Effects of Land Cover Change on Forest Ecosystem and Carbon Dynamics in Indonesian Borneo

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Bentung Kerihun National Park, W. Kalimantan

Big Questions

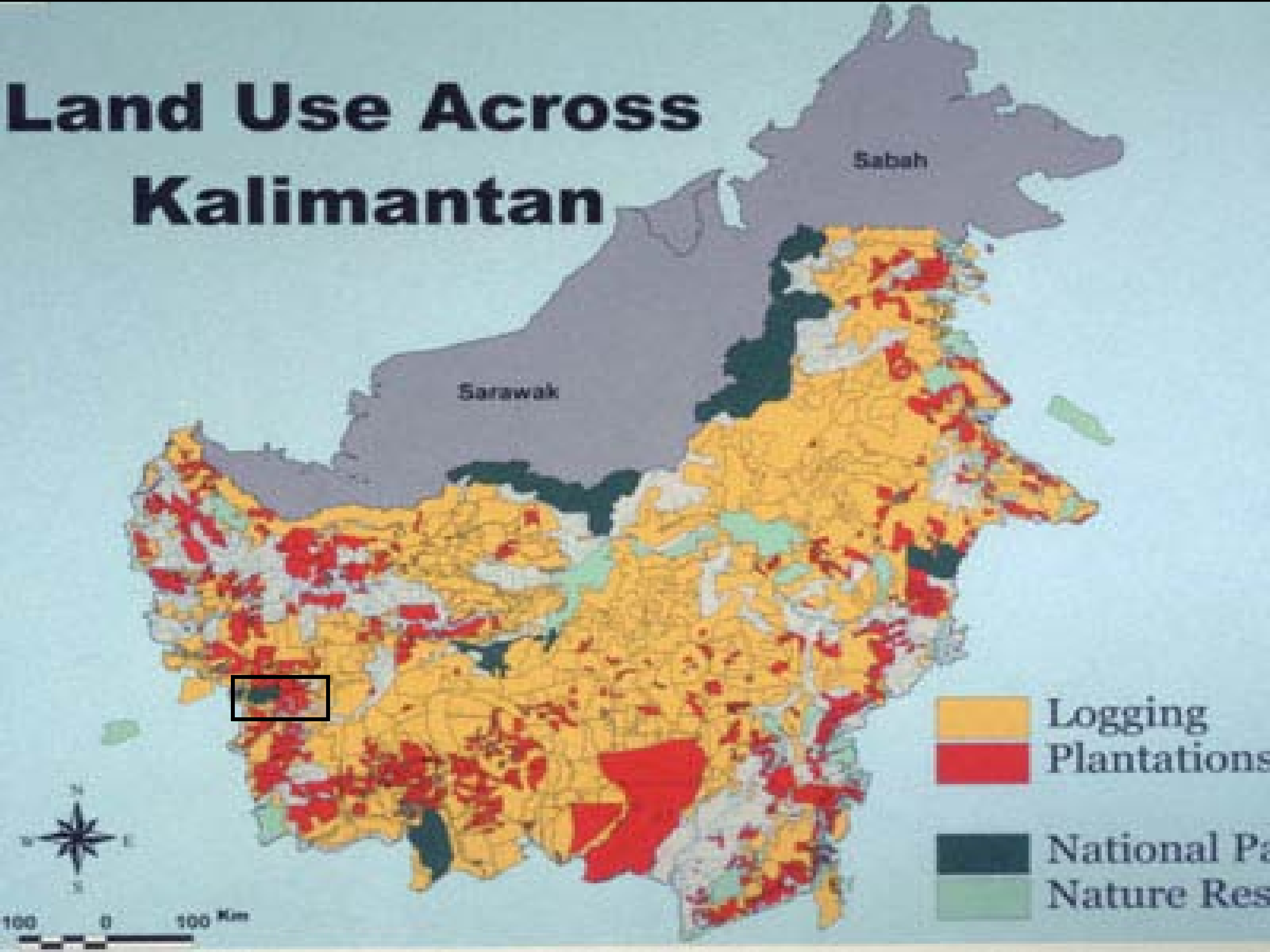
- What are the relative contributions of land use, natural ecosystem dynamics, fire and climate variability on forest and carbon dynamics in Bornean tropical forests?

- What are their synergistic effects and potential future trends?

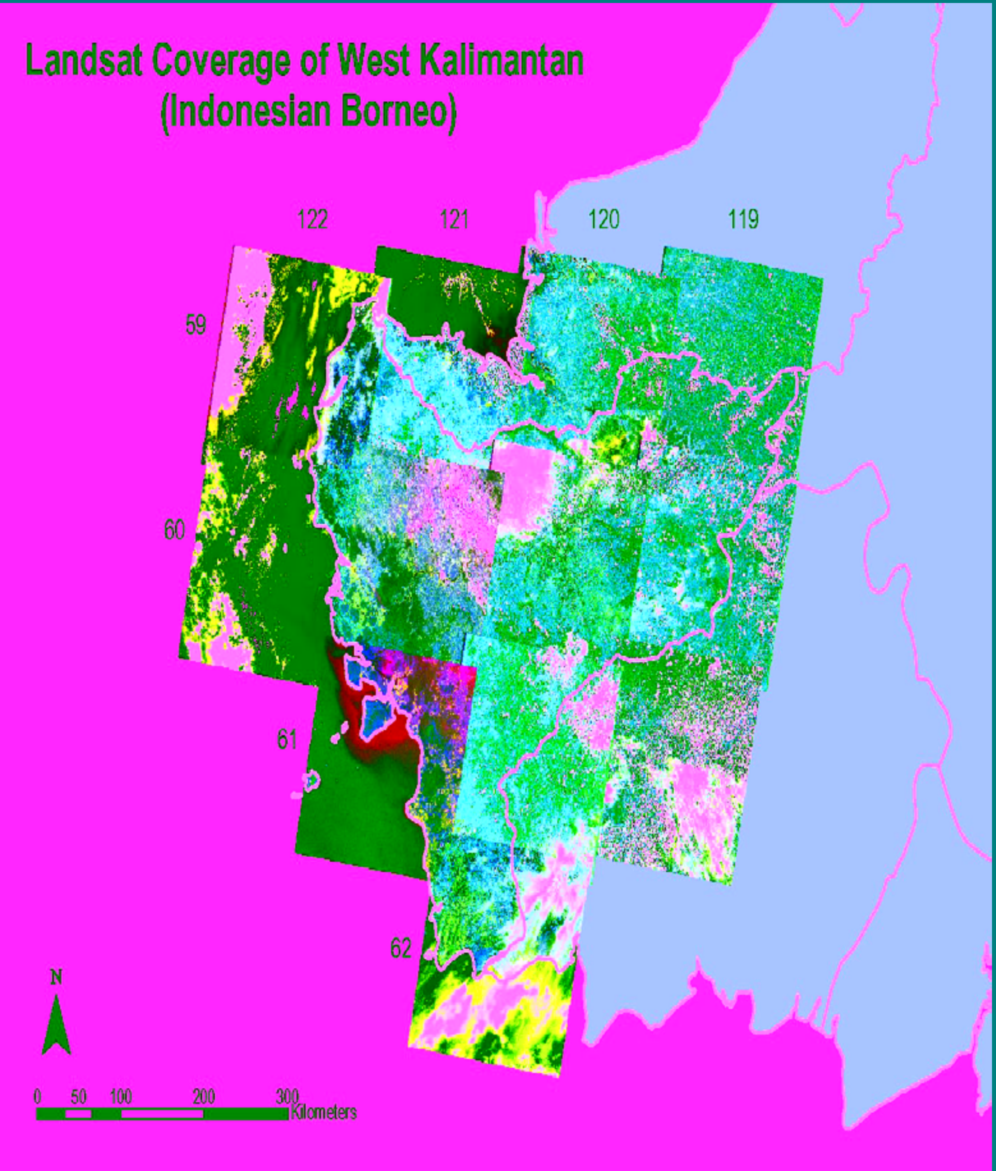
Objectives

- Determine carbon storage variation across forest and land use types;
- Conduct remote sensing derived analyses of LCLUC and carbon dynamics;
- Input field and remote sensing derived data from case regions into models;
- Evaluate carbon source/sink dynamics using models: past, present and future

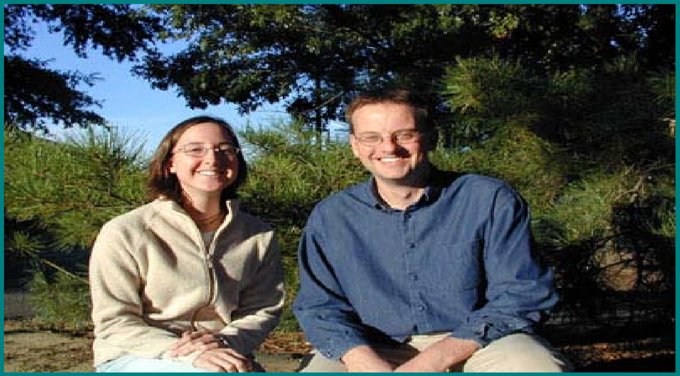
Land Use Across Kalimantan

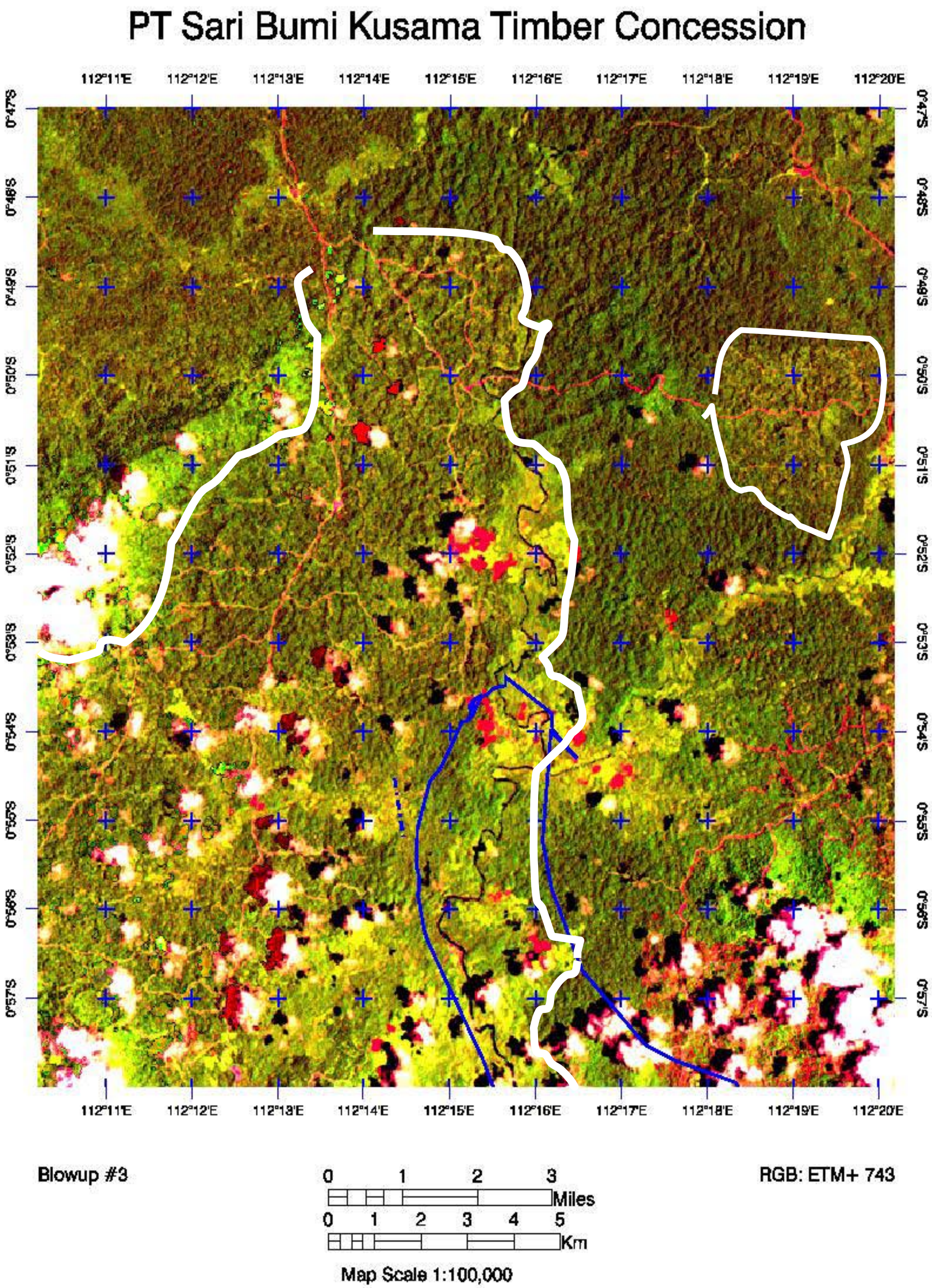


LCLUC with Nested-Scale RS Analyses Linked to Spatial-scale of Ecological Processes



- Landsat Coverage for 1970-1 1985-6, 1990-91; 1995-6; 1999-2002
- Area: ~250,000 km^2
- Every 2 yrs (1985-2002) for Two Case Study National Park Regions
- 10 IKONOS 1m & 4m resolution in case study regions;
- MODIS 250m Borneo-wide (540,000 km^2) 2001-2005





Curran, Trigg, McDonald et al. in press Science

- From 1970-2003, 72 timber concessions once occupied 7.2M ha or 79% of forest area (<500 m a.s.l.) in West Kalimantan;
- March 2003, six holdings (8.3%) with active timber harvest;
- Only 416,280 ha; 94.3% reduction;
- <60,000 ha primary remain in timber concessions;
- Abandoned areas highly degraded 80-90% canopy removed; often entered coupe several times;
- Logging easily detected on Landsat (w/o cloud cover) coupled with maps/limited ground surveys;
- Patches of primary forest are all <500 ha in former logged areas

