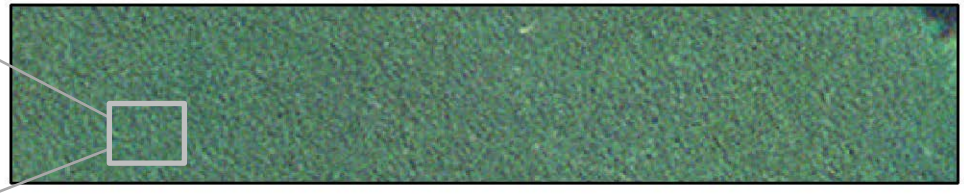
Estimation of AGB change

Assessment of AGB increase and loss

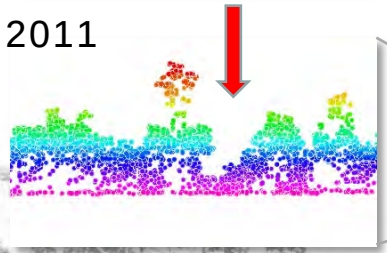
LiDAR 2007



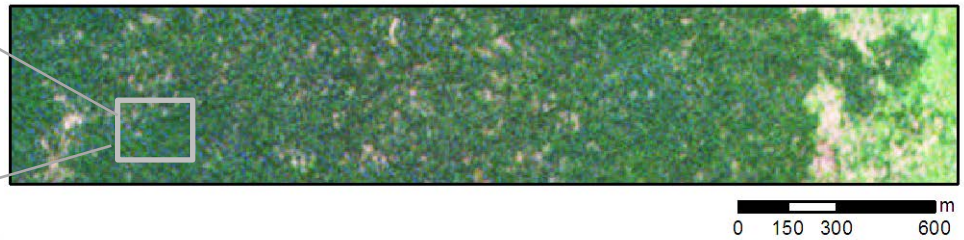
Rapideye 2009

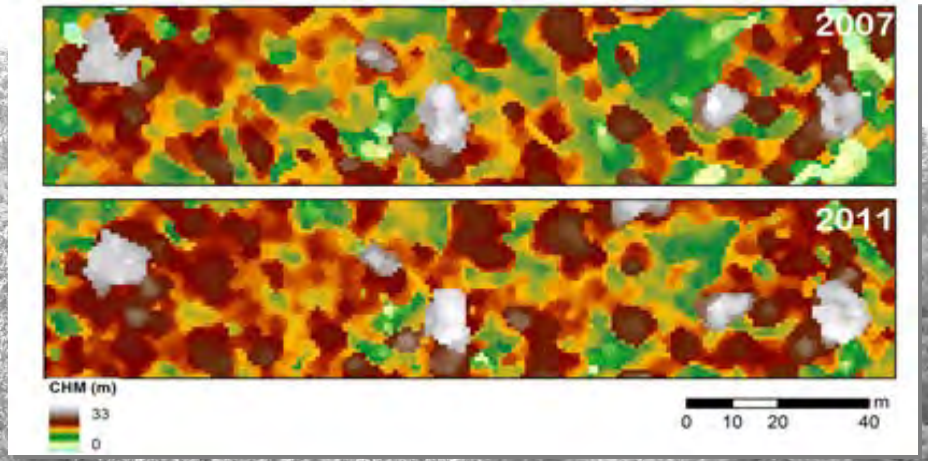


LiDAR 2011



Rapideye 2011





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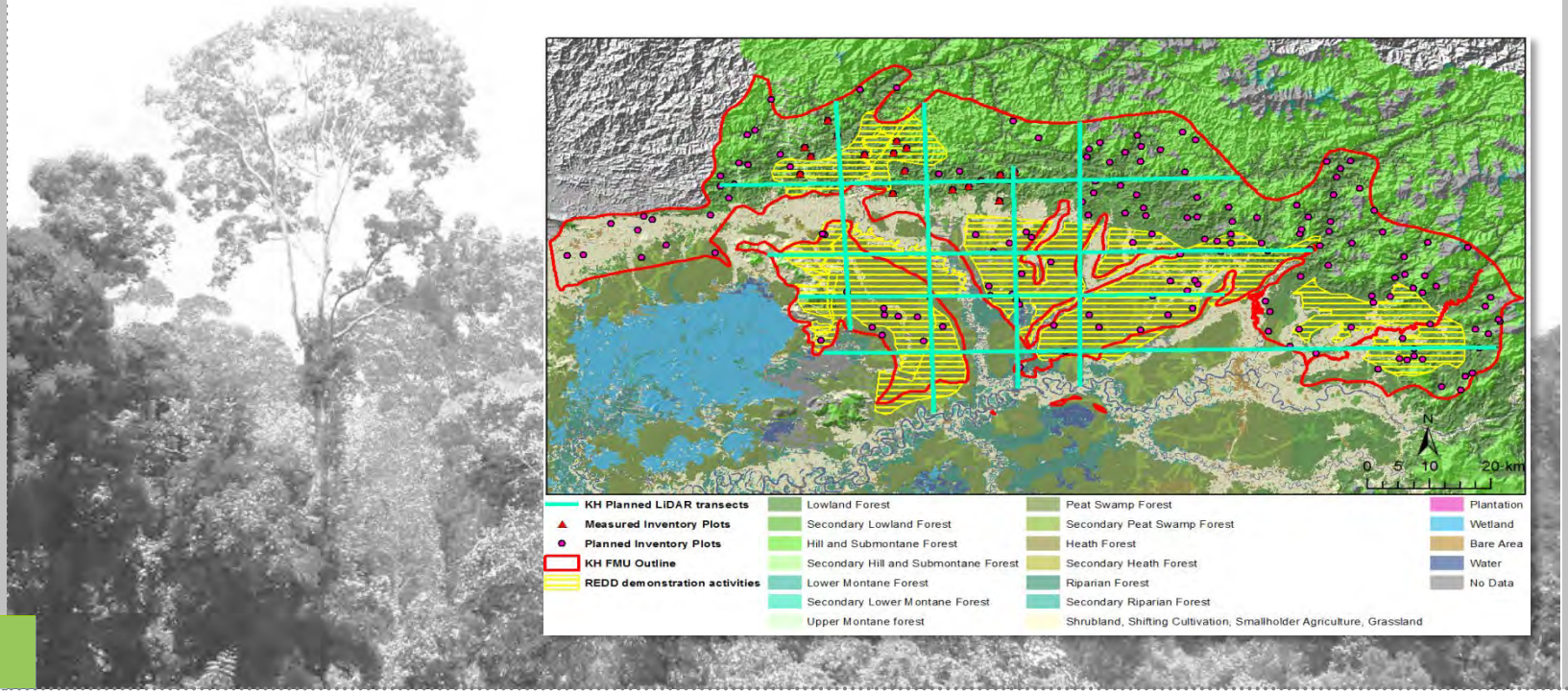
Estimation of carbon stock change

Assessment of AGB to improve regional data base

ForCLIME LiDAR survey:

- 1500 km of transects
- Coverage of different forest types (lowland, hill, montane, swamp, riverine)
- Coverage of different degradation stages
- Coverage of existing and planned forest inventory plots
- Create on-site AGB biomass models for FMUs



