Peat Land Topography derived from 30m resolution SRTM-X-SAR satellite images for Sebangau catchment and Kahayan area, Kalampangan, Central Kalimantan

remote sensing of kalimantan

KALTENG CONSULTANTS

UNIVERSITY OF HELSINKI

KEYTROP

CIMTROP

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2) University of Helsinki, Finland.

3) CIMTROP, Palangka Raya, Indonesia.

International Symposium on Nature and Land Management of Tropical Peat land in South East Asia in Bogor, Indonesia, 20.–21. September 2006

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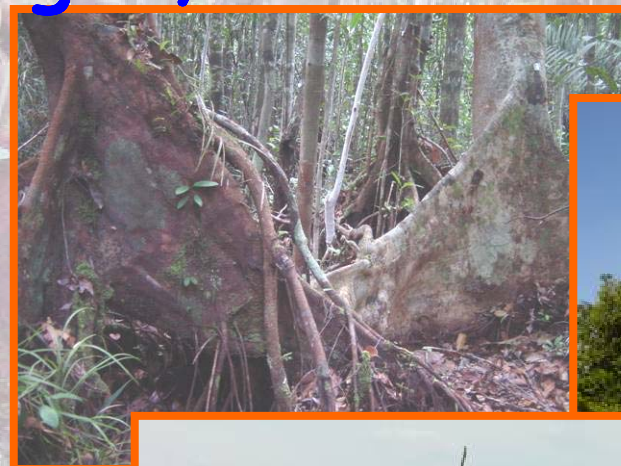

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International Symposium on Nature and Land Management of Tropical Peat land in South East Asia in Bogor, Indonesia. 20.–21. September 2006

Tropical peatlands and stored carbon

- **Tropical Peatland** has been accumulated between the Rivers Kahayan, Sebangau and Katingan in Central Kalimantan during the **last 10 000 years.** Since the 1980s peatland and **Peat Swamp Forest (PSF)** is being cleared by selective and illegal logging and destroyed by fires. Before then access to that area of peatland was possible only by boat.
- Since 1996 the **Mega Rice Project (MRP)** has inserted irrigation channels into the Block C and destroyed pristine PSF. Partly development took place by human settlements, agricultural cultivation and plantations, which have greatly increased the risk of **peatland fires** during the dry season.
- In **1997 and 2002 El Niño prolonged the dry season** considerably causing additional risk of fire. With the help of Remote Sensing (RS) and a Geographical Information System (GIS) exact survey is possible, providing information as to the changes in the landscapes and the condition of the environment. An integrate planning and management program can be achieved.

Tropical peatlands and stored carbon

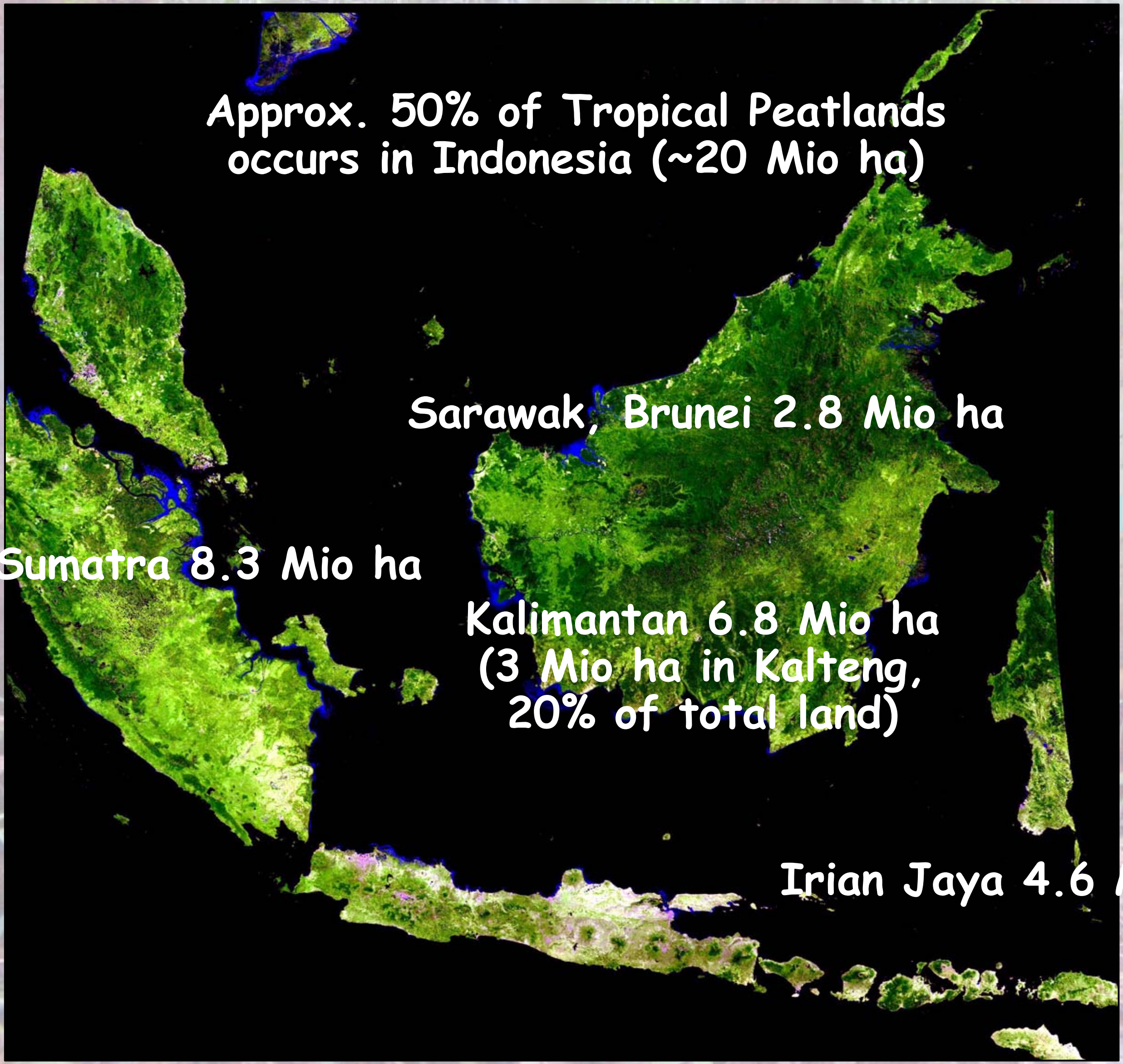
- Tropical peat comprises 12% of the world's peatland resource by area and carbon stores by mass may represent nearly 30% of the total.
- Deep tropical peatlands are ombrotrophic and the dominat forest vegetation has adapted to thrive on nutrient poor, acidic and waterlogged conditions.
- Carbon store conservation requires appropriate environmental conditions, including high peat water table, highly productive vegetation, protection from disturbances (such as logging and fire).

Motivation of this study

- One of the largest land conversion projects in SE Asia has been so called Mega Rice project which took over nearly 1Mha area, largely on deep peat, in Central Kalimantan in mid 1990's.

- Restoration attempts on degraded areas aim, for example, to induced vegetation recovery, reduced carbon loss and fire risk.
- With the help of Landsat and SRTM DEM-X-SAR Satellite images (Shuttle Radar Topography Mission, Digital Elevation Model, Synthetic Aperture Radar) of 30m resolution in x and y and 3-5m in z-direction the topography of that area have been analysed from which the hydrology and carbon storage and emission situation can be estimated.

Indonesian Peatlands



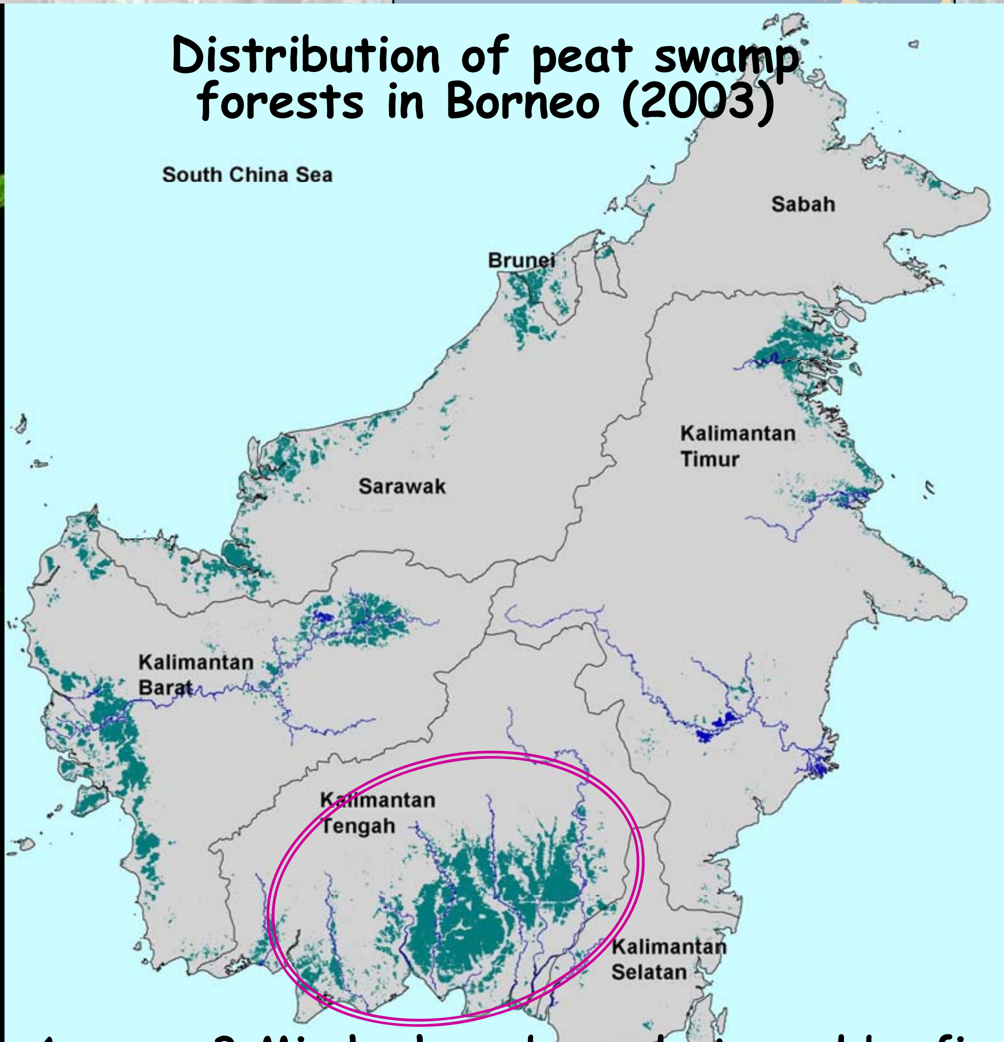
Approx. 3 Mio ha have been destroyed by fires in Kalimantan

Study sites

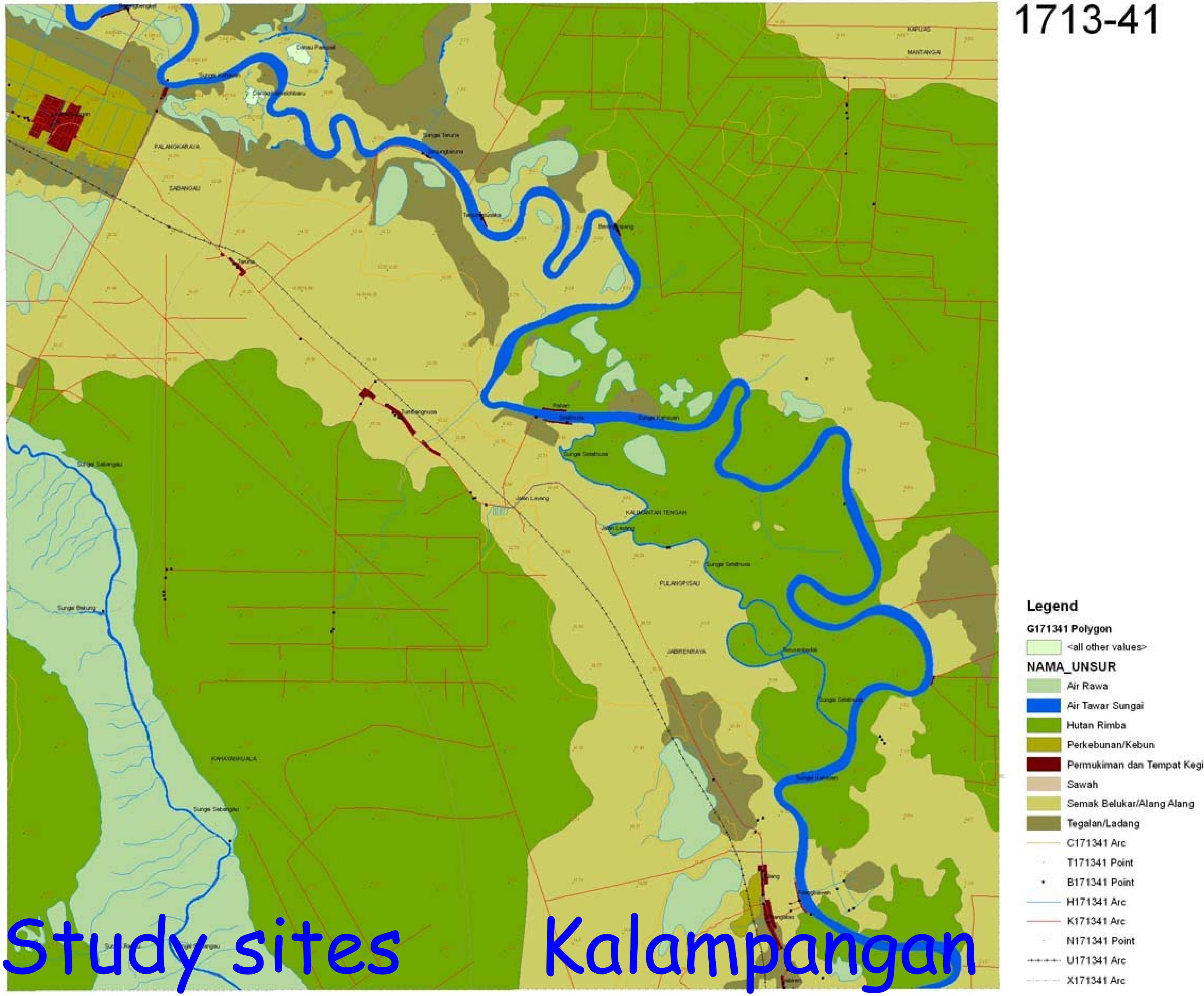
Borneo Peatland

Cloud free 60 MODIS images mosaic of Borneo (2003)