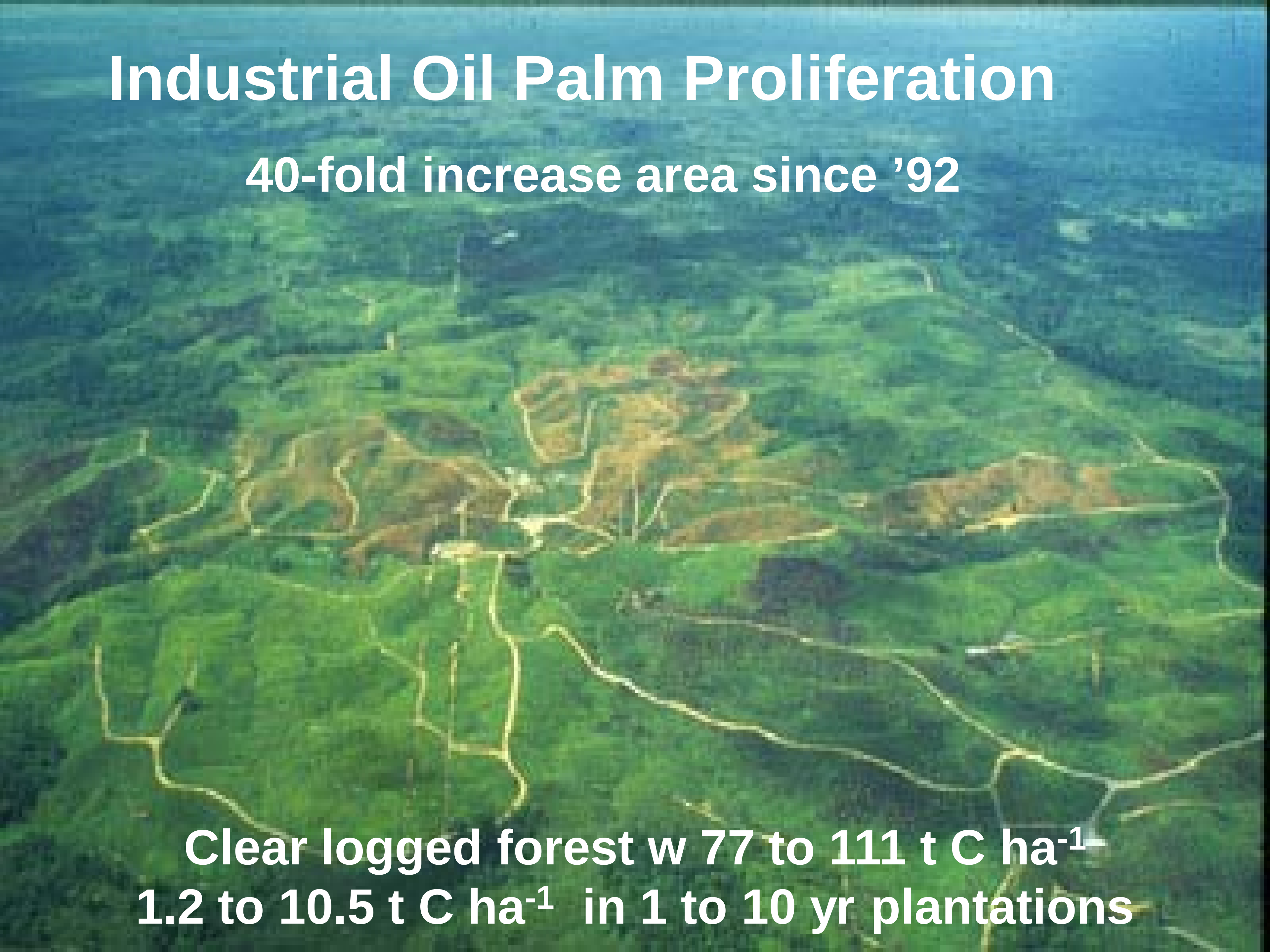
Shifting loggers

Over-Capacity Wood-Based Industries

- W. Kalimantan:130 wood-based industries: 5M m^3yr^{-1};
- 14 plywood industries: 2.6M m^3yr^{-1};
- Exceed concession capacity: '94-95: 22%; '99-00: 132%; '02-03: 162%

Industrial Oil Palm Proliferation

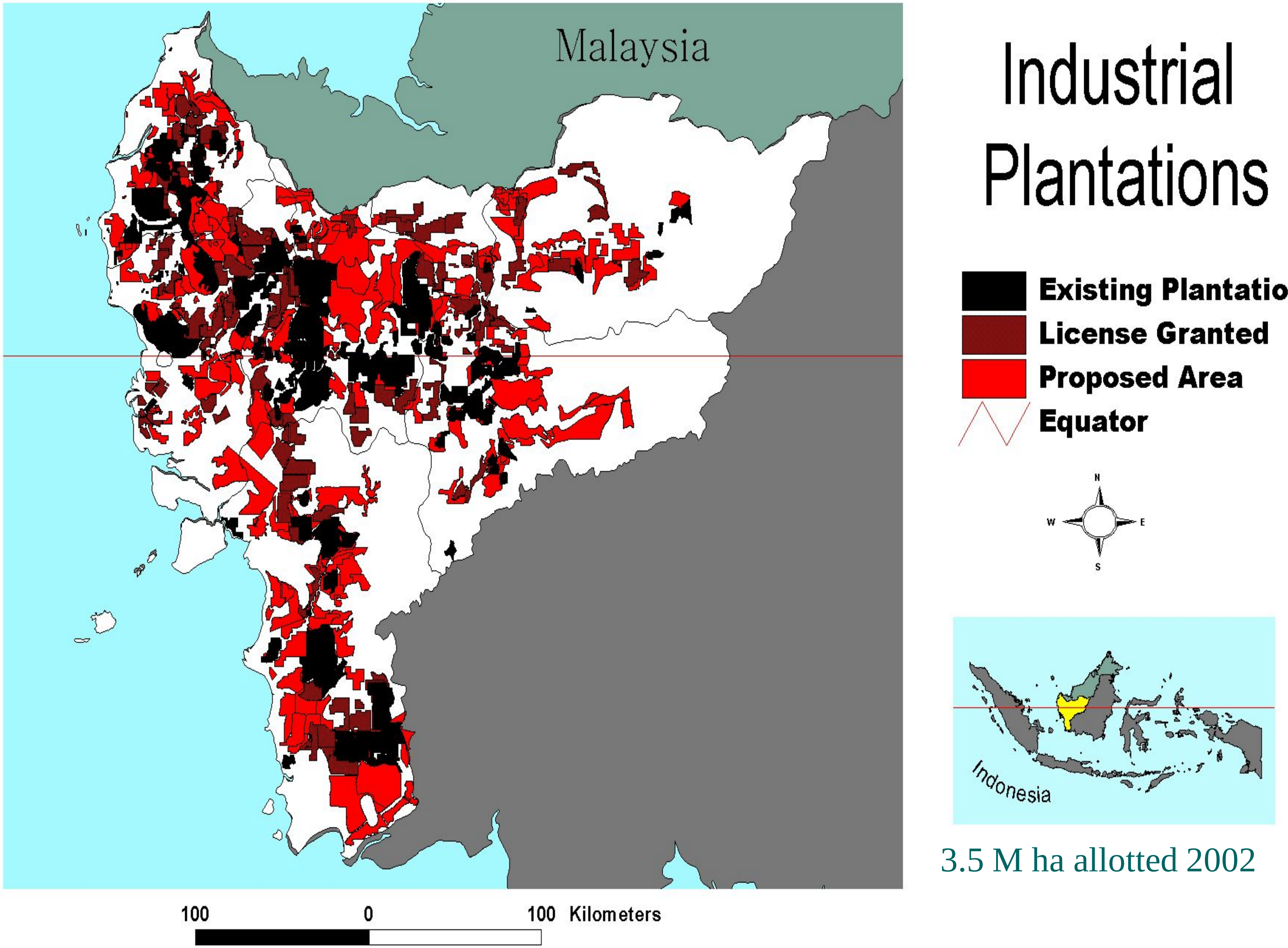
40-fold increase area since ’92



Clear logged forest w 77 to 111 t C ha^{-1}

1.2 to 10.5 t C ha^{-1} in 1 to 10 yr plantations

WEST KALIMANTAN, INDONESIA



3.5 M ha allotted 2002

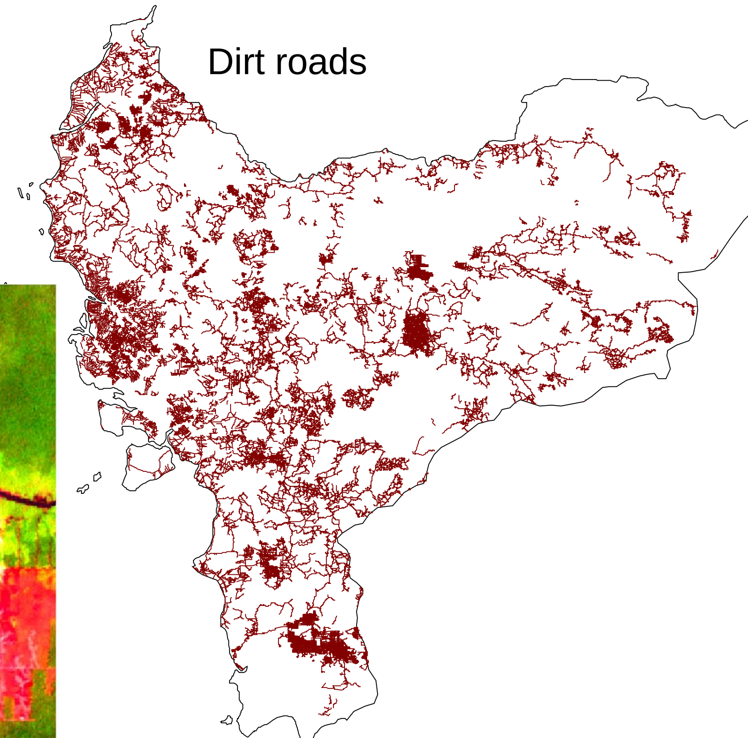
Mapping oil palm plantations

Ikonos: resolves individual crowns, but over small areas

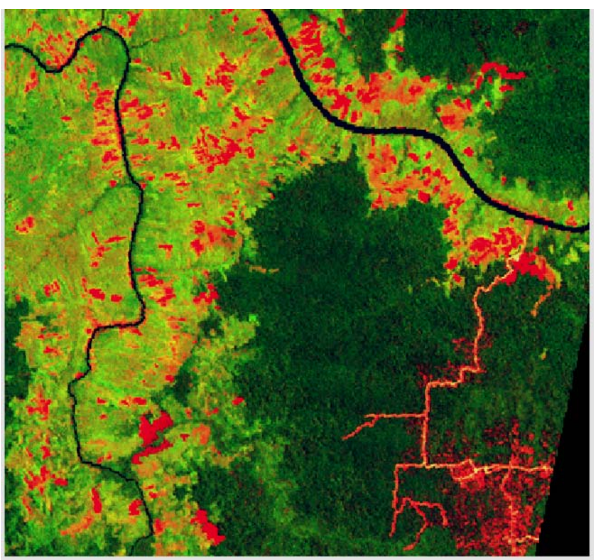
Challenge to mapping oil palm with TM:
Depending on age, oil palm is spectrally confused with bare soil and secondary regrowth.

So, to approach mapping oil palm, we:

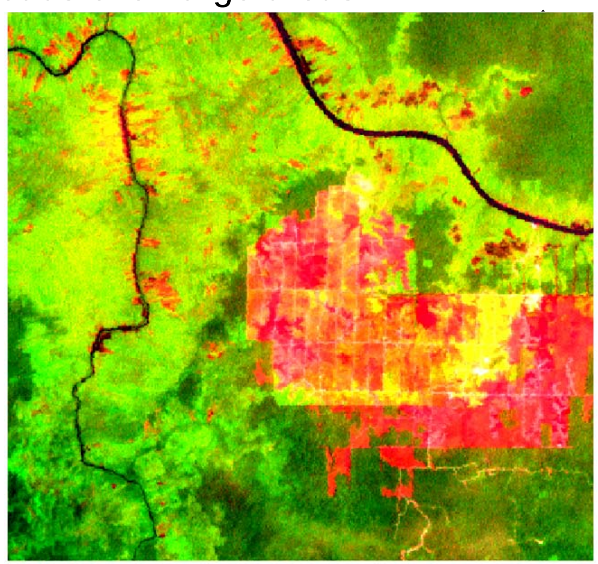
- train detection methods on known plantations observed on Ikonos
- incorporate into the mapping method:
  - changes observed on TM (1990 – 2000)
  - proximity to dense road networks:



TM: resolves forest conversion and roads over large areas

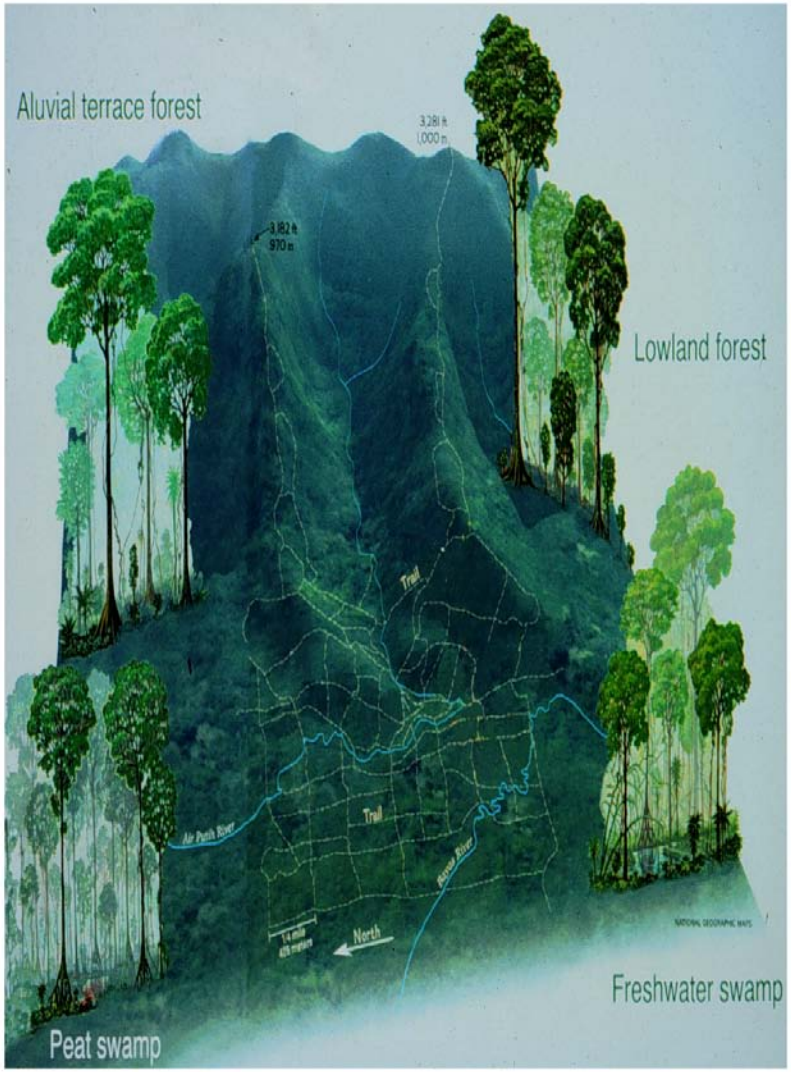


1992



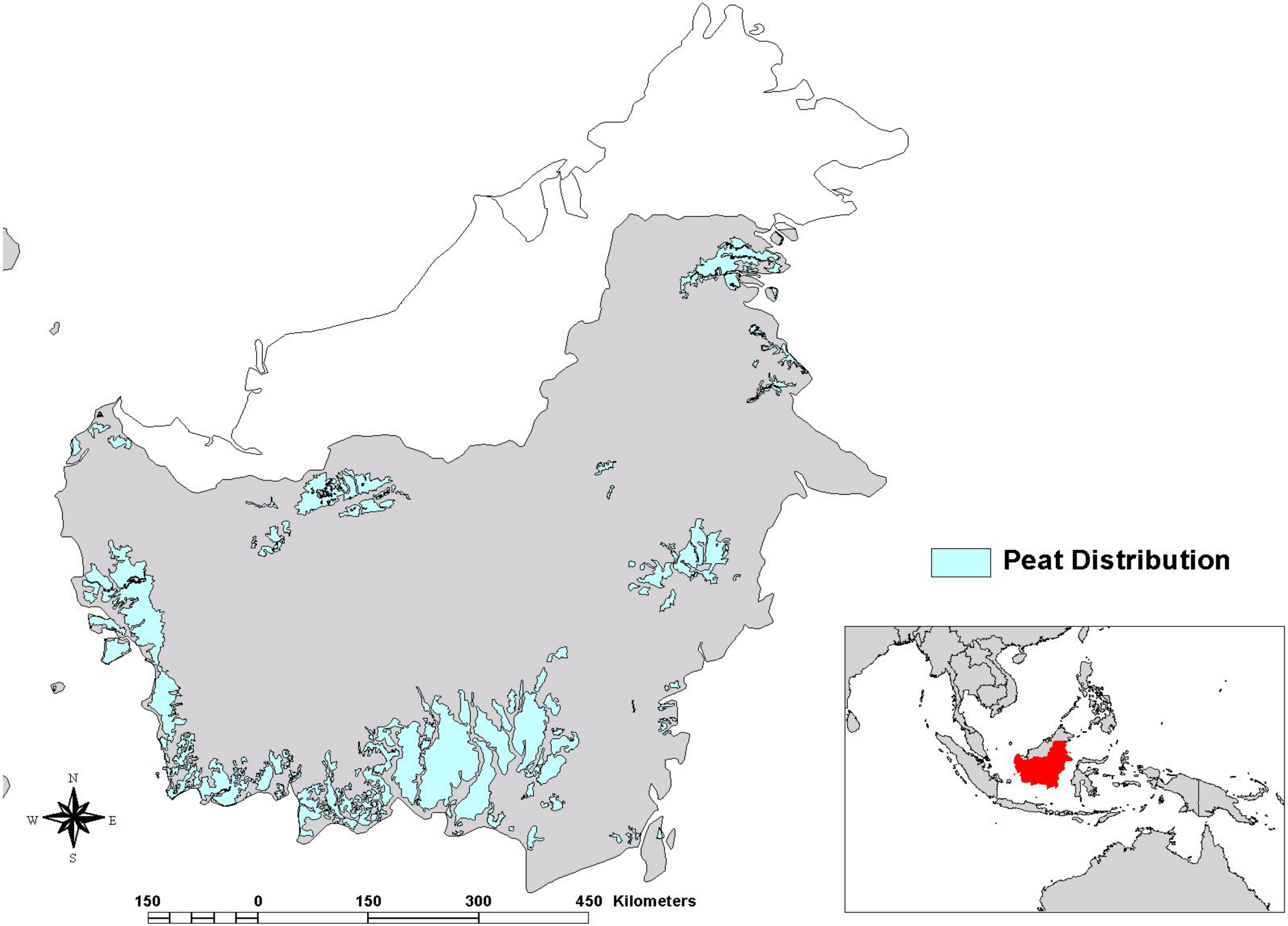
1999

Carbon Measurements



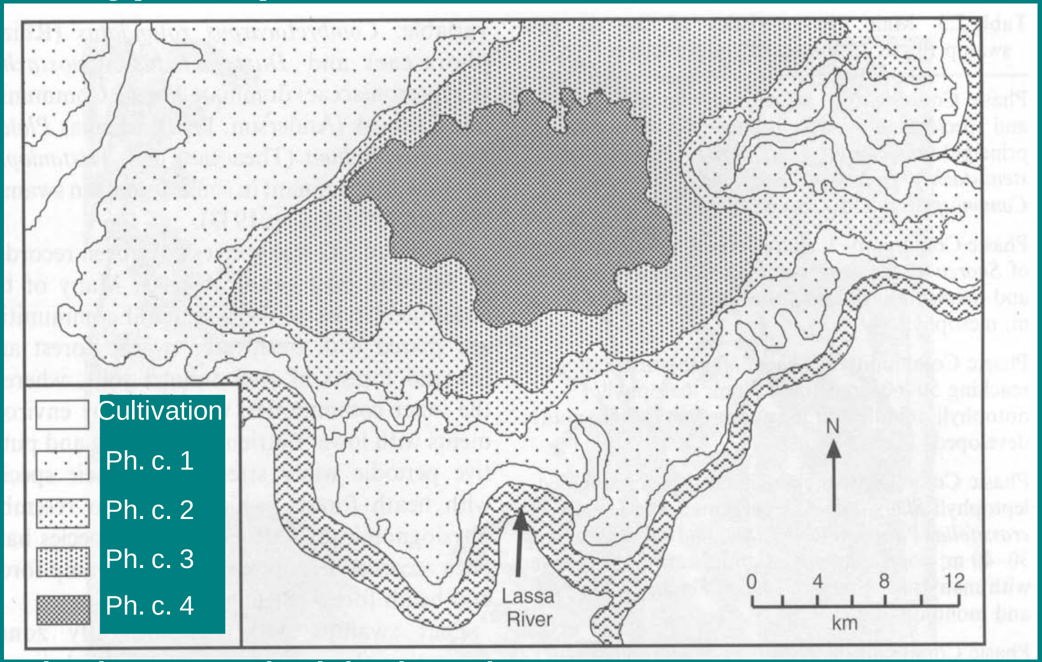
- Four forest types: 4 yrs; NUE, biomass, growth (18 yrs);
- Logging Chronosequence: 12 yrs; before/after;
- Oil palm chronosequence; 10yrs;
- Secondary forest; 0-21 yrs; Lawrence et. al. in press;

Distribution of Peat in Kalimantan



Peat Swamp Forest: Potential for Remote Sensing of Phasic Communities

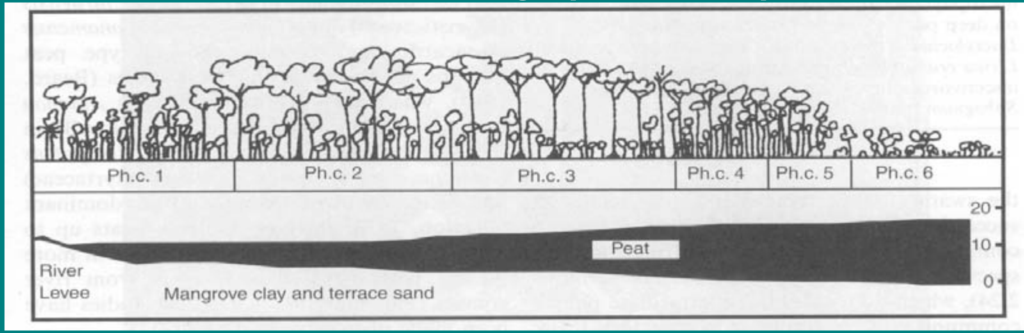
A. Typical pattern of concentration zonation



Phasic community (Ph.c.) number:

1 *Gonystylus – Dactyocladus – Neoscortechinia* association
2 *Shorea albida – Gonystylus – Parastemon* association
3 *Shorea albida* consociation
4 *Shorea albida –Listea – Parasetamon* association

B. Schematic transect through peat swamp forest



C. Zoning in Peat Swamp Forest as seen in classified ETM+ image

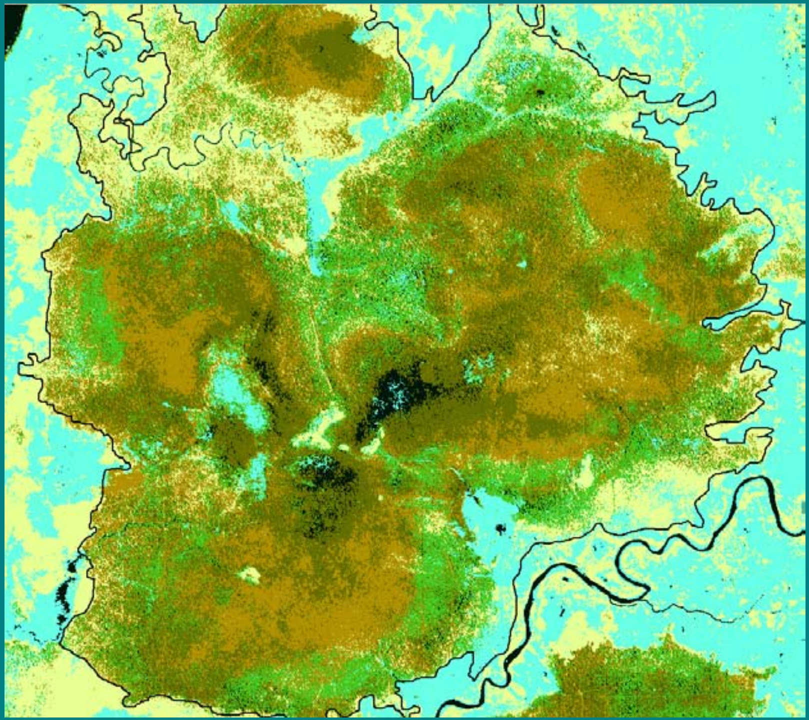
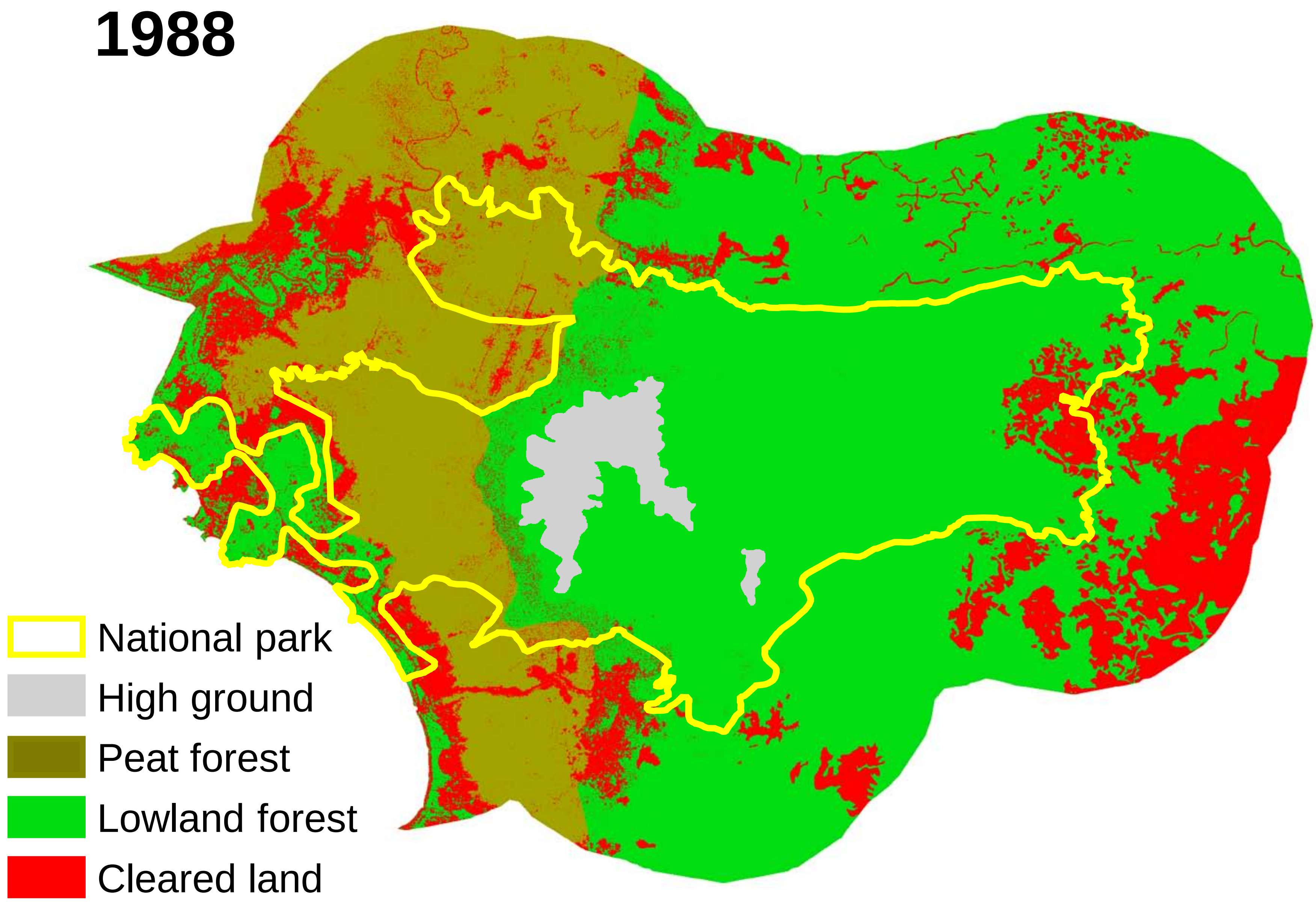
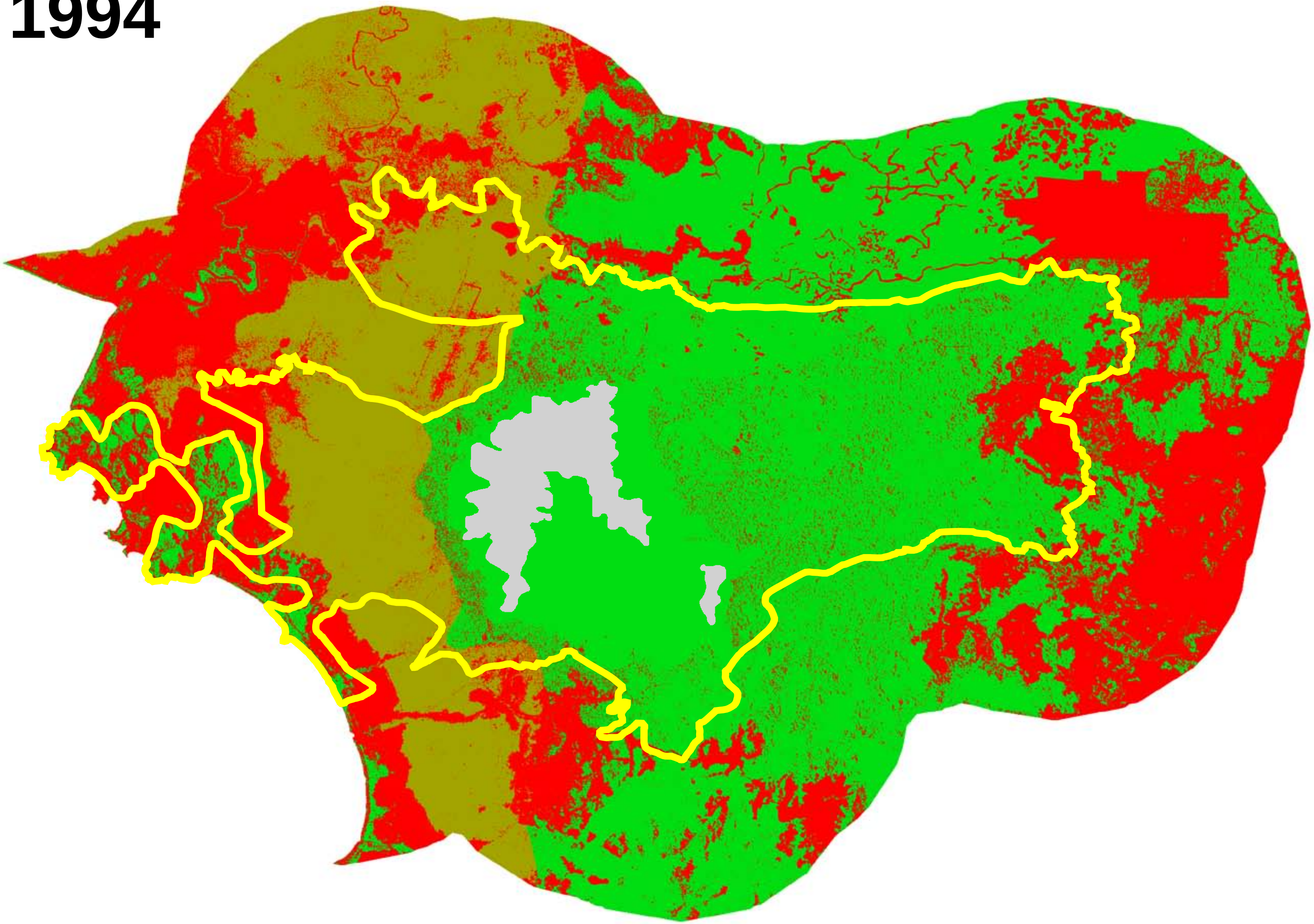