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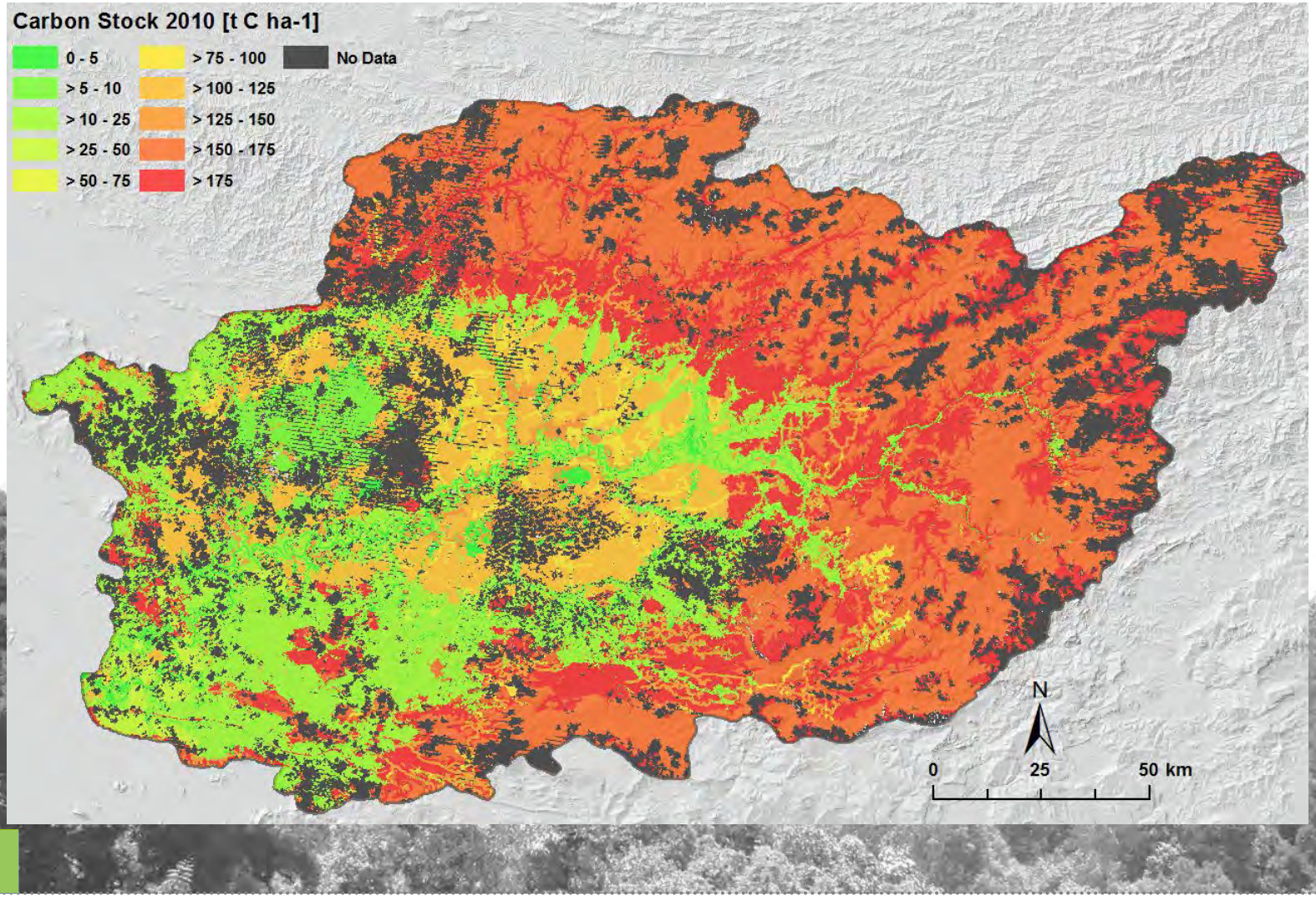
Carbon stock map based on forest inventory data, LiDAR and land cover

Carbon stock



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Accuracy assessment, uncertainties capacity building

Training on

- RS and GIS methods for forest mapping and monitorinhg
- Field data collection
- Validation