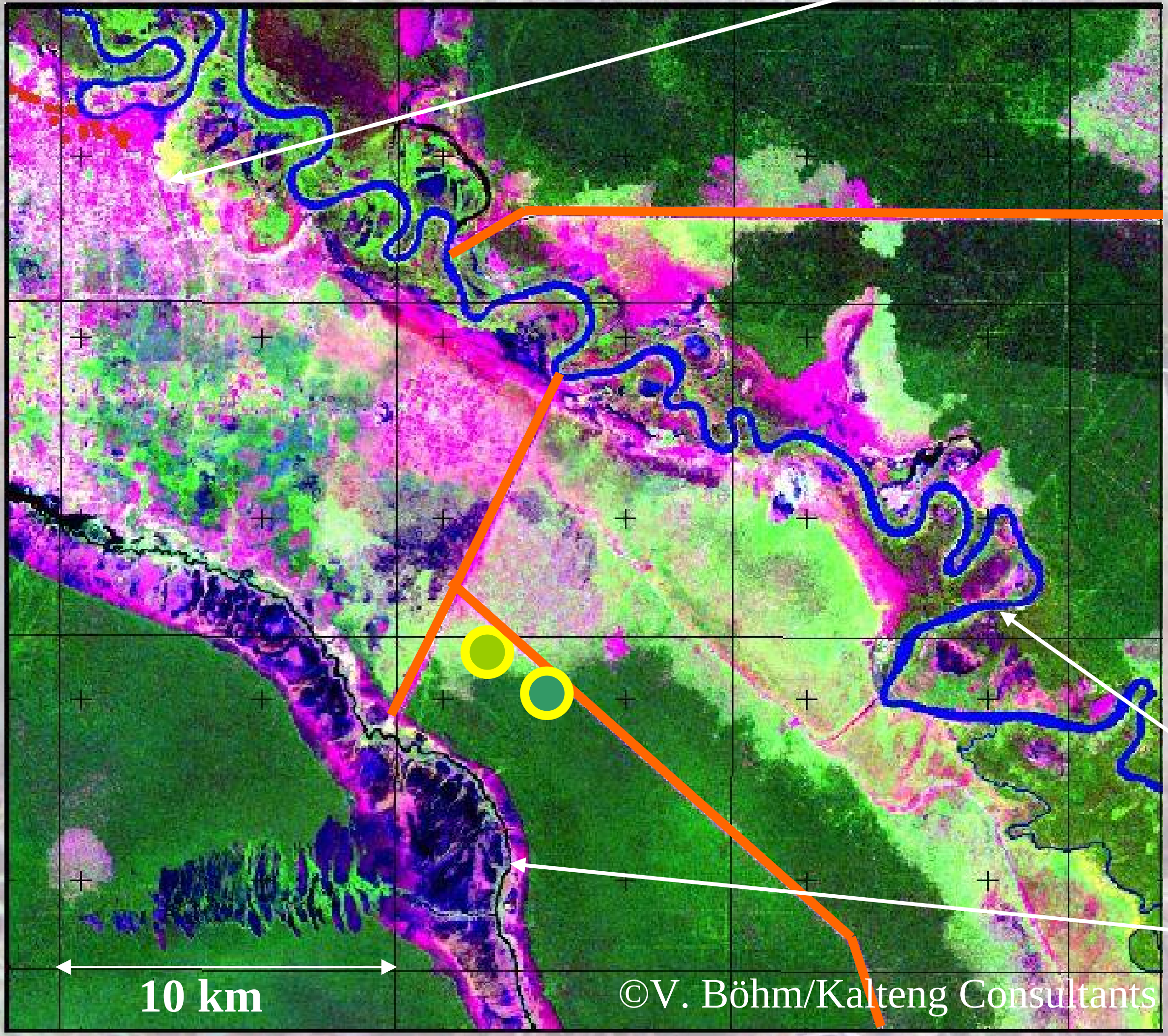
Distribution of peat swamp forests in Borneo (2003)

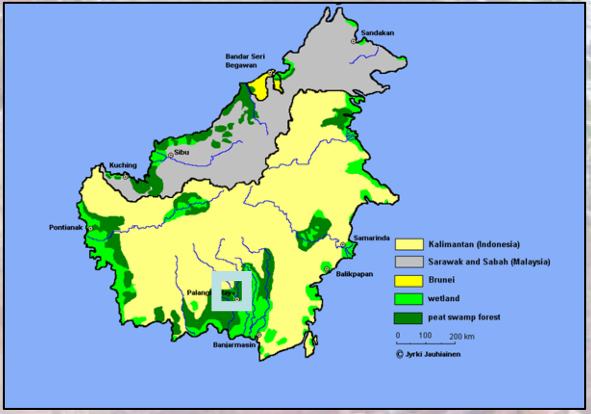


Approx. 3 Mio ha have been destroyed by fire

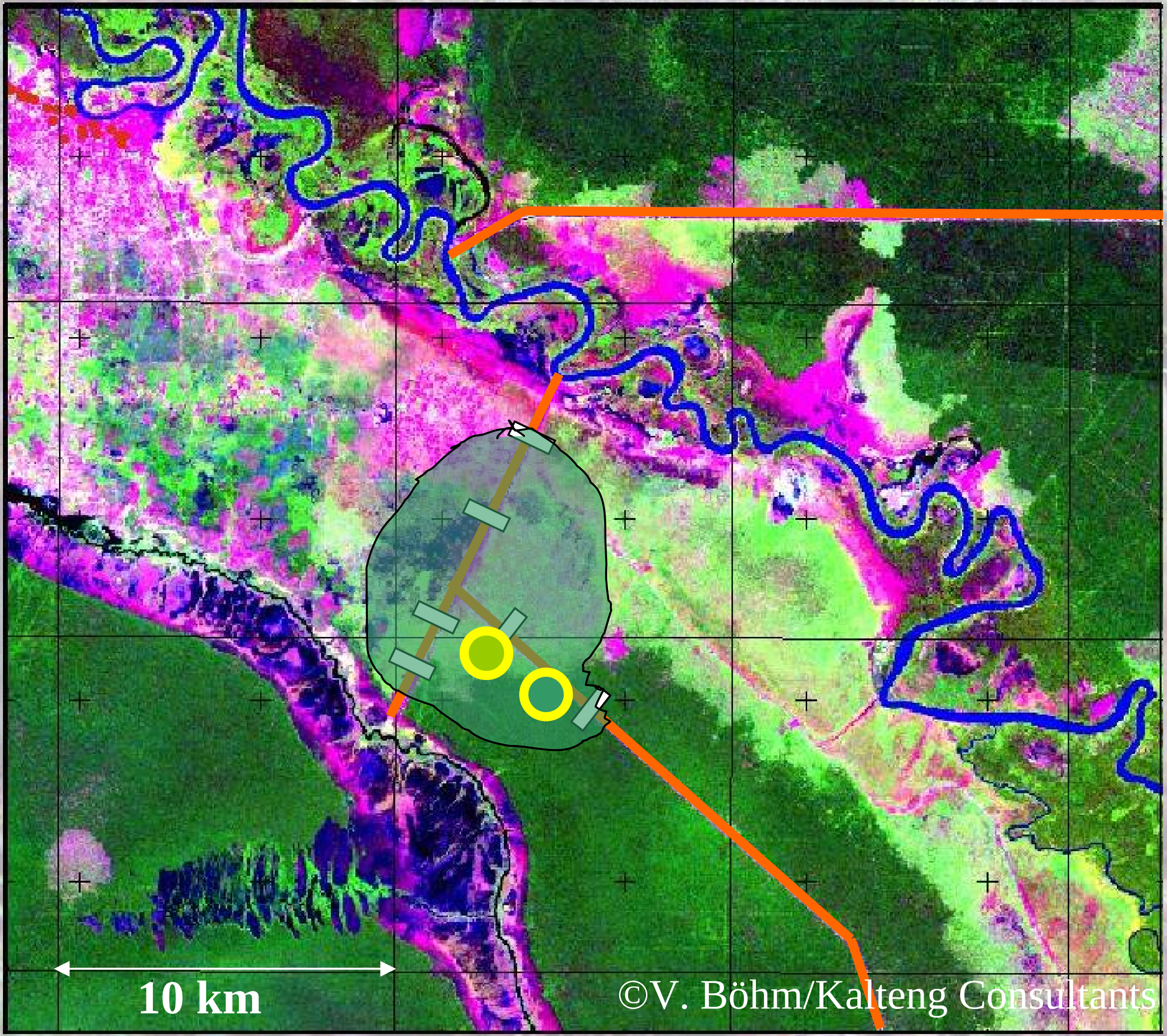

1713-41
Legend
G171341 Polygon
<all other values>
NAMA_UNSUR
Air Rawa
Air Tawar Sungai
Hutan Rimba
Perkebunan/Kebun
Permukiman dan Tempat Kegia
Sawah
Semak Belukar/Alang Alang
Tegalan/Ladang
C171341 Arc
T171341 Point
B171341 Point
H171341 Arc
K171341 Arc
N171341 Point
U171341 Arc
X171341 Arc
Study sites
Kalampangan

Study sites

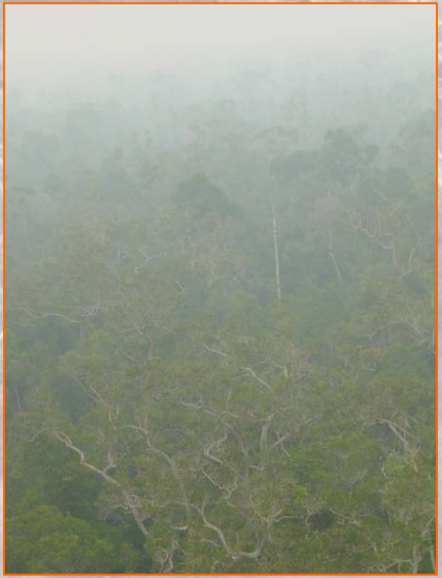

Palangka Raya
Sg. Kahayan
Sg. Sabangau
10 km
©V. Böhm/Kalteng Consultants


Sandakan
Bandar Seri Begawan
Sibu
Kuching
Pontianak
Samarinda
Balikpapan
Banjarmasin
Kalimantan (Indonesia)
Sarawak and Sabah (Malaysia)
Brunei
wetland
peat swamp forest
0 100 200 km
© Jyrki Jauhiainen

Study sites



Taruna Canal Dams
May-July 2005



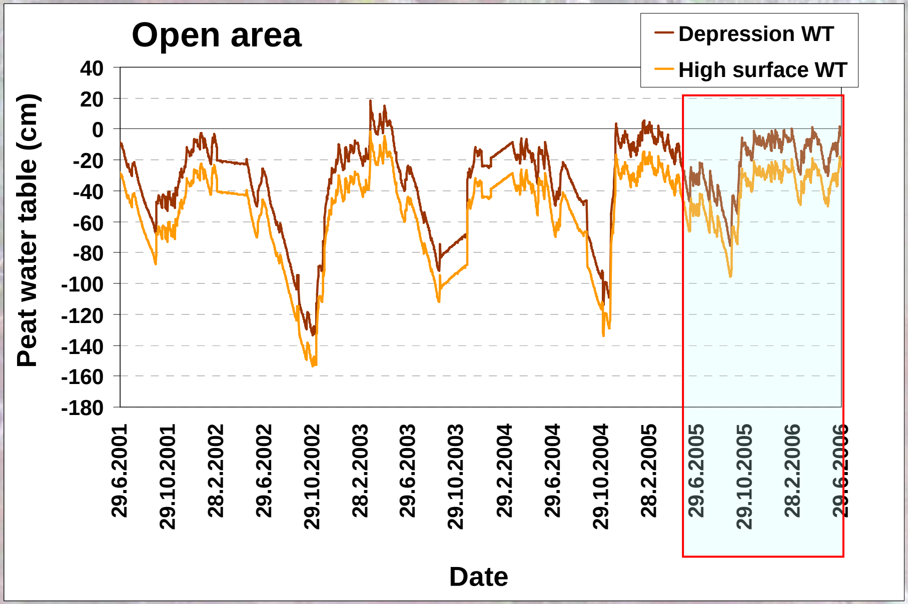
Ex-MRP forest area (forest):

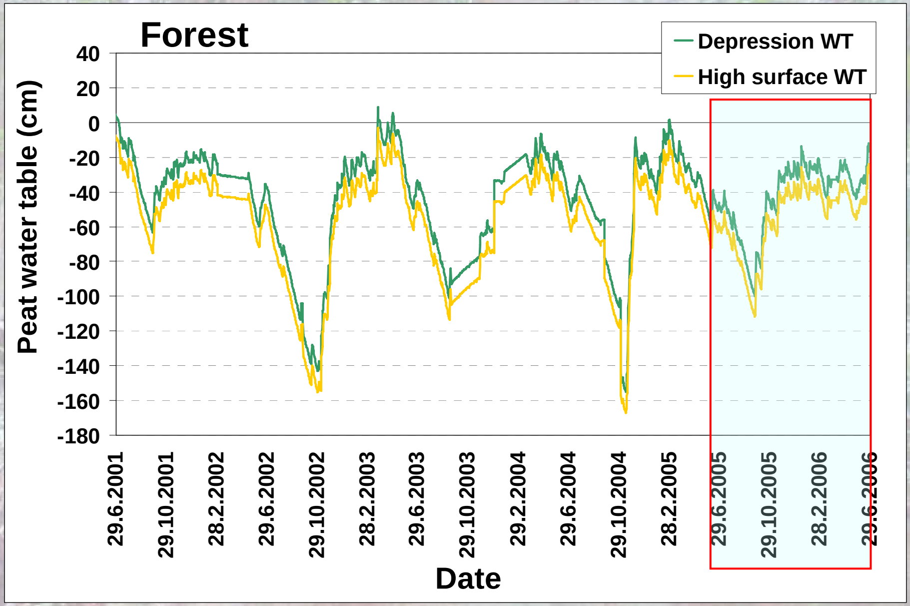
- Selectively logged prior to year 1998
- Influenced by drainage canal

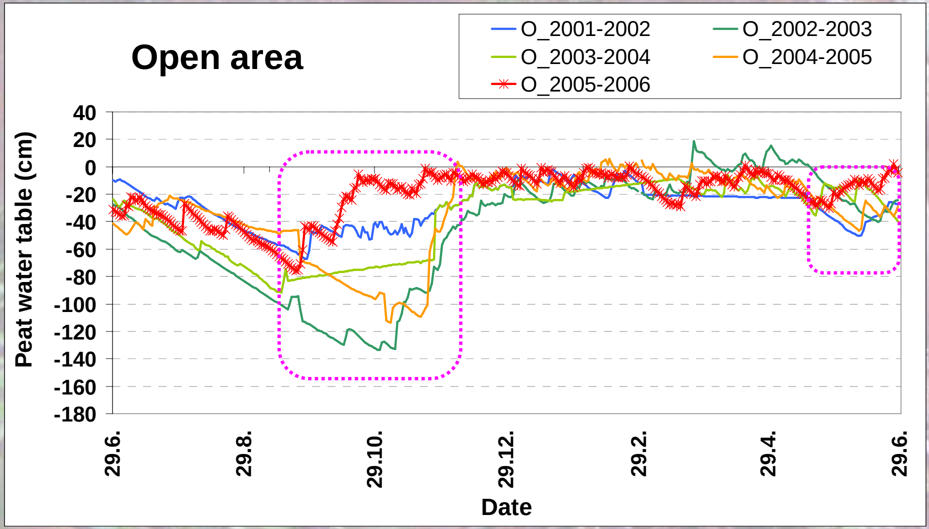
Ex-MRP degraded area (open area):

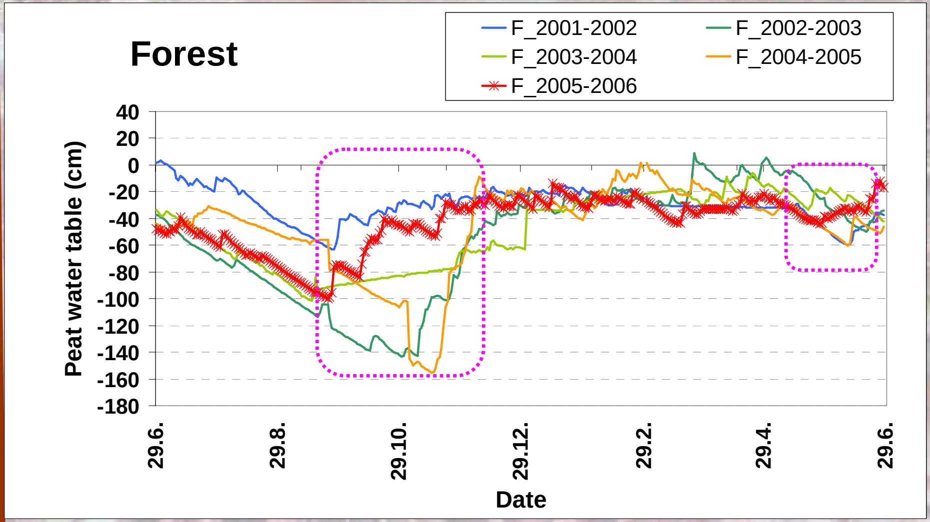
- Clear felled prior to year 1998
- Influenced by drainage canal
- Influenced by fires 1997/98 and 2002