Image date = 28 August 2002
Location = West Kalimantan
Classification method = Neural Net

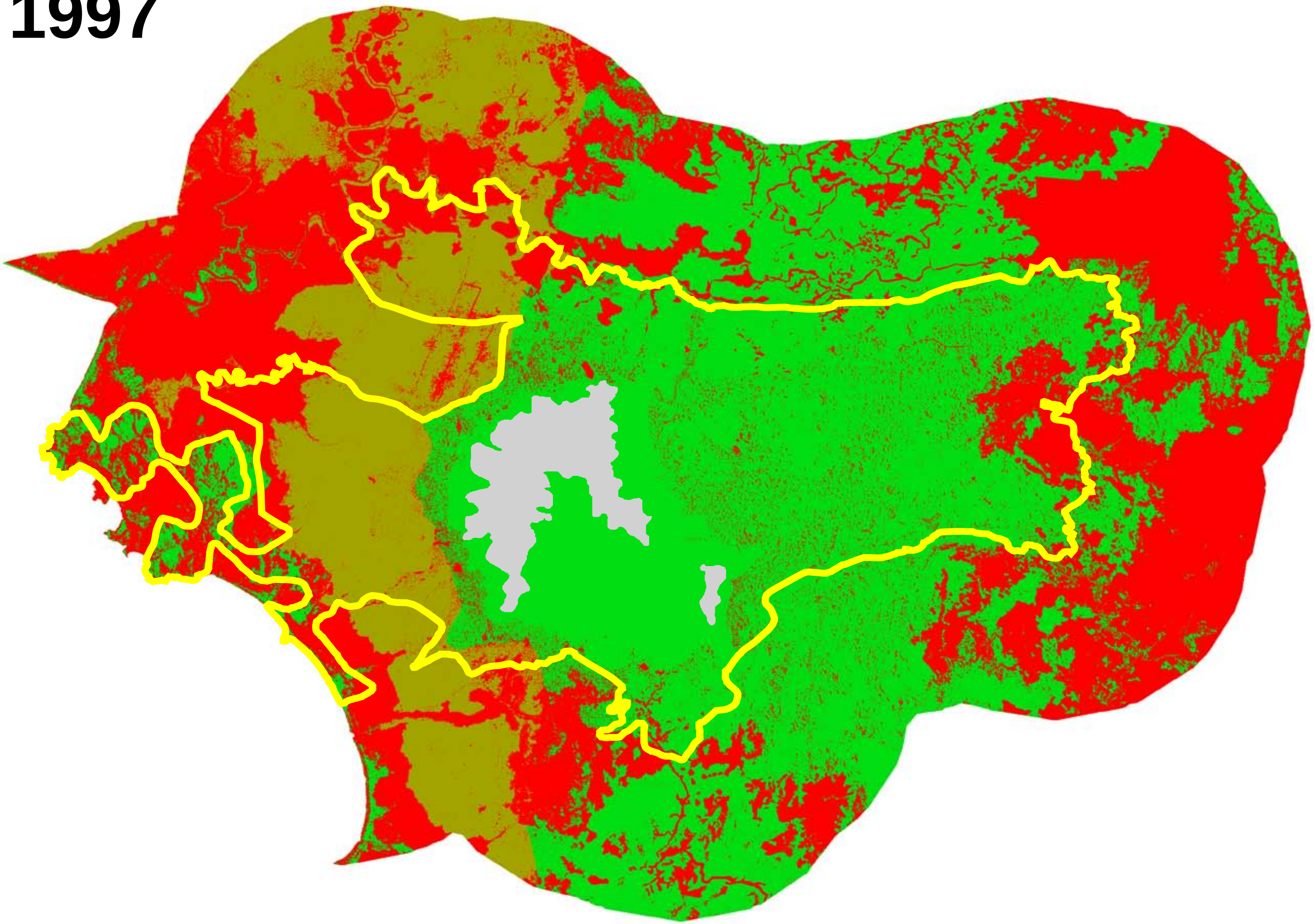
(Source for figures A and B: Morley, 2000 after Brunig, 1990
Data from Sarawak, Borneo)


