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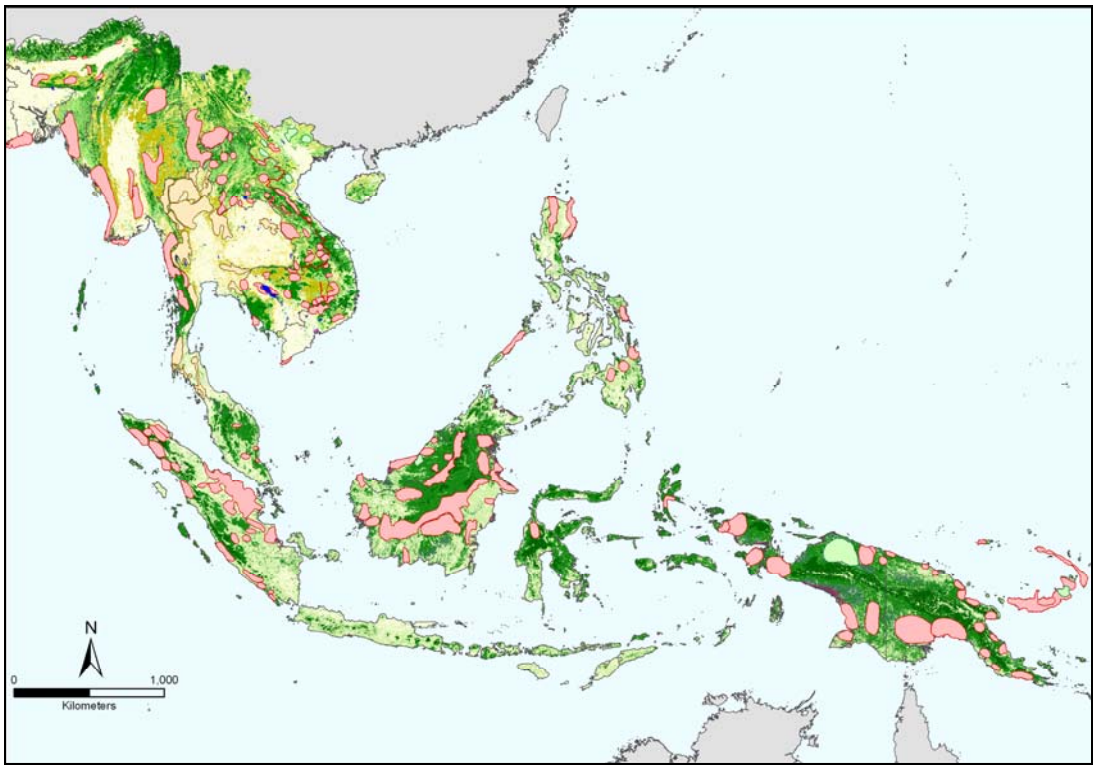

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Forest Cover Change in Southeast Asia
- The Regional Pattern -

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Abstract

This document provides an overview of the present pattern of forest change in Southeast Asia at a regional scale. Areas of forest change were identified and approximately delineated by a team of national and regional experts. This was done in the context of sub-regional workshops, held in Vientiane (Laos) and Jakarta (Indonesia) at the beginning of 2007. The main processes of forest change are described, providing indications on the time scale, intensity and the main causes for the change. The regional change pattern established from this information shows that most of the accessible forests in Southeast Asia, and specifically the lowland forests, are experiencing change. The most evident cause of forest loss is the conversion of forest to cash crop plantations. The establishment of timber plantations and timber exploitation, including illegal logging, are responsible for considerable change of forest canopies and structure. The geographical layer established from this information will serve for stratification of the region's forest cover, to be used for a remote sensing based sampling approach in the context of regional forest monitoring. It can also provide useful background information for regional forest and conservation strategies.

Contents

Acronyms and Abbreviations

ADB	Asian Development Bank
ACTO	Amazon Cooperation Treaty Organization
ASEAN	Association of Southeast Asian Nations
A&R	Afforestation and Reforestation
CBD	Convention on Biological Diversity
CEOS	Committee on Earth Observation Satellites
COMIFAC	Commission en charge des Forêts d'Afrique Centrale
DG ENV	Directorate General Environment
DG DEV	Directorate General Development
DG RELEX	Directorate General External Relations
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resources Assessment
GCOS	Global Climate Observing System
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GTOS	Global Terrestrial Observing System
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
MRC(S)	Mekong River Commission (Secretariat)
NP	National Park
NTFP	Non-Timber Forest Products
PA	Protected Area
PFE	Permanent Forest Estate
PNG	Papua New Guinea
REDD	Reducing Emissions from Deforestation and Degradation in Developing Countries
TREES	Tropical Ecosystem Environment Observations by Satellites
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
WSC	Watershed Conservation
WRI	World Resources Institute

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1 INTRODUCTION

Two sub-regional workshops on 'Regional Forest Cover Change in Southeast Asia' were held in February 2007 in Vientiane (Lao P.D.R) and Jakarta (Indonesia), covering the sub-regions of continental and insular Southeast Asia, respectively. The workshops were organized by the European Commission's Joint Research Centre (JRC, Ispra, Italy), supported by the World Resources Institute (WRI, Washington, USA), and – for continental Southeast Asia – by the Mekong River Commission Secretariat (MRCS, Vientiane). The workshops are part of a number of workshops foreseen for the three tropical regions of Africa, Latin America and Southeast Asia in the context of JRC's Global Forest Monitoring activity.

2 BACKGROUND ON JRC'S GLOBAL FOREST MONITORING ACTIVITIES

The JRC Global Forest Monitoring activity (TREES-3) has been launched in 2007 in the context of the EU 7th Research Framework Program (2007- 2013). The new research activity builds on the expertise gained in former TREES (Tropical Ecosystem Environment Observations by Satellites) projects: TREES (1991-1995) and TREES-2 (1996-2000) have delivered a range of remote sensing techniques for mapping and monitoring of moist tropical forest cover at global scale (Malingreau *et al*. 1995; Achard *et al*. 2002).

The main goal of TREES-3 is to improve present knowledge of the extent of and change in tropical and boreal forest cover. This will be achieved by making intensive use of most recent satellite remote sensing technology, establishing regional forest cover maps, documenting forest change processes and deriving forest change estimates based on regional samples of satellite imagery.

The key objectives are

- to help in reducing uncertainties in global estimates of forest cover change and related carbon emissions with a focus on the tropics and boreal Eurasia,
- to provide information to European Commission services (DG ENV, DG DEV, DG RELEX) in support to the definition of policies in the framework of international agreements, such as UNFCCC and its Kyoto Protocol, CBD and UNFF.

The core activities include

- *Regional forest cover mapping* – at regional scales and based on satellite imagery of medium spatial resolution (250-300m), and
- *Forest cover change assessment* – based on a statistical sample of satellite imagery of high spatial resolution (10-30m) for the reference years 1990, 2000 and 2005. This component will be implemented in collaboration with and in contribution to the FAO Global Forest Resources Assessment 2010.

The main users addressed include – apart from the EC services – the scientific community (e.g. IPCC, CEOSS, GCOS, GOFC-GOLD), policy makers (e.g. Parties of the UNFCCC and other UN agreements), and – in the context of cooperation and scientific support – also international or regional organizations (e.g. FAO, ACTO, COMIFAC, ASEAN or MRC).

TREES-3 will further foster scientific cooperation with experts and institutions in the tropical regions.

3 WORKSHOP IMPLEMENTATION

3.1 WORKSHOP OBJECTIVES

The objective of the two sub-regional workshops was to generate from expert knowledge an up-to-date spatial overview of recent forest cover dynamics (deforestation, afforestation, degradation, amelioration) in Southeast Asia. In spite of the profound knowledge on local forest change available in the tropical countries and of regular reporting of forest change figures to the FAO Global Forest Resources Assessment (FAO 2007), it is difficult to maintain an up-dated overview of the spatial pattern of forest change at a regional scale. Such an overview, however, helps to better understand the spatial relationship of different change processes and their potential cumulative impact across country boundaries.

It can further serve to focus monitoring efforts on most significant areas of change. The idea of focusing forest monitoring on the most active zones of deforestation, so-called 'Hot Spots', was already proposed in the 1990s, for the purpose of rapid and efficient estimation of deforestation rates in the tropics (Myers 1993). The concept of expert-defined 'Deforestation Hot Spots' was then used in the context of the JRC TREES-2 project for stratified sampling with satellite imagery, where higher sampling intensity was assigned to the 'Hot Spot' stratum (Achard *et al*. 1998).

For the present sub-regional workshops this concept was loosened to a certain extent, attempting to provide a more general overview of the forest change pattern in Southeast Asia. Based on expert knowledge it would be possible to include also those areas where change is most likely to happen in the near future, which is of value for national and international policy makers.

3.2 GEOGRAPHICAL EXTENT COVERED

The geographical area covered by the workshops is hereafter referred to as 'region' of Southeast Asia, comprising the 'sub-regions' of (i) '*continental Southeast Asia*' (Myanmar, Thailand, Lao P.D.R – hereafter referred to as 'Laos', Cambodia & Vietnam) and of (ii) '*insular Southeast Asia*' (Malaysia, Singapore, Indonesia, East Timor, Brunei & Philippines) (Fig. 1).

Fig. 1: Geographical extent of the 'region' covered (Southeast Asia and countries included).

The geographical coverage was extended in the sense that the Northeast of India, Bangladesh and tropical parts of Yunnan (China) were included in the continental sub-region, whilst Papua New Guinea (Oceania), hereafter referred to as 'PNG', was described together with the insular sub-region of Southeast Asia.