Peat water table 29.6.2001-28.6.2006









Presidential Decree No.32/1990

Peat deeper than 3 meter should not be developed in relation to their value as water storage areas

but

- Implicitly allows **reclamation and drainage of the outer zone** of a peat dome with a depth of less than 3 meters
- This invariably will lead to **subsidence** of the deeper parts of the dome
- The drainage will lead to oxidation and thus **CO_2 emissions**
- Continued process will lead to **collapse of entire dome** which will thus become lower than 3 meters and "eligible" for reclamation

Decree of the Forestry Minister No.260/Kep-II/1995

Guidelines for Prevention and Control of Forest Fire

Government regulation 4/2001

Forbids all forest and land fires

MDG 1: Poverty Reduction

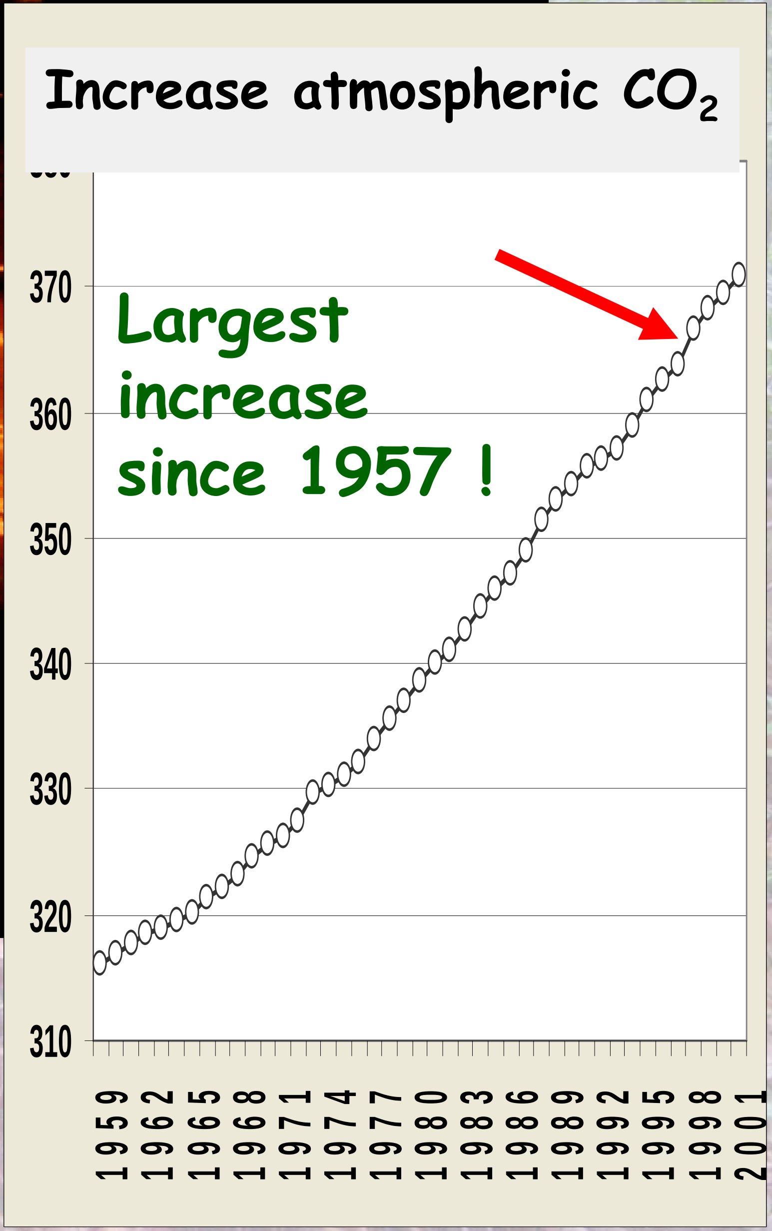
reduce the number of people surviving on < 1 US$/day by half in 2015

In many regions of the world poverty is more associated with peatlands than other areas

In Indonesian peatlands poverty is 2 to 4 times as high as elsewhere

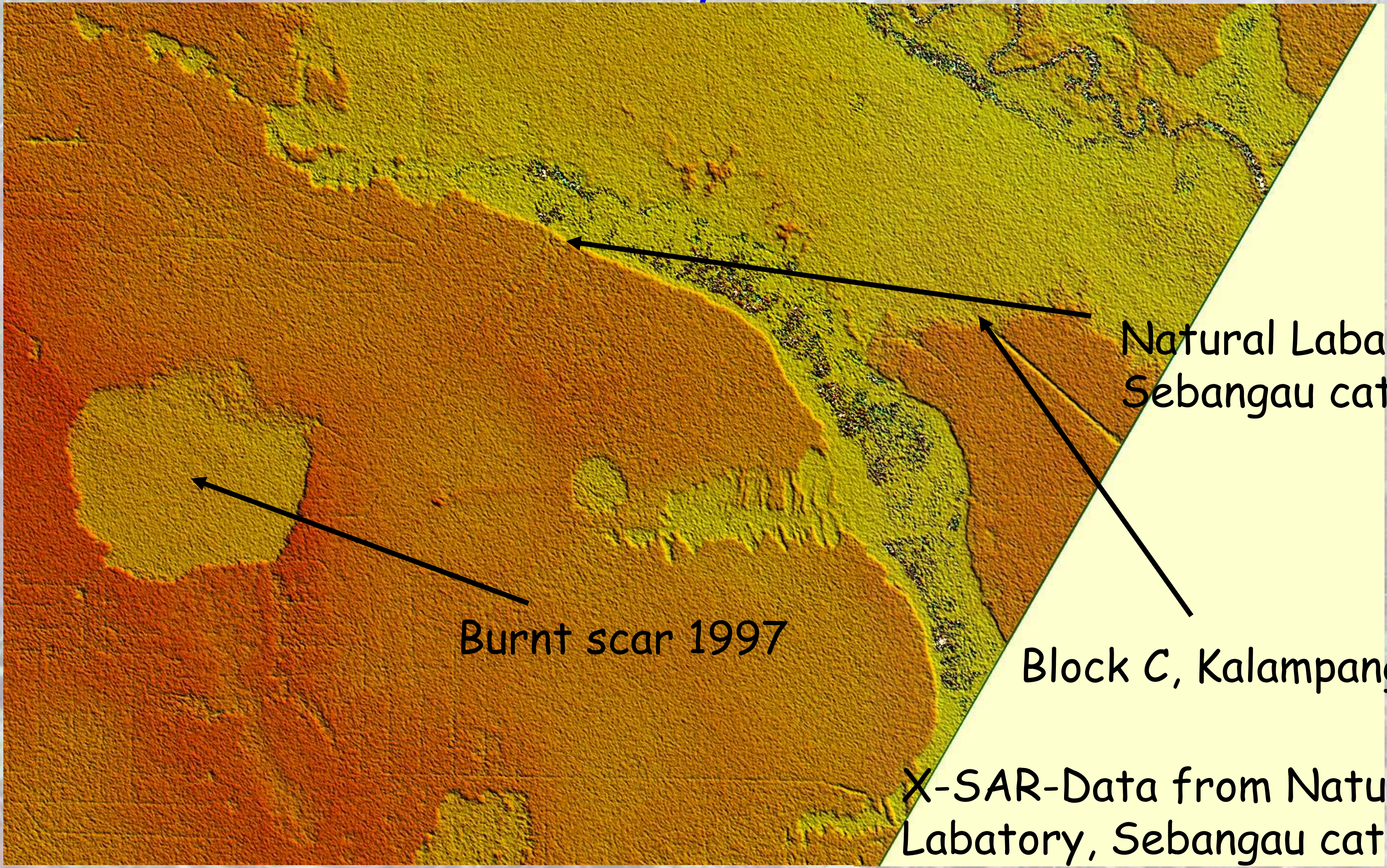
Introduction: Peat fires and climate change

- Indonesian peat fires in 1997/1998 covered 1.5-2.2 million ha and emitted 0.810 – 2.570 Gton CO_2
  (Page et al., 2002)



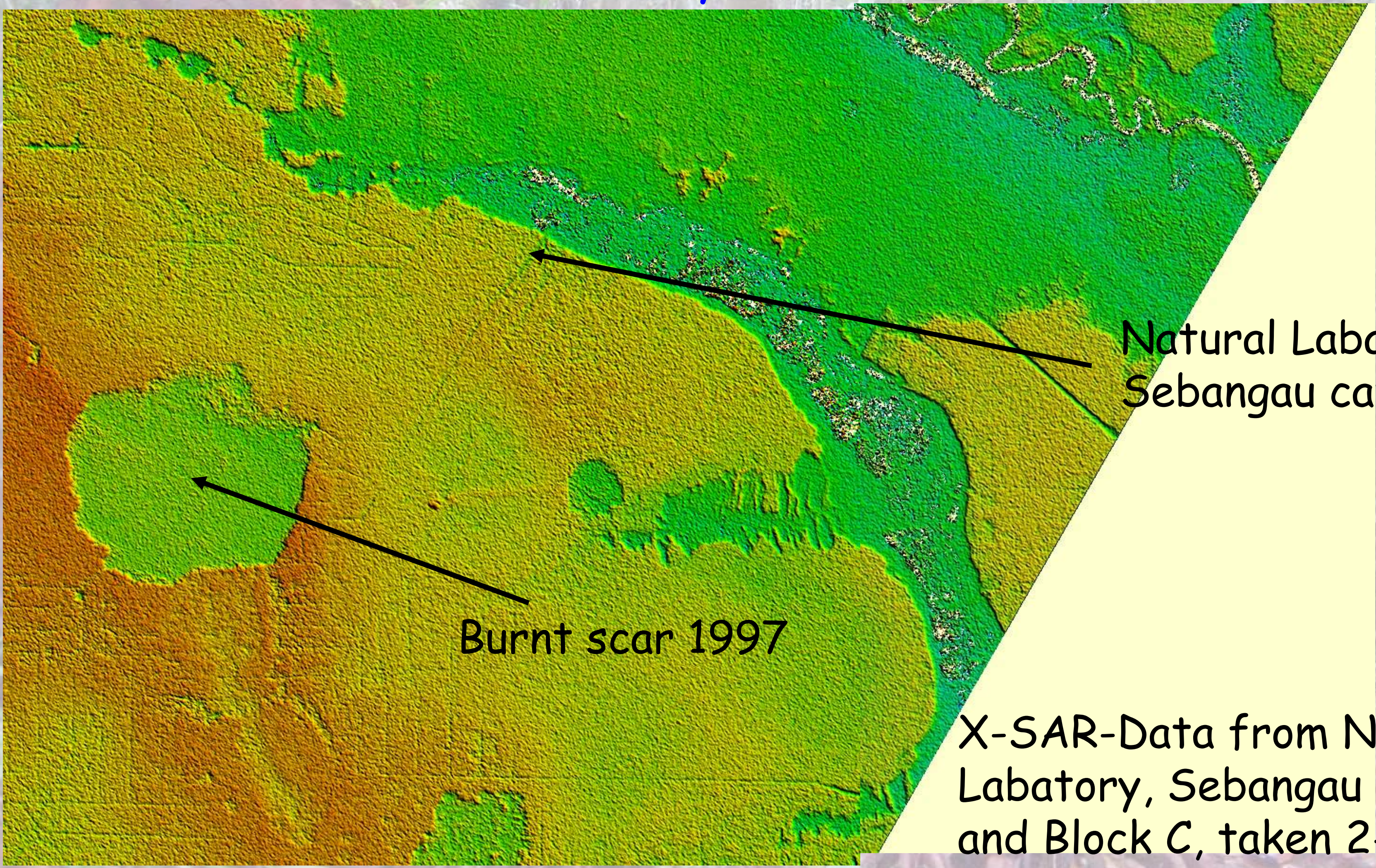
- = 8 to 25 years of successful Kyoto implementation

Methods: SRTM DEM-X-SAR Satellite images of 30m resolution in x and y and 3-5m in z-direction the topography of that area have been analysed



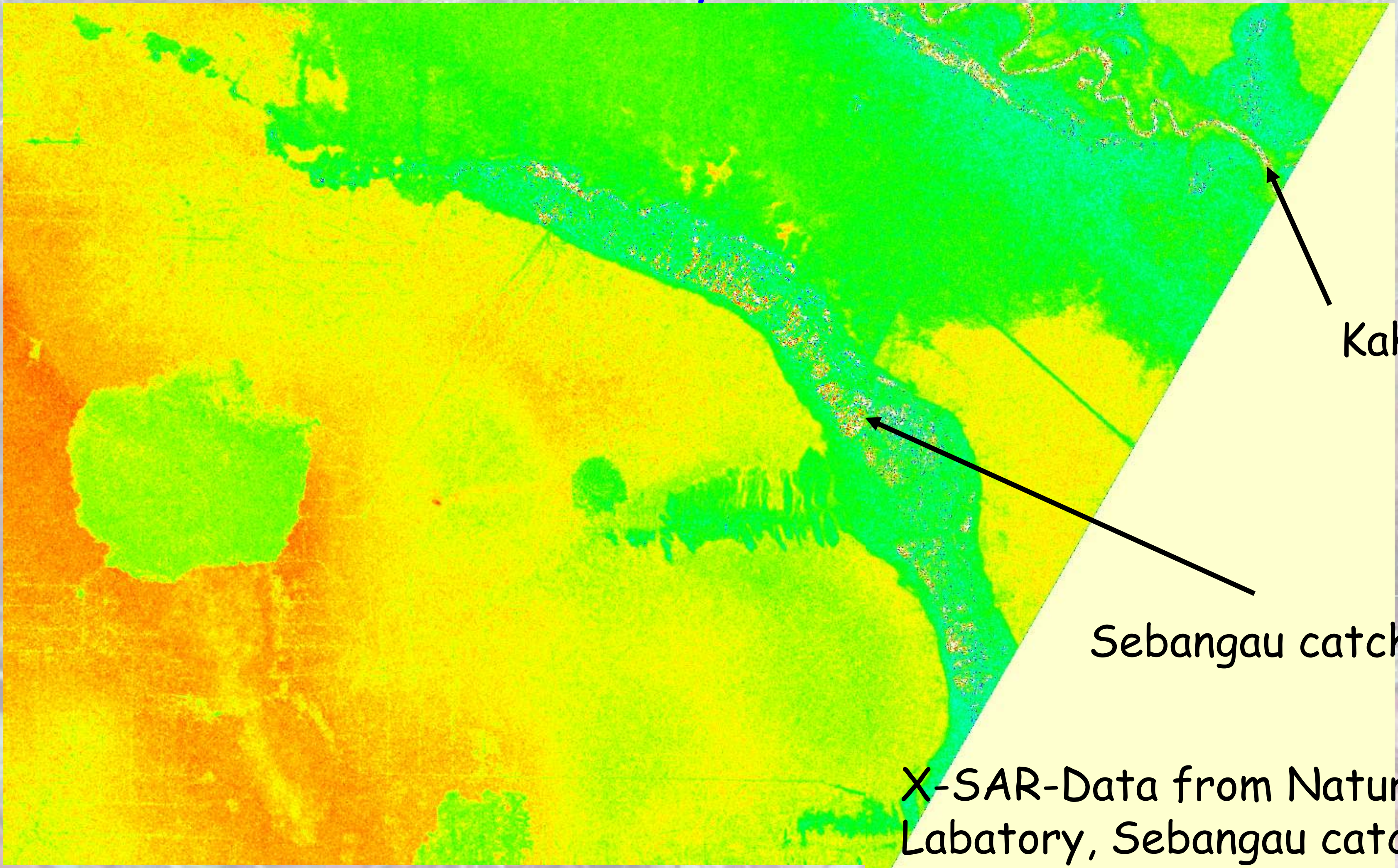
X-SAR-Data from Natural Labatory, Sebangau catchment and Block C, taken 2-2000
With shadow

Methods: SRTM DEM-X-SAR Satellite images of 30m resolution in x and y and 3-5m in z-direction the topography of that area have been analysed



