REPORT OF GROUND TRUTH CAMPAIGNS INCL. AERIAL SURVEY IN KALIMANTAN TENGAH

27th of March - 20th of April 1996

by
Dr. H.-D.V. Böhm
and
Stefan Haisch

Report of Ground Truth campaigns incl. aerial survey in Kalimantan Tengah 27th of March - 20th of April 1996

by
Dr. H.-D.V. Böhm
and
Stefan Haisch

Kalteng Consultants, Dr. Böhm
Kirchstockacher Weg 2
D-85635 Höhenkirchen
Tel. * 49-(0)8102-774848 Fax:-774850
e-mail:viktorboehm@t-online.de

Contact adresses:
Kalteng Consultants
Dr. H.-D.V. Böhm
Kirchstockacher Weg 2
D-85 635 Höhenkirchen, Germany
Tel: 0049-8102-~~4950~~ 774848
Fax: 0049-8102-~~72359~~ 774850

Stefan Haisch
Rosenheimer Landstr. 126
D-85 521 Ottobrunn
Tel: 0049-89-608 511-09 and 609 09 69
Fax: 0049-89-608 511-08

Content

1. Introduction

Kalimantan Tengah (Central Kalimantan, Kalteng) has a large remaining area of Peat Swamp Forest (PSF). This is a unique and highly diverse tropical ecosystem which is extremely sensitive to logging, clearcuts and agricultural land conversion. Uncontrolled economic exploitation will have major implications on biodiversity, ecology, hydrology and the regional climate. The natural resource function of PSF as a resource of biodiversity and secondary forest products, as well as a carbon sink and as an area for flood mitigation must be preserved.
In the end of March 1996, **Kalteng Consultants** (Dr. Böhm, Dr. Rieley, Dr. Sieffermann, Dr. Siegert) held a presentation in front of the chairman of the Indonesian Peat Land Society Dr. Bambang Setiadi and the director Anur Rofiq at BPPT, Jakarta. This presentation revolved around the **Peatland Evaluation and Land Use Planning in Kalimantan Tengah, Indonesia by Multispectral and Multitemporal Remote Sensing with Satellites Images and ground truth campaigns.**
Additionally there was performed in Kalimantan Tengah a ground truth campaign of Dr. Böhm, Dr. Rieley, Dr. Page, Dr. Sieffermann and Stefan Haisch with tremendous help of lectures from the University of Palangkaraya in April 1996. An aerial survey was performed with a Cessna 185 in the southern and northern part from Palangkaraya over a part of the PSF area conducted by Dr. Böhm in co-operation with Dr. Rieley and Stefan Haisch (see fig. 1 and 2).
The Governor and the Vice-Governor of the Province Kalteng invited Kalteng Consultants for a presentation of the PSF-proposal and for discussions of conversion aspects of poor PSF to an 1 million ha of rice fields. Officials from e.g. BAPPEDA and BPN were present.
Another presentation was given to the Environmental Minister Ir. Sarwono in Jakarta. The minister plans to establish a data-bank of the PSF zonation which includes the thickness of the PSF, soil quality and the hydrology (watersheds) in the area between the rivers Kapuas and Barito. Kalteng Consultants can support the government to collect important basic data in a Geographical Information System (GIS) and to map Kalteng with the aid of satellite images.

2. Meetings and contacts of Kalteng Consultans

2.1 Dairy of meetings and contacts in Jakarta, Java

29.03.96 at BPPT : Kalteng Consultants presentation of Dr. Rieley, Dr. Sieffermann and Dr. Böhm to Mr. Anur Rofiq and Dr. Bambang Setiadi and several officials: Public Work, BPN, ProLH and agricultural people from Bogor.
01.04.96 visit to Herrn G. Felber, team leader ProLH/GTZ with Dr. Sieffermann
02.04.96 at LAPAN: quick-look of LANDSAT and ERS images and order of a LANDSAT image. Visit of Dr. Aris Poniman - head of remote sensing - at BAKOSURTANAL and Mr. Nugroho at the Center for Soil and Agroclimate Research (CSAR) in Bogor; visit of Rona Denis, ODA.
03.04.96 visit of Herrn Merkle at the HSF and Dr. Fraser from ODA in the MoF.
04.04.96 visit of Mr. Kuswanda from ITTO in the MoF.
15.04.96 invitation of the Environmental Minister Ir. Sarwono Kusumaatmadja and his staff at Arthaloker Building of BAPENAS; 2. visit of Herrn Felber, team leader at ProLH/GTZ

16.04.96 BPPT-Workshop on: **Direct Reception of Satellite Data for integrated and sustainable Environmental Monitoring in Indonesia** and visit of Dr. Dress at HSF.
17.04.96 visit of Dr. Indrajono Soesilo (director for remote sensing) and Mr. Mubekti at BPPT and Dr. Fraser (ODA) to receive new LANDSAT images
18.04.96 LAPAN procurement of the LANDSAT TM5 image 118/62 dd. 24.7.94, sponsored by BPPT
19.04.96 Travel through the Javanese rice fields behind Pundjac Pass.

2.2 Dairy of excursions, meetings and contacts in Palangkaraya and Kalteng

05.04.96 Flight to Palangkaraya and visit of the water factory from Ridwan Dobson near Sungai Sebangau and survey of a Transmigrasi village in the south of Bukit Tangkiling;
Meeting with Prof. Usop and Mr. Suwido Limin from UNI Palangkaraya
06.04.96 Boats trip with Dr. Jack Rieley and Dr. Susan Page from UNI Nottingham visiting PSF at Camp Seti Alam Jaya on the S. Sebangau.
07.04.96 Geological excursion with Dr. Sieffermann to Bukit Tangkiling and to the unsuccessful Transmigration village Marang
08.04.96 Short visit to BAPPEDA, LREP II and ProLH
Three PSF boreholes in the direction of Pulang Pisau in the south of Palangkaraya
09.06.96 PSF excursion with motor cycle on the other side of S. Kahayan. Heath forest, drilling and illegal logging in the PSF.
10.04.96 visit of the UNI Palangkaraya: Suwido Limin, Sehat Jaya and Sulmin Gumiri, meeting of people from the concession Kayu Mas at Batang Garing
11.04.96 2 ½ hour aerial survey over the PSF with a Cessna starting in Palangkaraya.
12.04.96 Kalteng Consultants presentation to the Governor and Vice-Governor, in front of 40 Kalteng government people concerning PSF and the 1 Mio. ha rice project.
13.04.96 Visit of the Palangkaraya harbour and down town
14.04.96 Flight to Jakarta

3. Field campaigns in Kalteng

3.1 Geological Field Trip incl. soil determination

3.1.1 Tangkiling Mountains and the soil around

Dr. Gaston Sieffermann, geologist and tropical soil specialist, from ORSTOM, Paris, has more than 35 years experience with geology and soils in the tropical zones of South America, Africa and Indonesia. He worked for the French ORSTOM with the Transmigrasi Department Jakarta on rock and soil questions in Kalteng from 1979 until 1995. We made several excursions to determine the thickness of PSF with peat drillers with him, to figure out the quality of the soil in different areas around Palangkaraya to see Transmigration villages and to analyse the rocks of the Bukit Tangkiling Granite (fig. 3, 13A).
On the 7th April we had one excursion leading along the main road from Palangkaraya to the north-western direction of Bukit Tangkiling approx. 35 km away.

In a 3 m deep hole (fig. 3A), near the road, foreseen for fishing ponds, the people dug through the hardpan, the B-horizon, and the iron- and aluminium-containing layers. Below this level the soil has an approx. 15% kaolinite content.
Around the area of Bukit Tangkiling are 6 major hills consisting of intrusive young Alkali Granite of Miocene age (27-28 M years). These hills have an altitude above sea level of 125m, 130m, 135m, 164m, 174m and 186m.
Between 130.000-110.000 b.p. the mean sea level was higher than the actual one and reached the Bukit Tangkiling. Between 90.000-10.000 b.p. the mean world sea level was mostly below the actual sea level (around 40 m). Then the water disappeared to the cost of today and partly below even this level. Every year since this time they have roughly 2.000 mm rain: that means a total of 240 km. The leaching of the soil in this area is the reason. Around the hills you will find red fertile soil. The content of the granite is approx.:

Granite:
the mineralogical composition:
K-Feldspar 37,1%, N-(Na-Ca)Feldspar 28%, Quartz 28%, Pyroxene 0%, Amphibole 1%, Magnetite 1%, Ilmenite 0,5%, Apatide 0,4%, Mica white 2%, Mica black 2%, and the chemical composition:
SiO_2 72%, $Al_2O_3$13,9%, Fe_2O_3 2,5%, TiO_2 0,4%, MgO 0,5%, CaO 1,3%, Na_2O 3,1%, K_2O 5,5%, P_2O_5 0,2%, Mn_3O4 0,1%, H_2O 0,5%.

There are several quarries at the hills. The indigenous people use wood fire on the surface of the rocks to crack parts of the granite. Children break up the cracked rocks to small pieces. These stones they use mainly for road- and house-buildings. It would be much better if this material could be used as a fertilizer (K_2O).
We measured the position SEIGO1 (see table 1, page 13) in the north-east direction of the Tangkiling mountains at the corner of the main road Palangkaraya - Kasongan to Sei Gohong.

3.1.2 Podzol and soil quality (taken from ref. 15)

The podzol unit, the most closely connected with the peat, occurs over thousands of square kilometres and forms a very flat landscape in Kalteng. The giant podzols can be morphologically compared with those of temperate climates, but differ from temperate podzols by the greater thickness of their horizons. They are characterised by a white quartz horizon, often more than 5 m thick, overlying an iron and aluminium hardpan, frequently more than 2 m thick. The hardpan forms a nearly permanent water table with only lateral outflow.
At their southern limits in Kalimantan, the giant podzols are overlaid by ombrogenous thick peats. The great contrast in these soils, between the white quartz sand and the iron and organic hardpan, is not caused by a change in depositional source materials but by thousands of years of clay mineral breakdown through rain water percolation.
The giant podzols have been formed riverine sediments which are similar to those deposited by modern rivers, and composed mainly of quartz gravels and sands, kaolinites, and iron hydroxides. The percolation of the equatorial rain water through such sediments created the bleached horizon in which only quartz remains. If past rainfall is comparable to the modern, a column of 50 km of rainwater has percolated slowly through these soils during the last 30 000 years. One might be surprised at the fact that such leaching did not give more than 5 m of bleached horizon. However, this is due to the fact that the quartz is not insoluble under equatorial climates. When we see a 5-metre-thick white podzol horizon, we should never forget that there was much more

quartz sand before and that a large part had dissolved, and been carried towards the brackish water lagoons and the sea.
Due to this prolonged leaching, the tropical podzols are particularly poor in elements necessary for plant life. The forest on podzols represent a limited stock of vital mineral elements which are continuously recycled. This recycling occurs in the upper part of the profile and therefore the root system is always concentrated in the top soil: the rootlets literally invade the litter where the life sustaining elements such as potassium, calcium and phosphorous are released. Consequently, there are no roots in the middle and deep horizons which are extremely poor in nutrients.
The affirmation „beautiful forest, good soil" we frequently hear is unfortunately not true under the tropics. Cutting and burning a forest on a giant podzol is an ecological disaster: all the nutrients released by the fire are washed away by the first rain to the sea. Forest on podzols are very fragile ecosystems like many other in the tropics.
Quartz is good for Jena Pyrexglas because of the pure SiO_2.