3.3 MOTIVATION FOR GENERATING THE REGIONAL CHANGE PATTERN

Motivation to generate a new regional overview of the forest change patterns were:

- ***to provide an updated spatial overview of forest change in Southeast Asia***

  The spatial presentation of the regional pattern of forest change highlights spatial links and potential cumulative impact of forest change across country boundaries. Such information helps to understand environmental threat levels and driving forces of change in a regional context, which can support regional policies as for example of the European Union, of regional institutions like ASEAN, of international donors or of the UN conventions. The geographical layer will be made freely available on the Internet and can be used by anybody for any purpose.

- ***to support stratification for regional, satellite-image-based forest change assessment***

  The *pre-stratification* of regional forest cover in strata of different level of expected change will support the envisaged TREES-3 and FRA 2010 sampling approach, which is based on a 1° x 1° systematic geographical grid. An examination of the extent to which an increased sampling intensity in the 'high change' stratum can improve sub-regional and possibly permit national forest change estimates needs to be carried out. In addition, there is potential for a *post-stratification* of the existing sample units.

- ***to enhance the interpretation of high resolution satellite imagery***

  The *a-priori* and possibly complementary information collected on forest change will support the interpretation of change features from satellite imagery, foreseen in the context of the TREES-3 regional forest cover change assessment.

- ***to derive information on driving forces and changes not visible on satellite imagery***

  The use of expert opinion makes it possible to get an idea of processes and driving forces that are not provided by remotely sensed satellite information. Processes like forest degradation, which are difficult to identify from satellite imagery, in all likelihood affect an area larger than that affected by active deforestation. The regional change pattern will allow assessing the extent to which such processes are reflected by the regional TREES-3 change assessment.

- ***to assess the threat level of forest change in a regional context***

  The change pattern can help to identify those areas for which the probability of future change is high. This may contribute directly to the debate in the fields of conservation, avoiding deforestation and reducing emissions from deforestation and degradation in developing countries (REDD).

- ***to provide complementary input to regional vegetation modelling***

  The new spatial layer will provide complementary information on forest change, of potential use for regional scale environmental and ecological risk analysis or for vegetation modelling in the context of climate change.

3.4 APPROACH AND CRITERIA

Aiming at an approximate stratification of the region's forest cover, the principal approach was to identify all areas experiencing major forest change and assuming the remaining forest cover as less likely to be exposed to change.

A team of experts with a profound knowledge of the region's forests identified and located to the best of their knowledge all areas of recent forest change. These areas were delineated on the TREES regional forest cover maps of Southeast Asia (Stibig *et al*. 2003 & 2004) of scales of 1:4-5 million, underlining the regional character of the approach. Boundaries and spatial extent of these areas would be indicative and not intended to provide a degree of detail or accuracy as required for example for local-scale forest inventory, land use planning or conservation purposes.

The sole criterion for identification was 'forest change' of relevance in the regional context. Change areas were therefore identified independent of whether the change was due to natural or anthropogenic factors, planned or uncontrolled, caused by legal or illegal intervention or resulting from sustainable or unsustainable forestry. Neither was the importance for biodiversity (endangered habitats or species) the decisive criterion for selection. The impact of the change was not further assessed.

The identification of change areas was performed in sub-groups, splitting the sub-regions into geographical sub-zones. It was tried to include for each sub-group views from forestry experts and also experts in nature conservation. Change areas were identified when there was consensus by the teams. In cases where the available expertise was considered insufficient, complementary information was sought after the workshop.

The main change processes, the type of forests concerned, the speed and time scale of change, and the main causes and driving forces were described for each identified area, using a standardized questionnaire (see Annex), but leaving opportunity for additional remarks.

Taking into account that expert knowledge is based on judgement and not on measured variables there were no strict criteria imposed for the identification of change areas. For assuring consistency across the region the following was used as a guideline:

Change areas

- would include a major conversion of forest cover to non-forest (deforestation) or vice versa (afforestation, reforestation, protection of non-forest areas for natural re-growth),
- would include areas of significant change of canopy cover density or structure (degradation, amelioration), deemed to have a long-term impact on the sustainable development, on forest functions (ecosystem stability, soil-water protection, biodiversity) or on protected areas,
- should have a minimum width of approximately 1cm on the regional forest maps – corresponding to about 40-50 km in diameter, permitting also some non-forest portions to be included,
- should indicate notably higher change than occurring in non-delineated forests,
- would be identified independently from the causes (natural-anthropogenic, planned-uncontrolled, legal-illegal, management related).

There was no intention

- to identify all areas where change is due to sustainable forest operations in existing production forests, with little and short-term impact on forests and their functions.
- to identify areas only because of their high ecological value (threatened habitats and species).

3.5 EXTERNAL DATA SETS USED

External data sets were used for displaying country boundaries and protected areas.

Country boundaries were extracted from the FAO data set '*Coastline and International Boundaries of the World*' (http://www.fao.org/geonetwork) and from the ESRI (Environmental Systems Research Institute) data set '*ESRI Data & Maps*' (http://www.esri.com/data/data-maps/overview.html).

Protected areas were derived from the World Database on Protected Areas (WDPA) of UNEP-WCMC, the IUCN World Commission on Protected Areas and the World Database on Protected Areas Consortium (http://sea.unep-wcmc.org/wdbpa/index.htm), including all national protected areas of known boundaries (IUCN categories I-VI and areas without IUCN categories).

4 FOREST COVER CHANGE IN SOUTHEAST ASIA

4.1 MAIN FOREST FORMATIONS

The forests of Southeast Asia comprise some of the world's most valuable and productive tropical forests, forming unique ecosystems of high biodiversity composition. The following overview refers to detailed descriptions of forest types and characteristics in literature (Champion & Seth 1968; Whitmore 1984; Lamprecht 1989; Collins *et al*. 1991; Goldammer 1993; Saunders 1993; Rundel & Boonpragob 1995; Blasco *et al.* 1996; Spadling *et al*. 1997; Schulte & Schöne 2001; Smith 2001, Page *et al*. 2002):

In continental Southeast Asia moist tropical evergreen rain forests are of a rather small extent, for example in southern Myanmar, Thailand or Cambodia. Most evergreen forests are dry evergreen and semi-evergreen, occupying mostly the mountainous zones. Seasonal forests are widespread in the monsoon dominated sub-region: Moist and dry 'mixed deciduous forests', of different composition in 'upper' and 'lower' elevations, stretch from the northeast of India through Thailand and Laos to Cambodia and Vietnam. Depending on site conditions these forests contain a varying mix of evergreen and deciduous species (=semi-deciduous), shedding leaves at varying degree and timing during the dry months. They comprise some of the most valuable timber species, such as teak (*Tectona grandis*). Very dry forests and woodlands (Dry *Dipterocarpus* forests) occupy plains, plateaus and other sites, where soils are shallow and water is a limiting factor. These forests turn almost leafless at the peak of the dry season and are frequently affected by human activities and fires. Mangrove forests are still present along the Andaman coast of Thailand and Myanmar, and in the deltas of the Irrawaddy and the Mekong rivers. The *Sundarbans* of India and Bangladesh represent the world's largest mangrove area.

In insular Southeast Asia the majority of forests are moist evergreen tropical rain forests, consisting to a large extent of highly productive *Dipterocarpus* forests. Heath forests ('Kerangas') grow on nutrient-poor soils, for example on Borneo. There are still extensive mangrove forests areas on Borneo and New Guinea, although many of them have faced depletion and degradation in the last decades. In the lowlands of Sumatra, Borneo and of New Guinea there are still large areas of swamp and peat swamp forests, the latter store large amounts of organic carbon in their peat layer. In Indonesia's Papua province (former Irian Jaya or West Papua) and in PNG tropical mountain forests reach at altitudes above 3000 meters, including for example *Nothofagus* and *Podocarpus* forests.

4.2 FOREST CHANGE RATES IN SOUTHEAST ASIA

Forest loss in Southeast Asia has remained at high levels also during the period from the year 2000 to 2005, accumulating to an annual deforestation rate of about 2.76 million ha or 1.3% of the region's forest area (FAO 2007). In Indonesia alone the moist tropical forests experience an annual loss of almost 1.9 million ha, corresponding to an annual deforestation rate of some 2% (Table 1). High forest loss is reported also by Myanmar and Cambodia, with annual deforestation rates of 466,000 ha (1.5%) and 219,000 ha (2%), respectively (FAO 2007). For the whole region, the annual net loss remained at the same level as reported for the 1990s (2.79 million ha). PNG's annual deforestation rate is estimated at 0.5% or 139,000 ha. In India (S-Asia) forest cover has increased in the recent past due to the establishment of forest plantations.

Table 1: Forest area and change in Southeast Asia and neighbouring countries *

Country (whole)	Total Forest Area	% Land	Forest Plantation Area	Annual Change 1990-2000		Annual Change 2000-2005	
	(1000 ha)	(%)	(1000 ha)	(1000ha)	(%)	(1000 ha)	(%)
Bangladesh	871	6.7	279			-2	-0.3
Bhutan	3,195	68.0	2	+11	+0.3	+11	+0.3
India	67,701	22.8	3,226	+362	+0.6	+29	
Nepal	3,636	25.4	53	-92	-2.1	-53	-1.4
Sri Lanka	1,933	29.9	195	-27	-1.2	-30	-1.5
Brunei	278	52.8	-	-2	-0.8	-2	-0.7
Cambodia	10,447	59.2	59	-140	-1.1	-219	-2.0
Indonesia	88,495	48.8	3,399	-1,872	-1.7	-1,871	-2.0
Lao P.D.R	16,142	69.9	224	-78	-0.5	-78	-0.5
Malaysia	20,890	63.6	1,573	-78	-0.4	-140	-0.7
Myanmar	32,222	49.0	849	-466	-1.3	-466	-1.4
Philippines	7,162	24.0	620	-262	-2.8	-157	-2.1
Thailand	14,520	28.4	3,099	-115	-0.7	-59	-0.4
Timor(Leste)	798	53.7	43	-11	-1.2	-11	-1.3
Vietnam	12,931	39.7	2,695	+236	+2.3	+241	+2.0
PNG	29,437	65.0	92	-139	-0.5	-139	-0.5
Total	**310,658**		**12,653**	**-2,673**		**-2,946**	

** source: FAO 2007, based on country reporting;*

Indeed, the loss of natural tropical forests might be even higher: (i) The reported figures are based on national forest inventories and refer to forest land, which may include un-stocked forest areas. (ii) The change estimates are net figures, taking into account areas of forest re-growth and of forest plantations. The latter are in many aspects not an adequate replacement for natural forests. (iii) Last not least, some uncertainty and heterogeneity is due to the fact that national inventories may differ in terms of reference year, methodology, but also in inventory intensity and accuracy.