1988
National park
High ground
Peat forest
Lowland forest
Cleared land

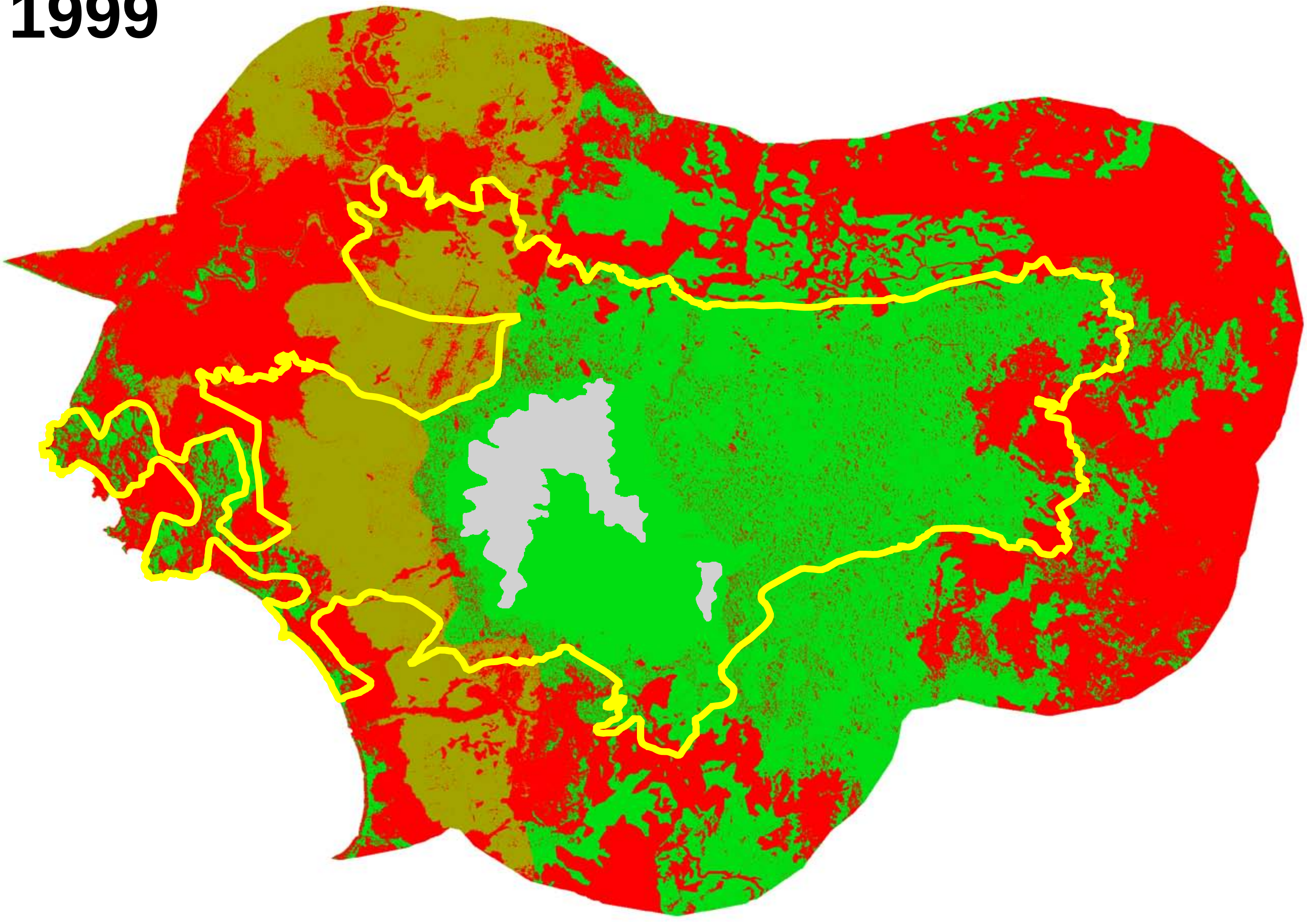
1994



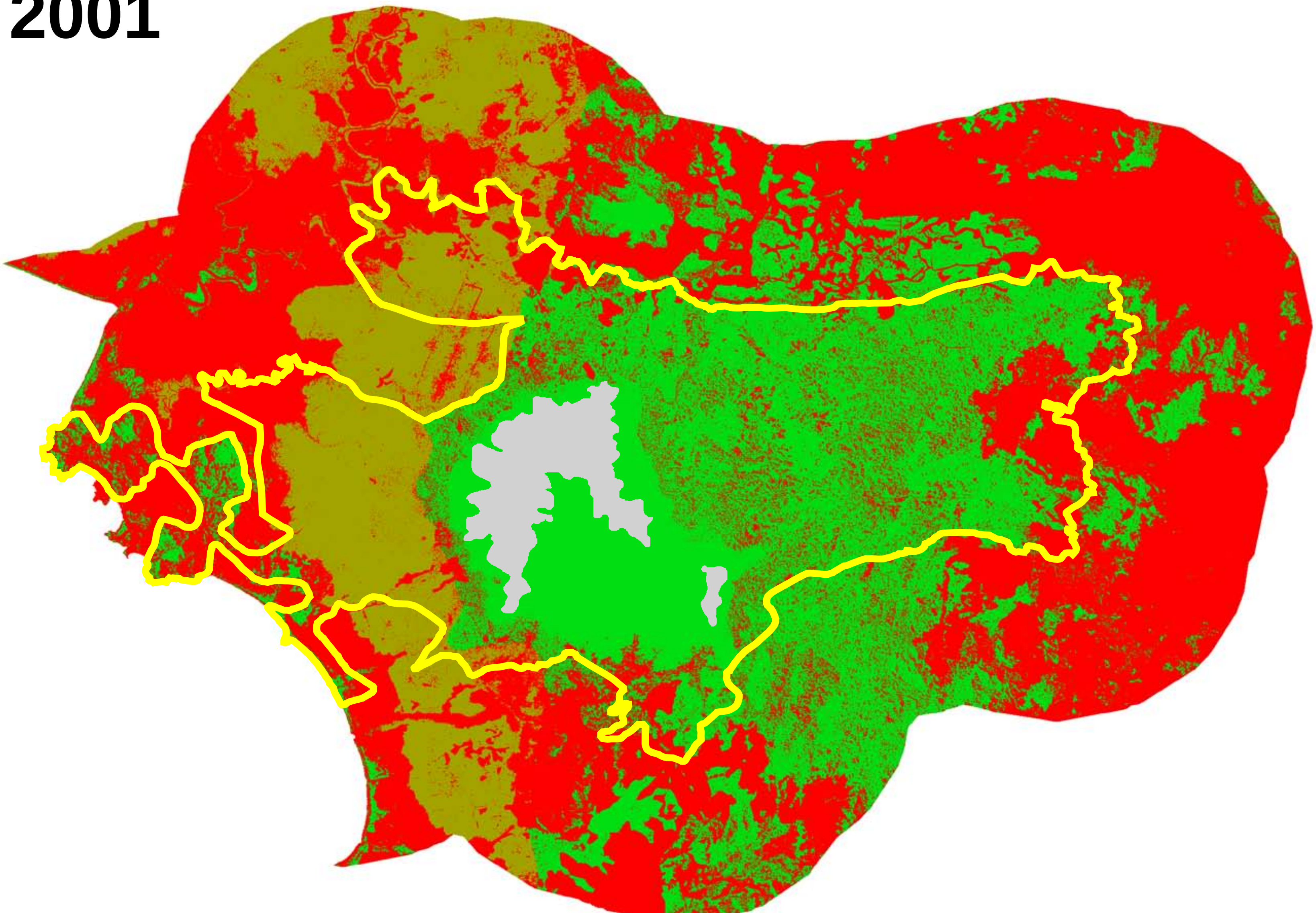
1997



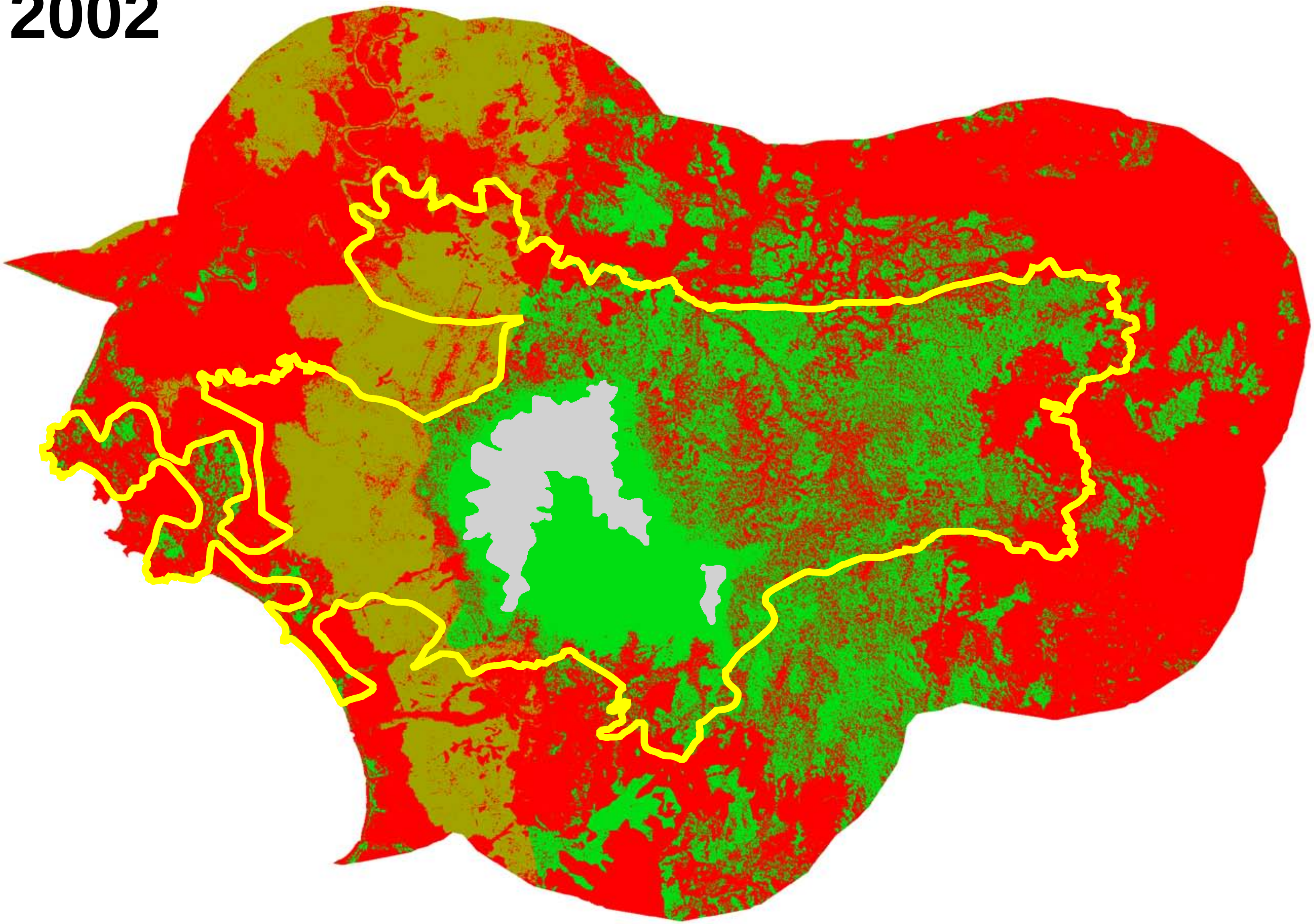
1999

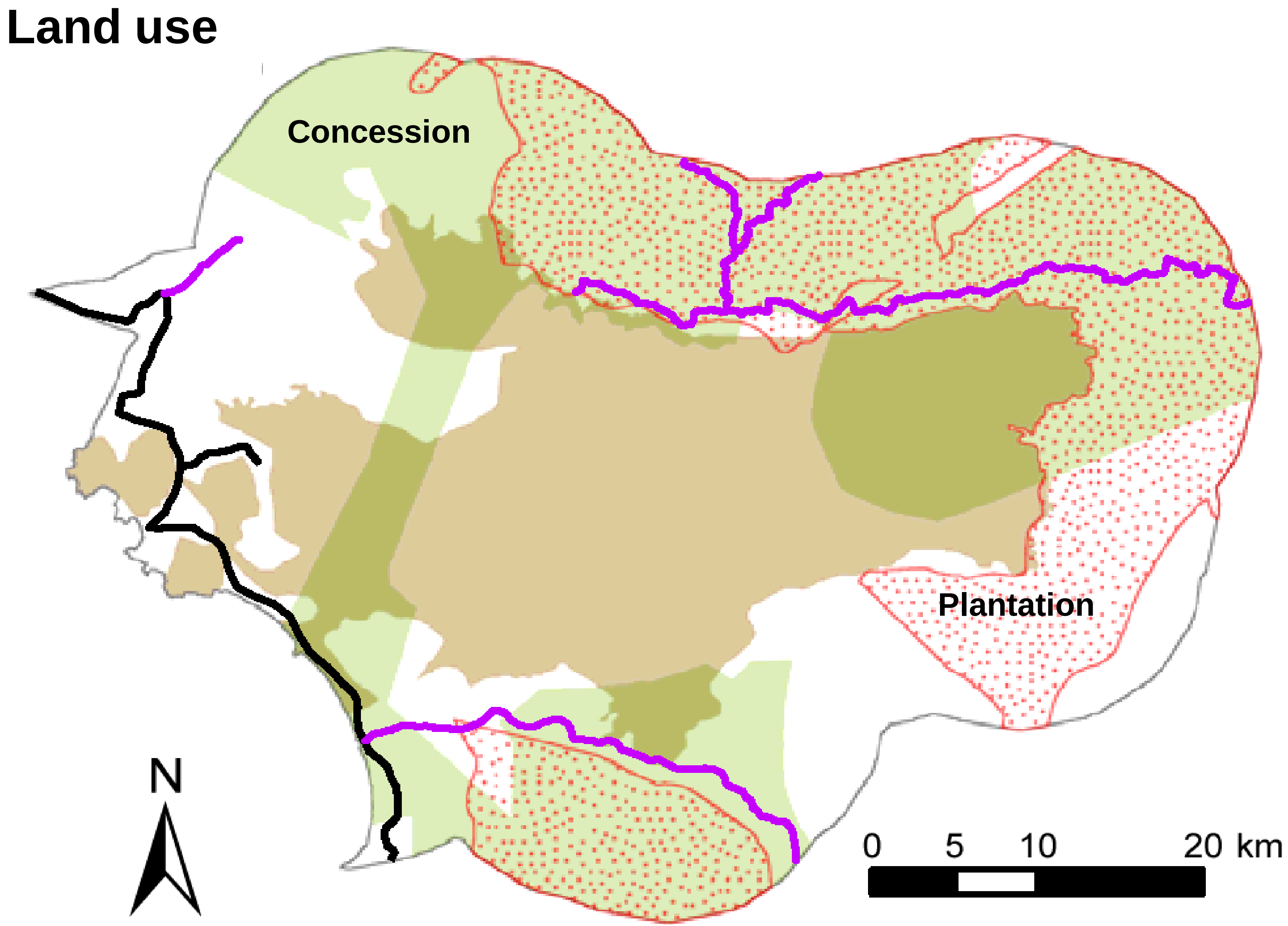


2001

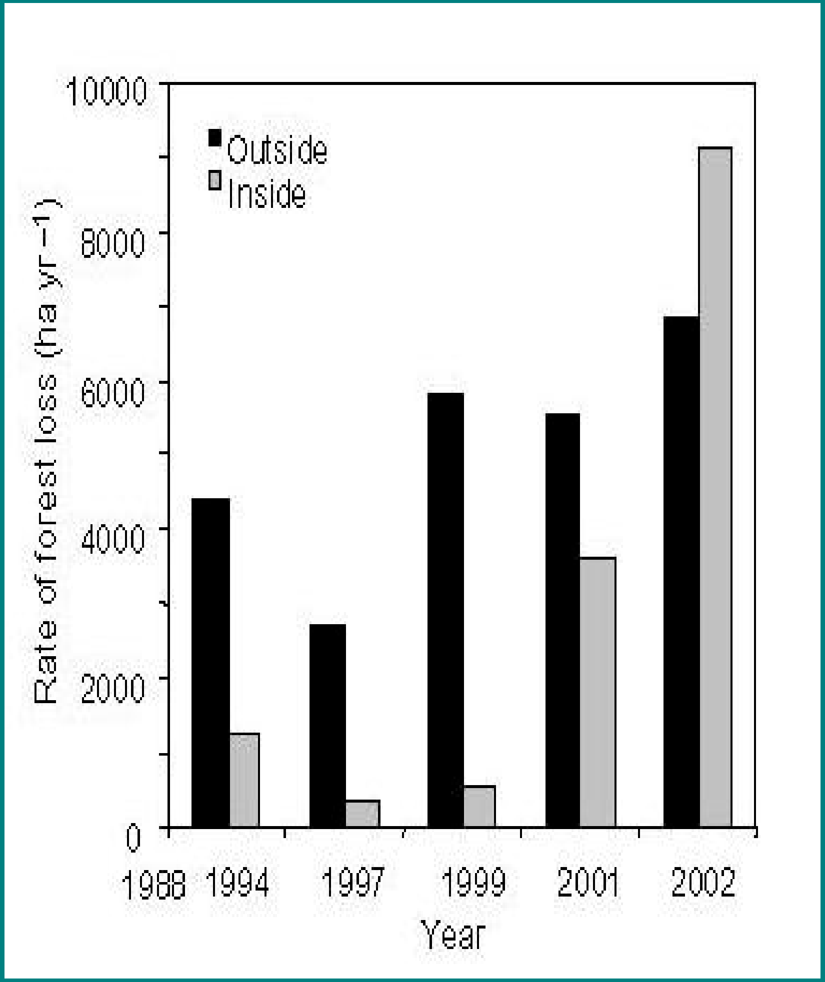


2002




Land use
Concession
Plantation
N
0
5
10
20 km

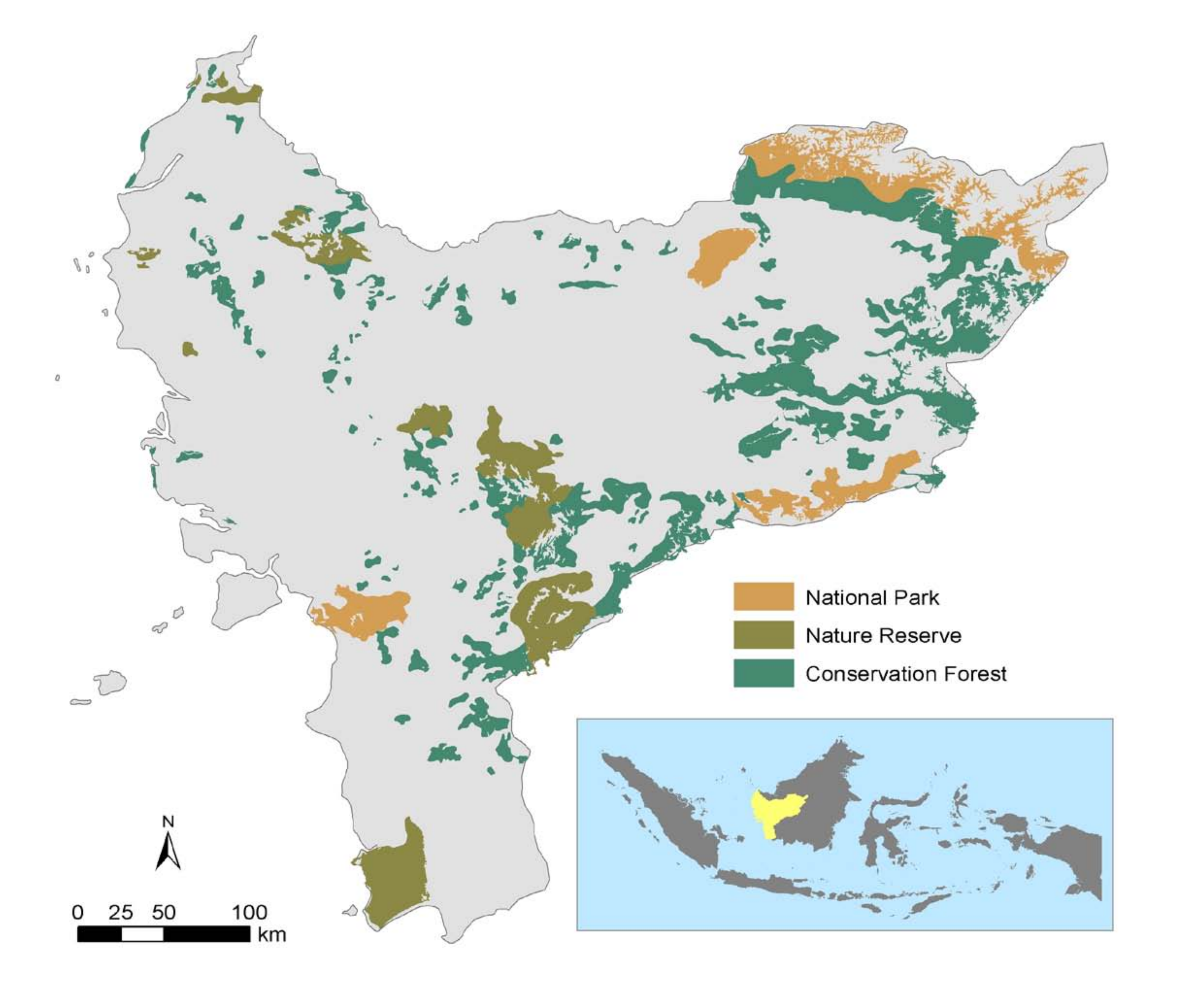
Matrix to Park



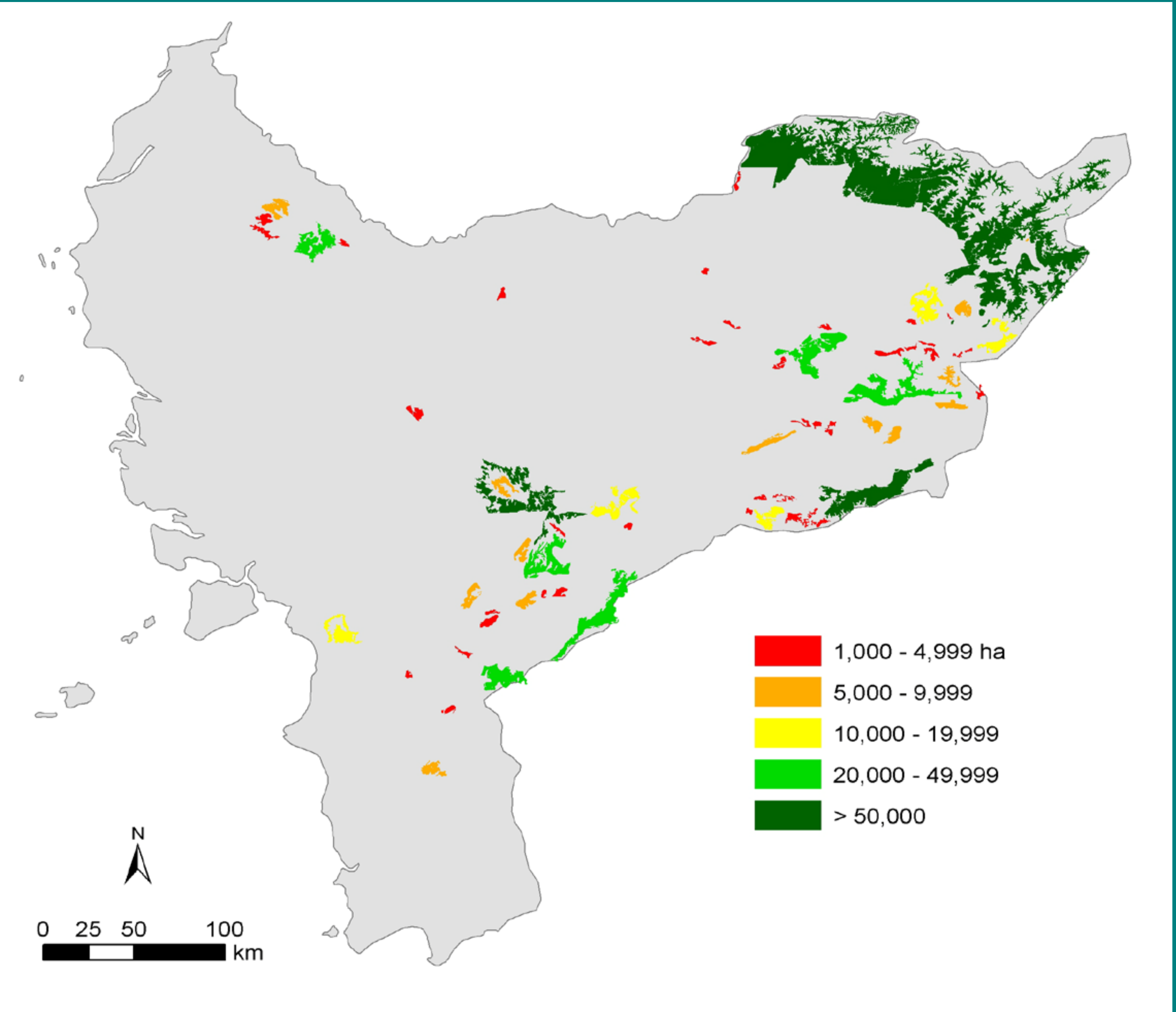
- 70% Park 10 km Buffer Deforested; <9% intact;