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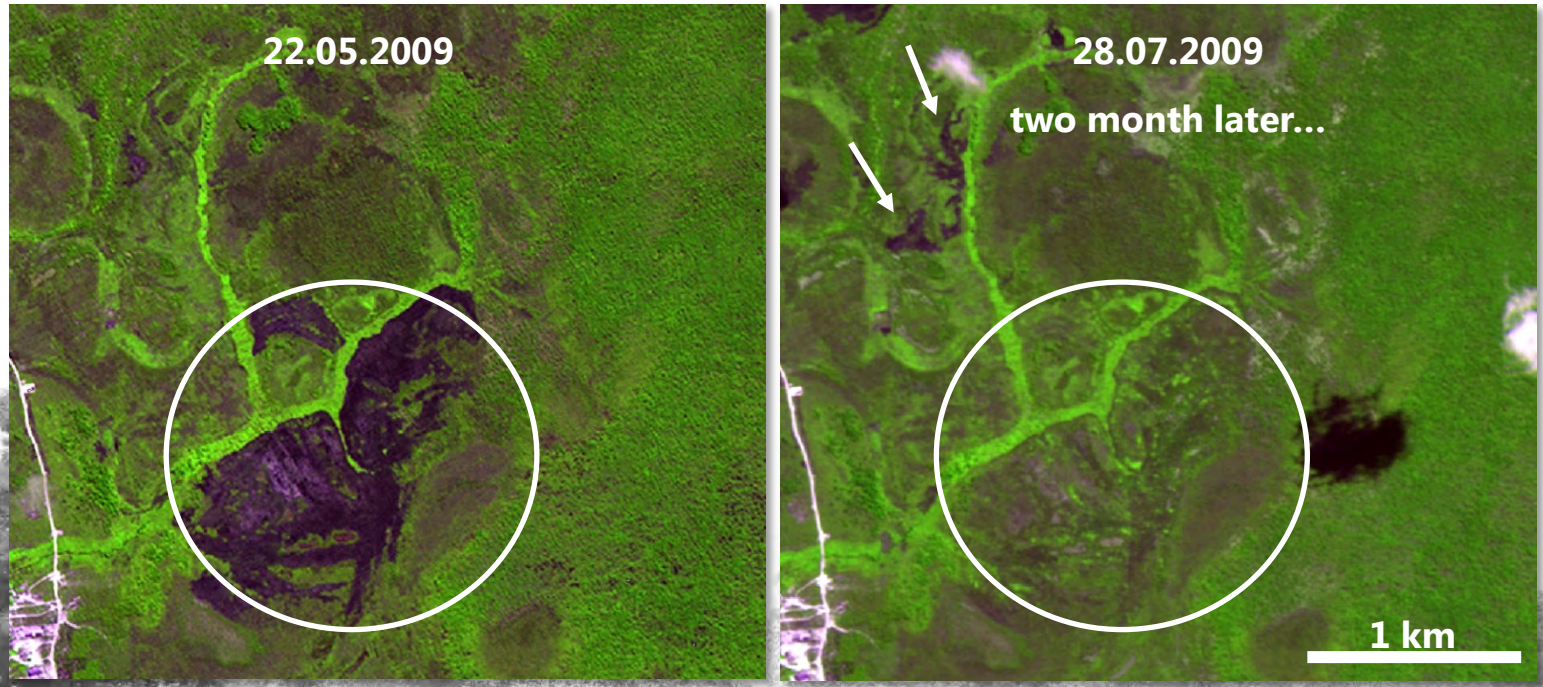
Forest Disturbance Assessment

Quick land cover change

Quick vegetation regrowth after fire impact



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Forest Disturbance Assessment