The continuing loss of forests in Southeast Asia is alarming not only in terms of the sustainable development of the forest resources, but specifically for biodiversity conservation. Asia is one of the regions of the world with the highest number of vulnerable species. Indonesia, for instance, has the largest number of critically endangered species (122), whilst Malaysia is home to the largest number (403) of vulnerable species (FAO 2007).

For the 1990s the JRC TREES-2 project estimated the deforestation rate for Southeast Asia based on a pan-tropical sample of satellite imagery. TREES-2 made use of a stratified statistical sample of satellite imagery (Fig. 2), where a so called 'Deforestation Hot Spot' layer served as one parameter for stratification and for the choice of sampling intensity (Achard *et al.* 1998). The study confirmed the order of magnitude of forest loss in the 1990s (Achard *et al*. 2002), estimating deforestation for Southeast Asia – the humid forests of India and PNG included – at 0.91% (Table 2). In addition, the 'satellite-image-visible' annual forest degradation rate (closed to open forest and fragmentation processes) was estimated at 0.42%, which is considered, however, to be only a fraction of the total forest area concerned (visible & not visible degradation).

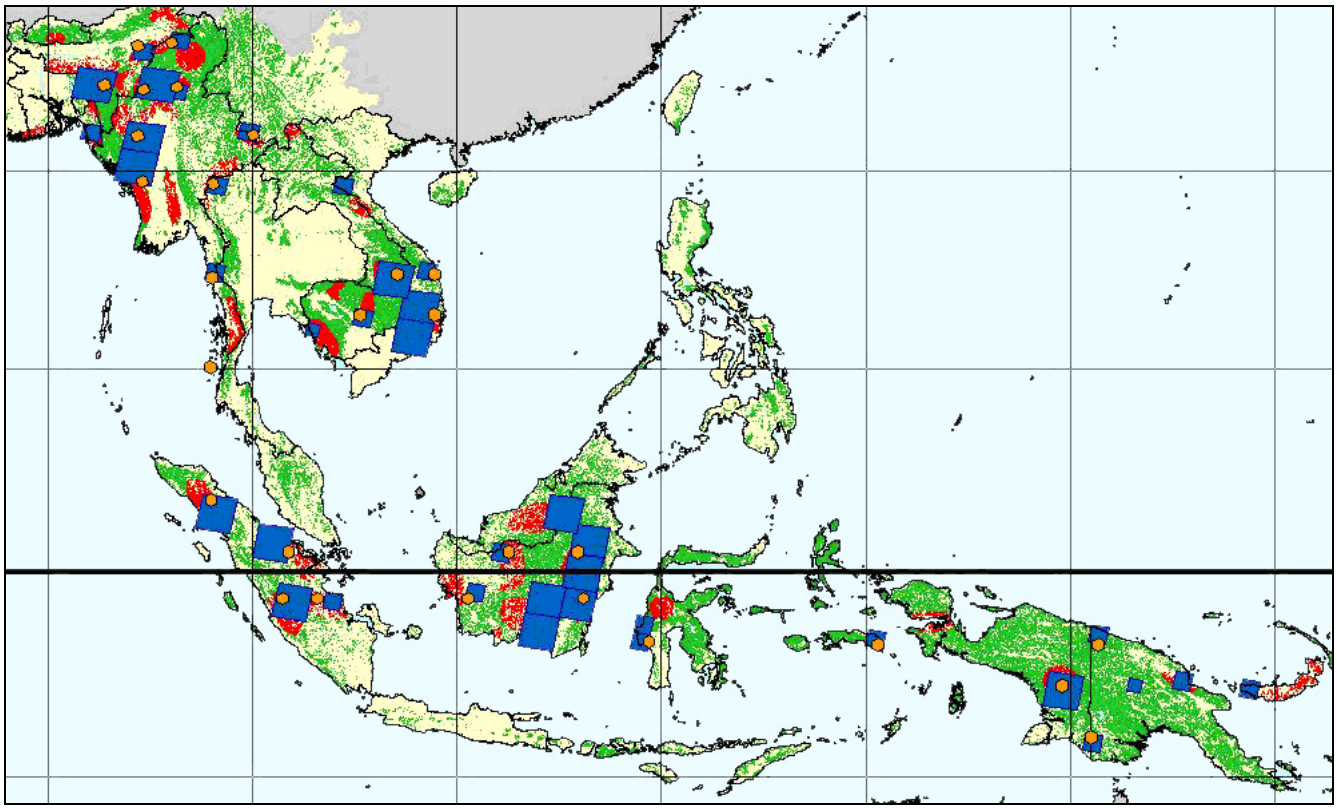

Figure 2: TREES-2 Stratified sample for Southeast Asia & PNG (green= forest cover; red= Deforestation Hot Spots in the 1990s; orange = sample units; dark blue = satellite imagery ultimately used for change assessment).

Table 2: Forest cover area and change estimated by the TREES-2 project for the humid tropical forest domain of Southeast Asia, including India and PNG (Achard *et al*. 2002)

Southeast Asia	**Area*** **(10^6 ha)**	**Rate (%)**
Total study area	446	
Forest cover in 1990	283 ±31	
Forest cover in 1997	270 ±30	
Annual deforested area	2.5 ±0.8	0.91
Annual re-growth area	0.53 ±0.25	0.19
Annual degraded area**	1.1 ±0.44	0.42

* error ranges are at the 95% confidence level
** canopy disturbance and fragmentation visible on satellite imagery

5 THE REGIONAL PATTERN OF FOREST CHANGE IN SOUTHEAST ASIA

The areas of major forest change identified during the two workshops are spread throughout the whole of Southeast Asia, their location and extent is displayed in the Figures 3 & 4. The vast majority of these change areas indicate ongoing processes of major forest conversion or decrease in forest canopy density or structure, however, there are also some areas of major afforestation and reforestation.

In almost all areas change is caused by a combination of different processes. For display only the most dominant or the most severe type of change (e.g. '*conversion'* compared to *'decrease of canopy'*) is indicated, along with the process closest to the present (e.g. '*ongoing now, fast* compared to *'last 3-5 years*). The complete and detailed information is provided in Table 4, including indications on the main reasons for the change. Information on the status of the forest is provided if available. The link between area identification number (ID) and location is given in Figure 12.

In continental Southeast Asia most of the change areas are located in Laos, Myanmar and Cambodia, the latter two reported also the highest change rates on the continent (Table 1). Change appears to be rather local in north eastern India, some degradation and forest loss was identified for Bangladesh, whilst areas with an increasing forest cover (plantations) were highlighted in Vietnam. Changes in Thailand were classified as less severe and dispersed in comparison to the neighbouring countries, but were included in the report because of their potential impact on the remaining and often protected forests. The high mountain zone of northern Myanmar and India was considered as having remained intact and undisturbed. In insular Southeast Asia the dense change pattern on Sumatra, Sarawak and Borneo reflects the ongoing rapid forest loss, particularly in the lowlands and lower elevations, and also the remaining mountain forests of the Philippines are under continuing pressure. The change pattern on the island of New Guinea still represents mainly canopy density changes.

It should be noted, that this regional change pattern does not necessarily cover 'historical' change. It would be therefore misleading to interpret all forests not covered by this pattern as 'un-disturbed' or even 'un-touched' (see chapter 6).

As the change pattern has been compiled from expert knowledge and is not based on measured parameters, there is certainly a component of heterogeneity and of subjective judgement.
For example, some change might have been missed due to a lack of information, or the ranking of the importance of a change might not be similarly shared by everybody. In some cases detailed knowledge might have led to a higher number of smaller and more precisely described change areas, whilst the extent of other areas might be in a broader outline with a more general description of processes. However, at the regional scale such variation was not considered a major drawback. On the contrary, expert knowledge provides a lot of information that is not obtainable from Remote Sensing. This concerns the whole context of change processes, estimates on the velocity of processes and judgements on change to be expected in the near future.