3.2 Peat Swamp Forest Excursion and Survey

3.2.1 Camp Setia Alam Jaya

Dr. Jack Rieley, biologist and botanist, from the UNI-Nottingham and Dr. Susan Page, from the UNI-Leicester, have worked for more than three years on the biodiversity and environmental importance of PSF together with UNI-Palangkaraya, Suwido Limin, with BPPT, Dr. Bambang Setiadi and with UK-Government. Secondary objectives are to distinguish between sub-types of PSF, to relate these to peat depth, to provide an accurate inventory of the peatland in Kalteng and prepare a map that combines PSF type and peat depth.
This project started in 1993 in Kalteng in the south of the Provincial Capital Palangkaraya on the edge of Sungai Sebangau opposite from Kereng-Bengkirai.
On the 6th of April 96 Dr. Rieley, Dr. Page, Suwido Limin, Sehat Jaya, Ridwan Dobson, Dr. Böhm and two other persons departed with a boat through the catchment of Sungai Sebangau to the old concession Seti Alam Jaya. The water level was high and different types of reed were growing on the water surface. The boat disembarked near the logging camp on the old railway trunks /sleeper, which lets into the PSF several kilometres. It was sometimes hard to balance on the rotten trunks between the rails (fig. 4). A GPS position (SEBAN1) was taken on the rails just at the edge of the forest.
The PSF is completely under water at this time of the year. The thickness of the peat increase from approx. 1 m up to 12 m at a distance of 18 km from the river side. The peat age varies from several hundred years up to 9 000 years.
The blackwater is dark-brown, blackish and acidic. It is flowing from the watershed where the peat is 12 m thick to the Sungai Sebangau. There can be detected different sounds of animals in the PSF and the atmosphere is specific. There are even traces of Orang-Utans cot visible on the sleppers. The temperature inside the forest is moderate If the PSF canopy is closed and is about 28 °C. A circulation of wind through the PSF is noticeable in the afternoon. This circulation is necessary for the micro climate in the Palangkaraya area. The soil in the water has a nearly constant temperature of approx. 23 - 24 °C. This is the reason why the different trees of the PSF are adapted to the peat with acid water. Special roots look out of the water to absorb oxygen. A Japanese scientist has established an automatic meteorological station to measure the different weather parameters during the year.

In the evening bull-frog's give there typical sounds and the bats flying to the northern parts of Kalteng.

The long term goals of the project from Dr. Rieley (taken from ref. 12) are to:
1. Record the nature of the PSF resource and its present vegetation, flora and fauna, and to relate these to hydrology, substrate and water chemistry, and macro- and micro-climate.
2. Understand the conditions which gave rise to peat accumulation in this part of Indonesia and to determine the peat development sequences involved since then (stratigraphy and palynology).
3. Determine the magnitude of the carbon store and carbon flux.
4. Investigate the productivity, tree regeneration times and nutrient cycling.
5. Investigate animal diversity.
6. Make recommendations for the environmentally sustainable management of this peatland resource in order to protect wildlife and maintain biodiversity.
7. Encourage local people to value the PSF as a sustainable resource for both timber and non-timber products.

3.2.2 Transmigration villages Marang and Transsabangoep

There was a change detection analysis made between the LANDSAT Image of 1991 with the one of 1994 (ref. 1 and 3) of the scene in the south of Bukit Tangkiling. As a result, there was a significant red signature detected which means that the LANDSAT IR-channel 5 (1,65 µm) detects the pure organic soil. Clearcuts or strong opening of the PSF canopy should be the reason.
On the 5th and 7th of April, we made first an excursion with Ridwan Dobson to Transsabangoep near Sukseskan and another one together with Dr. Sieffermann to the abandoned transmigration village Marang.

Marang
At km 22 on the right hand side there is the area from the older transmigration village Marang built in the 80ies. The street leads 3 - 4 km to the river Rungan. People live in the village nearby the river. The 230 families who have built their houses on relative thick peat along the road have left the place. No rice nor fruit grow properly. The area along the road is under water. Only one Dayak family still lives there. They earn their life by collecting latex. The family earns about $ 40 per package (fig. 2 and 5).
A similar situation occurs at the Transmigration village Bereng-Bengkel south of Palangkaraya on the Kahayan.
If rice grows on thick peat with acidic soil, the result will be poor. Even drained areas reduce the acidity only slowly. Fertilisers will wash out during a short period of time. are Important parameters to measure the soil quality are the pH value, the exchange capacity and the base saturation of the soil.

Transsabangoep
We found the entrance to this new Transmigration village Transsabangoep at km 30 at left hand side. It is 5 km away from the main street in the south of Tangkiling. At the beginning of the road trees were growing marvellously with pepper and pineapples. A small river is crossing the road and the peat soil is increasing in thickness from 10 cm to 2 m in the direction away from the river Rungan, compare fig. 2 and 6.

The Transmigration village is built in rectangular shape on the thin peat ground with small water channels which can be seen by aerial survey very precisely.
The inhabitants are poor. An older nice couple from East-Java have bought food in Tangkiling (fig. 6C). They went the whole way by feet because no bus exist for this village. At sunset birds are shouting and children are laughing. A woman from Java gave us boiled black water which was smelling like wood-fire/smoke. In front of the house a small hill of lime was donated by the government. the soil should be fertilised by the lime. It is very quiet on this spot. In the north-eastern direction the Tangkiling mountains are visible. Behind the village a big clear-cut is performed, which looked like the head of a „hammer" on the satellite image (fig. 2). In the picture from the aerial survey this is easily noticeable (fig.6A and 13B).

Sei Gohong
The road to the village Sei Gohong on the Rungan is approx. 2 km from the junction (SEIGO1) at the main street Palangkaraya - Kasongan. The soil quality degrades with encreasing distance to the Bukit Tangkiling. On the riverside the fertility of the ground improves again. No major peat areas are here. Approx. 500 people from different religions live here.
In the north western part of Sei Gohong, there is no primary forest left. Illegal logging and shifting cultivation have reduced the forest area, as can be seen in the aerial photo (fig. 12B). In the satellite LANDSAT images from 1991 and 1994, this signature is red if it is fresh and yellow when alang-alang is regrowing. Open white sand can be noticed in the LANDSAT images as well as white spots (fig. 2).

3.2.3 Pulang Pisau

On the 8th of April Dr. Sieffermann, Dr. Rieley, Dr. Page, Dr. Böhm, Stefan Haisch, Ridwan Dobson and a driver disappeared in the direction to Pulang Pisau which is approx. 80 km from the Province Capital away and leads towards Banjarmasin. On the LANDSAT image from 1991 and 1994 we could notice railways going into the PSF rectangularly to the street (fig. 7A,B). This location is 29 - 30 km away from the main roundabout in Palangkaraya. The concession has the name Dirgahapu.
The first drilling 100 m off the street (position TS1STR) showed a depth of 4.3 m (fig. 7C). Below the peat lies the clay. The position of the drilling point was measured by GPS (TS1PD1). A tissue cultivation for PSF is regrowing new trees adapted to the PSF.
With the Kijangs we drove afterwards to the Desa Pilang (fig. 1) located on the Kahayan 53 km from Palangkaraya (TS4PIL). On our way back we drilled at two positions into the peat. The first one showed a strong influence of the relatively closely flowing Kahayan river (TS5PD2). Two Dayak farmers try to grow rice on the peat. With poor success (fig. 8B). The second drilling point (TS6PD3) showed also a fluvial influence. Peat with clay sediments gave us hard work to analyse. The thickness of the peat is here up to 7 m (fig. 8A,C). Illegal logging shrinks the secondary forest. And even clear cuts along the road belong to normal aspects. 15 - 20 years ago, there was a growing primary forest here.
All the peat samples will be analysed due to the peat's age at ORSTOM, Paris with the carbon-14 method. Additionally investigations of pollen will be done in UK.

3.2.4 Motor bike excursion to the PSF near Bukit Liti

On the 1994 LANDSAT image a new road compared to 1991 could be detected between the river Kahayan and Kapuas in the north of Palangkaraya. It was the goal to monitor at the end of this logging road the peat thickness exactly at the watershed.
With 7 motor bikes Dr. Sieffermann, Dr. Rieley, Dr. Page, Stefan Haisch, Suwido Limin, Sehat Jaya and Sulmin G. and some drivers started to the excursion (fig. 9A). We crossed the Kahayan by Plangkaraya with a ferry-boat. Only a sand road leads to the north. Swamp forests with the influence of the Kahayan are at the beginning on the left and right side. May be in the next 10 years the river will change his meander. New settlements are being built along the road.
The soil types changed between peat and podzol. Only bicycles and small lorries are used for transportation of materials. After 30 km drive the new road leaves near Bukit Liti on the Kahayan 3 km to the west - only poor heath forest with bad soil - than 3 km to the north - here starts the PSF - and 7 km to the north-east. Approx. here we reached the watershed which can be seen by the water flow in the small channels beside the new sand road. Suddenly we saw interesting actions. Illegal logging at the end of the road which should became in future the Trans.-Kalimantan highway (fig. 9C). The end of the road is visible in the LANDSAT image from 1994. A small saw-mill lies aside of the road in the forest. Wooden rails lead over the street to the new place for a saw-mill. Parts of the trees were cut and fetched from the opposite side of the street, transported by a sliding carriage and stored near the new depot (fig. 10).
The saw cuts out of the trunks boards which are used for house construction. Beside the illegal logging there is a small factory where blocks of Latex are collected. Some of the trees in the PSF are natural latex/rubber trees. Other natives are collecting gamor for the medicine production (fig. 11).
The peat bore-hole on this location (PN2PD1) shows a peat depth of 3.3 m, not as thick as we thought it to be. Then the clay layer starts. Samples are taken in a depth of 1.3 m and 3.3 m. The PSF is relative good with thick trunks. On the way back to Bukit Liti we could see on the field campaign the edge of the two types of forest: PSF and heath forest (fig. 9B). The same information is stored in the satellite signature. Especially in the evening the tropical rainforest is full of sounds.

3.3 Aerial survey

On the 11th of April 1996 we organized an aerial survey with a small water-plane. This Cessna 185 was equipped with two swimming skids and powered by 320 hp single-engine. The advantage of this plane is that the wings are on the top. So aerial photography through the widely opened windows was easy and nearly unobstructed by any parts of the plane. The flight planning was made regarding the possible ratio between payload in kg (persons) and amount of fuel, which determines the duration respective track of the flight. It was decided to fly with three persons (Dr. Böhm, S. Haisch and Dr. Rieley) plus the pilot (fig. 12A).