- 38% Park Lowlands Deforested;
- After 1999, when <26% buffer remained; deforestation within park rose 9.5% yr^{-1}; r^2 =0.99)

Curran et al. *in press, Science*

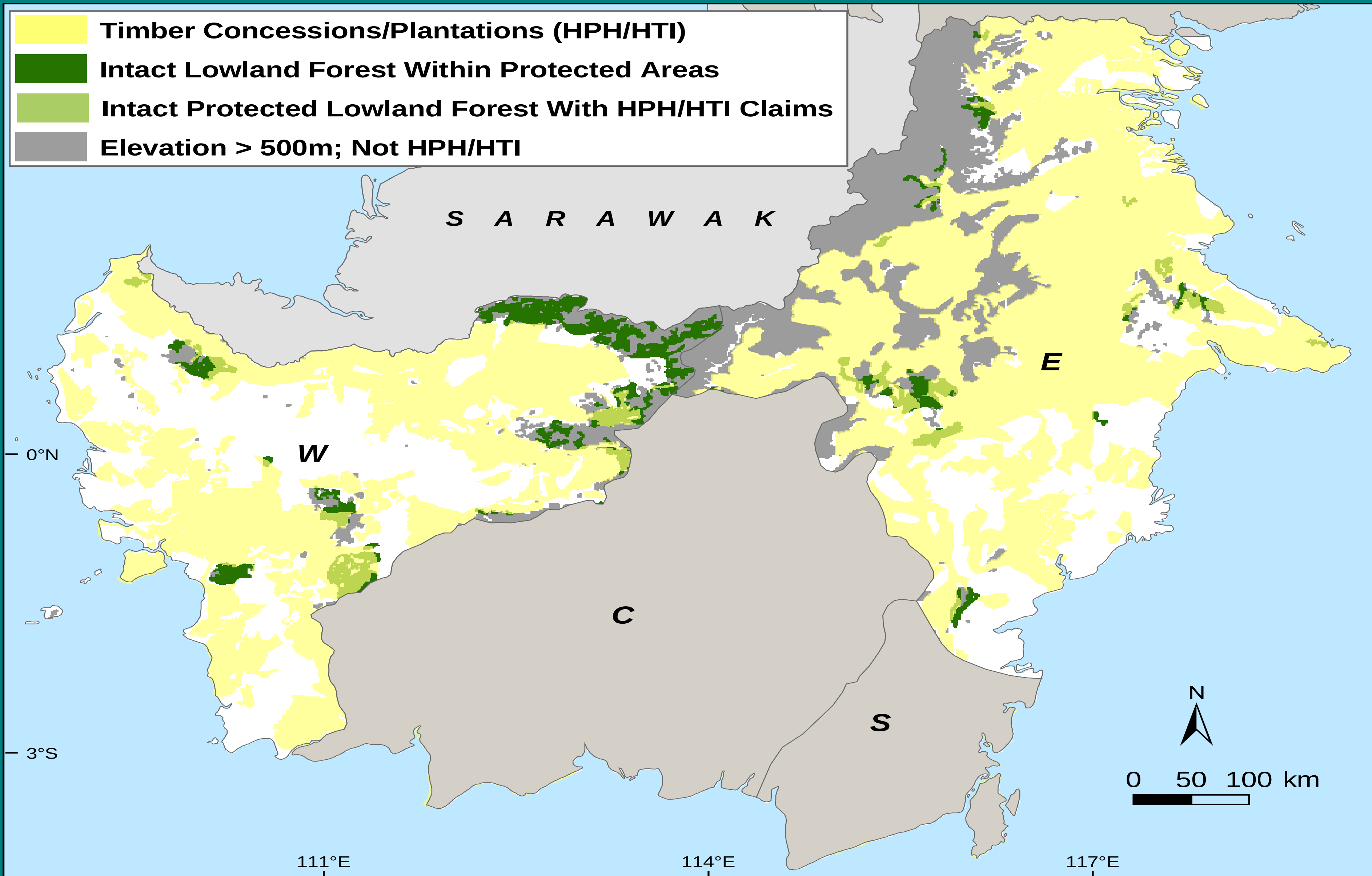
Lowland Protected Areas in West Kalimantan in 1985

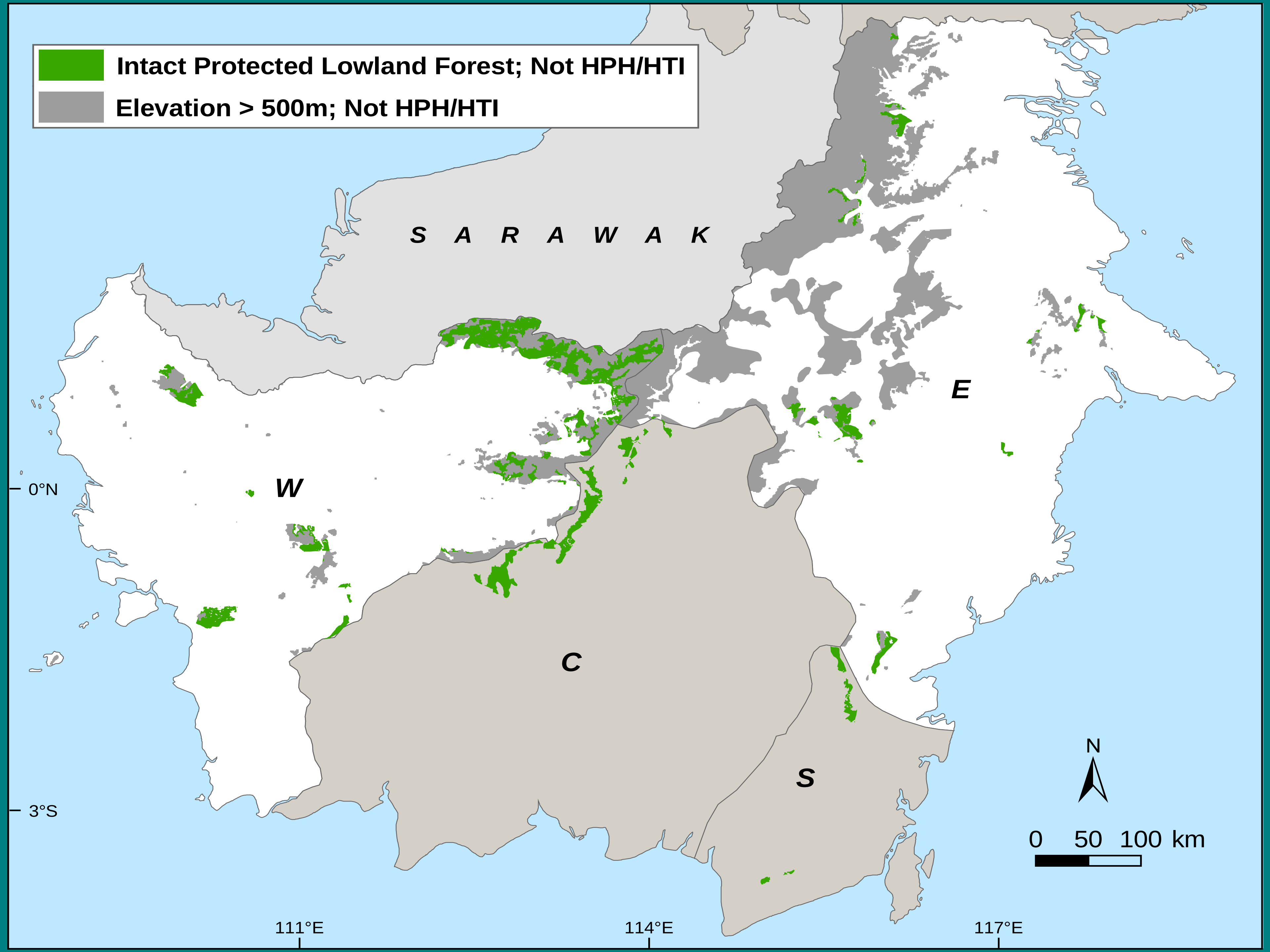


Forest Fragments Remaining Within Lowland Protected Areas In 2002



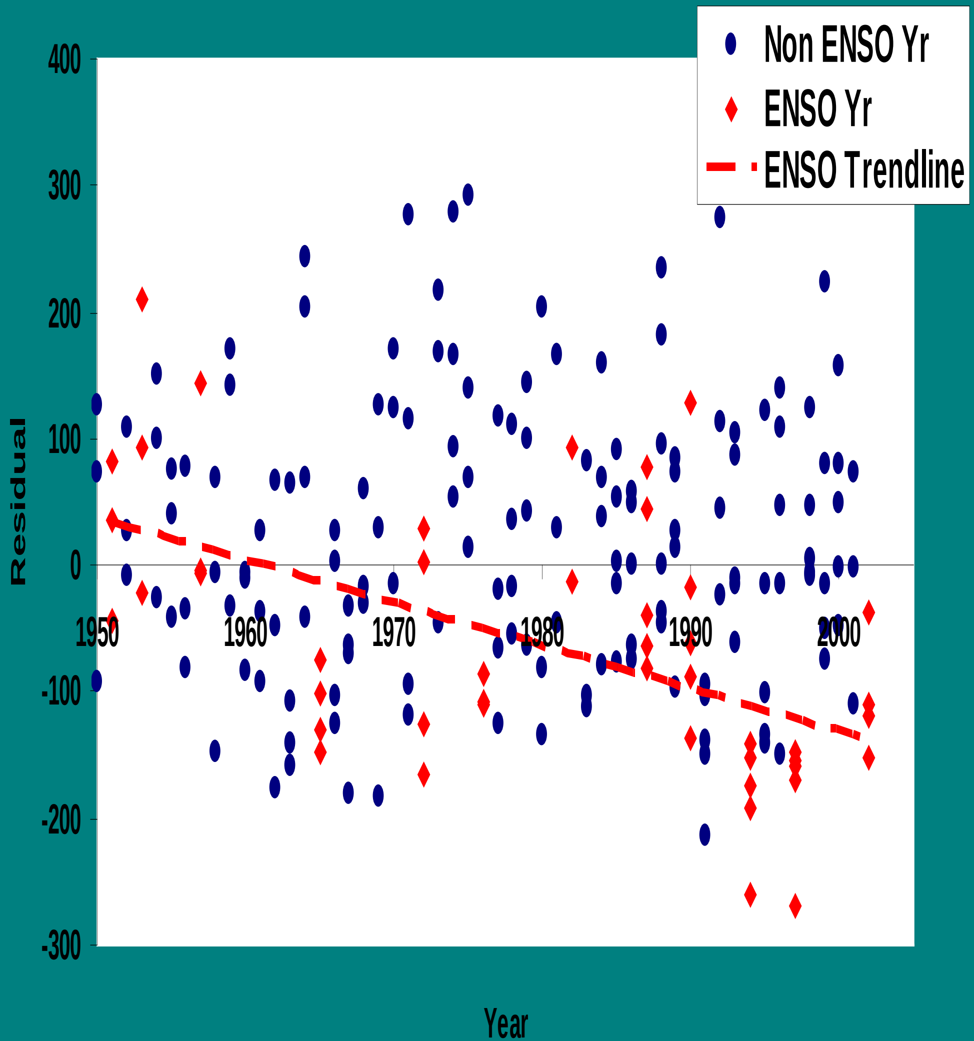
Spatial Distribution of Dipterocarp Forest Across Kalimantan 2002