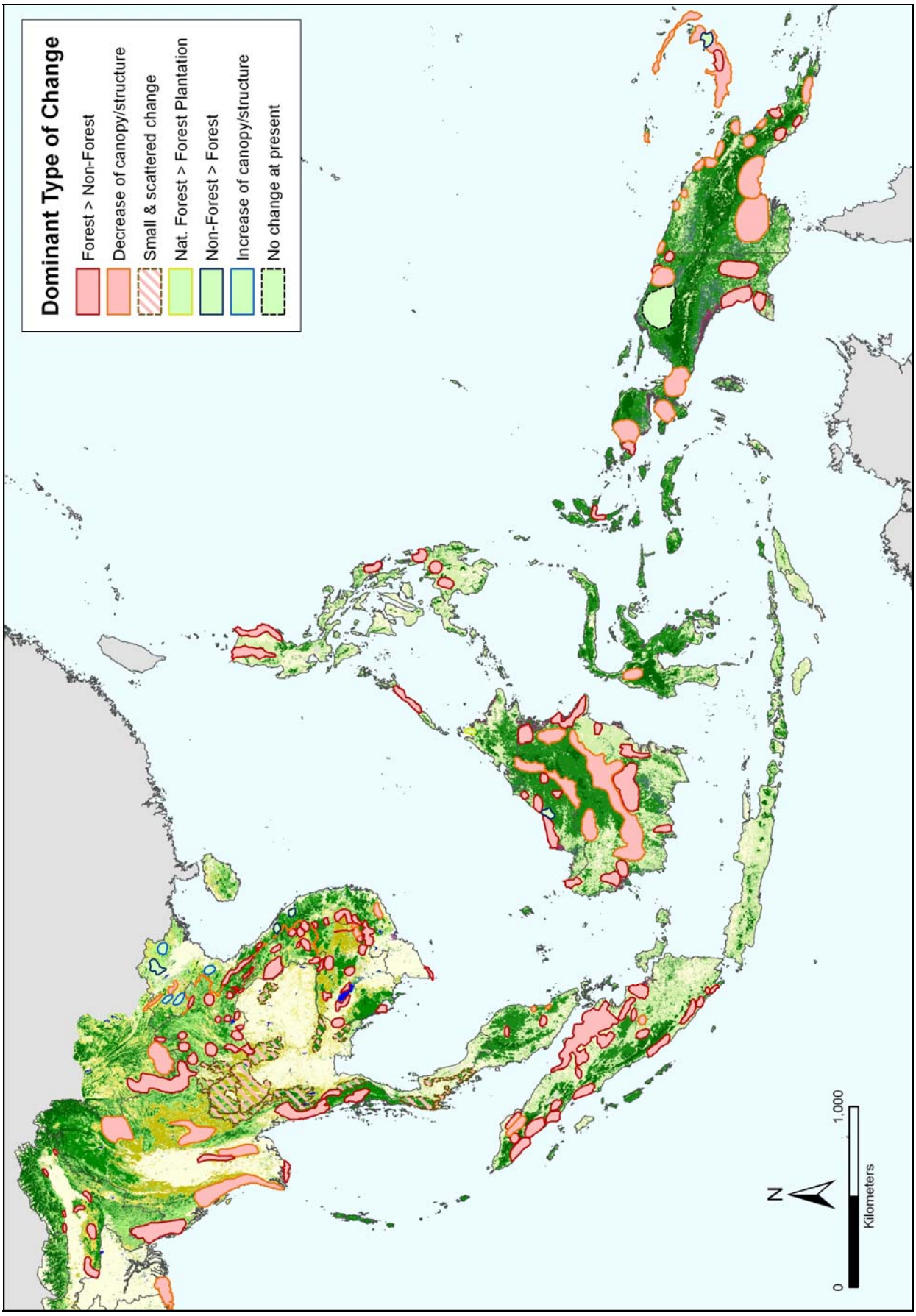

Figure 3: Regional pattern of forest cover change in Southeast Asia: main change processes. Background: TREES regional forest cover map: evergreen and semi-evergreen forests = *dark green*; dry deciduous forests = *orange*; mangrove forests = *deep purple*; woodland, shrub-land, mosaics = *light green & yellow*; other land cover = *white & beige*.

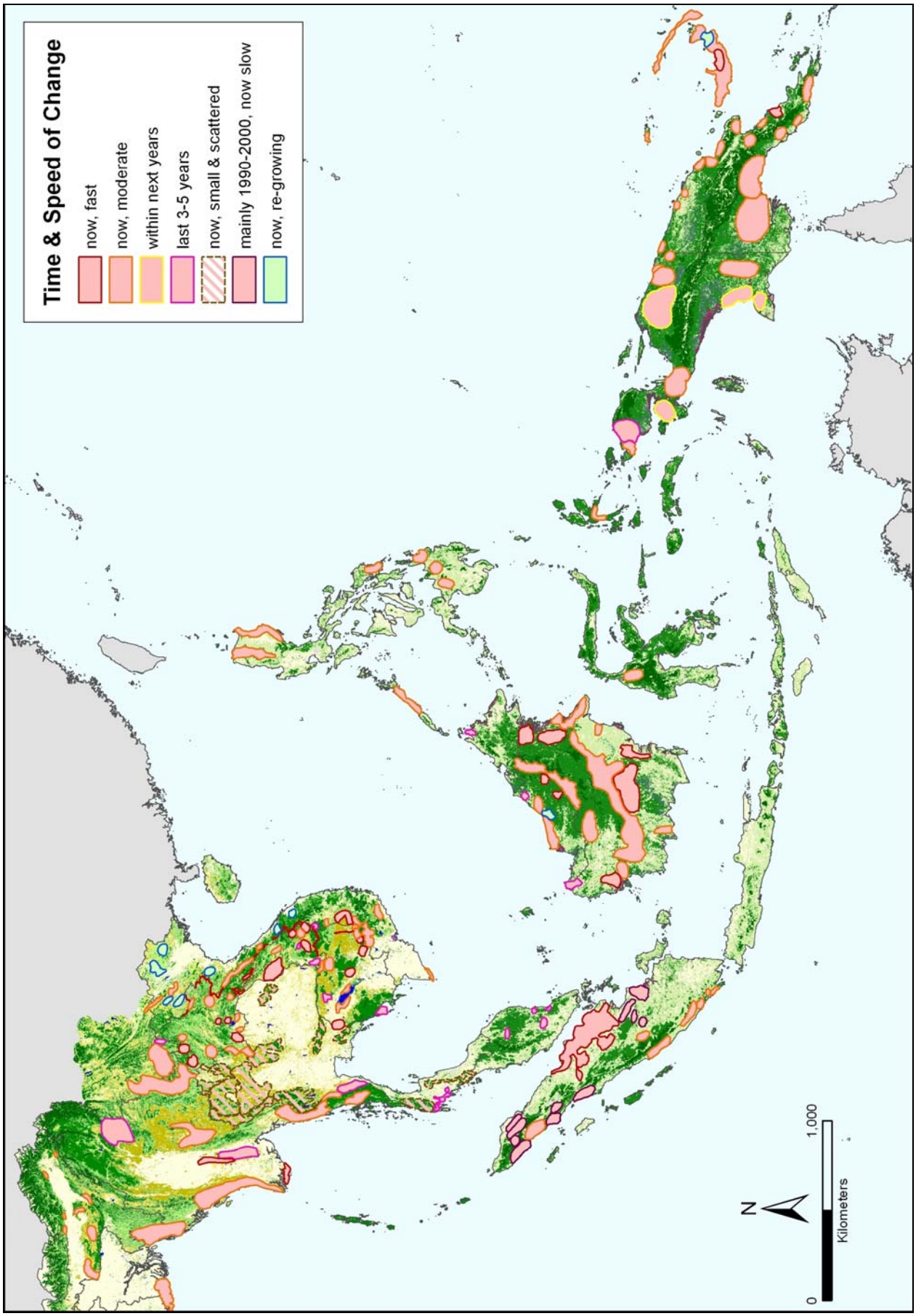

Figure 4: Regional pattern of forest cover change in Southeast Asia: time scale of change (legend of background map = see Fig.3).

At sub-regional levels change areas are displayed at more detail (chapters 5.1 and 5.2), the outline colour coding indicates the main change type, the numerical label the related time scale (Table 3).

Table 3: Coding of change processes for display at sub-regional level (Figs. 5, 6, 8-10)

Outline colour code: Type of change		Numerical Code: Time and speed of change	
	= conversion: forest → non-forest	**1**	= now, ongoing at fast speed
	= decrease of canopy / structure	**2**	= now, ongoing at moderate speed
	= small & scattered change	**3**	= within next years
	= natural forest → forest plantation	**4**	= last 3-5 years
	= conversion: non-forest → forest	**5**	= now, small & scattered
	= increase of canopy / structure	**6**	= mainly 1990-2000, now slow speed
	= no change at present	**7**	= now, (re-)growing

5.1 THE CHANGE PATTERN IN CONTINENTAL SOUTHEAST ASIA

The detailed change pattern obtained for continental Southeast Asia is displayed in Figures 5 and 6 (coding: see also Table 3), with the TREES sub-regional forest cover map in the background.

Most areas of forest loss and degradation can be found in the hilly zones of the sub-region and along the mountain ranges, which are mainly occupied by evergreen or semi-evergreen forests (e.g. Chittagong Hills in Bangladesh, the Arakan Yoma, Pegu Yoma and Bilauktaung mountains in Myanmar, the Annamite Highlands in Laos and Vietnam or the Cardamom Mountains in Cambodia). Change areas in evergreen lowland forests are mainly confined to the flatlands of Cambodia, and to mangrove and swamp forest areas in the river deltas and the Tonle Sap lake area (Cambodia), respectively. Change areas are, however, also located in the deciduous forest domain, as for example in central Myanmar, in the Mekong plain of central and southern Laos, or in the Srepok river plain of central Vietnam. Change areas are further frequently located along country boundaries where efficient control of land use and forest operations is difficult, like for example between Myanmar and Yunnan, between Laos, Cambodia and Vietnam, or between Cambodia and Thailand. Changes are less severe and rather dispersed in the change areas identified for Thailand, however, they often affect buffer zones and forest edges of protected areas. There is little change in those zones dominated since decades by shifting cultivation, as for example in northern Laos and northern Vietnam, where forest remnants have often only remained on steeper slopes. Most of the identified afforestation and reforestation areas are located in northern Vietnam on these formerly deforested mountain sites. Only few change areas were identified in the remaining forests of Vietnam, reflecting a tight control of land use and of protected areas. A large forest complex not affected by change remains in the northern mountains of Myanmar, stretching into Yunnan (China) and the north east of India. The main river plains of continental Southeast Asia, with the exception of parts in central and eastern Cambodia, have been cleared of forest cover already in historical times.

5.1.1 Conversion of forest cover

Conversion to cash crop plantation and agriculture

The conversion of forest to cash crop plantation is the most important cause of forest loss in Cambodia, Laos and Myanmar, it also plays a role in southern Yunnan (China) and in the central and southern highlands of Vietnam. The main driving force is the establishment of plantations for the production of rubber, coffee, tea, cashew nuts, cacao, coconut and sugarcane, and in the southern part of the sub-region also for palm oil. In recent years such conversion appears to have much stronger impact on the remaining forest cover than logging and timber exploitation. Indeed, Laos and Cambodia appear to be

facing waves of forest conversion to cash crop plantations, often uncontrolled and linked to incentives for foreign investment and to foreign demand. Such conversion occurs frequently in the context of contractual relations between (small holder) farmers and the large, foreign agro-business (contract farming).