X-SAR-Data from Natural
Labatory, Sebangau catchmen
and Block C, taken 2-2000
Colour between 40m – 100m,
With shadow

Methods: SRTM DEM-X-SAR Satellite images of 30m resolution in x and y and 3-5m in z-direction the topography of that area have been analysed



X-SAR-Data from Natural Labatory, Sebangau catchment and Block C, taken 2-2000
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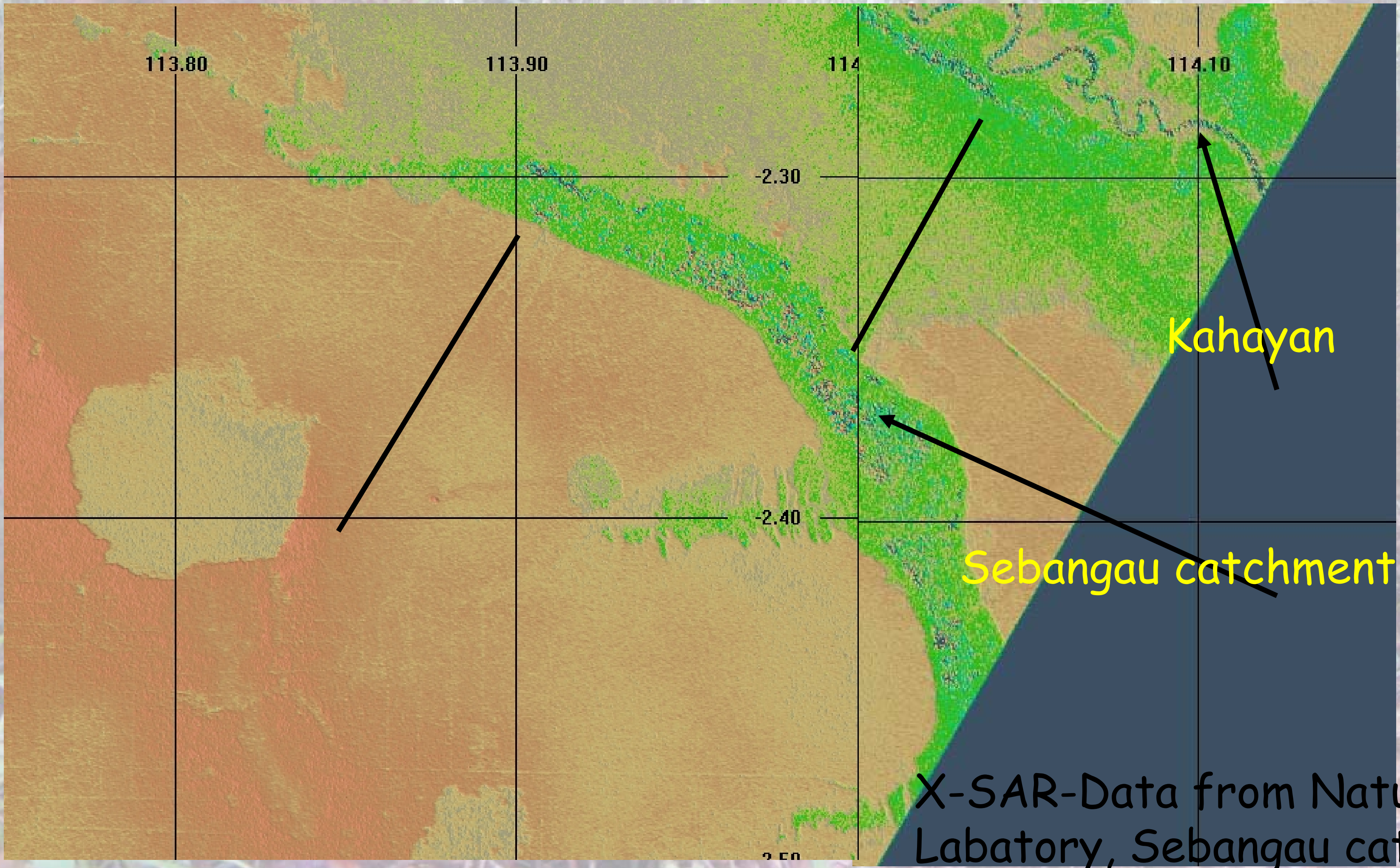
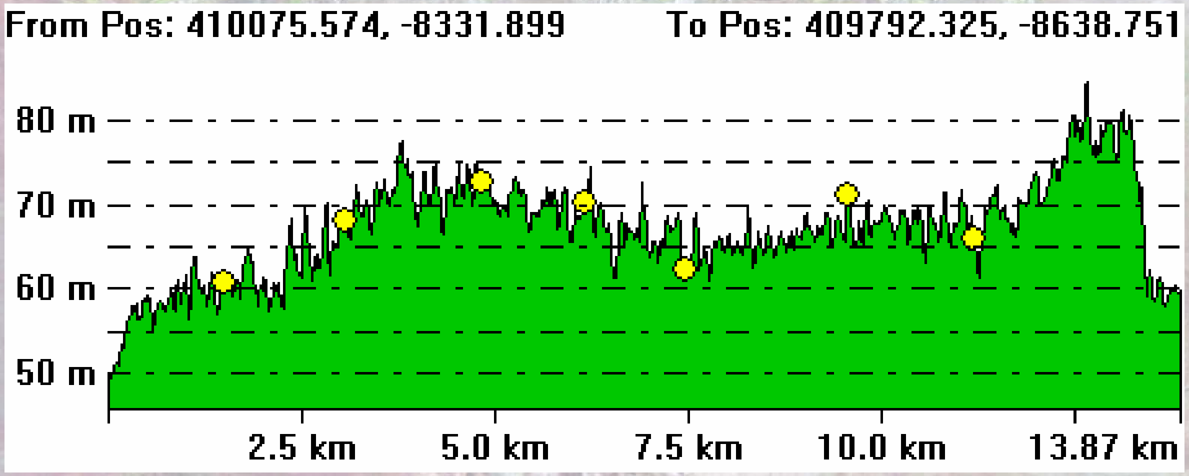
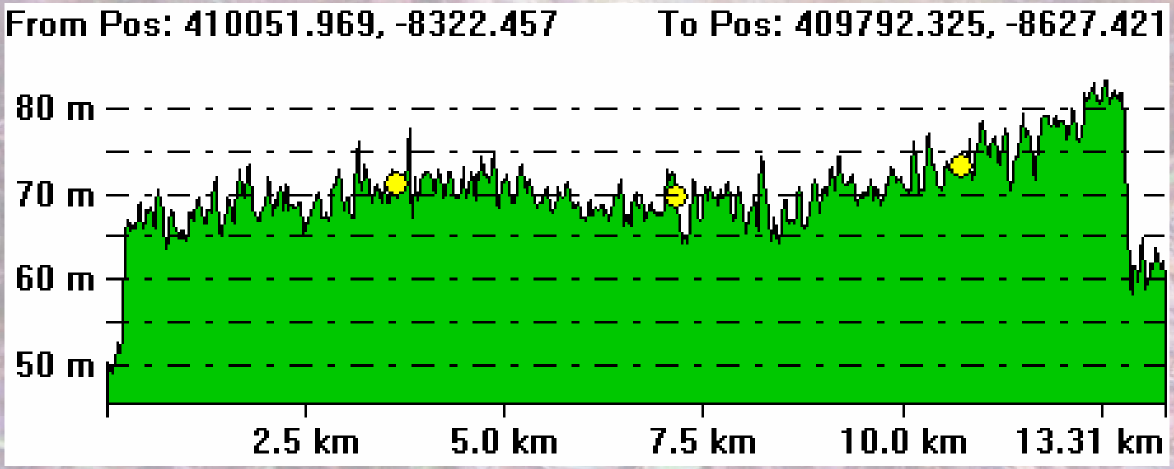


X-SAR-Data from Natural Labatory, Sebangau catchment and Block C, 40m – 100m, taken 2-2000

Results

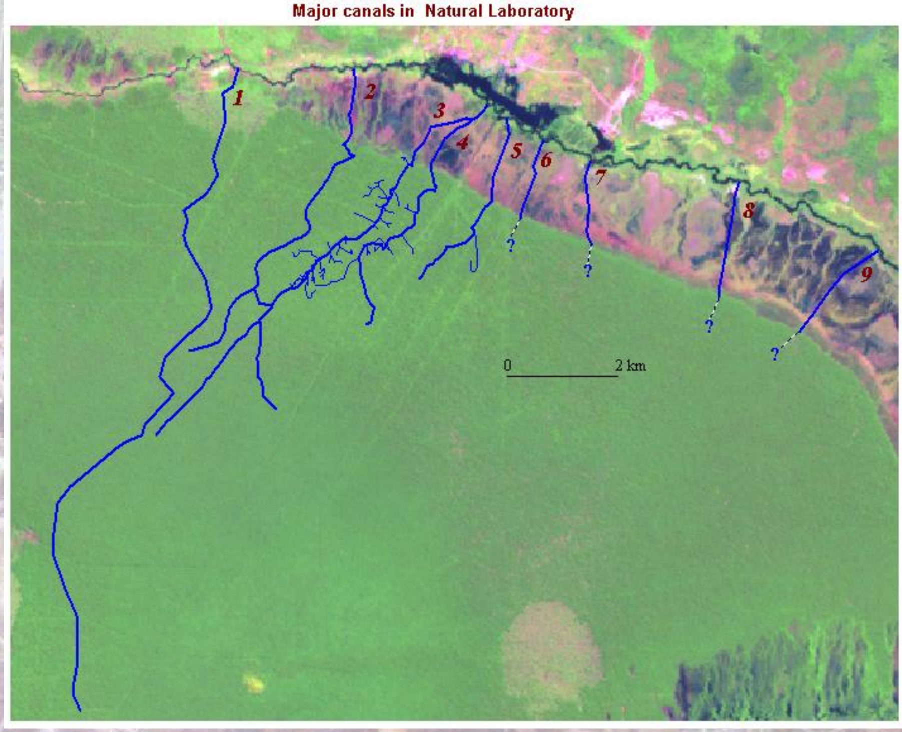


SRTM-X-SAR Cross-section along the National Lab transect without trees



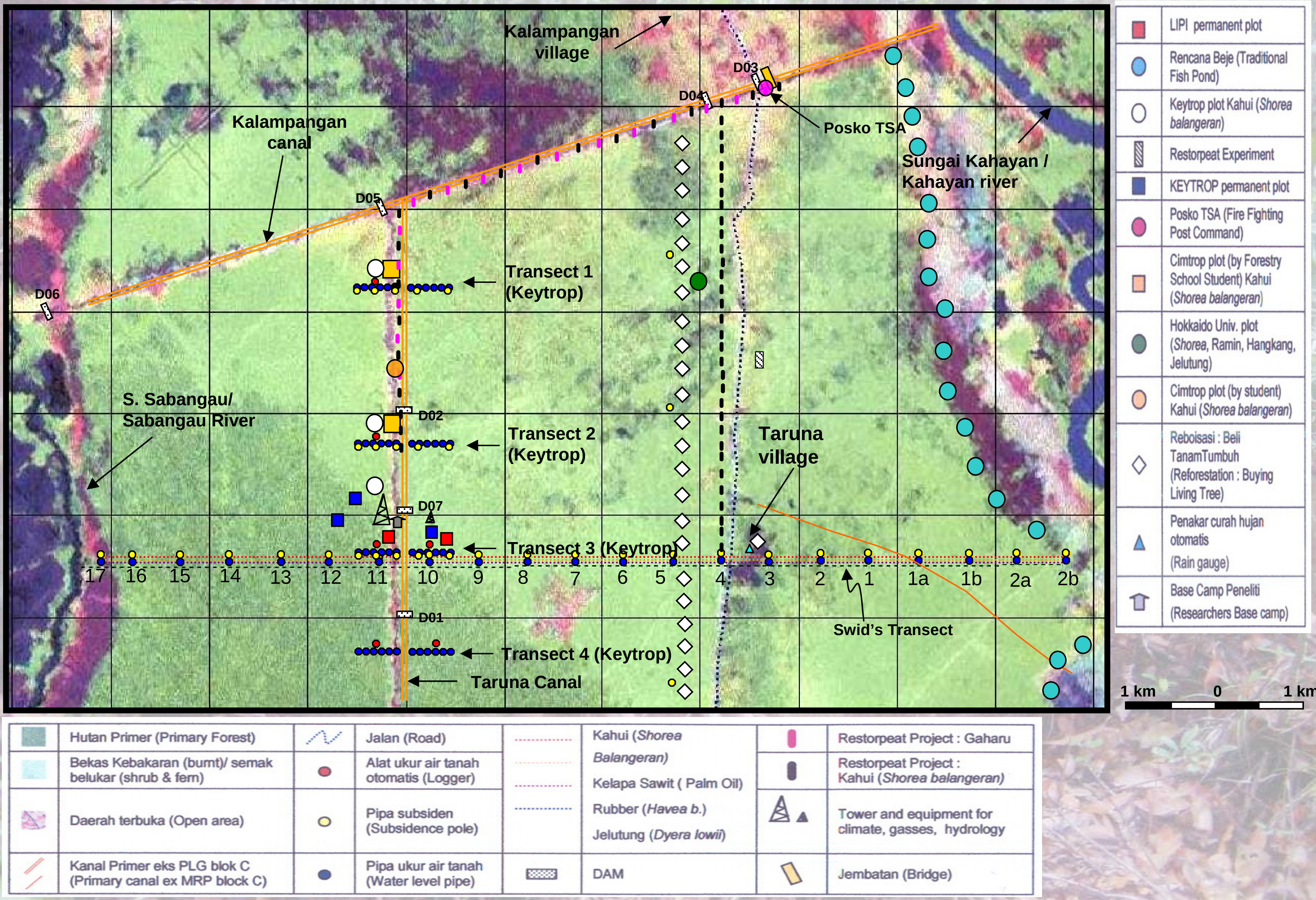
SRTM-X-SAR Cross-section along the National Lab transect with trees