The plane belongs to the Mission Aviation Fellowship (MAF), which owns planes all over the world. In Kalimantan MAF support two offices, one in Palangkaraya and one in Pontianak. There is a regulary shuttle flight to west Kalimantan each week.
We met at 7:30 a.m. on the 11th of April at the Palangkaraya oil harbour, where the plane was. It was a clear morning. After refueling the plane we climbed in and got a safety briefing. We had two S-VHS Video cameras, two mirror-reflex cameras with

zoom lenses and a pocket camera with us. The plane was equipped with a GARMIN 100 GPS (see chapter 3.4), so it was possible to store waypoints during flight (fig. 1). A lot of flotsam whole trees inculded was coming down the Kahayan river (fig. 12C). The pilot started against the flow in a northern direction. He followed the curve of the river also during the starting phase and as we took off the water, we came quite close to the trees at the river's edge. We made a turn to the right and flew to the south. After crossing the Palangkaraya airport the track lead towards Camp Seti Alam Jaya which is the old logging camp at the Sungai Sebangau (fig. 4A). The whole Sebangau area was flooded because it was the end of the raining season. Then we followed the logging rails towards a small hill (30 m altitude). After one loop around the hill were we took pictures, we tried to find the edge between the bright and the dark green PSF. It was not sure that this edge will be visible by eye, because the satellite image where the edge can be recognized very well used two Infrared channels and only one in the visible band (fig. 15A). The edge was clearly recognizable as fig. 15B shows (view in northern direction).

The next targets were the chain of three little hills north of the Bulan catchment. The Bulan catchment itself was totally flooded. The bended river bed of the origin river was visible by the trees growing at the river's edge. A logging rail coming out of the forest in the south ends at the river. Even the rails were flooded by the black water.

A turn to the east took us again over the forest. We flew most of the time in about 100 meters altitude over the forest canopy. Single trees were clearly recognizable. The impression from the left to the right horizon was like "a sea of green". The area of the tropical rain forest is still huge in this part of Kalimantan. But we found nearly everywere traces of human beings: the logging rails and sometimes also small logging channels (about 1 meter wide; see fig. 18C)
Before reaching again the Sungai Sebangau we crossed two clear cut areas in the middle of the forest (Fig. 17). They cannot be detected by anybody outside the forest but easily by aerial survey or by satellite images.

Our next target was Dr. Rieley's new research area, a little river flowing into the Sungai Sebangau from the West (Fig. 16D). A small pile village is located at the river junction. The houses at the river side are standing in one row. The houses are built on stilts because the whole area is flooded, also the forest. The brownish water flood in the forest is very well visible through the trees (Fig. 16D bottom). The second research canpaign will start in August 1996. Peat analysis will be done as well as determination of the bio-diversity of this area.

Now we made a turn to the south to find the transmigrasi area at the Kahayan river (Fig.19A). It is about there where the planned area for the 1 Mio ha rice project starts. The whole area is clear-felled or burnt down (Fig.19D). Drainage ditchs lead in regulary distances parallel to a center drainage which takes the water into the Kahayan river. Although the area was converted at least 5 years ago, nothing of value is growing here (Fig.19B). Only in the vicinity to the Kahayan river's edge the aspect is a bit better (Fig. 20C). There grow a few useful plants (i.e. sago, rice) because the river brings minerals from the mountains with it.

The area between the Kahayan and the Kapuas river is more fertile than the area between the Sungai Sebangau and the Kahayan river. We found small stripes of plantages with banana plants, coconut palms, sago, pineaple and some other plants.

The most fertile areas are mainly covered by rice fields. A few channels and streets connecting the Kahayan and the Kapuas river attract the people to live there (Fig. 20B). At the Kapuas there were several small sawmills located together.

Eastern of the Kapuas river we reached our most south-eastern point of our flight route and turned to the north. Just before flying over a big island in the Kapuas we were lucky to find the first construction area of the 1 Mio ha rice project. They started with a number of about 15 brandnew hydraulic excavators to digg out one of the secondary channels (fig. 20D). It will be built 25 m wide and 5 m deep leading the first some kilometers to the east and then about 60 kilometers up to the north into the direction of Mengkatip on the river Barito. There it will hit the main channel between Palangkaraya and Mengkatip.

In the forest between the Kahayan and the Kapuas we lost our orientation a little bit because we couldn't find any landmarks visible on our satellite image we had with us in the plane. But as we recognized the first white sand in the forest, we knew that we were just east of Palangkaraya. Here starts the Podzol soil with the white sand as the top layer. We found new logging roads for trucks which are not on our satellite images. At last we came to the logging road leading up from Bukit Liti where we found the illegal logging activities (see chapter 3.2.4). The brown colour of the Kahayan river shows that its water takes a lot of earth from the northern mountain area with it which is an effect of the erosion caused by clear cutting. Reduced erosion occurs in areas with selective logging activities. On the horizon the small Tangkiling Mountains - our next target - were just recognizable. Before reaching this group of hills we flew over Rungan river with its numerous bendings. At the river side of the Rungan we saw Sei Gohong where we took a GPS position at the street junction (SEIGO1) as well as in the sand pit nearby (TENGO2).

Then we flew a loop around the Tangkiling Mountains. Numerous small gravel pits were spread all over the granite-hills. Families work here under quite hard conditions. All trees are cut for the fires to crack the granite. Only grass grows on the slopes. Where the granite is visible through the vegetation, its colour is dark brown which could be traced back to lichens (fig. 13A).

Our last important target on the aerial survey was the big clear cut area west of the transmigration village Transsabangoep (see chapter 3.2.2 and fig. 6A). On the clear cut area were burning some small fires (fig. 13B). Burning is the only way for the transmigration people to get rid of the tree stumps. Following the road from Tangkiling to Palangkaraya we closed our loop of 2.5 hours flight. The pilot had no problems in landing between some Klodogs coming down the Kahayan river (fig. 12C). Figure 1 shows a plot of the flight route

3.4 GPS measurements

GPS stands for "Global Positioning System". The US GPS NAVSTAR is a satellite borne radio navigation system. It provides worldwide and continously three-dimensional (3D) position and time. Initially it was invented for the US army. It send two codes: the C/A-code for the civil users and the military P-code with high accuracy. The civil C/A-code is modulated by a random function in order to impair the accuracy for the civil users to about 100m accuracy. The system consists of three main segments:
- space segment (24 satellites in 6 orbits in approx. 20.000 km altitude)

- controll segment (1 main/ 5 monitoring radio stations)
- user segment (military and civil GPS receivers)

The GPS receiver determines its position by distance measurements to the satellites visible to the receiver. The distance measurement is performed by run time measurement of the signals from the satellites.

The used GPS receiver was the GARMIN 45 (fig. 13C). It is a hand-held leight-weight GPS. Up to 256 positions - called waypoints - can be stored in the memory of this battery powered instrument. An interface to a personal computer gives the possibility to transfer the waypoint data directly to the PC.

During our field campaigns about 100 positions were measured and stored. Table 1 shows some of them. Accurate measurements can only be done if the GPS receives enough satellite signals. Inside the forest this is not possible because of the branches obscuring the signals from the satellites.

3.4.1 Geocoding of Satellite Images

The use of the GPS measurements has two reasons. Firstly the GPS provides the position at any time and any place (open for signals) of the world. So it is possible to determine the position of any peat drilling or sampling during our ground truth campaigns. Secondly the GPS is used for geocoding of satellite images.
A pure satellite image has no precise geographic reference. It could be located anywhere on the earth. The first step before starting image analysing and interpreting is the geocoding process. At least two points in each satellite image have to be located in a coordinate system of the earth (latitude and longitude). The points can be for example street or river junctions which are unambiguously visible in the satellite image and reachable on earth. Geocoding needs a special software on the computer. After geocoding, any other position within the area of the satellite image can either be measured and pointed out on the computer screen or measured by GPS and showed on the satellite image.
To maintain exact geocoding we prepared special work sheets, one for each waypoint (see Table 2). The sheet comprises a photography of the location, a section of the satellite image scene, a hand-made scetch of the exact measurement point as well as the GPS data.

WPT#	Waypoint name	location (N or S)			location (E or W)			date	time	comment
1	SUBUD	S	06°	17,122'	E	106°	47,867'	30.03.1996		Subud, Jakarta, Lati han Hall
2	BAKO	S	06°	29,514'	E	106°	50,709'	02.04.1996		Bakosurtanal, entry
3	LAPAN	S	06°	20,557'	E	106°	51,569'	02.04.1996		LAPAN, near antenna
4	PAL-A1	S	02°	13,473'	E	113°	56,674'	05.04.1996		Palangkaraya, in front of airport
5	PAL-A2	S	02°	14,928'	E	113°	55,189'	05.04.1996		Palangkaraya, Tucan Roundabout
6	PALR02	S	02°	12,837'	E	113°	55,194'	05.04.1996		Palangkaraya, small Roundabout
7	WATFAC	S	02°	17,801'	E	113°	55,300'	05.04.1996		Ridwan's waterfactory
8	SEBAN1	S	02°	18,992'	E	113°	54,498'	06.04.1996		Sungai Sebangau, Camp Seti Alam, rails-forest
9	SEIGO1	S	01°	58,597'	E	113°	45,476'	07.04.1996		Sei Gohong, junction
10	TENG02	S	01°	58,417'	E	113°	44,835'	07.04.1996		Sandpit near Sei Gohong junction
11	TENG01	S	02°	03,696'	E	113°	45,920'	07.04.1996		Street to Tangkiling, junction to West
12	RON1-E	S	02°	12,452'	E	113°	55,006'	08.04.1996		Palangkaraya, big roundabout, east side
13	RON2-W	S	02°	12,455'	E	113°	54,993'	08.04.1996		Palangkaraya, big roundabout, west side
14	TS1STR	S	02°	20,893'	E	114°	05,464'	08.04.1996		Street to Pulang Pisau, junction with logging rail, west
15	TS1PD1	S	02°	20,971'	E	114°	05,462'	08.04.1996		Street to Pulang Pisau, 1st drilling
16	TS2STR	S	02°	22,661'	E	114°	07,525'	08.04.1996		Street to Pulang Pisau, large clear cut, street to Kaha.
17	TS4PIL	S	02°	28,697'	E	114°	12,026'	08.04.1996		Street to Pulang Pisau, Pilang, at the Kahayan
18	TS5STR	S	02°	28,374'	E	114°	11,441'	08.04.1996		Street to Pulang Pisau, north of radio station Pilang
19	TS5PD2	S	02°	28,388'	E	114°	11,370'	08.04.1996		Street to Pulang Pisau, 2nd drilling
20	TS6PD3	S	02°	26,088'	E	114°	10,312'	08.04.1996		Street to Pulang Pisau, 3rd drilling
21	TS7CAN	S	02°	21,660'	E	114°	06,320'	08.04.1996		Street to Pulang Pisau, junction with channel
22	PN1STR	S	01°	59,332'	E	113°	57,160'	09.04.1996		Street to Bukit Liti, junction near Bukit Liti
23	PN2PD1	S	01°	56,182'	E	114°	02,082'	09.04.1996		Street to Bukit Liti, drilling at the illegal logging area
24	PN2STR	S	01°	59,238'	E	113°	58,735'	09.04.1996		Street to Bukit Liti, long curve
25	PN3STR	S	01°	56,115'	E	114°	02,169'	09.04.1996		Street to Bukit Liti, drilling, street
26	PN4STR	S	01°	57,268'	E	114°	00,006'	09.04.1996		Street to Bukit Liti, small clear cut
27	PN6STR	S	01°	57,659'	E	113°	59,288'	09.04.1996		Street to Bukit Liti, borderline PSF - Heath Forest
28	PN7KAH	S	01°	59,350'	E	113°	56,967'	09.04.1996		Street to Bukit Liti, Bukit Liti at Kahayan
29	PN7STR	S	01°	57,950'	E	113°	58,798'	09.04.1996		Street to Bukit Liti, northern curve
30	UNPAR1	S	02°	12,871'	E	113°	54,004'	10.04.1996		UNPAR, Suwido's office
31	F1	S	02°	31,390'	E	113°	50,690'	12.04.1996		Flight, point 1
32	F2	S	02°	34,660'	E	114°	02,350'	12.04.1996		Flight, point 2
33	F3	S	02°	50,940'	E	114°	02,890'	12.04.1996		Flight, point 3
34	F4	S	02°	55,540'	E	114°	12,150'	12.04.1996		Flight, point 4
35	F5	S	02°	53,020'	E	114°	22,410'	12.04.1996		Flight, point 5
36	F6	S	02°	47,560'	E	114°	24,640'	12.04.1996		Flight, point 6
37	F7	S	02°	36,450'	E	114°	24,090'	12.04.1996		Flight, point 7
38	F8	S	02°	34,310'	E	114°	24,560'	12.04.1996		Flight, point 8
39	F9	S	02°	29,110'	E	114°	23,230'	12.04.1996		Flight, point 9
40	F10	S	02°	05,960'	E	114°	16,000'	12.04.1996		Flight, point 10
41	F11	S	01°	58,510'	E	114°	13,720'	12.04.1996		Flight, point 11
42	F12	S	01°	56,540'	E	114°	04,350'	12.04.1996		Flight, point 12
43	B-SULI	S	02°	13,350'	E	113°	55,120'	14.04.1996		Hotel Batu-Suli
44	PRO-LH	S	06°	10,771'	E	106°	49,339'	15.04.1996		PRO-LH in Jakarta

Table 1: Table of GPS positions (waypoints) measured with the GARMIN 45 and GARMIN 100 (aerial survey) GPS receiver.