- The expansion of rubber plantations is most evident in Laos and Cambodia, and there are plans to further increase rubber production (WRM 2006a). Rubber plantations remain a factor for forest loss in Thailand and in the central highlands of southern Vietnam.

- Forest conversion to oil palm plantations is an issue in the southern part of the sub-region, particularly in southern Thailand and southern Myanmar. However, some change areas are linked to oil palm plantation also in Laos and Cambodia, and the expansion of the plantation area is envisaged specifically in Cambodia and Vietnam (Lang 2002).

- The expansion of coffee, tea and cacao plantations is the main cause for the change areas in the central highlands of Vietnam (coffee, cacao), in the south of Laos (coffee), in parts of Thailand and southern Yunnan (tea).

- In central Myanmar forests are converted for agricultural expansion and specifically for paddy fields.

- The change areas identified in the coastal zones of Myanmar, Thailand and Vietnam are due to the establishment of shrimp farms at the expense of the remaining mangrove forests.

Forest conversion in the context of land speculation, tourism, resort development, Tsunami

There are forest change areas related to uncontrolled land 'grabbing' and encroachment, for example in Cambodia's southern and Siem Reap provinces, partly driven by land speculation with the intention of later sale (e.g. tourism investors). In Laos, smaller forest remnants in mixed landscapes frequently disappear after the purchase of land rights from local people by investors. The tourist and resort development causes still some forest loss in southern Thailand, where in addition the devastating impact of the 2004 Tsunami has left its mark on some coastal forest formations.

Shifting cultivation

In a regional context the impact of shifting cultivation was considered as secondary when compared to the other drivers of forest change. However, shifting cultivation and uncontrolled encroachment of land are still reasons for forest change in the north eastern provinces of India and in Bangladesh. Shifting cultivation by indigenous ethnic groups is still considered a major cause of forest loss in the mountain zones of Myanmar, where there is an increasing pressure for land by the growing population. Shifting cultivation causes some forest loss in northern Laos, although its expansion into the mainly secondary forests appears to be moderate. Instead, the cropping cycles are shortened in order to cope locally with an increasing population. Shifting cultivation still continues to cause some change in the forests of northern Thailand.

Hydropower projects

Several change areas identified in the upper Mekong tributaries of Laos are due to the establishment of hydropower projects and dams. The forests located above the high-water demarcation line are frequently encroached and 'illegally' logged, leading to uncontrolled loss of forest in the surroundings of the inundation area proper. A further expansion of such hydropower sites has to be expected due to the increasing demand for energy in the region (MRC 2003).

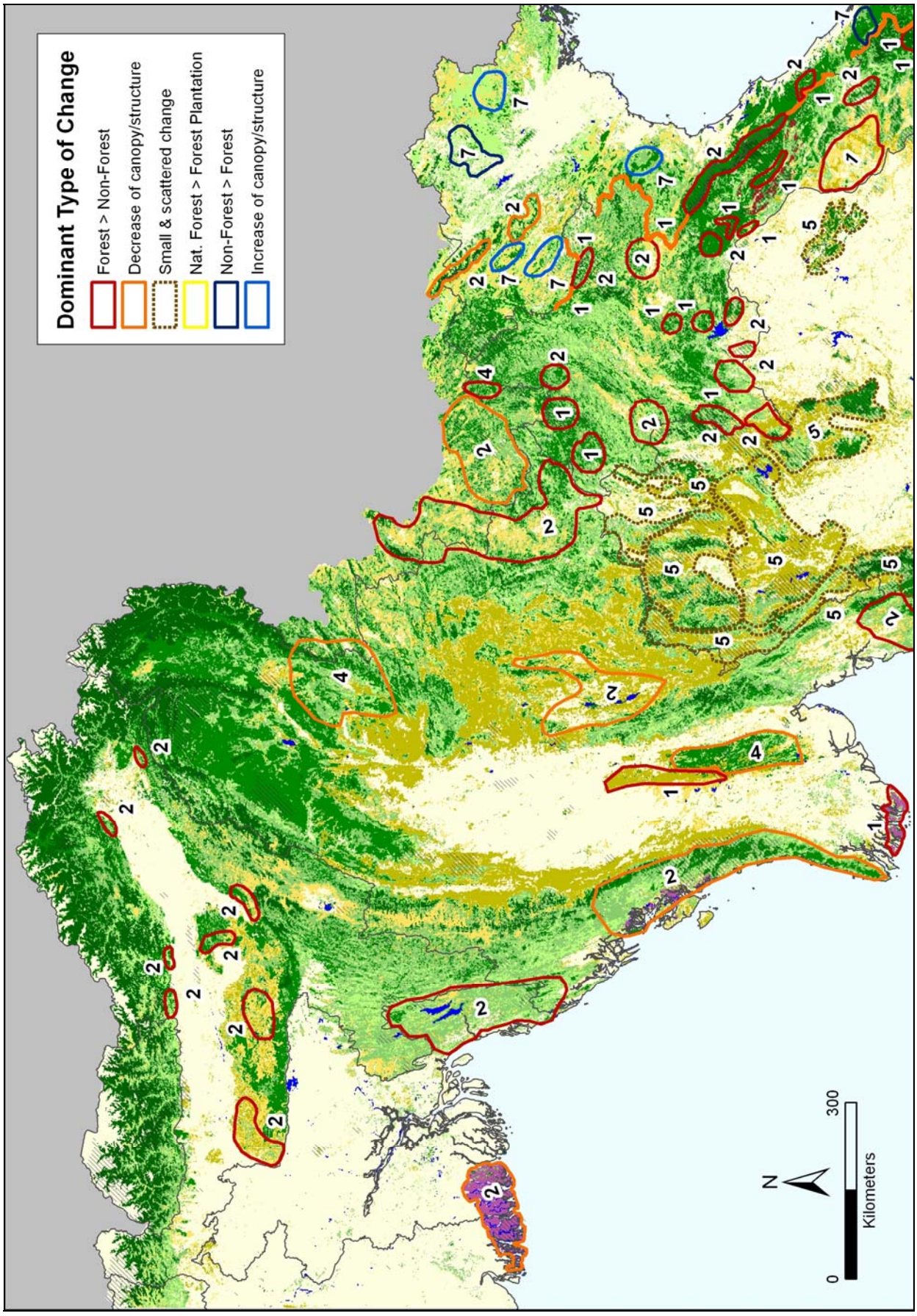

Figure 5: Change pattern in the northern part of continental Southeast Asia (numerical coding see table 3). Legend of background map: evergreen and semi-evergreen forests = *dark green*; dry deciduous forests = *orange*; mangrove forests = *deep purple*; woodland, shrub-land, mosaics = *light green, yellow*; other land cover = *white & beige*; Protected Areas = *hatched.*

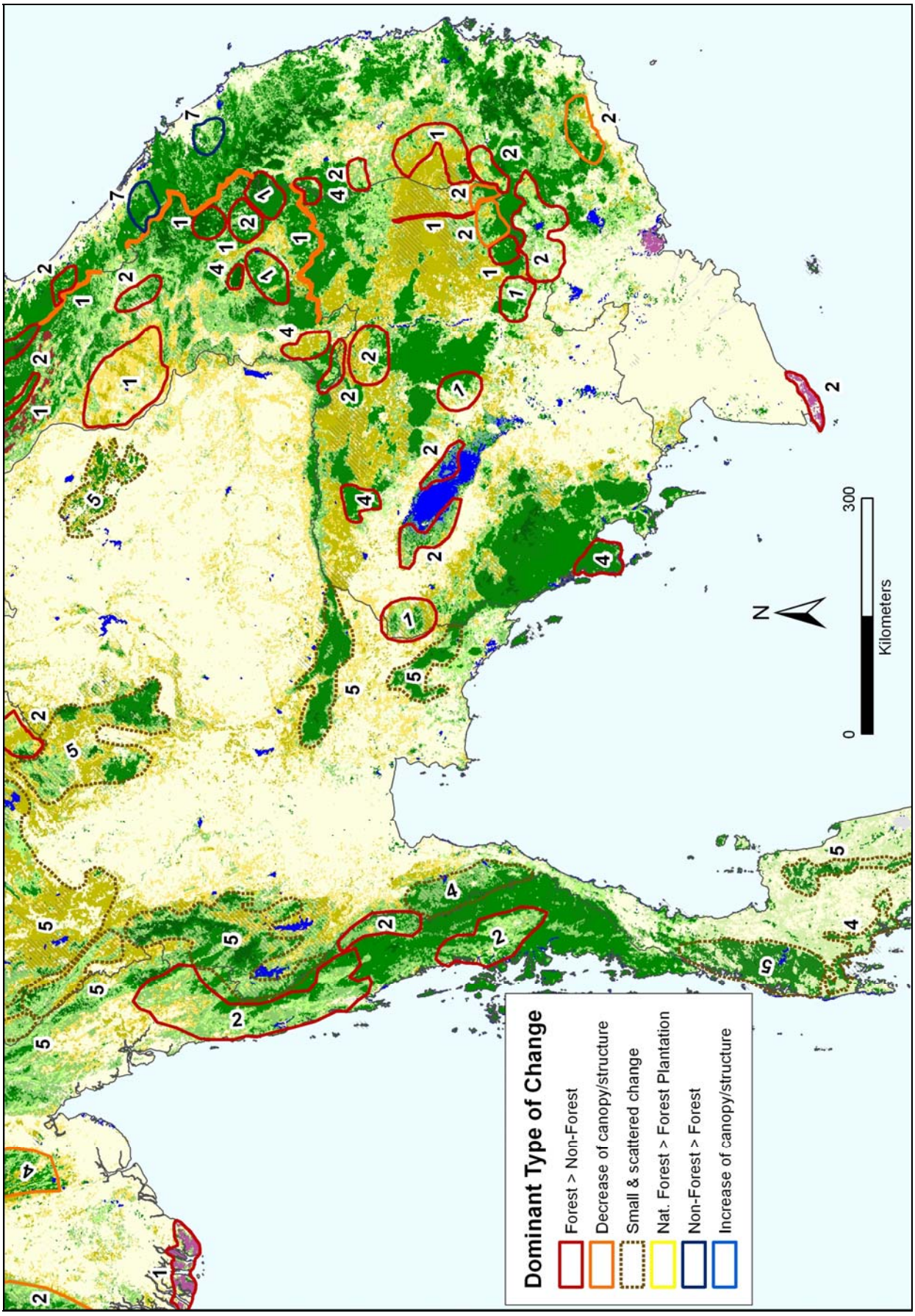

Figure 6: Change pattern in the southern part of continental Southeast Asia (numerical coding = see Table 3; legend of background map = see Fig.5).