Monitoring of logging operations

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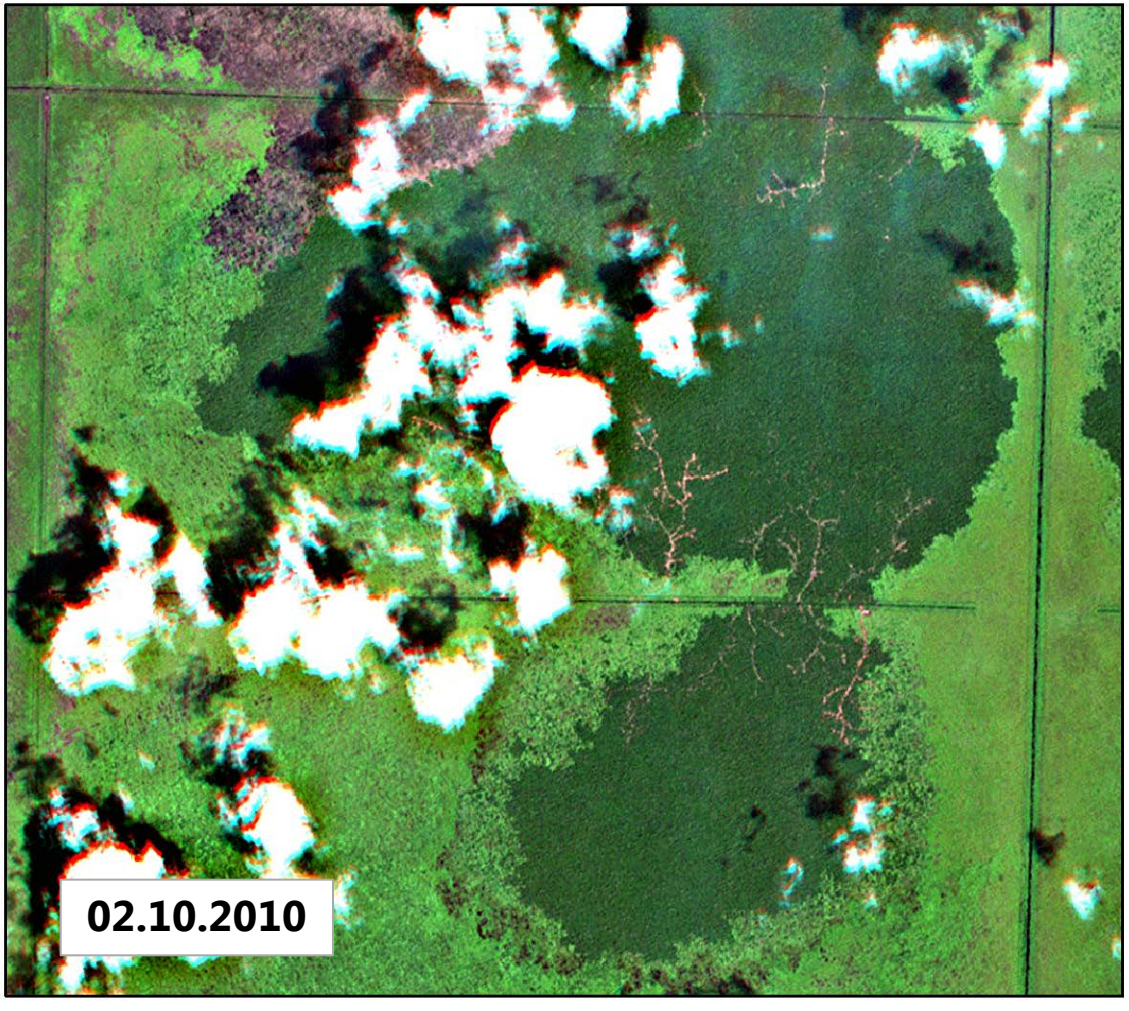
Forest Disturbance Assessment