Number: 23	Location: Bukit Liti Logging road from Bukit Liti to north-east
Date: 14.06.96	

KALTENG CONSULTANTS

Remarks:

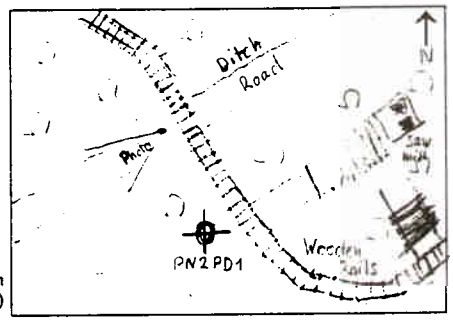
Drilling for peat depth

Illegal logging area

Picture of location

Satellite image
☒ LANDSAT5 TM
☐ ERS1/2
☐ other: _____

scene: 118/62
date: 24.07.94



Sketch
(north up)

GPS data

Waypoint name	PN2PD1	Position	S 01°56,182'
Route number	4		E 114°02,082'
Route name	B-LITI		
Mapdatum	WGS 84	Time at location	14:10
Number of satellites	8	Date at location	09.04.1996
Accuracy	32 m	UTC-offset	5h

File: [KTC_GPS1.DOC]	measured by: Stefan Haisch	approved: SH

Table 2: Worksheet for the geocoding field work with the GPS.

3.5 Interpretation of Landsat TM images

Multispectral LANDSAT TM image analysis, image classification, image fusion, change detection and mapping has been and will be performed in the future according to standard procedures with the up to now procured data sets from Kalteng:

LANDSAT5-TM:	118/61	from 30.06.1991
LANDSAT5-TM:	118/62	from 30.06.1991
LANDSAT5-TM:	118/62	from 24.07.1994
LANDSAT5-TM:	118/62 Q.5	from 08.07.1994
LANDSAT5-TM:	119/60 Q.4	from 18.10.1988
LANDSAT5-TM:	118/60 Q.3	from 26.01.1993
LANDSAT5-TM:	118/61 Q.1	from 26.01.1993
LANDSAT5-TM:	119/60 Q.4	from 02.02.1993
LANDSAT5-TM:	119/61 Q.2	from 02.02.1993
LANDSAT5-TM:	120/61 Q.4	from xx.xx.199x

ERS-1 Orbit 9438 from 6. May 1993 frame 3627 and 3645

In order to identify different land use classes it is necessary to establish an interpretation key for each class. 7 classes belong to vegetation units while 8 classes define different patterns of land use:
1. - 3. PSF (Hutan gambut); 4. heath forest (kerangas); 5. swamp forests; 6. lowland Dipterocarp forests; 7. floating grassland; 8. water bodies; 9. clear-cutting; 10. forest fires; 11. selectively logged forest; 12. secondary forest and plantations, agriculture with subclasses; 13. shifting cultivation; 14. permanent agriculture and 15. infrastructure.
From the LANDSAT TM images with the channel 5,4,3 according to red, green, blue as shown in fig. 1,2, 15-20 it becomes evident, that the PSF is characterized by different shades of green. Extensive ground survey performed between 1993 and 1996 by Dr. Rieley and before by Dr. Sieffermann showed, that the peat depth has strong influence on the forest type leading to a characteristic zonation. They found, that the more thick the peat the poorer was the forest stand. The zonation is characterised by forest stands with high canopy (approx. 40 m) close to the outer edge of the peat area (thin peat) which is replaced by denser, lower growing pole forest having a canopy height of about 20 m (deep peat). The tree diversity varies from 30 - 50 species in low pole forest to 240 species in the marginal forest.
White signature means especially quartz sand.
The zonation can be recognised in LANDSAT TM images as different shades of green (and at high magnification different roughness) and most likely also in processed RGB ERS-1 SAR images, thus allowing the acquisition of data from areas which are frequently obscured by clouds.
Figures 16B,C,D show that different types of PSF are characterised by a different roughness of the canopy. The corresponding locations are indicated by white arrows in the LANDSAT image and show that this differences in roughness are clearly visible as different signatures. Furthermore PSF on high peat is characterised by increasing xeromorphisms and chlorosis of the foliage leading to distinctive colours in the LANDSAT image.
Figure 19A shows Transmigrasi areas near River Kahayan. Cleared land with water channels appears in green and red colours, whereas recently cleared land with crops

or fallow land covered by undergrowth appears in light green. Dark green is PSF. The arrows B and C in figure 19 indicate the corresponding ground truth photographs, the unlabelled arrow indicates a large forest fire. The smoke of the fire is drifted by wind to the upper left corner of the image. Figure 19C shows that the total area consist of a thick layer of dark brown peat flooded by water. Under these circumstances sustainable agriculture is impossible, even if large amounts of lime are applied. After one or two harvests such land must be abandoned by the farmers and they have to open up new forest in order to grow their next harvest. Such actions are highly destructive and lead to substantial financial losses to the Province and their inhabitants. In future such areas as well as other classes will be quantified by supervised classification and/ or digital delineation and the results will be stored in the Geographical Information System (GIS) data base.

4. Next Actions and Conclusions

a. Thesis (Ph.D.) by Mr. Haisch:
"Interpretation von Satellitenbildern des tropischen Regenwaldes mit Mitteln der Bildverarbeitung und unter Zuhilfenahme eines mit Sensoren ausgestatteten Hubschraubers zum Zweck der Landnutzungsplanung"
English title:
"Interpretation of satellite images of the tropical rain forest with the means of image interpretation software and with the help of an helicopter equipped with sensors for land use planning."

b. Visit of Kalteng in summer ´96 by Dr. Florian Siegert, Dr. Jack Rieley and Dr. Susan Page.

c. Projekt Proposal: Peat Swamp Forest Evaluation in Kalimantan Tengah, Indonesia by Multispectral and Multitemporal Remote Sensing.

d. Conclusions

- PSF is a sensitive biosphere and ecosystem which should be conserved for its biodiversity, ecology, hydrology and the regional climate focused on the catchments of S. Sebangau and S. Bulan.
- Only areas with thin peat layers up to 1 m have agricultural potential; these are near the river banks where the rivers are bringing sediments and minerals with the flood.
- Often people think that areas of PSF with green vegetation have also good soils to use for conversion to rice fields; in the south of Kalteng are pure soils: white sand, podzol, acidic soil with low nutrition's.
- The Bukit Tangkiling is good for fertiliser. Limestone for liming the acid soils can be found in the northern part of the Rungan river.
- Conversion of big PSF areas will change the micro climate, which is not reversible, the drawbacks are very dry periods with low drinking water and very wet and floody periods.
- Not only poor people with low skills should develop Kalteng.
- Planting of secondary and logged forest is necessary for the future of Kalteng.
- Illegal logging damages the wealth of Kalteng.

- If 1 Mio ha PSF should be converted in 4 years, approx. 1000 ha pro working day have to be logged; many machines for drainage will be necessary.
- Kalteng needs better maps and a GIS with more basic information's for a good planning.
- Remote Sensing is a good tool for establishing thematic maps and for land use planning; HW with a good PC-Computer and a simple SW costs approx. 10 T$.
- The planning of infrastructure should be done on solid grounds.
- A profound hydrological knowledge of waterbodys and watersheds is necessary. Satellite images taken by Radar sensors can help to provide the information; Radar images are independent of weather and free of cloud effects.
- Remote Sensing should include change detection and multi spectral analysis in order to do monitoring, forest inventory, forecast, land use planning, controlling of sustainable logging etc.

5. References

1. **H.-D.V. Böhm, S. Haisch, E. Friauf (1995)** "Environmental Helicopter with Modular Sensor Concept: Example on Forestry Monitoring", presented at the Conference on Remote Sensing and GIS for Environmental Resources Management the Indonesian - European experience Jakarta, June 6 - 8, 1995, Session 15.

2. **G. Felber (1995)** "Pro Lingkungan Hidup" Mei 1995, Edisi 1 Tahun1 (GTZ).

3. **E. Friauf (1995).** "Untersuchung von Spektralsignaturen in Datensätzen abbildender Sensoren (Infrarot- TV-Kameras, LANDSAT Thematic Mapper und ERS-1 C-SAR Satellitensensoriken) durch Entwicklung und Anwendung von digitaler Bildanalyse-Software", Diplomarbeit bei EUROCOPTER Deutschland GmbH, München 19. Juli 1995, 167 pages

4. **S. Kuntz & F. Siegert (1994).** "Evaluation of ERS-1 SAR data for tropical rainforest monitoring" Earth Observation Quarterly, No. 45 - September 1994

5. **S. Kuntz, R. Fritz, F. Siegert (1994).** "Tropical Rain forest and Use of Land Investigation (TRULI)", 1. Progress Report, ESA Pilot Project PP2-D11

6. **S. Kuntz, C. Streck & F. Siegert (1995).**"Tropical Rainforest and Use of Land Investigation (TRULI)", TREES ERS-1 '94 Study Final Workshop, JRC Ispra, 23.-24.2.1995

7. **S. Kuntz & F. Siegert (1995/6):** Dipterocarp Forest Mapping and Monitoring by Satellite Data - A Case Study from East Kalimantan, in: Dipterocarp Forest Ecosystems - Ecology, Sustainable Management and Products, Indonesian-German Forestry Project, Faculty of Forestry / Mulawarman Univ., Samarinda, in press.

8. **S. Kuntz, C. Streck & F. Siegert (1995/6).** "Multitemporal Evaluation Of ERS-SAR Data For Monitoring Deforestation of Tropical Rainforest", Paper presented at the 2. ERS-1 Applications Workshop, 6.-8.12.1995, London, proceedings p.83 -93

9. **ORSTOM & Dept. Transmigrasi (1981).** Reconnaissance survey in Central Kalimantan. Phase I 14 maps 1/250 000 and three reports, ORSTOM-Transmigrasi Project PTA-44. Dept. of Transmigration, Jakarta.