Road construction

The construction of roads is a main cause of forest change along the north-south connection from China to Thailand through the northwest of Laos, and along the west-east connection from eastern Thailand to the coast of central Vietnam, through southern Laos. There is also forest change resulting from the road construction in the northern part of Cambodia, connecting to the south to Phnom Penh. Forest loss is not only a result of the clearing for the roads, but also of opening formerly less accessible forest areas, such as in the northwest of Laos. The envisaged development of the regional transportation and economic corridors (ADB 2004) will make forest areas even more accessible, particularly in Cambodia and Laos (Fig 7).

Figure 7: Regional transportation concept for continental Southeast Asia: green = economic corridors, red = regional road network. (*by courtesy of ADB)*

Mining

An increasing mining activity causes forest loss in some areas identified in Laos and in central Cambodia.

Urbanization and settlement

The increasing urbanization is becoming a more common reason for forest change in Myanmar. New and growing settlements were frequently identified as a factor for change in areas of Thailand and of Laos. In Laos there are furthermore still re-settlement activities ongoing.

Decentralization

In Laos the process of decentralisation of both, land and forest management, was considered to have had up to now a rather negative effect on forest cover, triggering further forest loss and degradation rather than protecting it.

Fire

In continental Southeast Asia fire is not considered a major driver of forest change. In fact, many dry deciduous (*Dipterocarpus*) forests and woodlands face regular fires but are fire adapted. Although fires may cause degradation effects for example on soils, the regeneration of a number of species of dry forests benefit from regular burning (e.g. Goldammer 1993).

5.1.2 Change of forest canopy or structure

Conversion of natural forest to forest plantations
The conversion of natural forests to forest plantations (e.g. *Eucalyptus spp., Acacia magnium, Pinus spp.*) is leading to a loss of natural forests in a number of localities across the sub-region. There are reports on the ongoing massive expansion of fast growing tree plantations, partly initialized by international development programs and driven by the demand of the international pulp and paper industry (e.g. Lang 2002).

Logging
The forests of continental Southeast Asia have been exploited for precious timber (Teak, Rosewood) since colonial times. Many forests are therefore logged-over and have experienced more or less intensive degradation in the past, even if not identified as present change areas. At present, intensive, (selective) logging activities in production forests were seen as a reason for change of forest canopies and structure in sites in central Myanmar, in southern and central Laos (state owned as well as foreign enterprises), in Cambodia, and to some extent in the highlands of southern Vietnam.

Illegal logging
Uncontrolled and illegal logging has long been an issue in the sub-region (Currey *et al*. 2001). Illegal logging activities were identified as a main reason for change along the northern border zone of Myanmar and China. Frequent illegal logging is found along the borders and in the border triangle of Laos, Vietnam and Cambodia, including logging in protected areas. There is less illegal logging in Thailand and Vietnam due to tight control and largely efficient protected areas and national parks. In many of the identified change areas illegal logging is one factor among others. The main flows of illegal timber are from Myanmar to China, Thailand and India, and from Cambodia and Laos to Thailand and Vietnam (Currey *et al.* 2001). Official logging bans are in place in Thailand since 1989 and in Cambodia since 2002.

Fuel wood collection
Fuel wood collection was reported to be a non-negligible factor of forest loss and degradation in the vicinity of populated places in Cambodia.

5.1.3 Change from non-forest to forest, re-growing forests

In Vietnam, there are large areas that have been afforested or reforested in the recent past, mainly on the hilly and former shifting cultivation areas, leading to an overall increase of forest cover. These plantations consist mainly of fast growing species (*Eucalyptus spp*. and *Acacia magnium,* but also *Pinus spp.)*, however, there are also areas protected to enable natural re-growth of indigenous species. With an increasing demand for timber, also by Vietnam's growing population, there is even pressure on agricultural areas to be converted to forest plantations. In Laos and Cambodia there are numerous small-scale afforestation activities, such as Teak plantations (*Tectona grandis*), which were not captured at the regional scale.

5.2 THE CHANGE PATTERN IN INSULAR SOUTHEAST ASIA

The detailed change pattern obtained for insular Southeast Asia is displayed in figures 8 to 10, with the TREES sub-regional forest cover map in the background.

Forest loss and degradation occurs basically in most lowland forests of Sumatra and Borneo (Fig. 8). Pressure on forest is lower in the high mountain zones due mainly to accessibility, however, the border zone of inland Sarawak towards the international boundary with Indonesian Borneo (Kalimantan) was almost completely classified as 'change affected'. The centre of Borneo has been declared the 'Heart of Borneo' by the World Wide Fund for Nature, this area straddles the trans-boundary highlands of Indonesia and Malaysia, and reaches out through the foothills into adjacent lowlands and to parts of Brunei (Rautner *et al.* 2005). Recently the governments of Brunei, Malaysia and Indonesia signed a voluntary declaration to protect this area. Catastrophic events such as the El Niño induced drought of 1997 and 1998 severely damaged the lowland forests of East Kalimantan, in particular, and also peat swamp forests in West and Central Kalimantan (Siegert *et al.* 2001; Page *et al.* 2002) which has left many of these forests, if not destroyed, in a fragile state. There was not much information available for Sulawesi and for the smaller Indonesian islands, although encroachment by smallholder agriculture is assumed to be present.

The Philippine change pattern coincides with the remaining and mostly already degraded mountain forests (Fig. 9).

In Papua (former Irian Jaya, Indonesia) the change pattern covers much of the lowland forests along the coastal zones in the west, the north and the south (Fig. 10). In PNG change areas (mainly logging activities) are of somewhat smaller extent along the northern coast and in the southeast, but they are quite large in the south-western provinces (Western Province, Gulf Province) (Fig. 10). The island of New Britain (PNG) is known for intensive timber exploitation since more than 20 years.

The establishment of cash crop plantations, specifically for palm oil, is certainly a most important driver of forest loss in insular Southeast Asia. Commercial ('selective') logging remains the cause of forest degradation in many parts of the sub-region and becomes increasingly an issue on the island of New Guinea. However, in almost all identified change areas there is a combination of different change processes ultimately responsible for the total impact (Table 4).

5.2.1 Conversion of forest cover

Conversion to cash crop plantation for oil palm, rubber and coffee

The expansion of oil palm plantations is the main driver for forest loss in the lowland and swamp forests of eastern Sumatra (Riau, Jambi), along the coastal plain of Sarawak, and in many localities across Kalimantan. The peat swamp forests of Central Kalimantan are under a general threat of being converted to oil palm plantations in many places, including the boundary zone of the Tanjung Puting National Park, famous for its Orang Utans. In East Kalimantan large-scale oil palm plantations are being established in the north of the province in formerly logged forests. This is similar in West Kalimantan where logged-over forests in various locations are slated for conversion to oil palm. Since the mid 1990s Malaysia's and Indonesia's oil palm plantation area has grown from 2.4 to 4 million ha and from 1.7 to 6 million ha, respectively; in Indonesia almost three times as much has been cleared for expansion and further huge expansion is foreseen (FAO 2002, Casson 2003, WRM 2006b). However, it should be stressed that not all oil palm development on Borneo or Sumatra will lead to forest conversion. In peninsular Malaysia the conversion of state land forest to oil palm plantation is of limited extent.

The present expansion of oil palm plantations is also driven by the increasing demand for bio diesel, which has led to new plantation areas in the very northwest of Papua (Indonesia) and which has stimulated plans for new plantation areas along the coast in the southeast of Papua.
In PNG forests are converted to oil palm plantations in the southeast, on New Britain (PNG) and on New Ireland (PNG). By 2005 the oil palm area of PNG had reached 88 thousand ha (Carrere 2006), tending to increase and possibly becoming a major threat to the forests.

Cash crops like rubber and coffee play a role for forest loss for a number of other places. In the southwest of Sumatra the intensive plantation of coffee by small holders is leading to notable encroachment into remaining upland forests (Gaveau *et al*. 2007; Suyanto *et al*. 2000).

Small holder agriculture causes forest loss in a number of localities, including a strip of land stretching from the western coast of Sumatra towards the uplands. On Sumatra and Kalimantan there is also forest encroachment by small holder agriculture due to spontaneous migration. In the Philippines, forest conversion due to small holder agriculture takes place in the higher mountain forests. In fact, most of the forests in the Philippines are secondary or more or less degraded, there is almost no primary forest left. However, the increasing population and unfavourable socio-economic and living conditions force farmers to further encroach these forests, as for example on Mindanao.

Fire
Since the 'Great Fire of Borneo' in 1982–1983, large-scale fires have become an increasingly significant feature of landscape disturbance and deforestation in western Indonesia (Malingreau *et al*. 1985; Siegert *et al.* 2001). Forest loss and degradation due to fires in the past decade concern a number of change areas in western, central and eastern Kalimantan. Fire is still used in many large scale conversion projects (oil palm, timber plantations) for land clearing and remains a major threat to lowland forests on Sumatra and Borneo (e.g. Dennis *et al.* 2005; Dennis & Colfer 2006). In PNG fires, often started deliberately in the context of hunting, cause some forest loss in the higher upland and mountain zones.