Observations

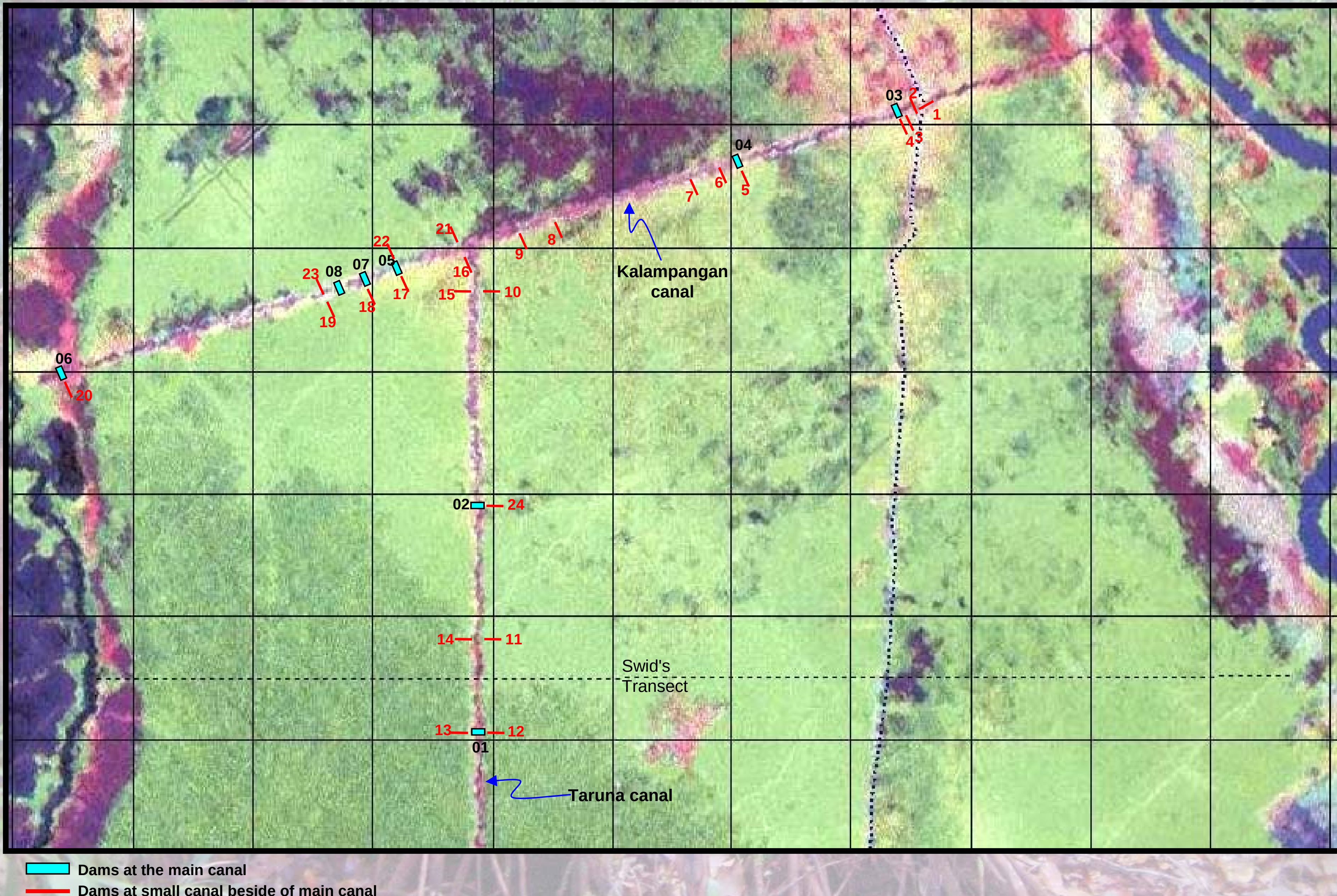


National Lab channels from illegal loggers

Courtesy by Alterra



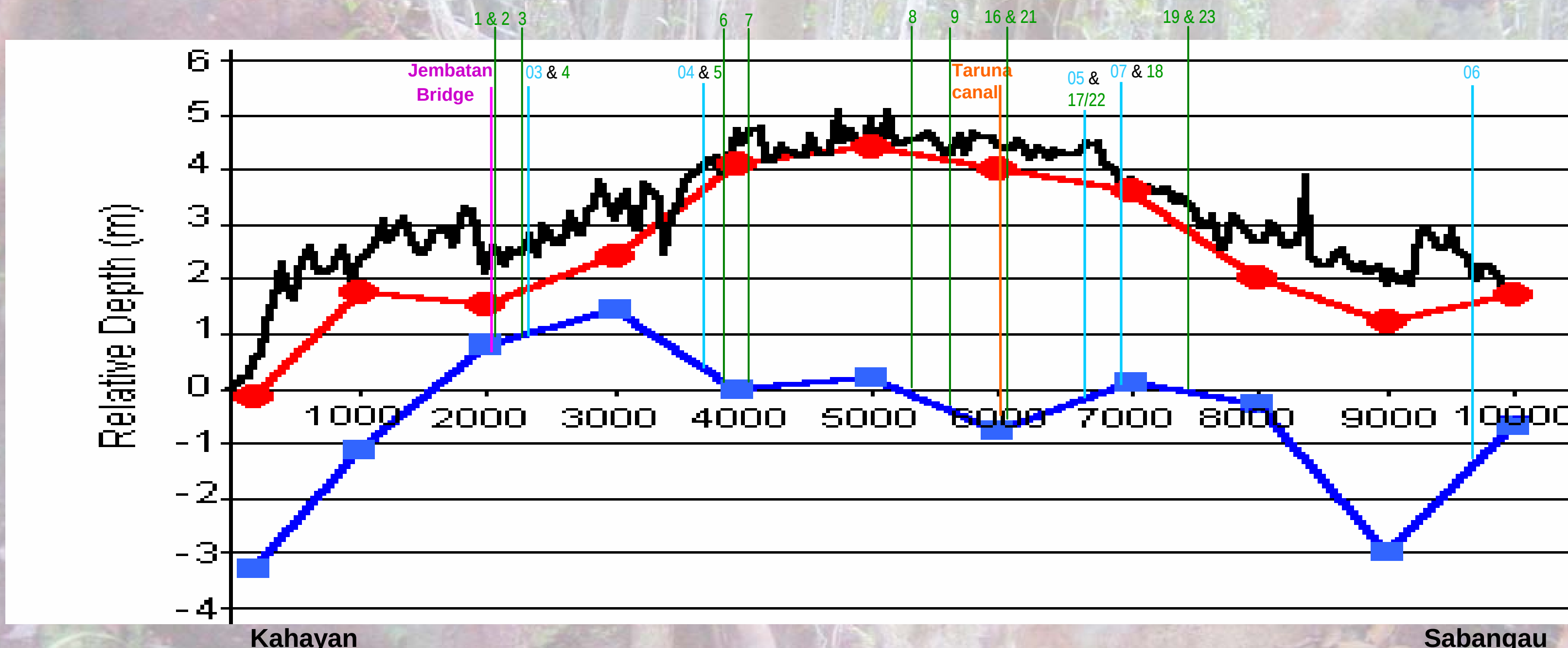
International Research Collaboration in Kalampangan Zone (Block C of the ex.MRP) Organized by CIMTROP-UNPAR



Position of dams at the Kalampangan and Taruna canals

Results

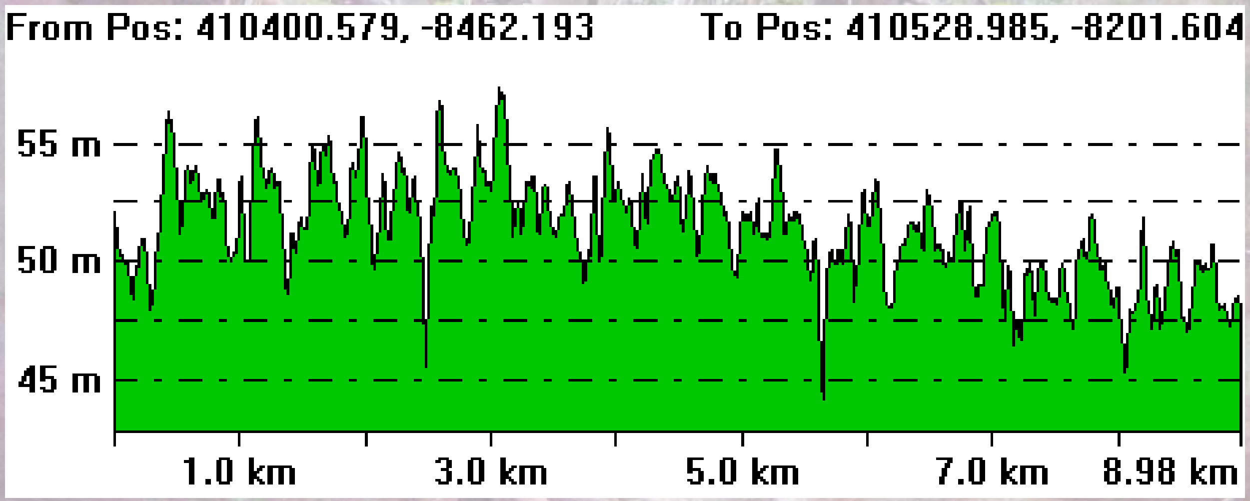
Kalampangan Canal



Position of dams and topography along the Kalampangan Canal (Block C of the Ex MRP)

Results

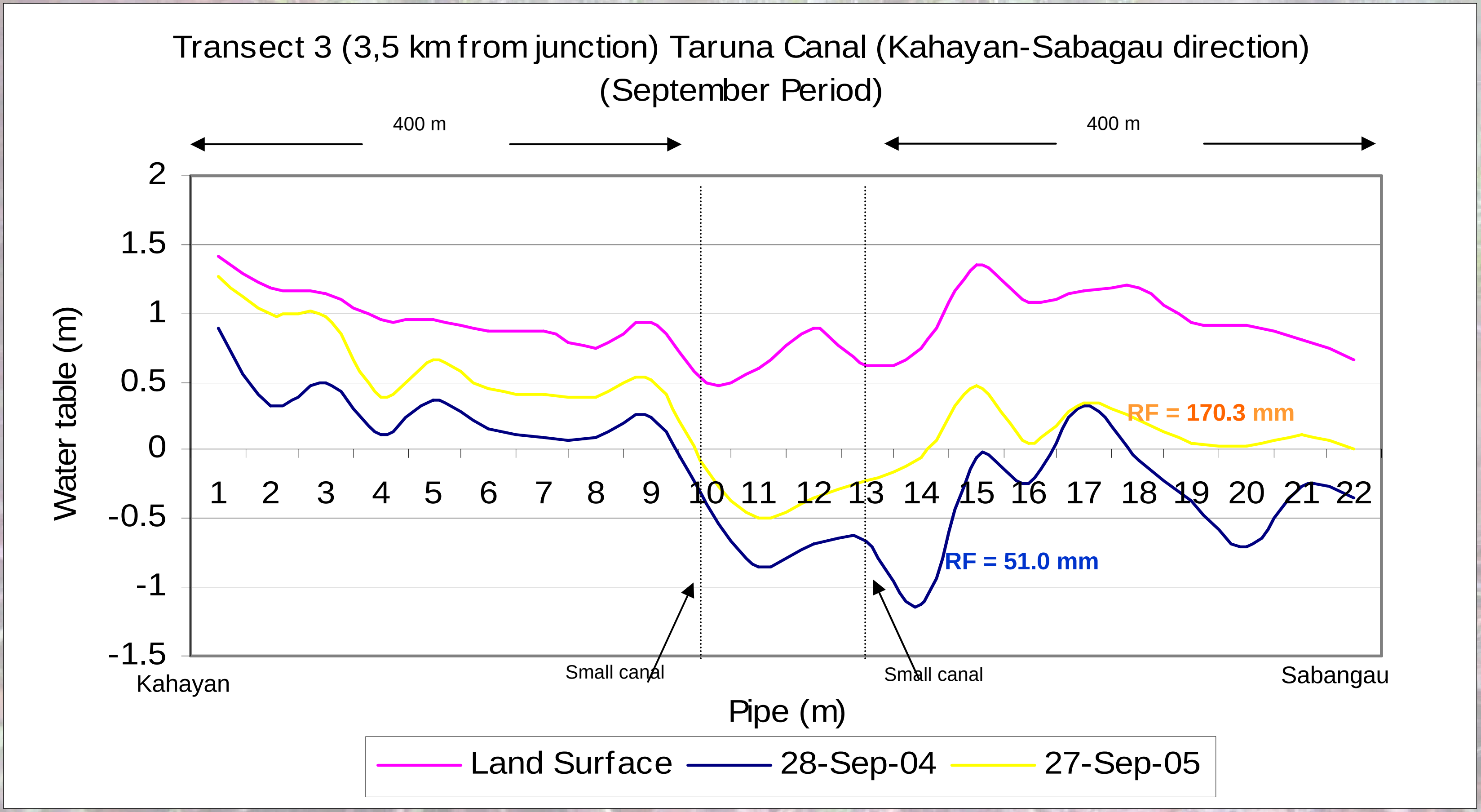
Sebangau



Kahayan

SRTM-X-SAR Cross-section along the Kalampangan canal transect without trees

Results



Water table fluctuation before and after dam constructed

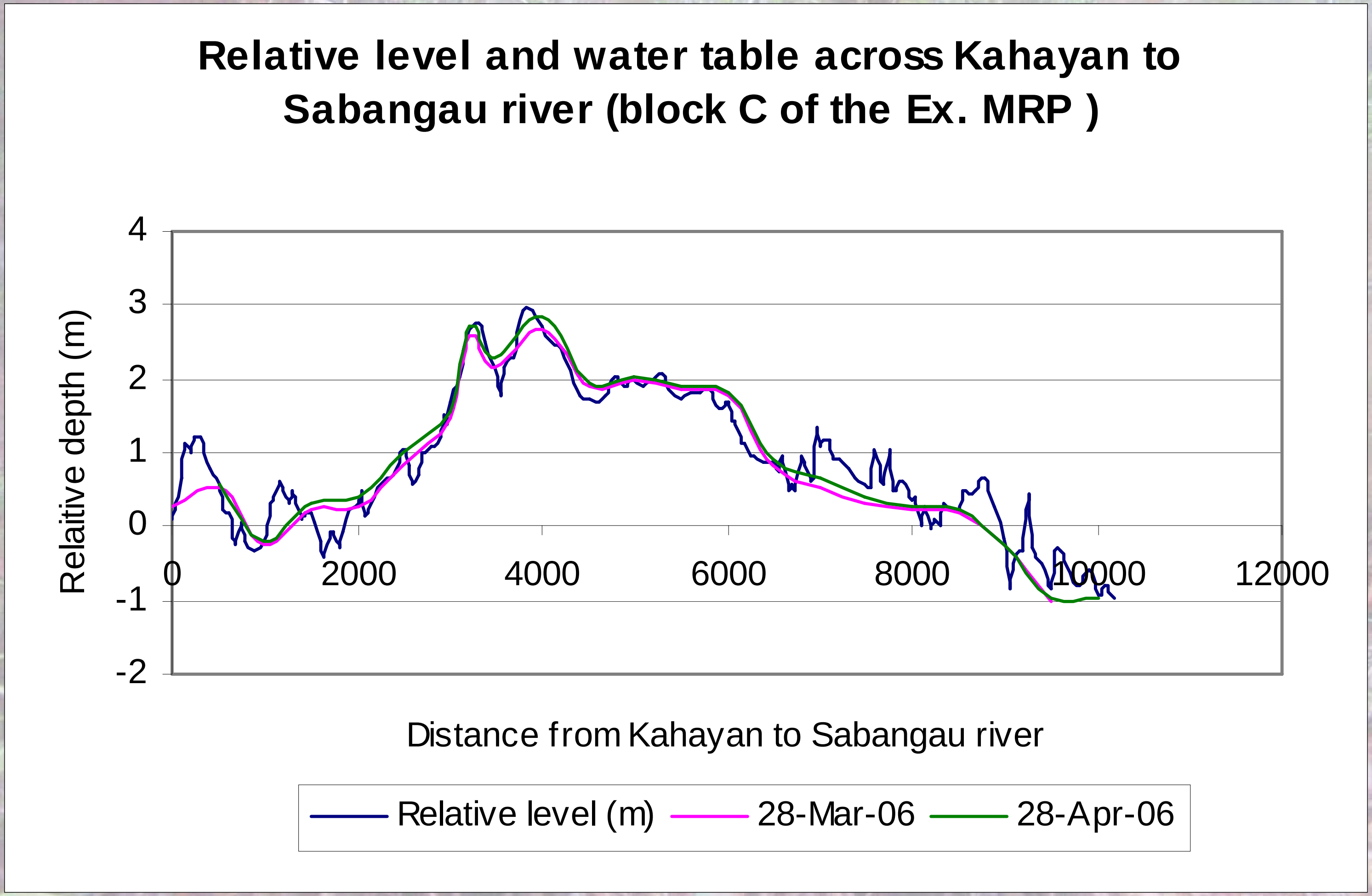
Part of dams in Kalampangan and Taruna canals (Block C of the MRP)

Part of dams in Kalampangan and Taruna canals (Block C of the MRP)