10. **J. Rieley, R.G. Sieffermann, S.E. Page (1992).** "The Origin, Development, Present Status and Importance of the Lowland Peat Swamp Forests of Borneo", SUO 43(4-5), 241-244

11. **J. Rieley, S. Page (1993).** "The Ecology and Environmental Importance of the Peat Swamp Forest in the Sungai Sebangau Catchment, Central Kalimantan, Indonesia, July-Sept.1993, July-Sept. 1994", 146 pages, unpublished

12. **J. Rieley, S. Page, Suwido Limin, Sih Winarti (1995).** "The Peatland Resource of Indonesia and the Kalimantan Peat Swamp Forest Research Project", presented at the Peatland Convention, held in Edinburgh, Scotland 24-28 July 1995

13. **B. Setiadi (1996).** Kalau tidak seperti di Pulau Sambu bahayanya besar sekali, published in info ALAT No.13 Th. ke III p.38, 1996

14. **G. Sieffermann, M. Fournier, S. Triutomo. M.T. Sadelman, A.M. Semah (1988).** "Velocity of Tropical Forest Peat Accumulation in Central Kalimantan Province, Indonesia (Borneo)", VIII International Peat Congress in Leningrad, 90-98

15. **G. Sieffermann, J.O. Rieley and M. Fournier (1992).** "The Low-Land Peat Swamps of Central Kalimantan (Borneo): A Complex and Vulnerable Ecosystem", presented at the International Conference on Geography in the Asian Region, 31st Aug.- 3rd Sept. 1992, Yogyakarta, Indonesia

16. **F. Siegert, V. Liebig, A. Wanninger (1993).** "Fernerkundung zum Schutz des Regenwaldes" Geographische Rundschau (GR), 4512/1993

17. **F. Siegert, S. Kuntz, C. Streck, W. Bergbauer (1995).** "Land Use Planning and Monitoring Using ERS-1 Radar (SAR) Data", presented at the Conference on Remote Sensing and GIS for Environmental Resources Management, Jakarta, June 6 - 8

18. **UNPAR (1995).** "International Symposium on the Biodiversity, Environmental Importance and Sustainability of Tropical Peat and Peatlands", Symposium Programme and Abstracts of Papers and Posters, Palangkaraya, Central Kalimantan, Indonesia, 4th - 8th September

19. **T.C. Whitmore (1984).** "Tropical rain forests of the Far East" 2nd ed. Oxford University Press

6. Figures and Photos

6.1 Maps

Fig. 1 and 2

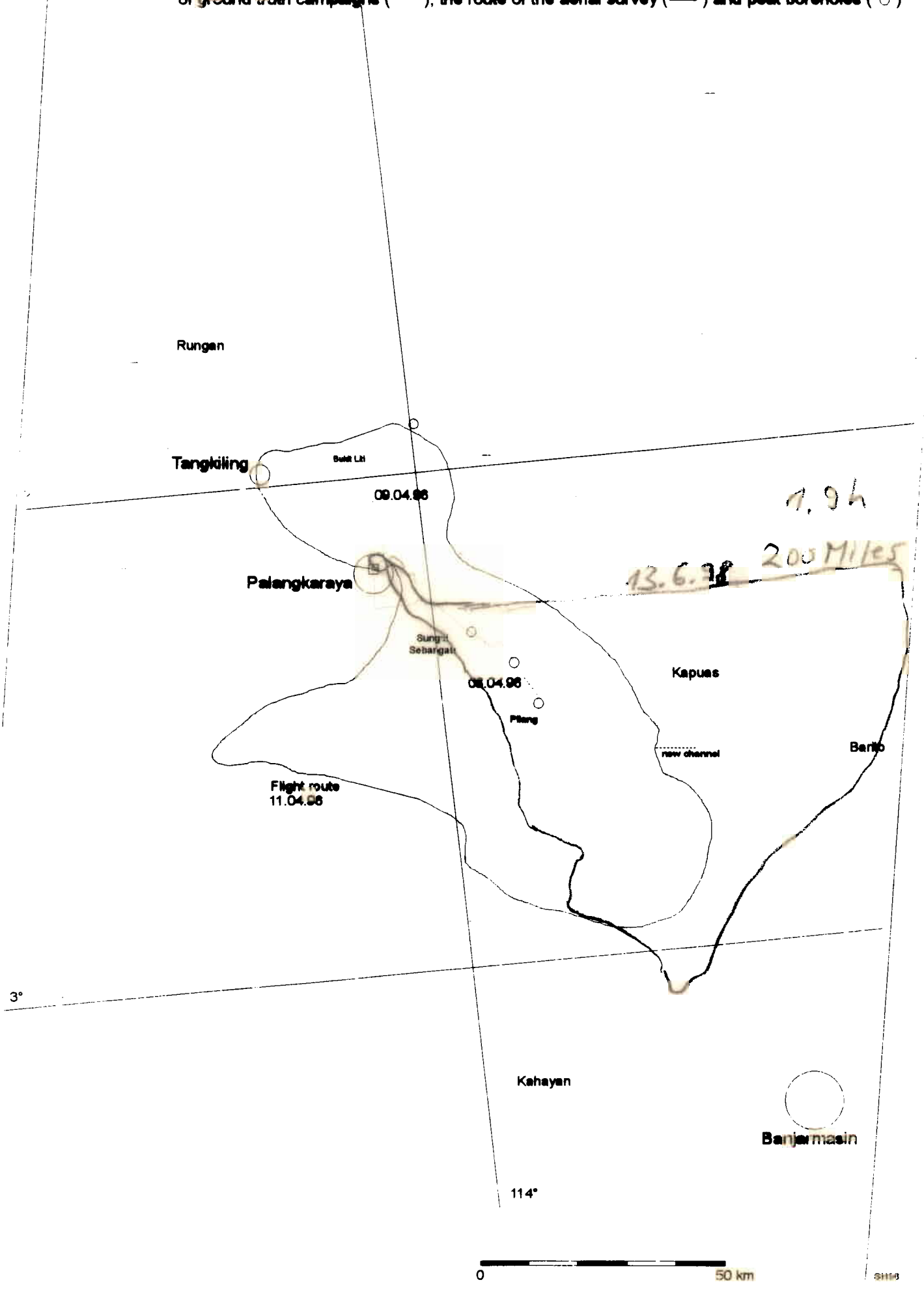
6.2 Photos

Fig. 3 - 13

6.3 Landsat Images with reference photos

Fig. 14 - 19

Figure 1: This map based on LANDSAT TM satellite images 118/061+062 (30.06.1991) shows the routes of ground truth campaigns ( ), the route of the aerial survey (——) and peat boreholes (○)



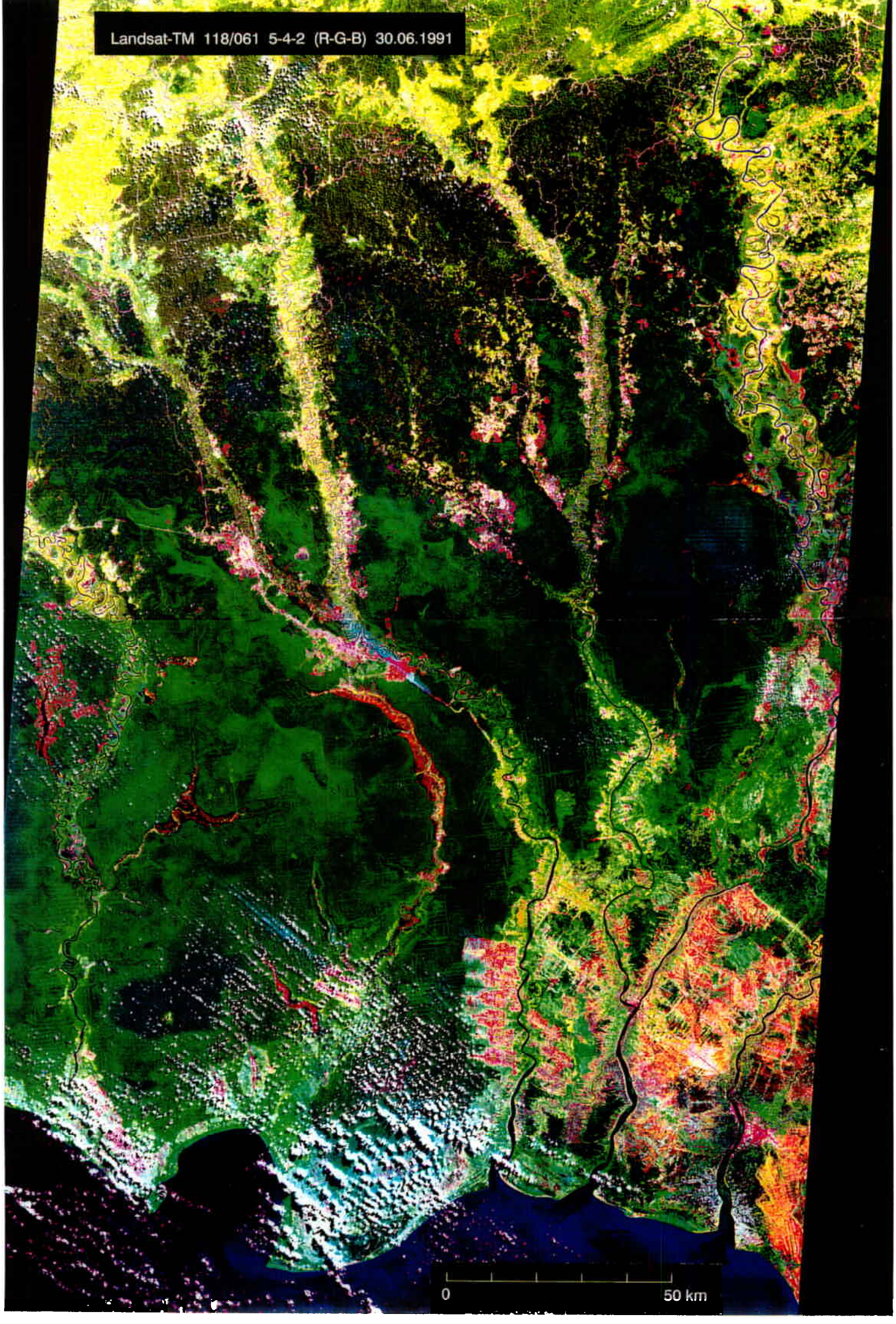

Landsat-TM 118/061 5-4-2 (R-G-B) 30.06.1991
0
50 km

Figure 2: This section from the LANDSAT image (08.07.1994) shows Bukit Tangkiling in the center and the street to Kasongan (bottom). North direction is left. (Transsabangoep, Marang and Sei Gohong see arrows)