Shifting Cultivation
Shifting cultivation still plays a role in the mountain zones of the sub-region, although it was not considered anymore a major driver of forest loss in a regional context. However, there is shifting cultivation that causes some forest change in the northwest and southwest of Sumatra, in Kalimantan, on the Philippines and in the uplands of PNG.

Mining
Mining is a large sector for example in Indonesia, but the contribution to forest loss tends to be rather localised. The local effects of open-cast coal mining in East Kalimantan are, however, increasing as the industry is entering a period of expansion. Illegal mining, in particular for coal and gold, also destroys forest areas in Kalimantan. There are also small areas of mining in PNG adding to the loss of forest, although not identified as areas of major change.

Road construction
Road construction appears to be a negligible threat at present time. The Trans-Kalimantan Highway is planned to run from east to west across Kalimantan, sections of the southern route are complete but this was not considered a major threat to forest cover currently, apart from improving access to adjacent forest areas. A northern route is planned but nothing so far has happened. Railways are also planned for Kalimantan as coal exploitation gains momentum.

Decentralization
Indonesia's regional autonomy law was introduced in 1999 and the initial effects of decentralisation were perhaps most dramatically felt in the forestry sector. In most forested regions of Indonesia, large numbers of small-scale timber extraction and forest conversion permits were issued at the district level, imposing new types of fees and royalties on log harvesting (Barr *et al.* 2006). There is still a struggle between local and central government over forest resources. One case in point is forest conversion, some local governments are still issuing permits for forest conversion under various guises. However, on the other side there are local governments who are increasing the number of protected areas.

5.2.2 Change of forest canopy or structure

Conversion of natural forest to forest plantations
For a number of areas identified in E-Sumatra (Riau, Jambi), in Kalimantan but also in the southwest of Papua forest change is related to the establishment of industrial timber plantations, mostly of fast growing species (*Eucalyptus spp. Acacia magnium*) for the production of pulp and paper. In East Kalimantan, for example, large scale timber plantations are being established in the northern parts in formerly logged-over forests. The expansion of plantations for pulp and paper in Indonesia dates back to the 1980s. By 2001 there were 8 million ha of land assigned for plantations, although not all of them were re-planted after clearing (WRM 2004), and there is apparently a new move towards an increase of the plantation area. Industrial timber plantations are also established in eastern Sarawak and in northern Sabah. In the central plain of Sarawak there is an ongoing process of conversion of old plantation forest. In PNG new timber plantations (*Eucalyptus spp.)* are created on the island of New Britain.

Logging
Commercial logging (selective logging) remains a driver for the loss and degradation of natural forests across insular Southeast Asia (including PNG), particularly in the lowland forests and in all areas easily accessible from the coast. Logging becomes damaging when too intense and when harvesting cycles are too short (small diameters), it is often accompanied by forest loss when creating new access to formerly less accessible forested areas.

Logging was identified as the main change process in the interior of Sarawak along the border to Kalimantan. Commercial logging has declined considerably in Kalimantan as timber stocks have dropped dramatically due to decades of unsustainable logging practices, leaving the remaining valuable timber in areas which are economically unviable to log. Central Kalimantan produces the highest timber volumes of all 4 provinces in Kalimantan, with 4.3 million m^3 in 2005 compared to 2.2 million m^3 for East Kalimantan (by comparison, in the 1990s the annual production was twice this, and in the 1970s almost three times). As indicated by the change pattern of East Kalimantan, today the logging and deforestation 'front' has moved towards the northern and coastal parts of the province, after the fires of 1998 had damaged the vast majority of the lowland forests further south. Quite often 'legal' logging is followed by 'illegal' logging in the former concession areas, leading to further forest degradation and increasing finally the threat of conversion to oil palm and timber plantation, particularly when the standing volume is below a certain threshold.

In Papua (Indonesia) the pattern of change areas is an indication for the move of the main timber frontier in Indonesia to the east, where it has become a major environmental issue. Large scale concession logging is concentrated in the west and in the southeast of Papua, rather small holder logging along the northern coast. Forest concessions often include permission to convert a certain percentage of the forest to oil palm.

In PNG most of the forest change pattern in the lowlands and along the coast relates to concession logging (selective logging), which is the dominant forest utilization. At present the impact appears to be more severe in the south of the central provinces, where remote concessions cannot always be sufficiently controlled. PNG is still rich of timber resources, but might become a focus for timber production as a consequence of shrinking or less accessible resources in the neighbouring countries. New Britain's timber resources have been exploited to a large extent already in the past.

In peninsular Malaysia selective logging causes some change in the Permanent Forest Estate (PFE) and in the peat swamp forest on the eastern coast. In the Philippines concession logging is still a driver for forest loss on the southern island of Mindanao, often followed by encroachment by shifting cultivators and small holder farming.

Illegal logging

'Uncontrolled' or 'illegal' logging appears to be widely spread throughout the sub-region and is an issue for the majority of the identified change areas, although none was identified for that reason alone. On Kalimantan recent illegal logging activities are reported for the border area to Sarawak, although levels appear now to be lower than in previous years. In East Kalimantan the front of illegal logging has shifted together with the legal logging activities to the northern districts. Illegal logging still exists in Central and West Kalimantan, as well as in parts of Sumatra. Illegal logging occurs frequently at smaller scale in Sarawak, it remains an issue in the Philippines (Luzon, Palawan). In PNG, the forests are owned by the country's tribal system and timber harvesting operations are officially licensed, however, there are issues of legal non-compliance at different stages of development and management of these operations (Forest Trends 2006).

For the whole Asia-Pacific region, the illegally logged timber was estimated at about 45% of the recorded logs; this is not only affecting national revenues, but damages the remaining forest and its regeneration, as most illegal logging takes place in already logged-over forests (Palmer 2000, Mir & Frazer 2003).

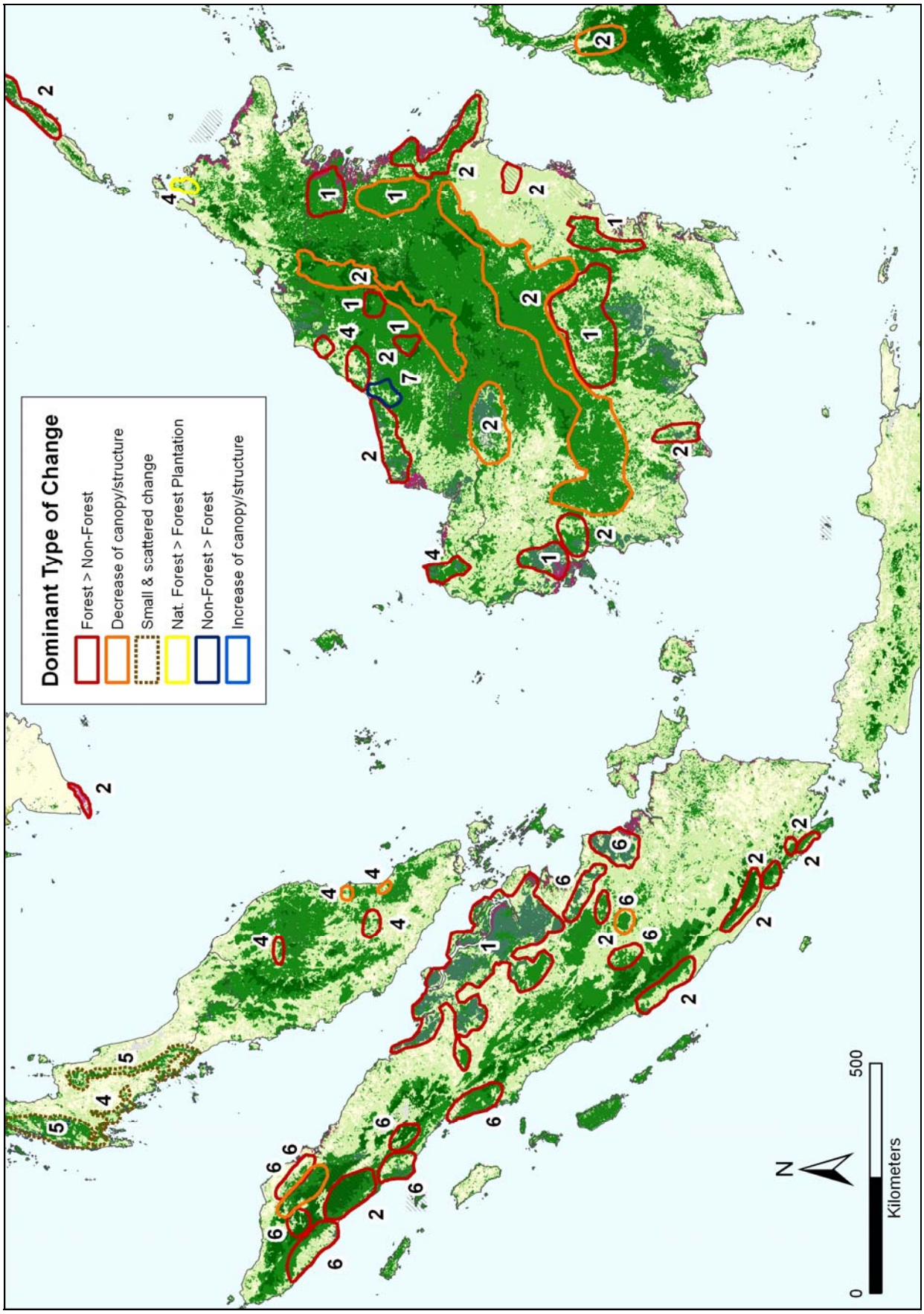

Figure 8: Change pattern in Peninsular Malaysia, Sumatra and Borneo (numerical coding = see Table 3). Legend of background map: evergreen mountain forests = *dark green*, lowland evergreen rain forests = *green*, mangrove forests = purple; peat swamp & swamp forests = *blue green*; thickets, shrub-cover, mosaics, perennial crops = *light green;* other = *white*); Protected Areas = *hatched*.