Monitoring of logging operations



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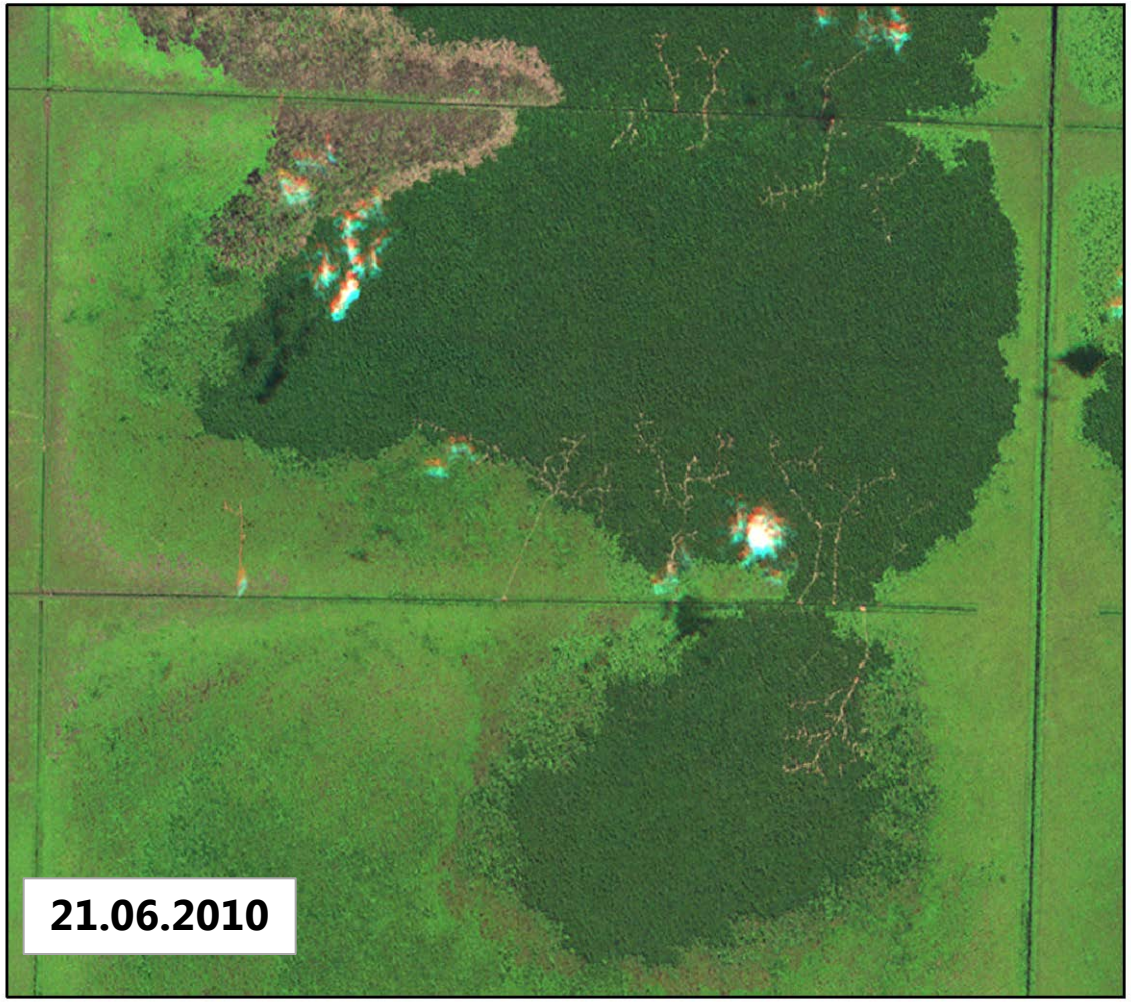
Forest Disturbance Assessment