Intact Protected Lowland Forest; Not HPH/HTI
Elevation > 500m; Not HPH/HTI
S A R A W A K
W
C
S
E
0°N
3°S
111°E
114°E
117°E
N
0 50 100 km

Land Cover Change & Climatic Effects



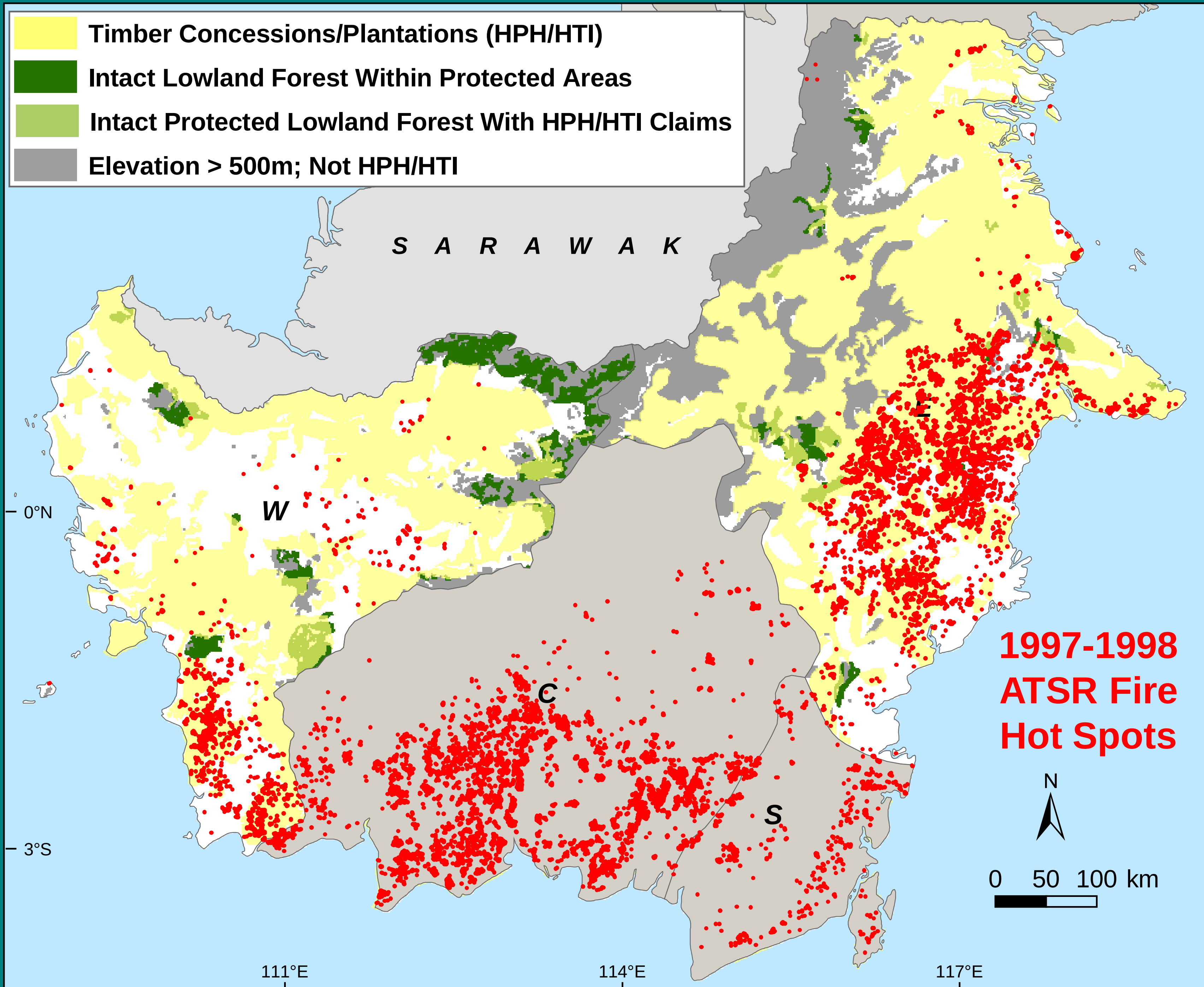
REGIONAL: 200,000 km^2

- Even with ENSO variability removed, since 1950: Increased drought stress across region (+36 days w/ rain; *P*<0.0001);
- Increase in min temp since 1976 Wet +1.4 C; Dry +1.6 C; *P*< 0.0001;

LOCAL: 2736 km^2

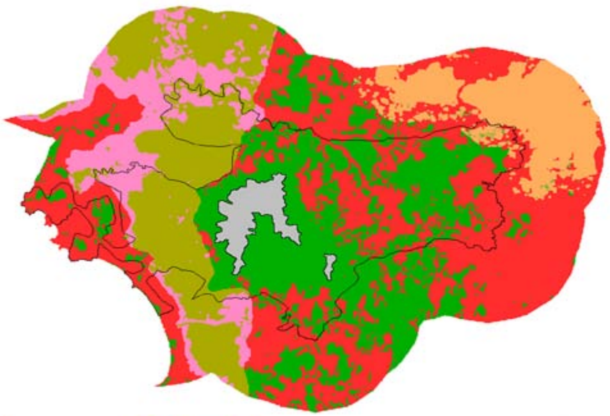
- Disruption of La Niña rainfall patterns 1987-1991 vs. 1999-2003: 4 vs. 16 periods in 10+ days w/o rain (*P* = 0.042)

Curran, Paoli & Peay, in review



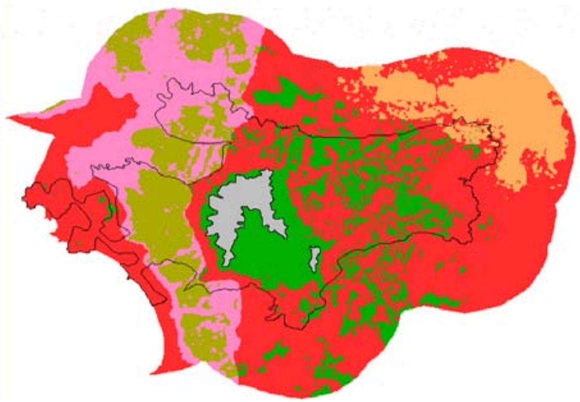
Timber Concessions/Plantations (HPH/HTI)
Intact Lowland Forest Within Protected Areas
Intact Protected Lowland Forest With HPH/HTI Claims
Elevation > 500m; Not HPH/HTI
S A R A W A K
W
C
S
E
0°N
3°S
111°E
114°E
117°E
N
0 50 100 km
1997-1998
ATSR Fire
Hot Spots

Projected Land Cover Classifications for 2015



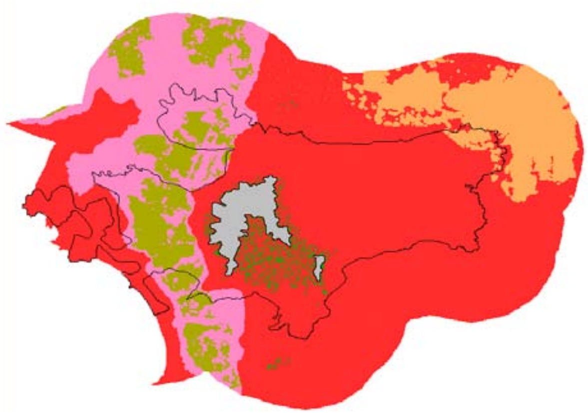
Continued Fragmentation I

- 2001-2002 transition
- Non-cumulative deforestation



Continued Fragmentation II

- 1999-2001 transition
- Cumulative deforestation



Continued Fragmentation III

- 2001-2002 transition
- Cumulative deforestation

Importance of Indonesian Borneo for Global Carbon Dynamics

- High carbon stock in primary, regrowth logging and esp. peat;
- Rapid & large-scale industrial conversion of logged dipterocarp forests to oil palm;
- Increased susceptibility to drought and fire with logging/logged roads and fire used for oil palm clearing

Work in Progress

- Model past, present and future carbon dynamics in the region;
- Integrate with effects of LCLUC on biodiversity;
- Build on current cross-site comparisons of frontier governance (esp. with Amazon);
- Extend to policy and regional land use planning and fire prevention with Indonesian collaborators

Land Use Planning and Development BAPPENAS Dedy and Herman Heruman, Ning, BAPPEDA-KALBAR, Eka, Rusnawir Hamid, Nova Sirait, Department of Parks and Conservation (PKA) and national parks; University of Tanjungpura and Dean of Forestry, Heru were collaborative sponsors.

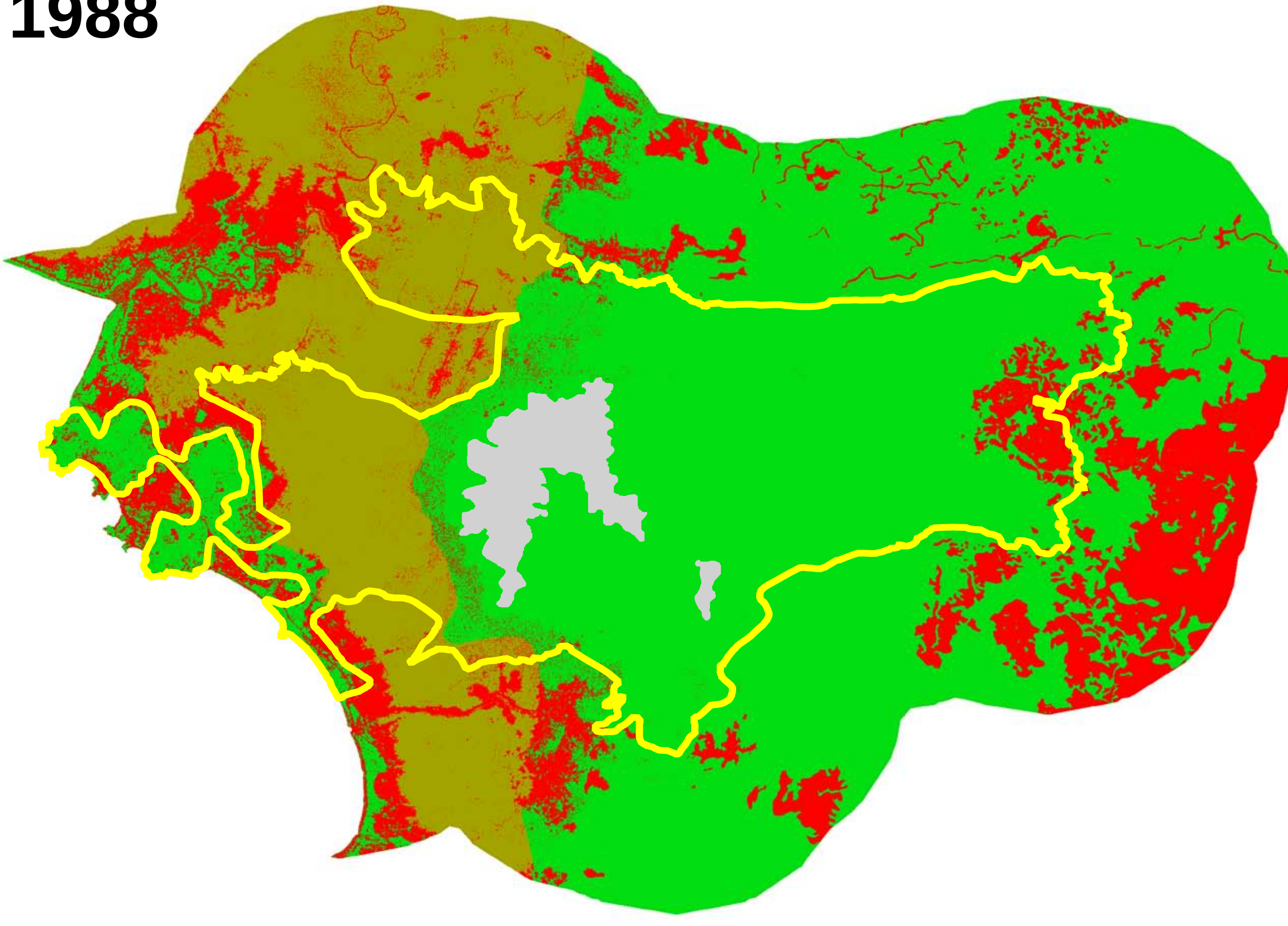
Eighteen timber concessions and seven oil palm plantations granted access and logistic support during surveys, local NGOs Biodamar, YPPN, WWF-Kalbar conducted community surveys and mapping,

Over 37 Indonesian students and eight faculty from University of Tanjungpura, KALBAR and six local NGOs participated in the surveying and mapping from 1999-2002.