Results

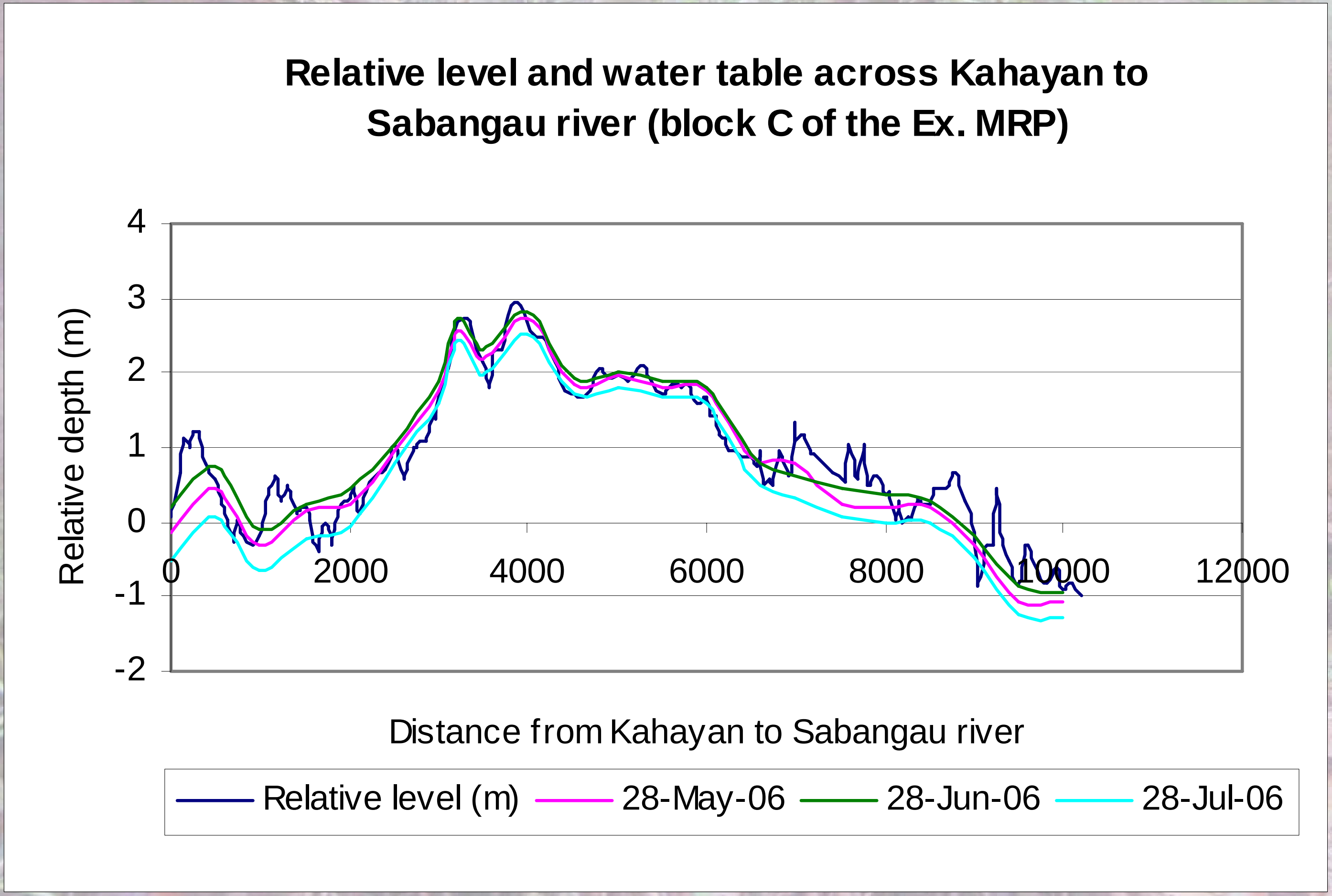
Part of dams in Kalampangan and Taruna canals (Block C of the MRP)

Results



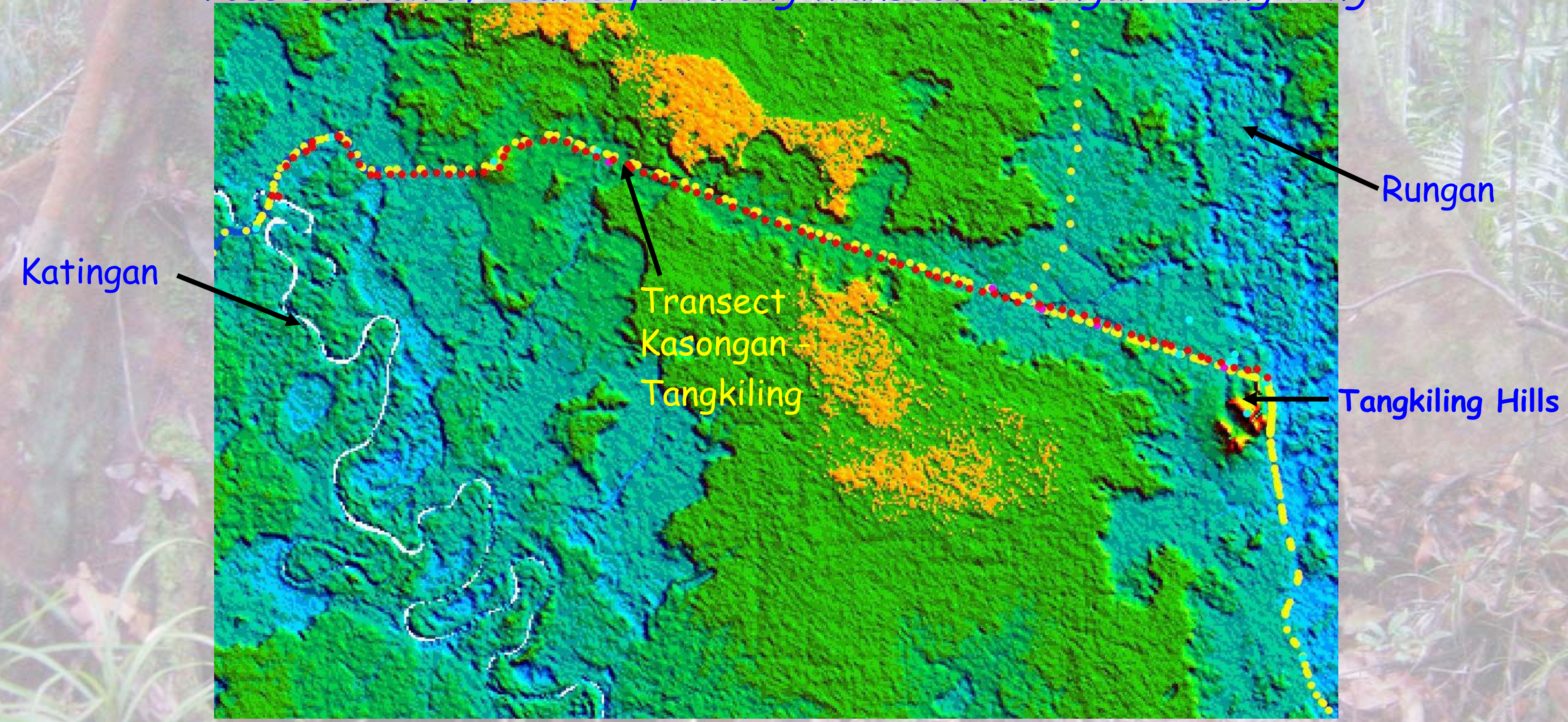
Relative level and water table across Kahayan to Sabangau river (block C of the Ex. MRP)
Relaitive depth (m)
4
3
2
1
0
-1
-2
0
2000
4000
6000
8000
10000
12000
Distance from Kahayan to Sabangau river
Relative level (m)
28-Mar-06
28-Apr-06

Results



Relative level and water table across Kahayan to Sabangau river (block C of the Ex. MRP)
Relative depth (m)
4
3
2
1
0
-1
-2
0
2000
4000
6000
8000
10000
12000
Distance from Kahayan to Sabangau river
Relative level (m)
28-May-06
28-Jun-06
28-Jul-06

Results: Data Processing
SRTM-DEM elevation data with existing vegetation types
90m x 90m
Cross-section of Peat depth along transect Kasongan - Tangkiling

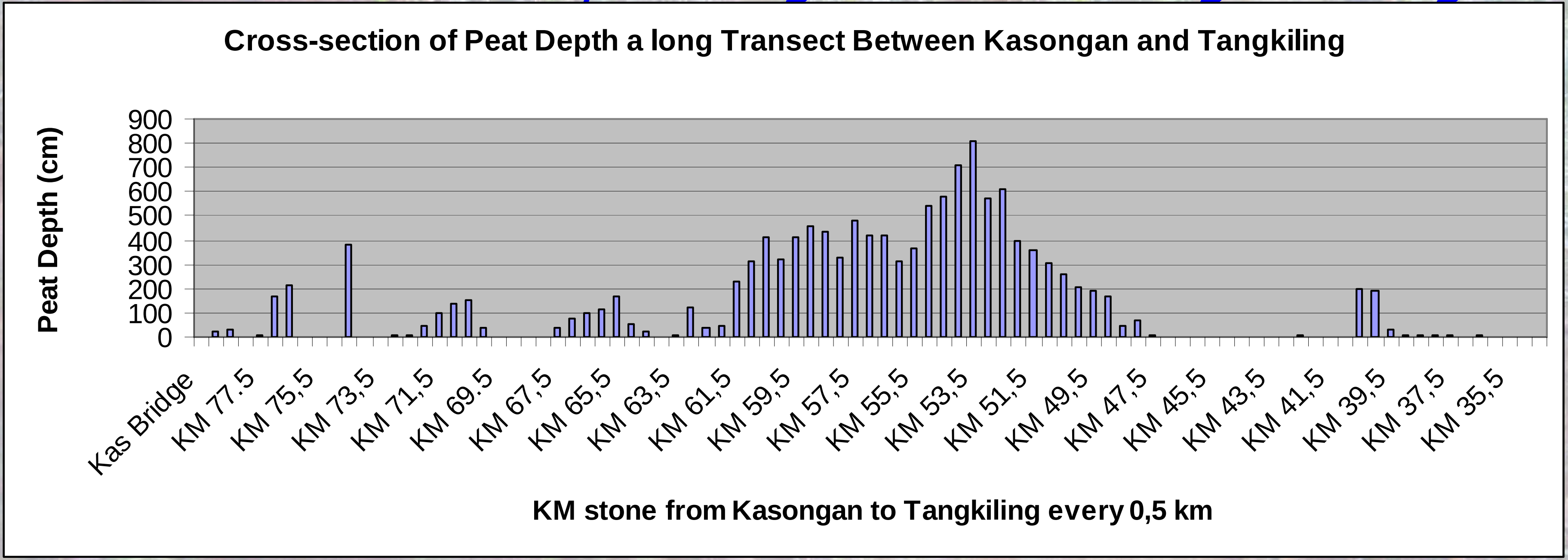


SRTM DEM-Image from Feb. 2000. The elevation is shown in colours. The brown (very high trees) and green colours includes the canopy of the PSF. Cleared peat land is lower, especially along the highway with yellow track points. River Katingan left, Rungan right and the Tangkiling hills can be identified. Up to **8.10m thick peat** at km 53.5 km

The peat drilling locations are marked by the red points parallel to the Kalimantan highway.

Results

Cross-section of Peat depth along transect Katingan - Tangkiling



5m to 6m in average x450 Mio m^2 = 2.25 to 2.7 G m^3 big peat area and
2.5m to 3m average x 1473 Mio m^2 = 3.68 to 4.42 G m^3 medium peat area.
The sum is for the northern Sebangau Catchment **5.93 to 7.1 G m^3 peat volume.**
One m^3 peat contains for this peat land 154.3kg Carbon.
So we find a stored **Carbon value of 0.92 to 1.1 G tons** for this area.
Up to **8.10m thick peat** at km 53.5 km

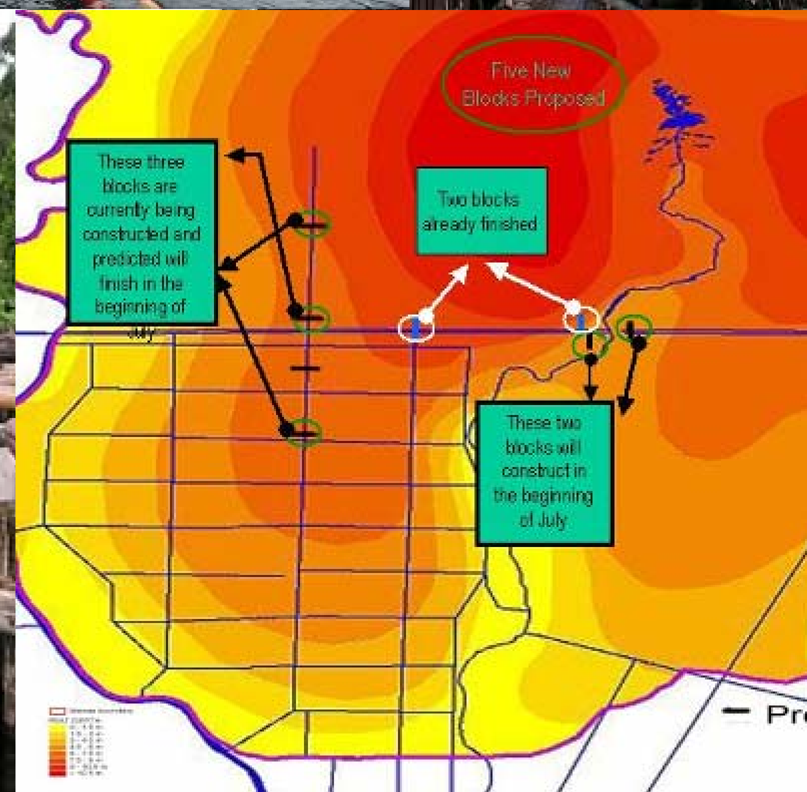
Approx. 1 Gt Carbon stored in the Northern Part of Sebangau

By Viktor Boehm & Yustinus Sulistiyanto

Main observations

- Speeded up water table raise and longer prevailed high water table conditions in comparison to previous years after the canal was blocked by dams.
- The highest CO_2 emissions were on the top of tree root plates in forest floor (presumably high root respiration) and open area hummocks resulted the lowest emissions (possibly due to peat dryness and sparse vegetation).
  - Annual CO_2 emissions in the forest floor were about 2x in comparison to the open area.
- CH_4 fluxes remained near zero - forest floor was a weak sink and open area peat a weak source.
- Based on the applied models, greenhouse gas emissions before and after restoration in year 2005 can be described as:
  - There was no marked difference in annual cumulative CO_2fluxes in either of the two areas before and after restoration conditions.
  - CH_4 emissions are slightly higher after restoration in the open area and the function of forest floor as a CH_4 sink may strengthen after improved hydrological conditions.

Restoration of hydrology of drained areas in Mawas



Courtesy Marcel Silvius WI

Concluding remarks

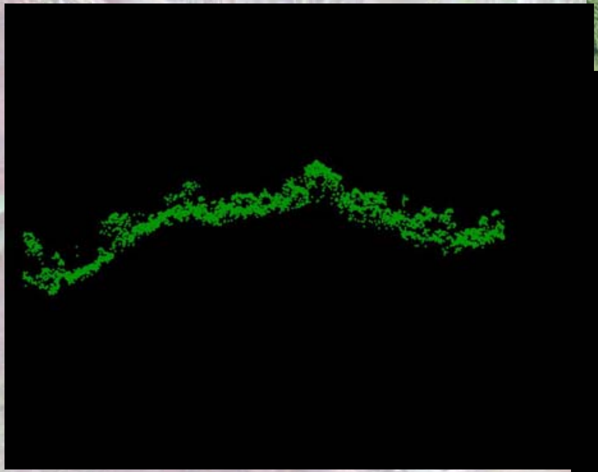
- Establishment of dams along the Kalampangan and Taruna canals in Block C of the ex. MRP has raised the water table as far as 400 m each side of the canal. The maximum value of water table increase before and after dam occurred in October 2004 and 2005, that is 151 cm.
- Blocking canals throughout the ex MRP by dams is needed urgently, especially these canal which have been excavated through the deep peat and those connecting to the big rivers.
- The effectiveness of dams for raising the water table could be proven after several years and this also should be indicated by vegetation re-growth and reduction in fire events. These responses must be monitored every year for a long time.