Monitoring of logging operations



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Forest Disturbance Assessment

Monitoring of logging operations

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Forest Disturbance Assessment

Hierarchical classification design

Classification Level	1	2	3
Extracted Land Cover Information	• Clouds • Cloud-Shadow • Waterbodies	• Forest • Non-Forest	• Degraded Forest • Intact Forest
Processing Technique	Object-based	Object-based	Pixel-based: • MTMF • Decision Tree

Multitemporal Application

Integrated Monitoring of Deforestation and Forest Degradation

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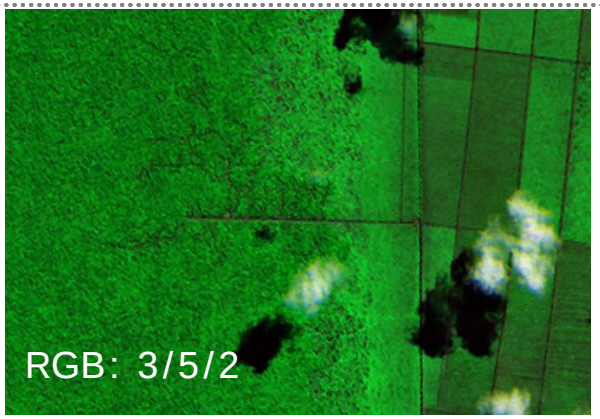
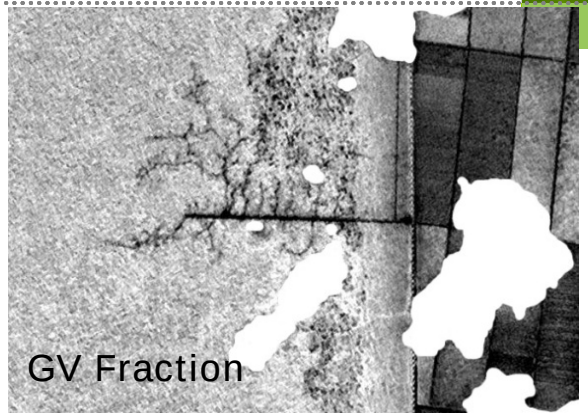
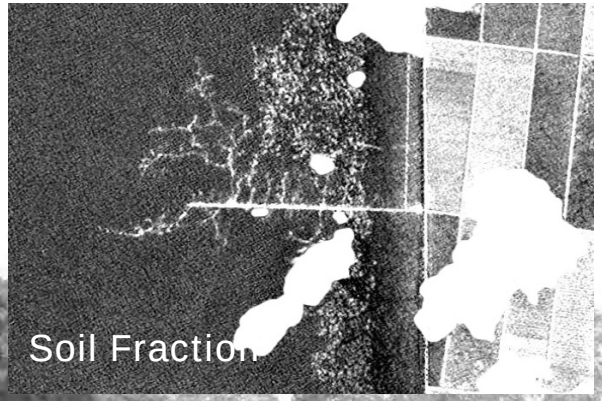
Forest Disturbance Assessment