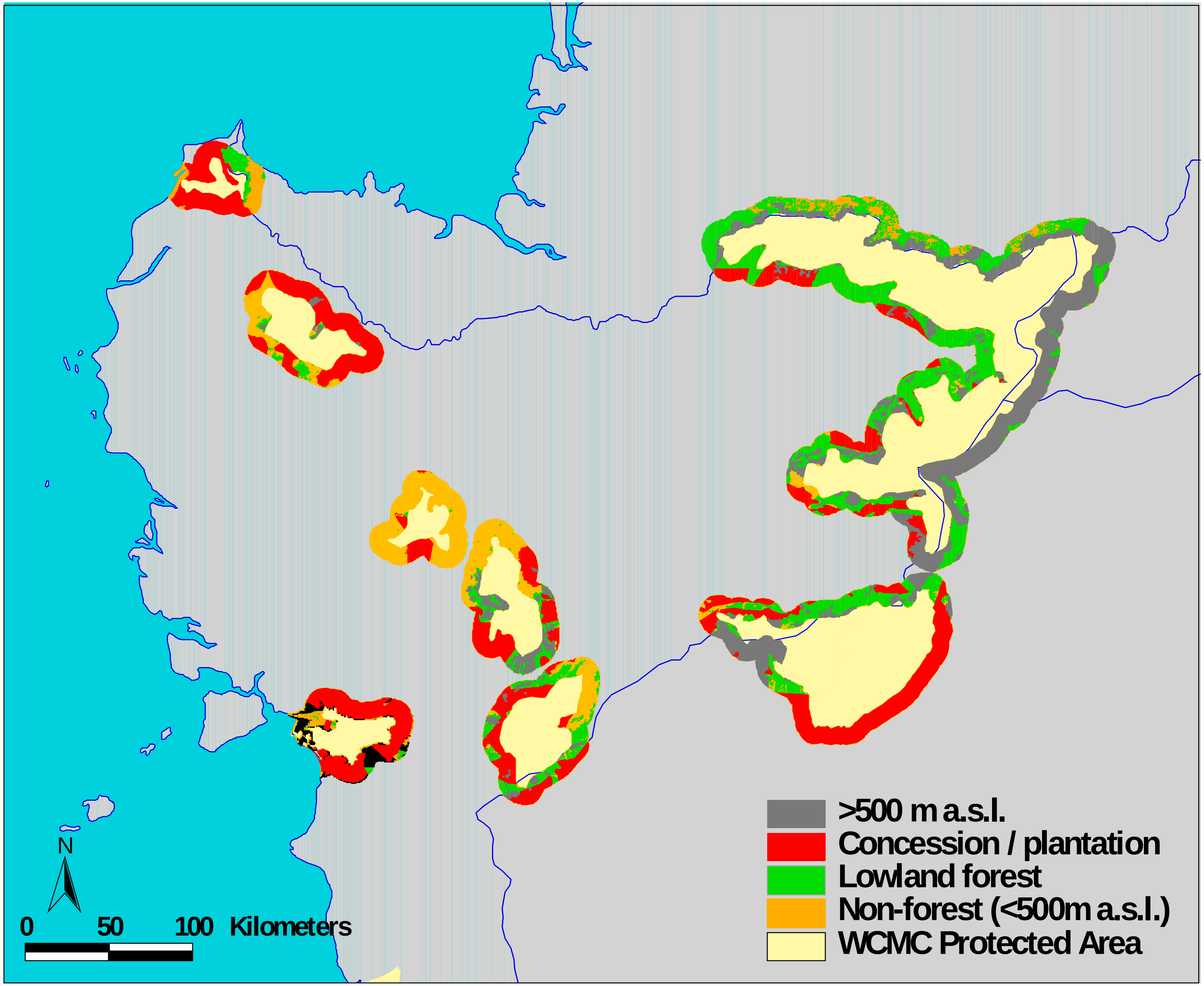
Drs. Evan Blumer, Director The Wilds, Jill Belsky (U of Montana); and Jefferson Fox (East West Center, Hawaii) Post doctoral fellows: Amity Doolittle and Simon Trigg; Michigan Lab Group: C. O Connor, G. Paoli, T. Gorog, E DeMattia, A. McEuen and D. DeJoode & Yale FES Lab Group: F. Miller, G. Lee, K. Peay, J. Balch, E, Jones, K. Karanth, D. Morton, J. Grimm; and A. MacDonald (U Maryland)

Financial Support: NASA Earth Sciences Program, US Agency for International Development (USAID), World Bank (Indonesian Mission), NSF BE-CNS, Fulbright Foundation, Conservation Food and Health, Tropical Resources Institute, Santa Fe Institute, Southeast Asian Studies and International Studies, Yale FES, University of Michigan

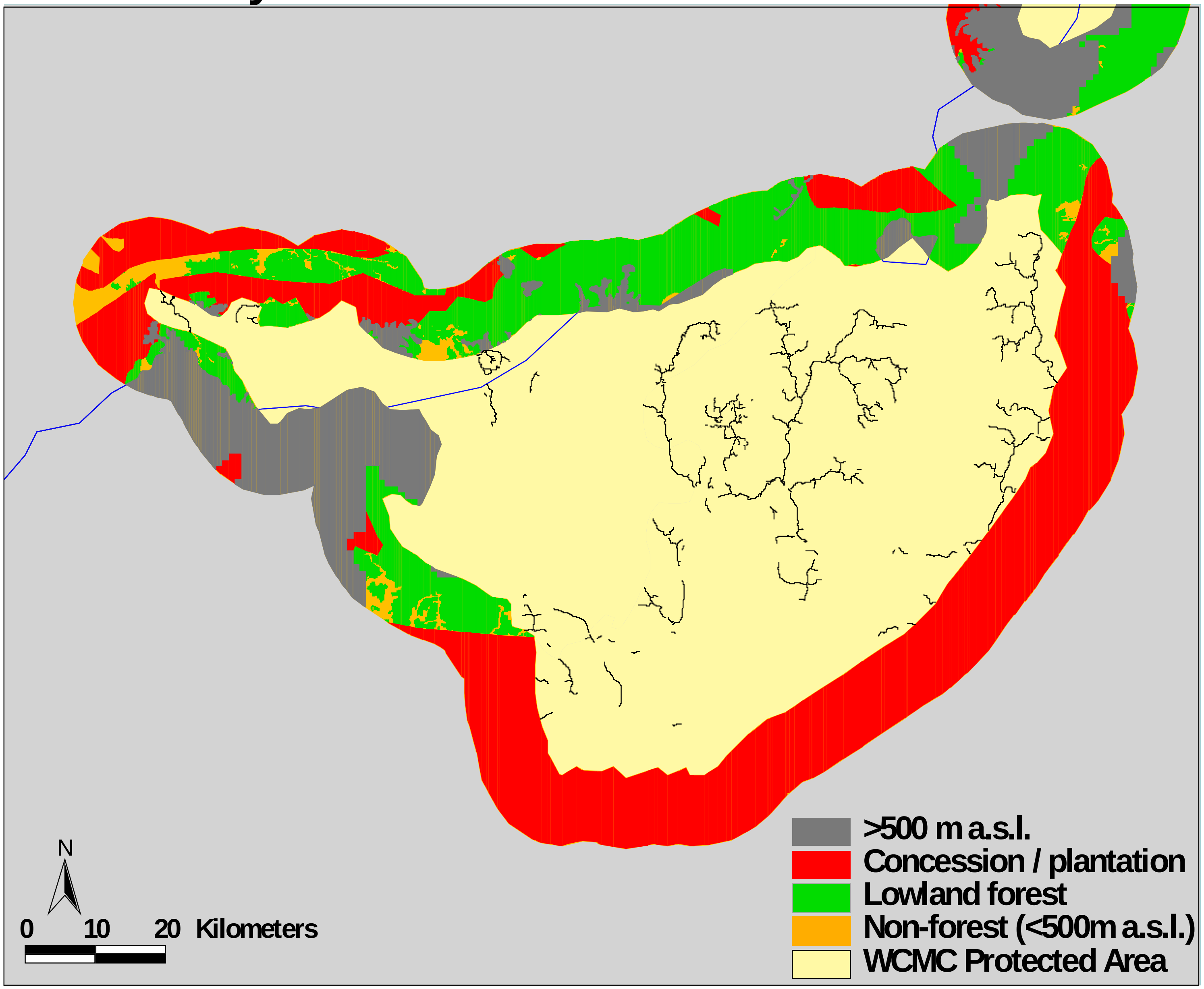
1988



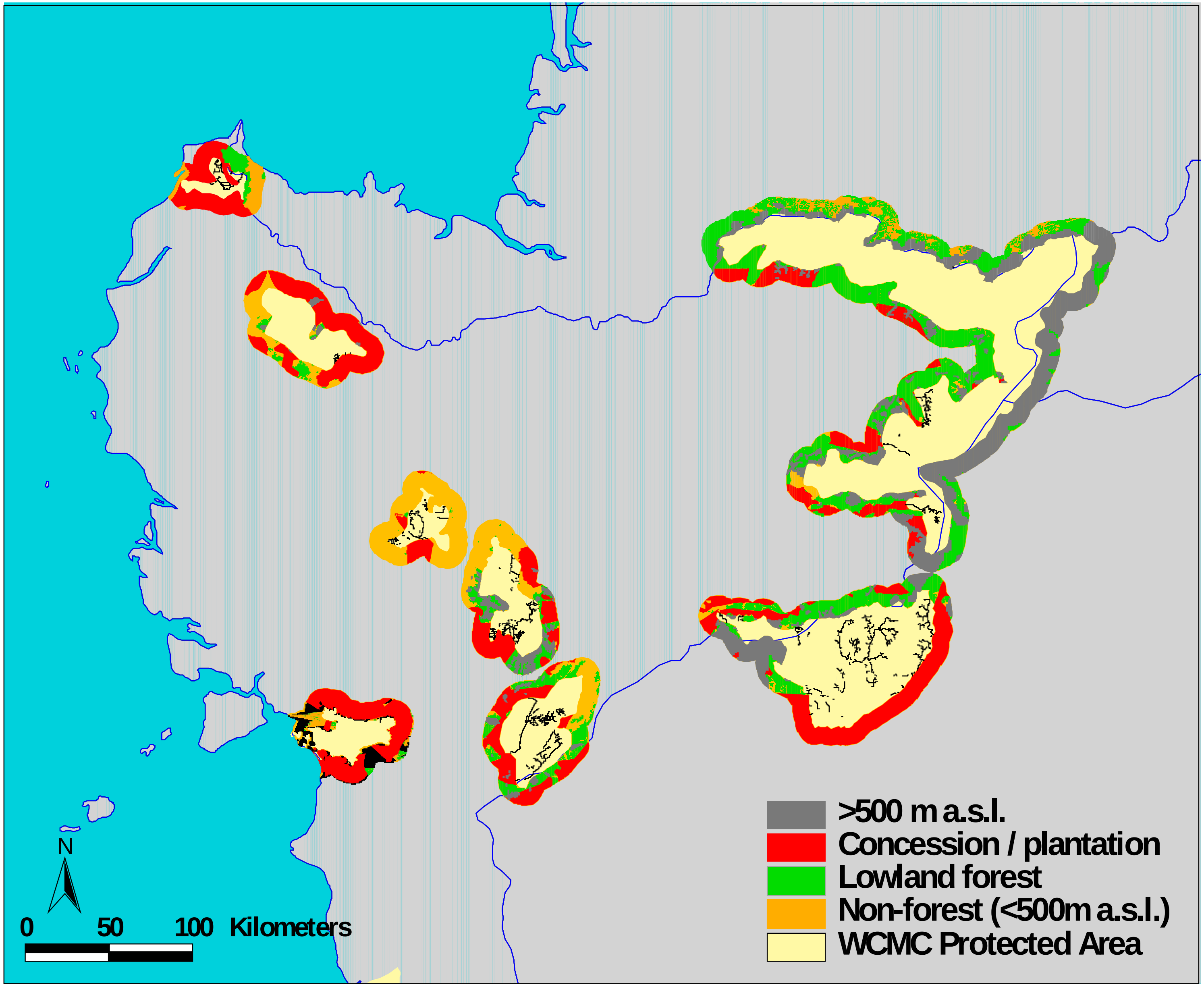
Analysis of 10km Buffers Surrounding WCMC Protected Areas in West Kalimantan

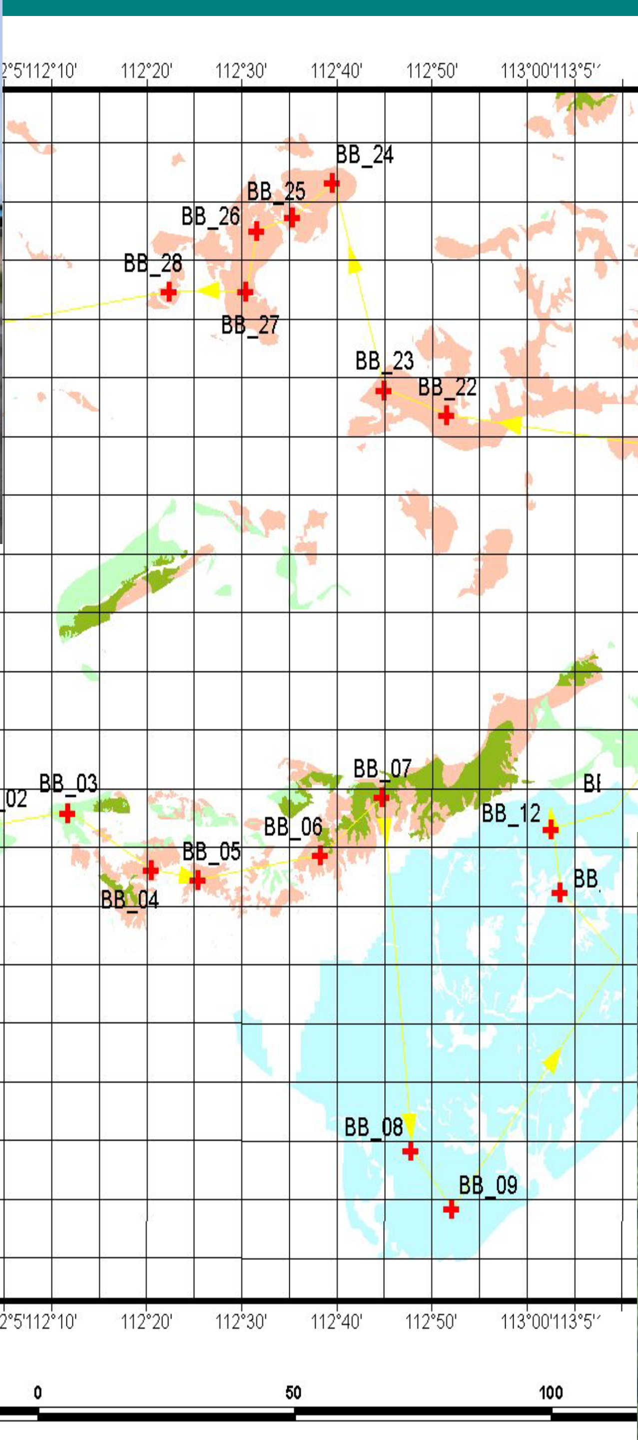


Logging Roads Digitized from TM Within Bukit Baka National Park/ Bukit Raya Nature Reserve in West/Central Kalimantan



Roads Within WCMC Protected Areas in West Kalimantan




112°5'112°10'
112°20'
112°30'
112°40'
112°50'
113°00'113°5'
BB_24
BB_25
BB_26
BB_28
BB_27
BB_23
BB_22
0°15'
0°20'
0°25'
0°30'
0°35'
BB_01
BB_02
BB_03
BB_04
BB_05
BB_06
BB_07
BB_12
BB_08
BB_09
0
50
100