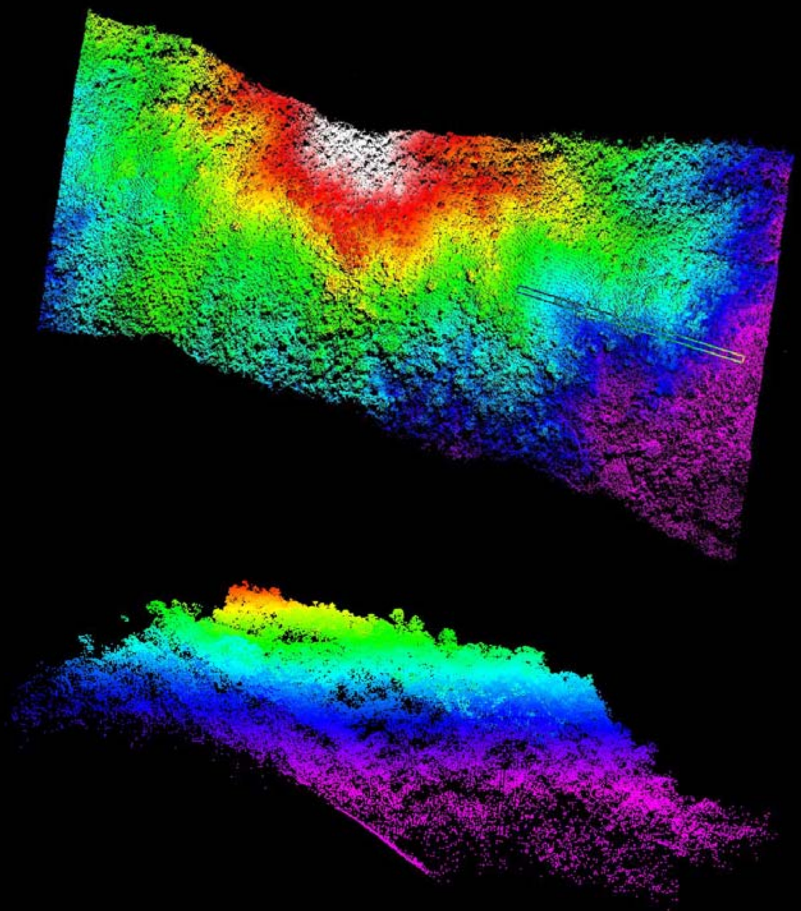
Concluding remarks

- Although forest may result larger CO_2 emission rates and cumulative emissions in comparison to reclaimed land, replacement vegetation is likely unable to match with the long-term capacity of tropical PSF to allocate and store carbon.
- Success of hydrological restoration can not be judged solely on basis of detected peat carbon fluxes because other important carbon cycle connected factors may likely benefit from prolonged high water table conditions
  - Decreased risk of peat carbon and vegetation loss by fire
    - lower ignition likelihood
    - shallower dry peat horizon
  - Slower peat physical characteristics change
  - Improved conditions for forest vegetation revival
  - Increased potential for net C-allocation in a long run
  - …

Way ahead with ALS

ALS has 15cm geo-referenced Elevation accuracy





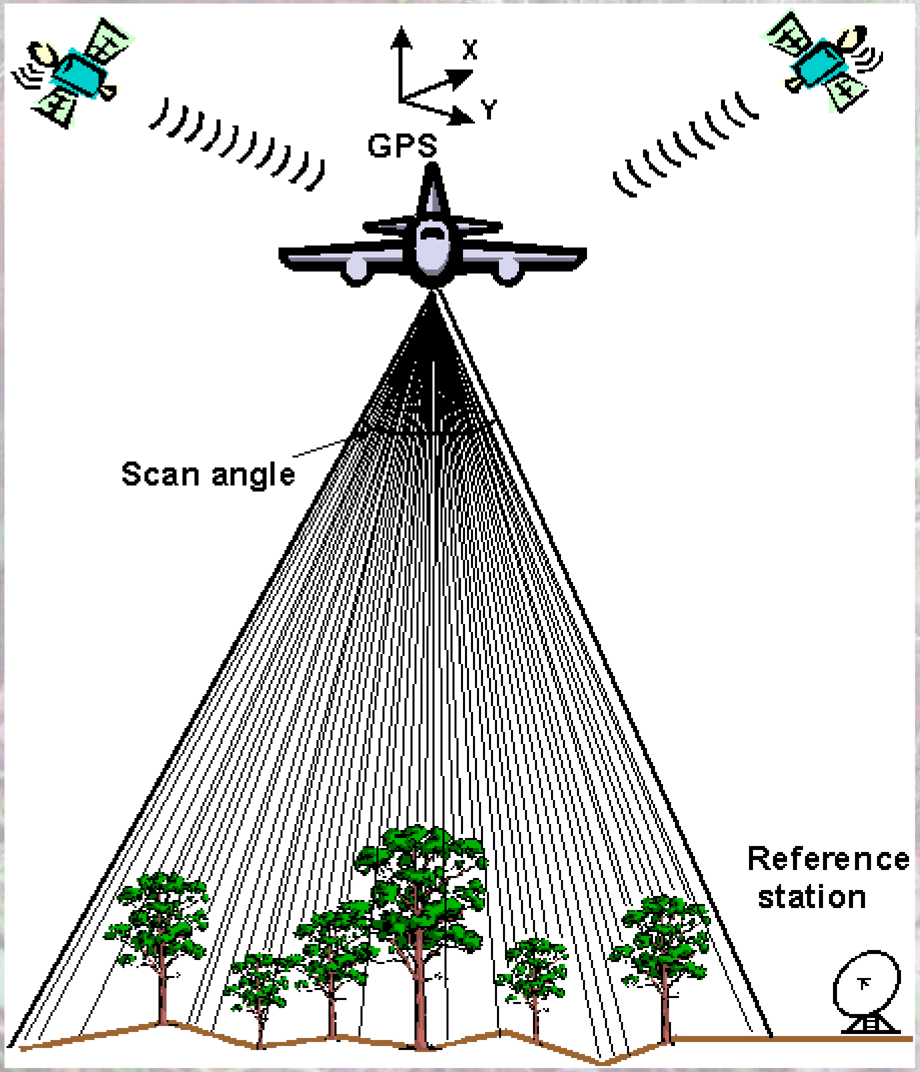
ALS in Malaysia

Courtesy by IGI GmbH

Way ahead with ALS

ALS has 15cm geo-referenced Elevation accuracy

Airborne Laser-Scanner, EU - High-Scan Project:



Aug-1998 – Aug-2001

The **main objective** of the **HIGH-SCAN project** was to explore and test methods of laser scanner for small-area (regional and stand-wise) at the retrieval of the following **forest attributes**:

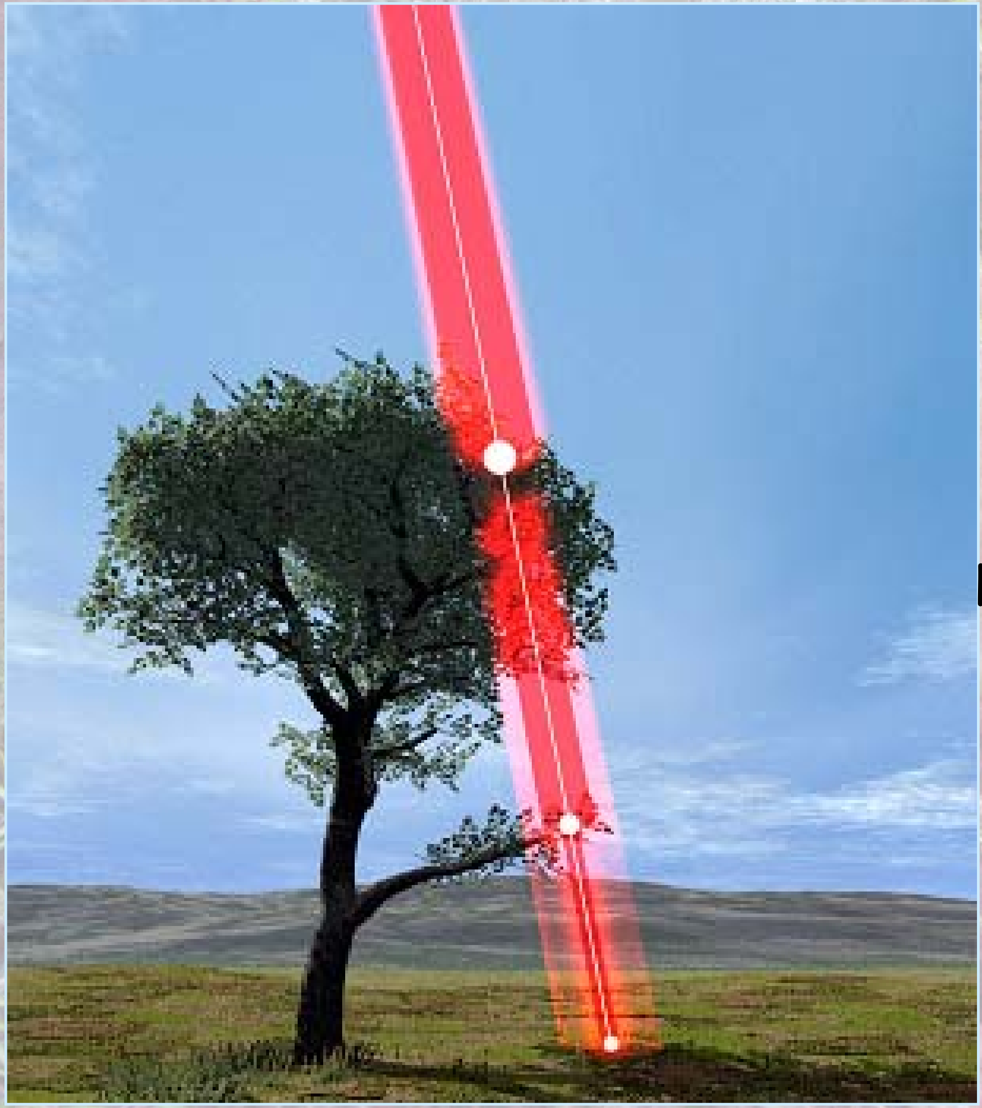
1. Timber Volume [m^3/ha]
2. Tree Species Proportions
3. Mean Tree Height
4. Stand Density/Basal Area
5. Structure of natural Age Classes
6. Soil Type and Fertility Classes
7. Crown Area, and
8. Stand Boundaries.

Courtesy High-Scan project

Way ahead with ALS

ALS has 15cm geo-referenced Elevation accuracy

3D- DSM/DTM-Model for forestry



Tree Height Measurement with First (FE), Medium and Last Laser Echo (LE) or

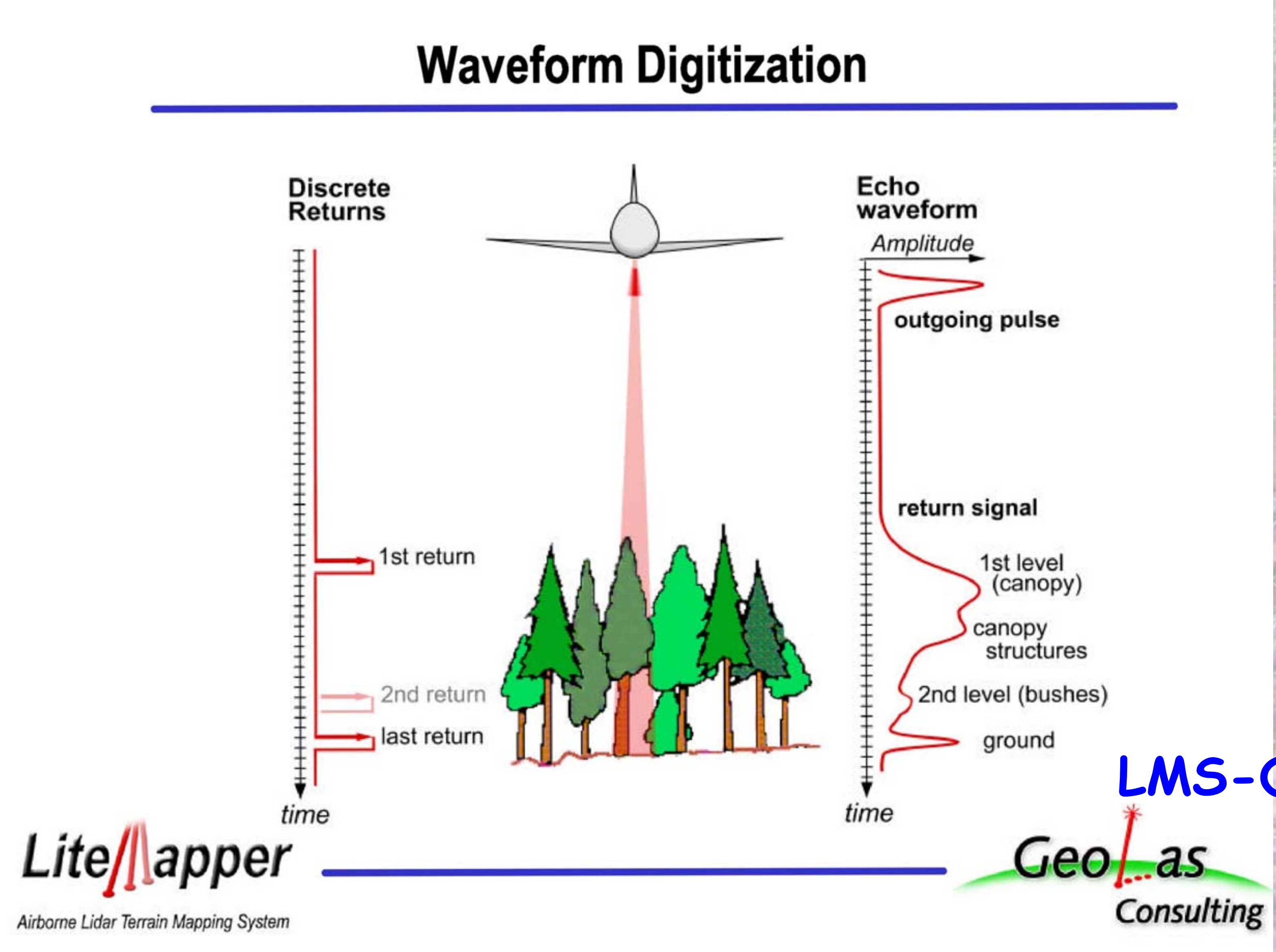
with Full Waveform Digitization

Courtesy Swissphoto

Way ahead with ALS

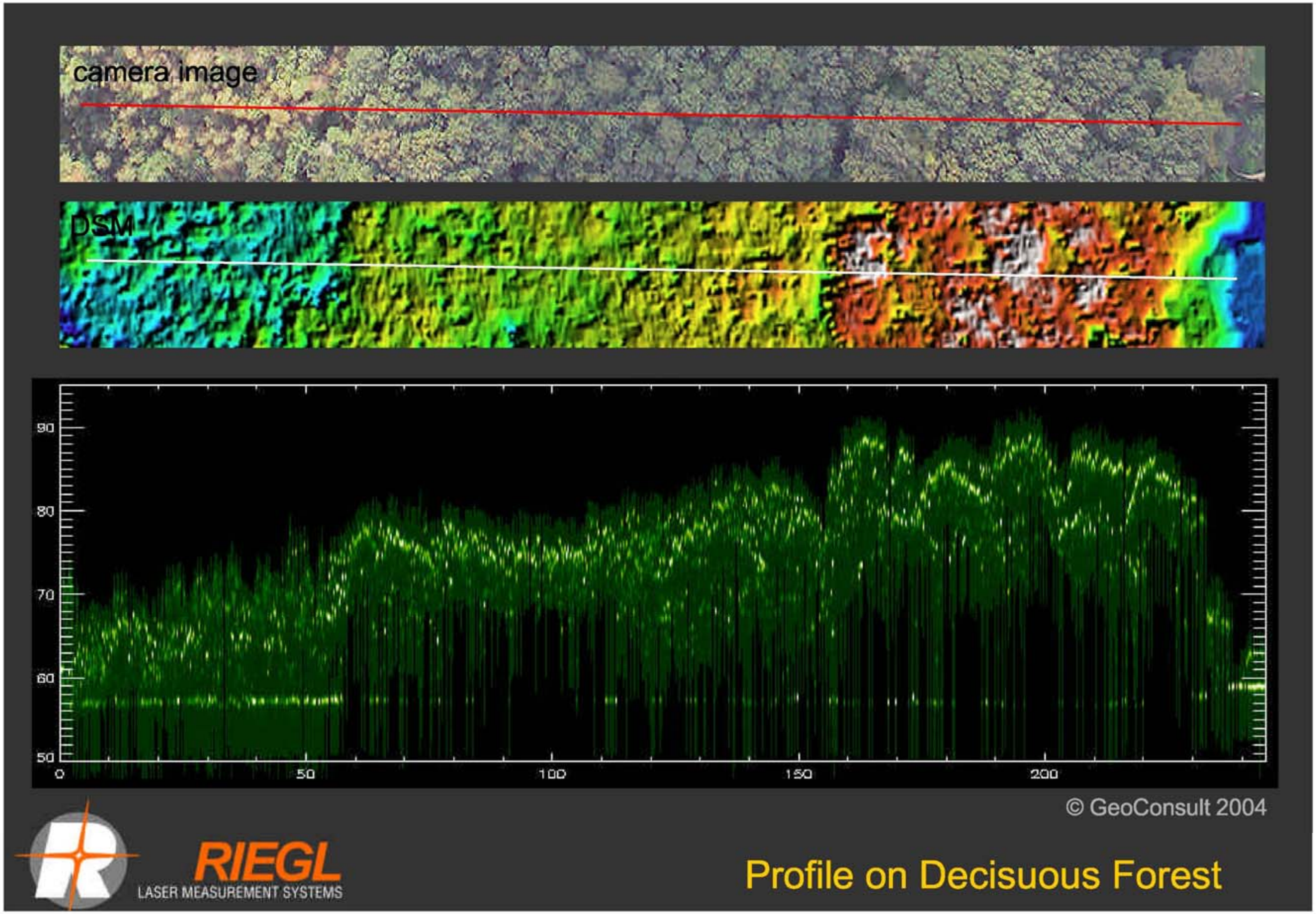
ALS has 15cm geo-referenced Elevation accuracy