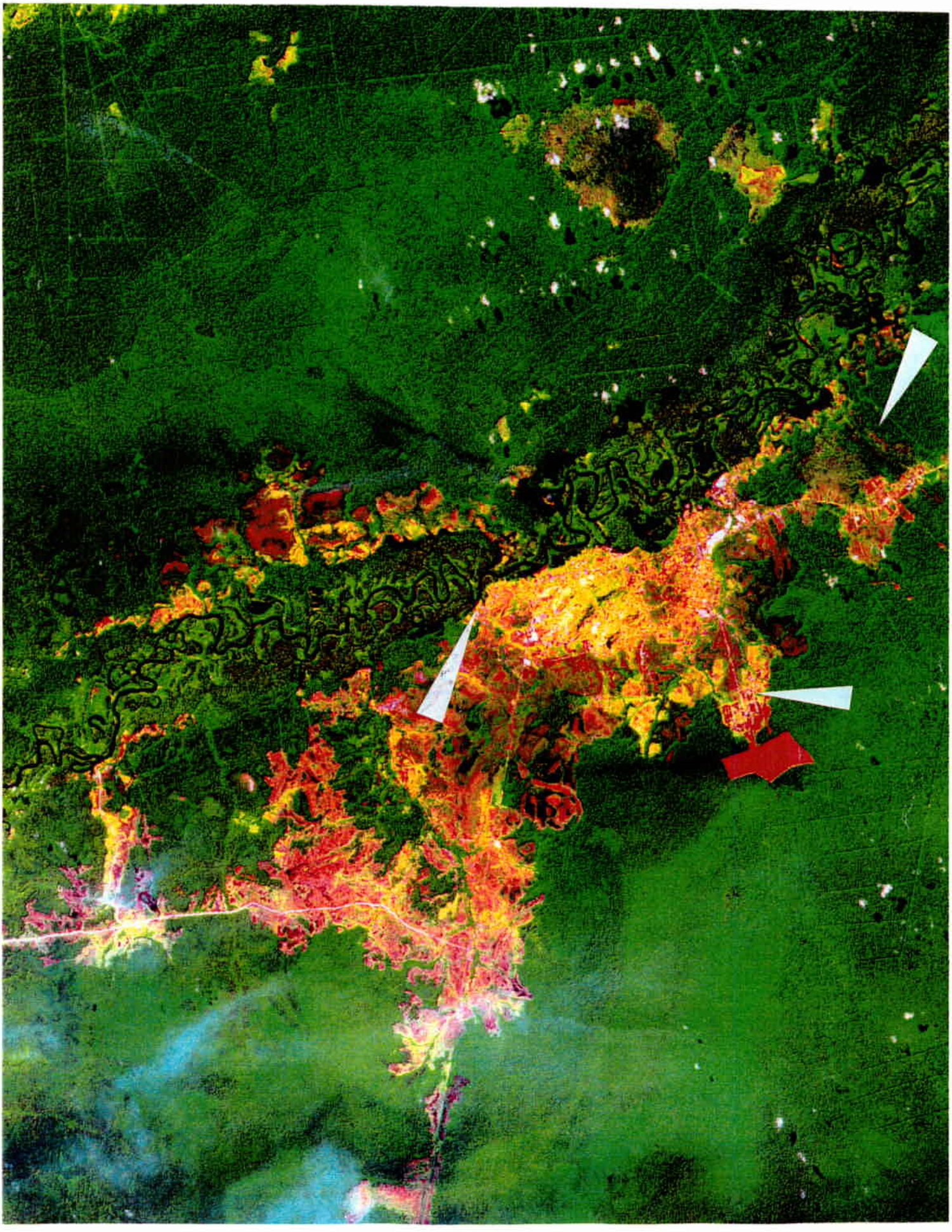


Figure 3:

A. Dr. Sieffermann in a hole where the soil-layers and horizon can be seen

B. Granite of the Tangkiling Mountains and the wooden trunks

C. View from the Bukit Tangkiling to the PSF

Figure 4:

A. Aerial photo from Camp Seti Alam Jaya on the edge between catchment S. Sebangau and the PSF

B. Railways in the Camp Seti Alam Jaya

C. Boattrip through the Catchment S.Sembangau to the camp

Figure 5:

A. A Dayak house in the quitted Transmigrasion village Marang

B. The Dayak who earns his money with latex (left)

C. Pineaple growing bad in the cutted PSF (right)

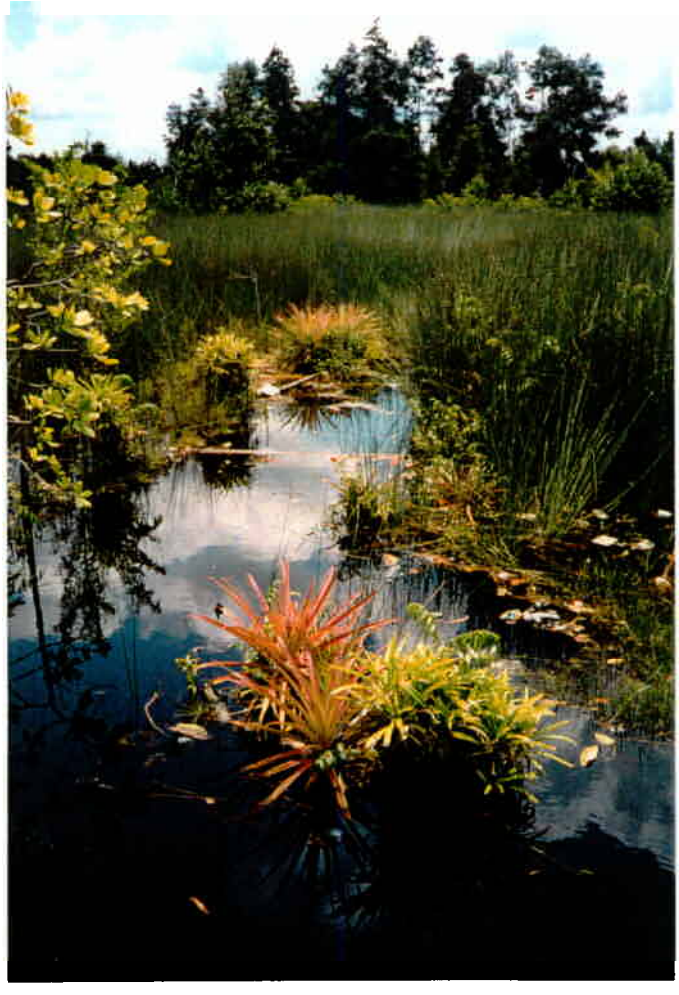


Figure 6:

A. Aerial photo from the new Transmigration village Transsabangoep

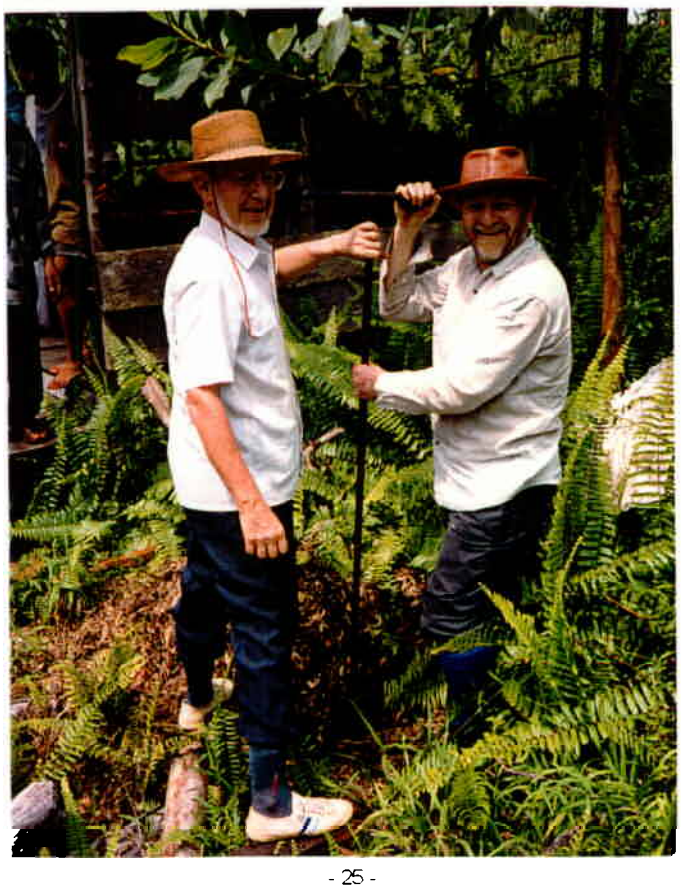
B. A drainage system and children of the new village, pineaples

C. An older Javanies couple from the village

Figure 7:

A. Planning of the ground truth campaign with the LANDSAT image

B. LANDSAT image with the street to Pulang Pisau, PSF and Catchment Sebangau



C. The first peat drilling at consession Dirgahapu, Dr. Sieffermann and Dr. Rieley

Figure 8:

A. Second peat drilling

B. Two Dayak famers

C. Wood cutters in the clearcut. During sunset they disappeared into the PSF

Figure 9:

A. Motor bike excursion to the area between rivers Kahayan and Kapuas

B. Poor heath forest on the podzol with red water (red from the humin substance)

C. Wooden rail for illegal logging

Figure 10:

A. Collecting of trees for the new sawing-mill

B. Old sawing-mill in the PSF

C. Lorries transporting the wood for the own house constructions

Figure 11:

A. A Rubber/Latex tree

B. A Dayak who collects the rubber from the trees

C. Rubber production ready for transportation

Figure 12:

A. Start to an aerial survey from Palangkaraya, Dr. Böhm, Stefan Haisch and Dr. Rieley in front of the Cessna 185 (from left to right)

B. Aerial photo from Sei Gohong on the river Rungan near Bukit Tangkiling

C. Aerial photo from Palangkaraya with the river Kahayan and the main street

Figure 13:

A. The Bukit Tangkiling with the numerous small gravel pits (white)

B. The clear cut area behind Transsabangoep with the shape of a hammer in the satellite image

C. GPS receiver GARMIN 45. The outer circle means the horizon, each number stands for one satellite visible at that time

Figure 14:

A. Kalteng Consultants at the Governer and Vice-Governer in Palangkaraya

B. The audience of the Kalteng presentation; LANDSAT images on the wall

C. Kalteng Consultants in Jakarta by the environmental minister Mr. Sarwono Kusumaatmadja

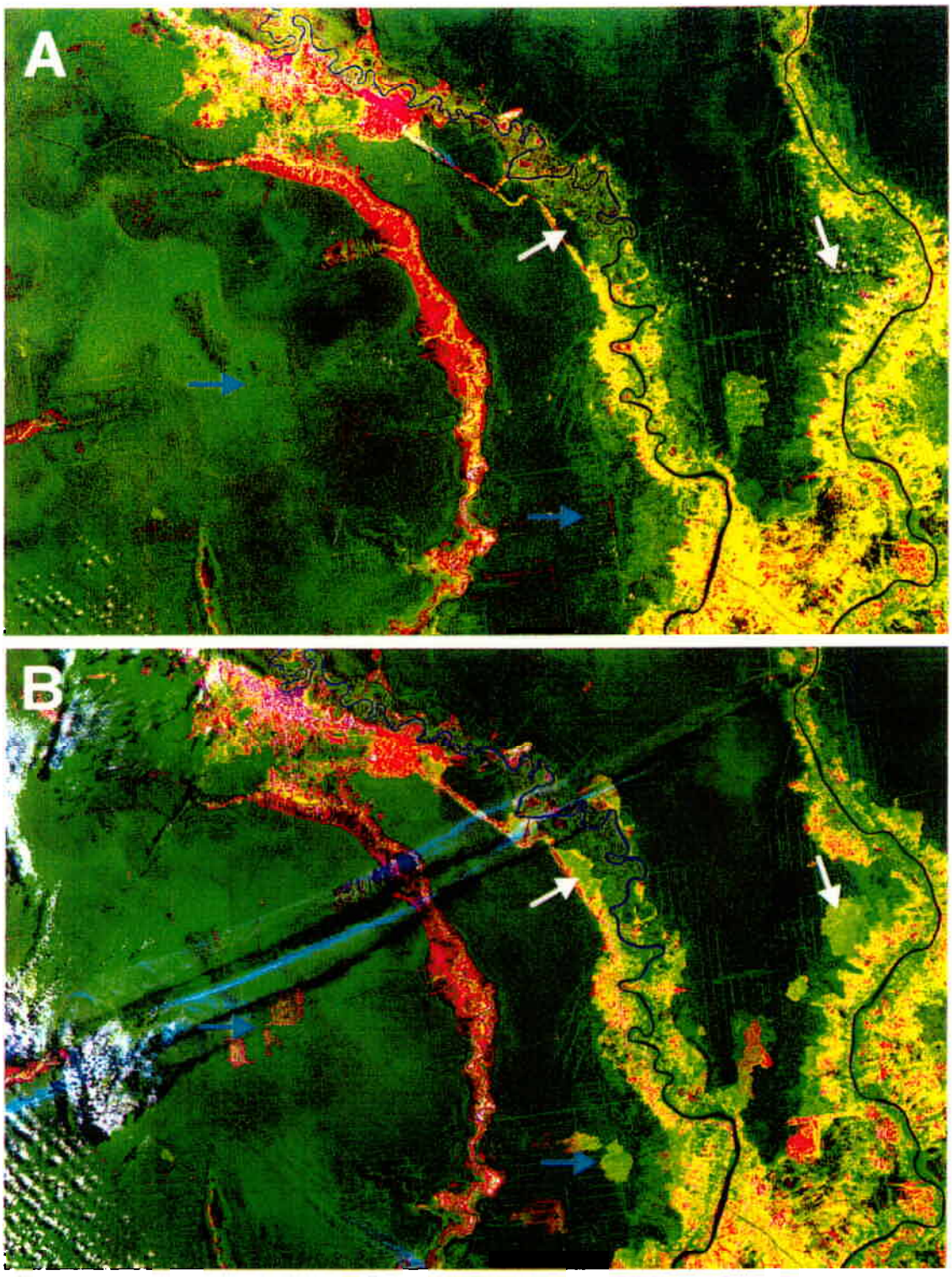


Figure 15: LANDSAT TM images of the area between the Sungai Sebangau (red) and Kapuas. In the middle the river Kahayan with Palangkaraya in the north. Arrows point out evident changes in three years.
A. 30.06.1991
B. 24.07.1994 (image disturbed by two aeroplane jetstreams)

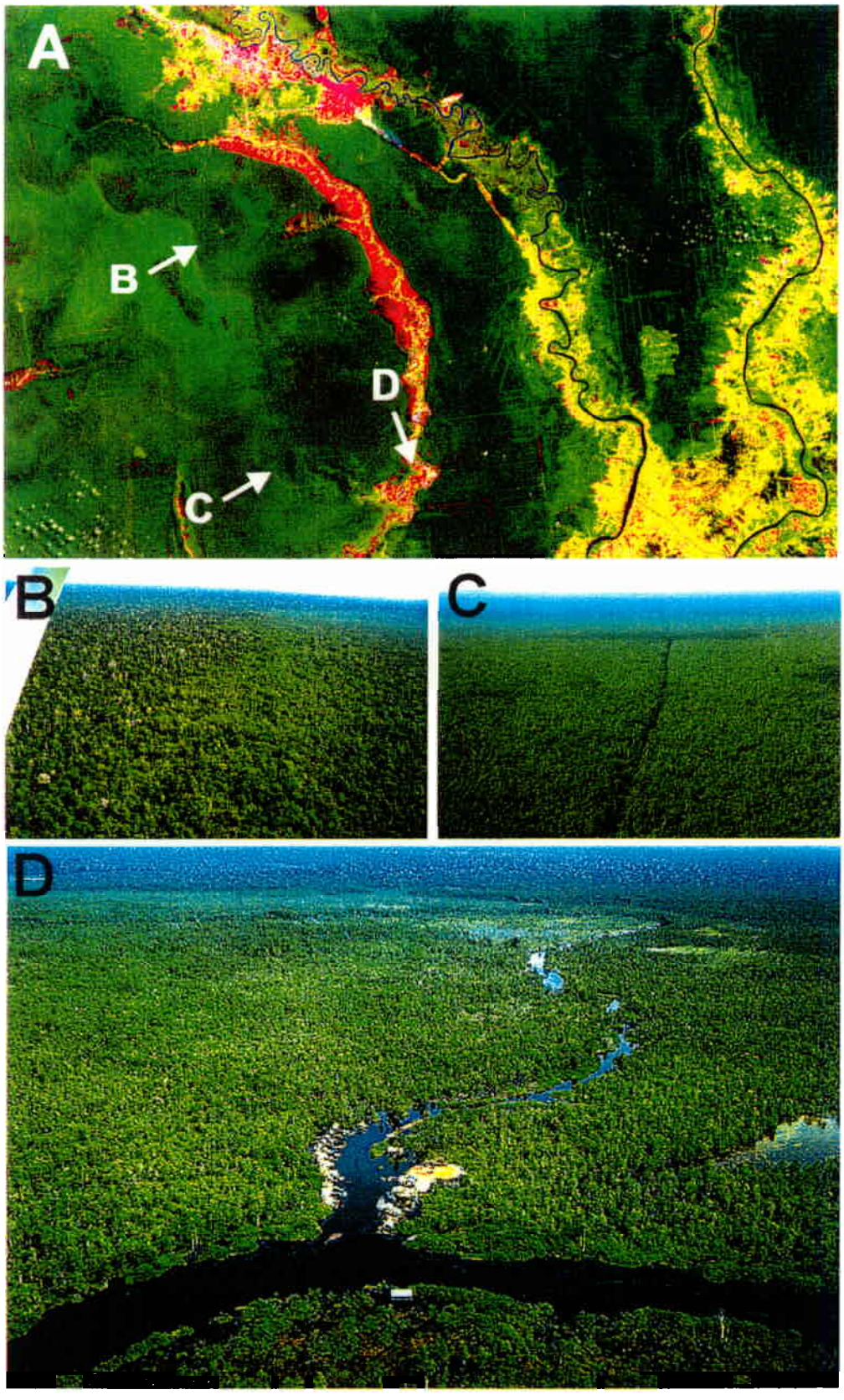
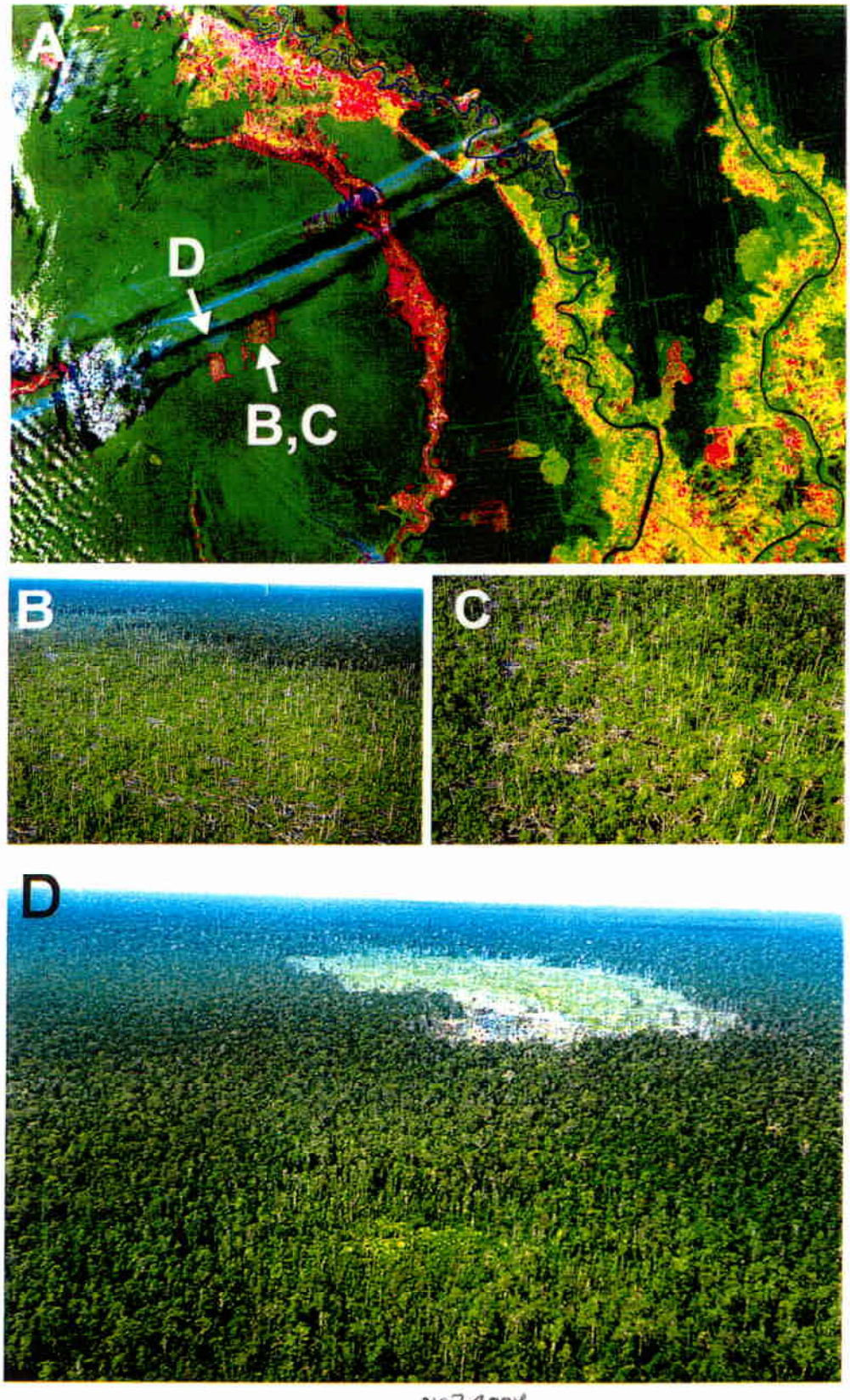


Figure 16: A. LANDSAT TM image from 30.06.1991
B. PSF with different roughness and colour of canopy appears dark and bright green in the satellite image
C. Old logging railway, directly visible also in the Landsat image.
D. Small pile village located at the Sungai Sebangau



2471034

Figure 17: A. LANDSAT TM image from 30.06.1991
B, C, D. Clear cut areas in the PSF. All useful trees are removed.