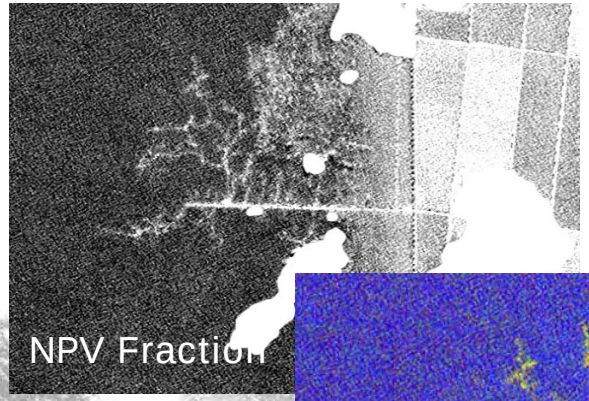
SMA Results

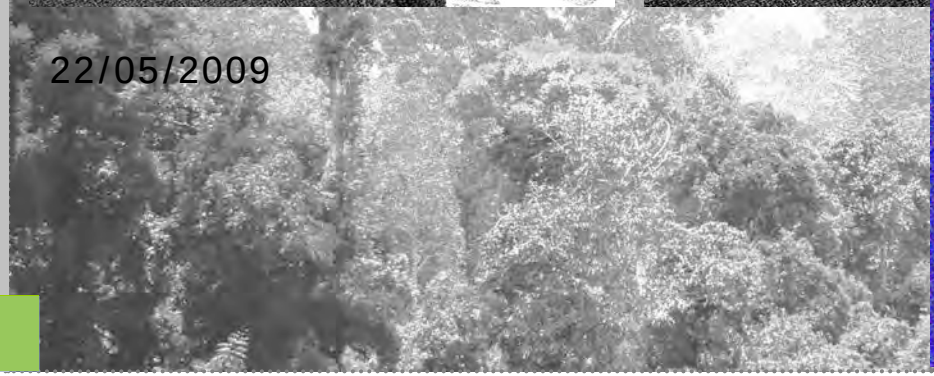


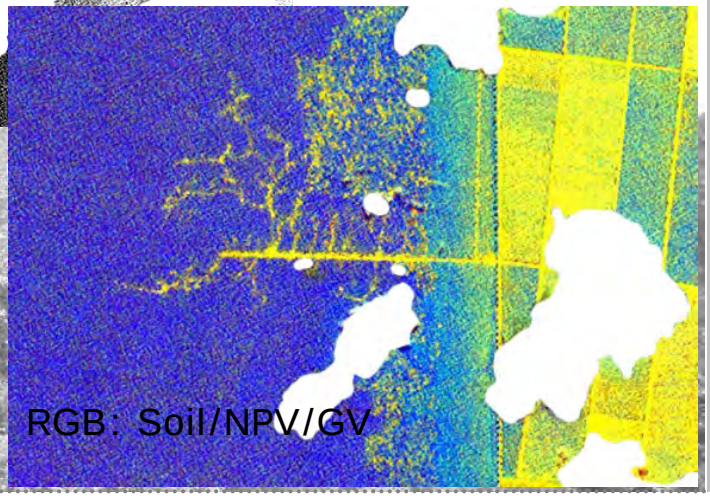


1000 m









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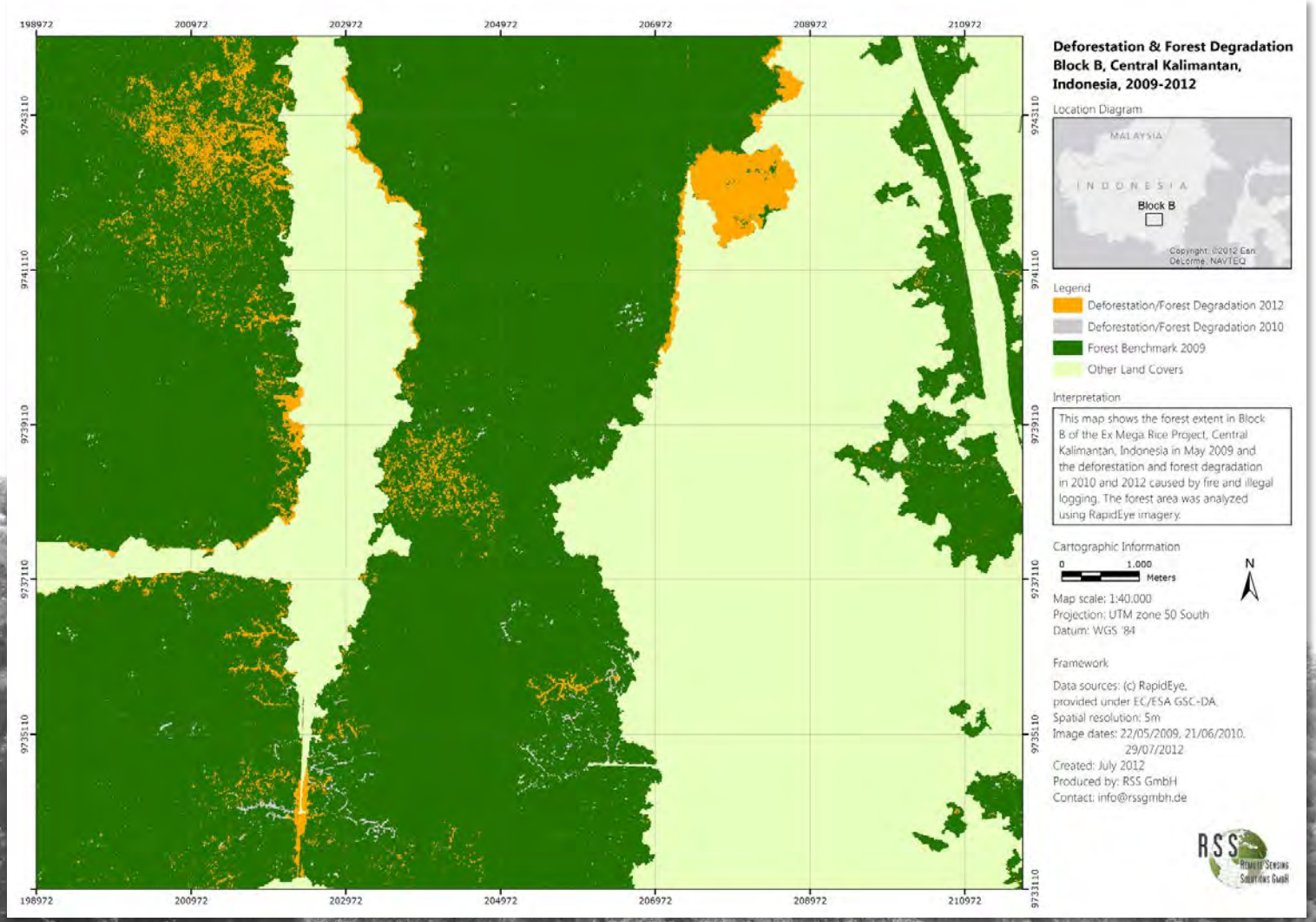
Forest Monitoring

Deforestation and forest degradation mapping



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Conclusions

- High resolution satellite data allows reliable detection of **deforestation** AND **forest degradation**
- Only few systems fullfill the requirement of high spatial resolution and large area coverage
- High spatial resolution is required to allow upscaling from field inventory data and LiDAR sampling
- Monitoring requires short revisit times
- Estimates of AGB and carbon stock require transect sampling by LiDAR to consider intra-class variability and to reduce uncertainties
- RapidEye is currently the preferred system which meets all requirements

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