3D- DSM/DTM-Model for forestry

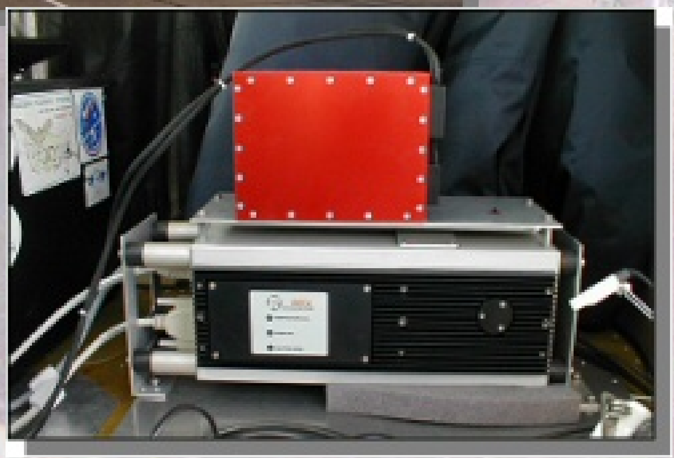


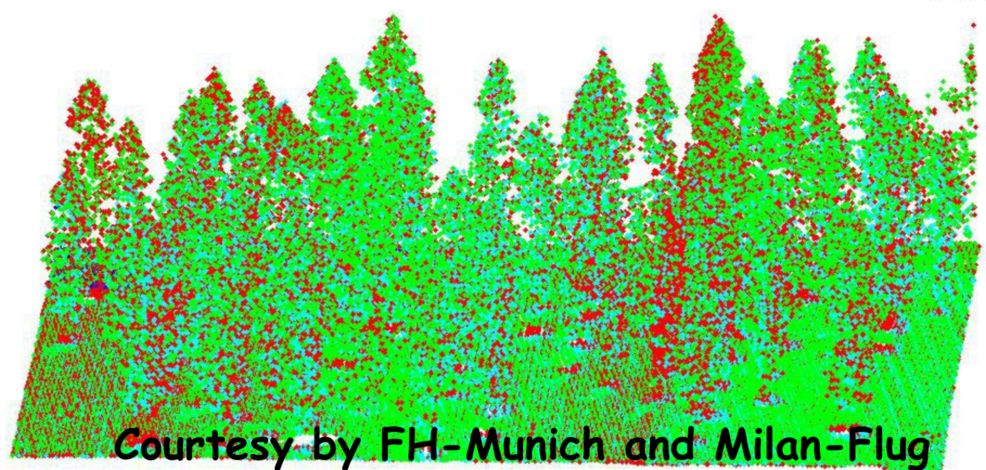
LMS-Q560

Way ahead with ALS Airborne Laser Scanner



Way ahead with ALS Airborne Laser Scanner





Way ahead with ALS Airborne Laser Scanner

ALS560

Plane

800m altitude

+

900m

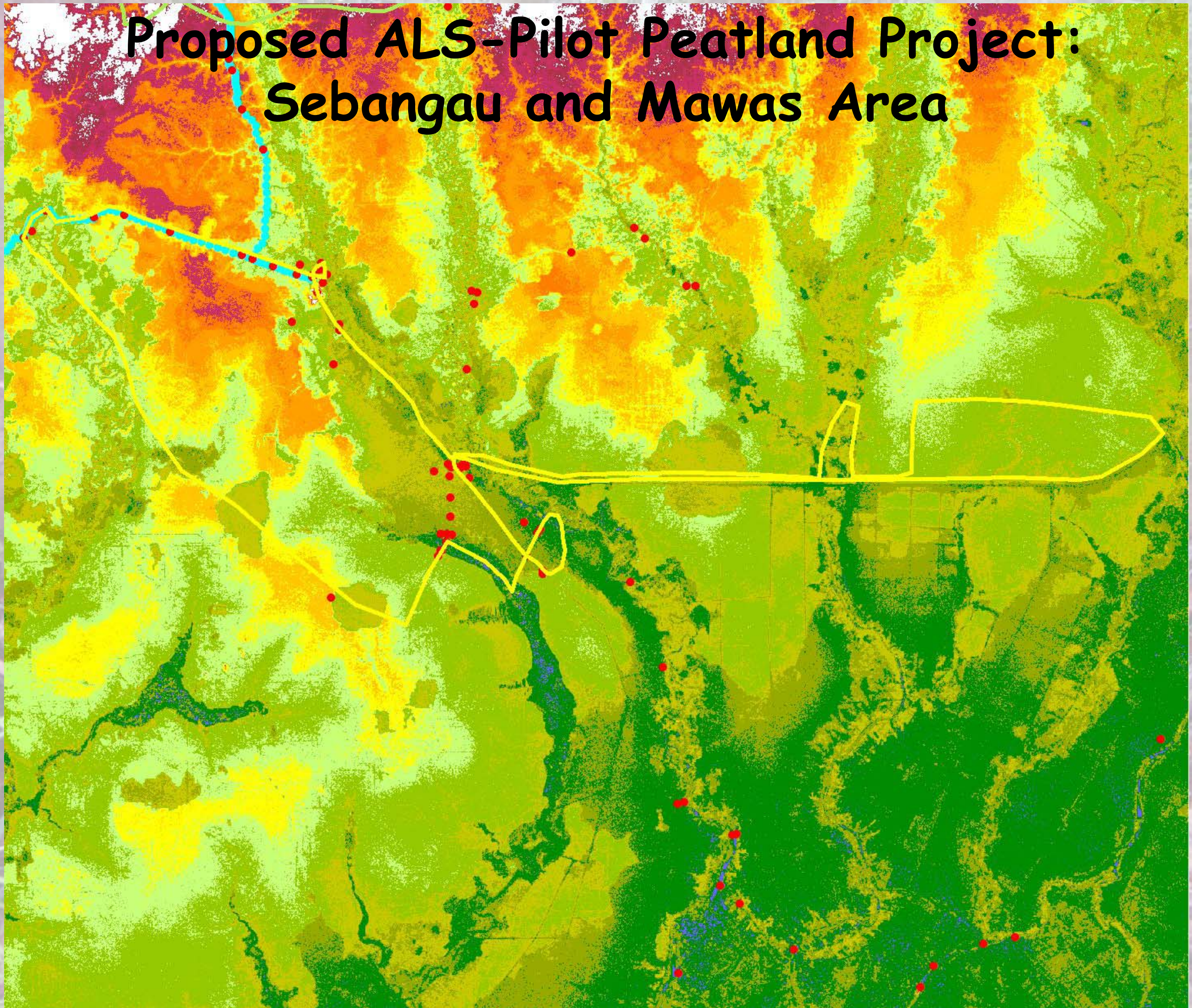
ALS-Scan

60m/s

236km + 231km

HC or Plane

2 Pixels per m²



Way ahead with ALS Airborne Laser Scanner

ALS560

Plane

800m altitude

+

900m

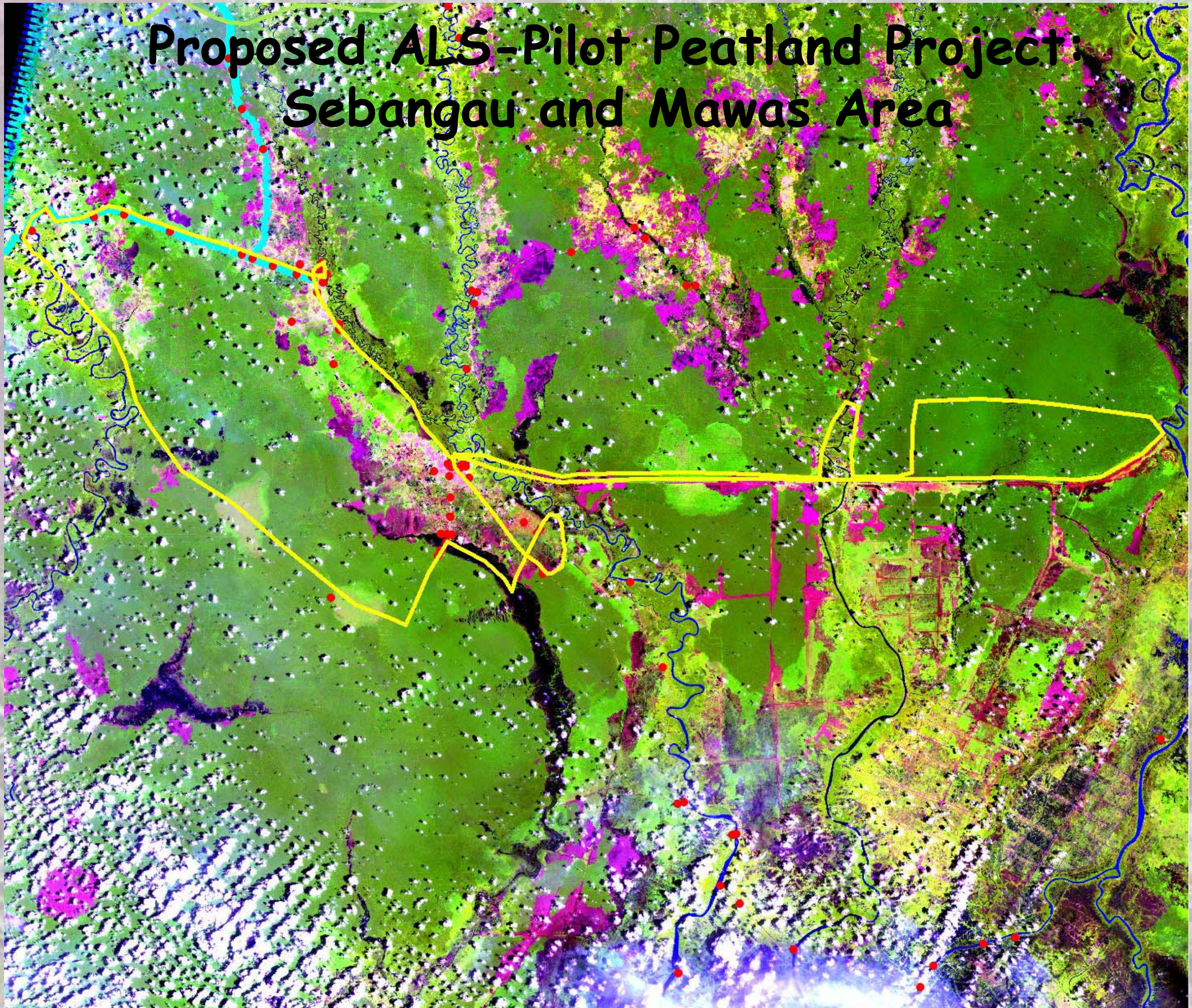
ALS-Scan

60m/s

236km + 231km

HC or Plane

2 Pixels per m²



Way ahead with ALS

ALS has 15cm geo-referenced Elevation accuracy

Proposed ALS-Pilot Peatland Project: Sebangau- and Mawas-Area

POD: 2.00m x 0.75m x 0.40m, water-resistence

POD: 20kg

POD with System: 40kg; Flight- license: approx. 4 weeks, Flight-permision

Electric: 24V with 20A (max.30A)

Position DGPS-Antenne (L1/L2): Heck

Kalibration: 10min after installation

Sensorics: LaserQ560 (eye-safe, 0.5mrad), INS, RGB-Camera, Datarecorder, Flightmanagementsystem CCSN4, GPS-Datarecorder

Scan-angle: 45°, optional 60°

RGB-Camera: at 800m, 10cm on Ground, approx. 40°, for Ortho-photo

DGPS: Station necessary (approx. 100km)

Scan-Area: approx. 100qkm per day at good wether,

Data available: approx. 4 weeks data-analysiation

Sebangau- + Mawas-Area: 236km + 231km HC; 2 Pixels per m^2 Laser

Way ahead with ALS Airborne Laser Scanner

Efficiency and Point Densities - TopoSys

- Falcon I LiDAR Image (GSD) Productivity
  - 30m/s, 400m: 27 points/sqm - 11 sqkm/hour
  - 60m/s, 800m: 7 points/sqm - 43 sqkm/hour
- Falcon II
  - 30m/s, 400m: 27 points/sqm 10 cm 11 sqkm/hour
  - 60m/s , 1200m: 5 points/sqm 50 cm 65 sqkm/hour
- Falcon III
  - 15m/s, 250m: 66 points/sqm 3 cm 7 sqkm/hour
  - 30m/s, 400m: 21 points/sqm 3 cm 22 sqkm/hour
  - 60m/s, 2000m: 1,3 points/sqm 15 cm 215 sqkm/hour
- Harrier 56
  - 20m/s, 200m: 15 points/sqm 3 cm 12 sqkm/hour
  - 40m/s, 800m: 1,8 points/sqm 5 cm 95 sqkm/hour
- Harrier 24
- 15m/s, 100m: 4 points/sqm 3 cm 6 sqkm/hour
- 30m/s, 200m: 1 points/sqm 3 cm 25 sqkm/hour

Courtesy TopoSys

Way ahead with ALS Airborne Laser Scanner

- Main Features of **Harrier 56 from TopoSys (LMS-Q560)**
  - Beam deflection **Polygon scanner**
  - Field of view 45 degrees (60° as option)
  - Measurement rate 50 kHz (45°) – 66 kHz (60°)
  - Operating altitude 30 m - 850 m
  - Range capture **Full waveform digitization**
  - Intensity capture 16 bit
  - Scan frequency 5 Hz – 160 Hz
  - Eye save Class 1
  - Swath width 76 % of op. Altitude (45°)
  - Range resolution 0.020 m, laser only; diverg. 0.5mrad
  - Vertical accuracy **< 0.15 m, (absolute)**
  - Horizontal accuracy < 0.25 m, (absolute)
  - Operation Aircraft and helicopter
  - Digital Camera (R,G,B,IR) 4,092 x 5,436 pixel;
  - Applanix DSS322

Courtesy TopoSys

Thank you!

Danke schön!

Terima kasih!

Kiitos!

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