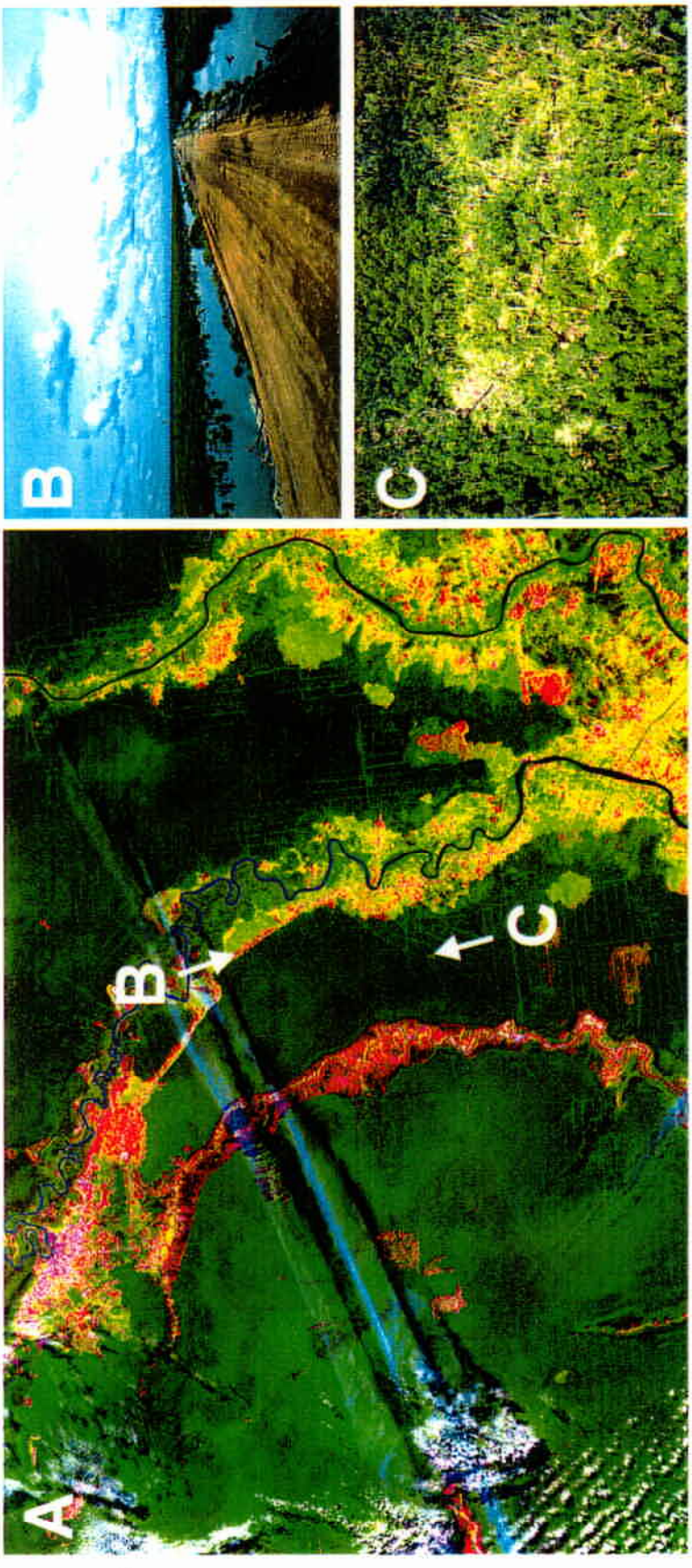


Figure 18: A. LANDSAT TM image from 24.07.1994
B. Road between Palangkaraya and Pulang Pisau at the location of the third peat drilling.
C. Selective logging activities.

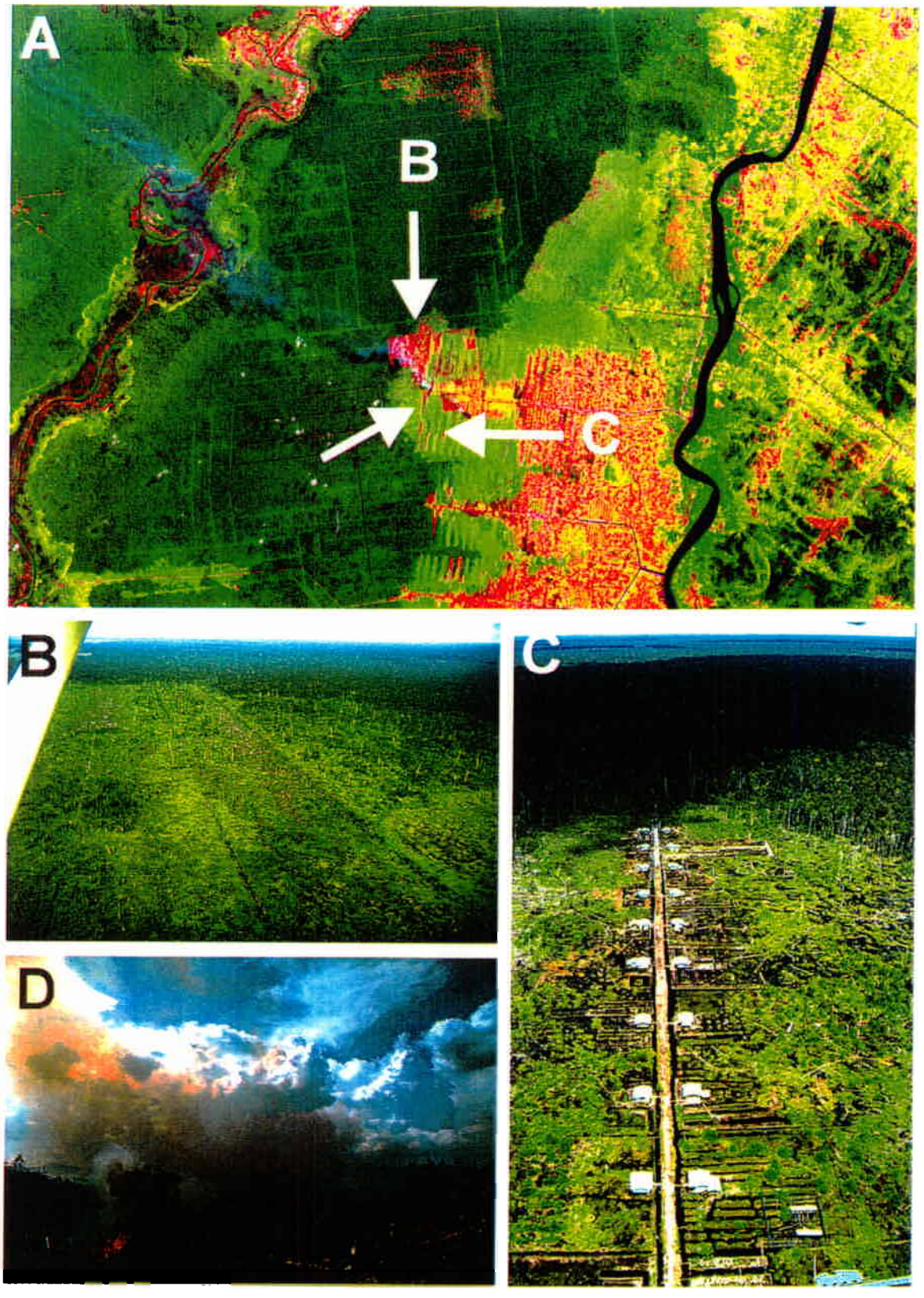


Figure 19: A. Section of the LANDSAT TM image from 24.07.1994 between Sungai Sebangau and Kahayan river (see fig. 1). Dark green: PSF, light green and red: Transmigrasi area with drainage and water channels
B. Drainage ditchs lead in regulary distances parallel to a center drainage
C. A Transmigrasi village like this is planned there
D. The whole area is clear-felled or burnt down

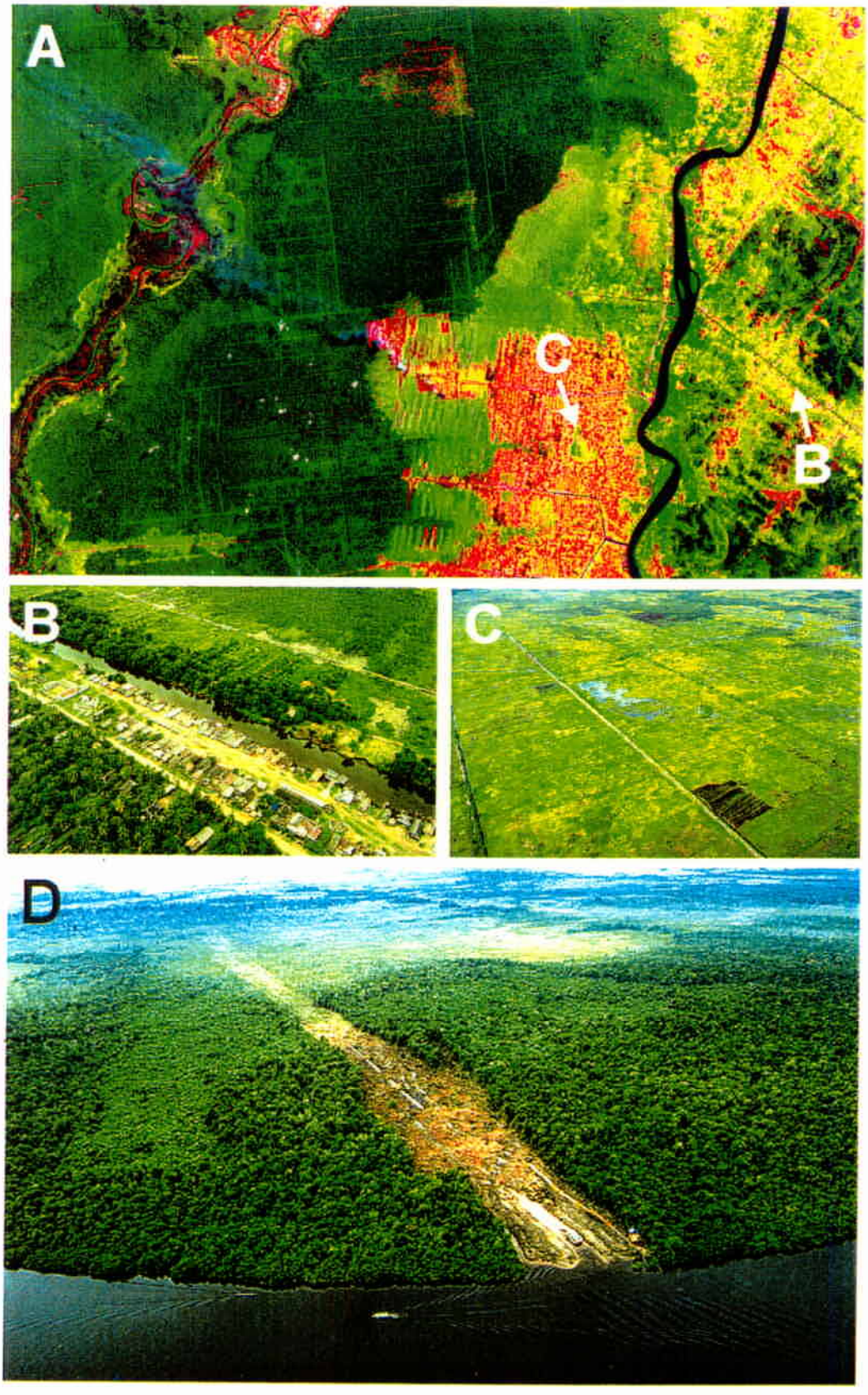


Figure 20: A. Section of the LANDSAT TM image from 24.07.1994
B. Connection channel between Kahayan and Kapuas with a village
C. Clear cuts with drainage channels prepared for plantages.
D. Preparation work for a secondary channel for the 1 Mio ha rice project.