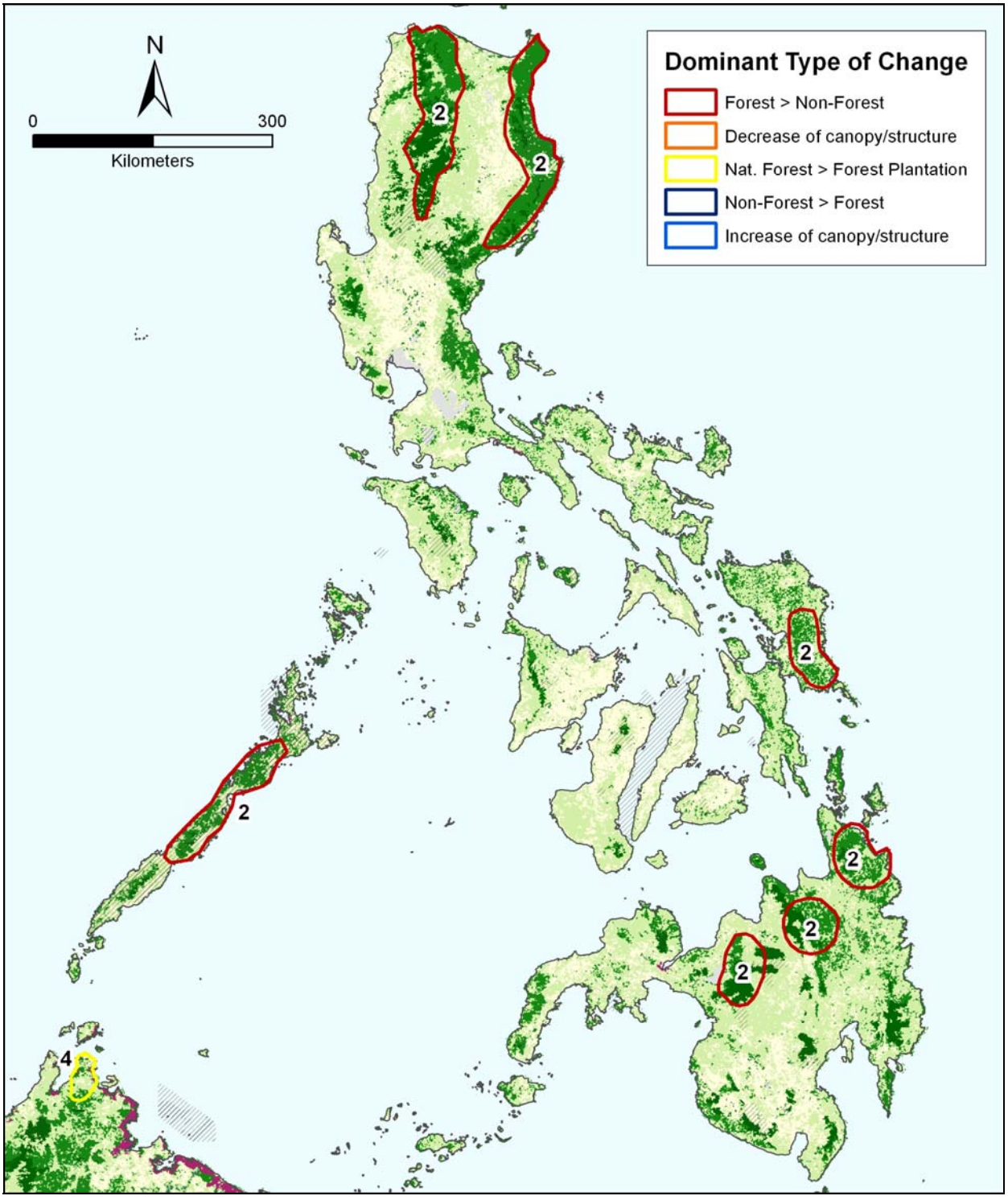

Figure 9: Change pattern in the Philippines (numerical coding = see Table 3; legend of background map = see Fig.8).

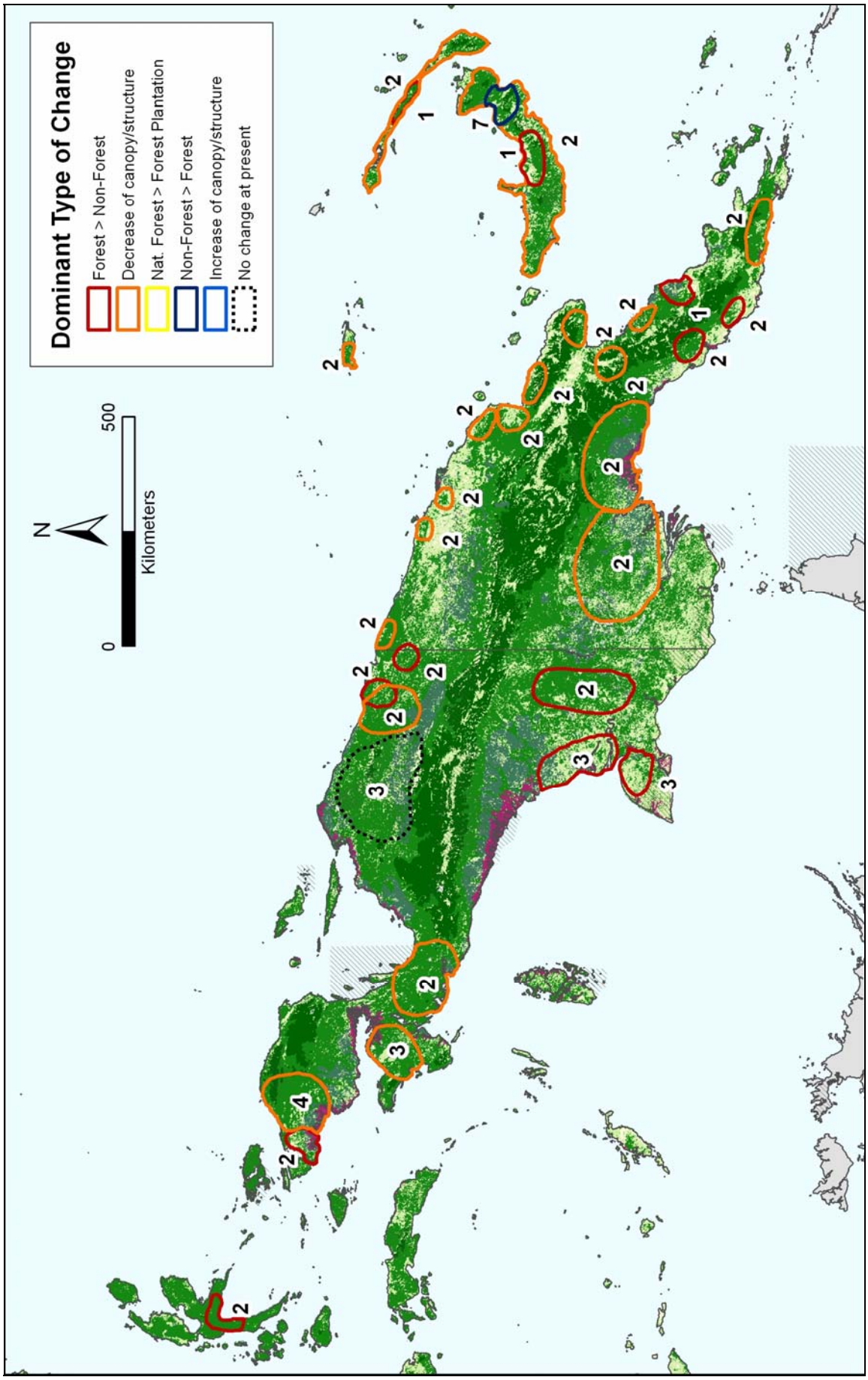

Figure 10: Change pattern in Papua (former Irian Jaya) and PNG (numerical coding = see Table 3; legend of background map = see Fig.8).

6 FOREST AREAS NOT IDENTIFIED AS 'CHANGE AREAS'

There are forest complexes which have remained intact and almost undisturbed, and which are unlikely to change in the near future. These are often mountain forests, at high altitudes or on steep slopes, where access is difficult and agricultural or forest utilization either impossible or too costly. A larger complex of intact and undisturbed forests covers for example the mountainous border zone of northeast of India (Eastern Himalaya Range, Mishmi Hills, Khamits), northern Myanmar (Kumon Taung, Abaung Plum and Shanngaw Taungdan mountains) and the south of China (Gaoligong Dhand, Hengdua Shan and Nu Shan mountains). Intact forest areas can for example also still be found in the centre of Borneo. The 'Heart of Borneo' comprises a number of existing and proposed national parks along the boundary zone of Malaysia, Indonesia and Brunei, included in a trans-boundary protection concept (WWF 2007). Undisturbed forests still cover extensive parts of Papua and of PNG. However, in the context of the workshops information on undisturbed forest was not compiled consistently.

Many other forested areas that were not identified as 'change areas' have experienced more or less heavy disturbance in the past due to timber exploitation, shifting cultivation or fires, potentially having caused long-term degradation. For example, in continental Southeast Asia many forests have been repeatedly logged-over for valuable timber like teak or rosewood. In insular Southeast Asia there are lowland *Dipterocarpus* and swamp forests that have been heavily exploited in the past and do not contain tree dimensions of economic interest at the present. Other forests might be under rather permanent, more or less intensive management. Having therefore not identified change for some forest areas does not necessarily mean that they are untouched or undisturbed (Fig 11).

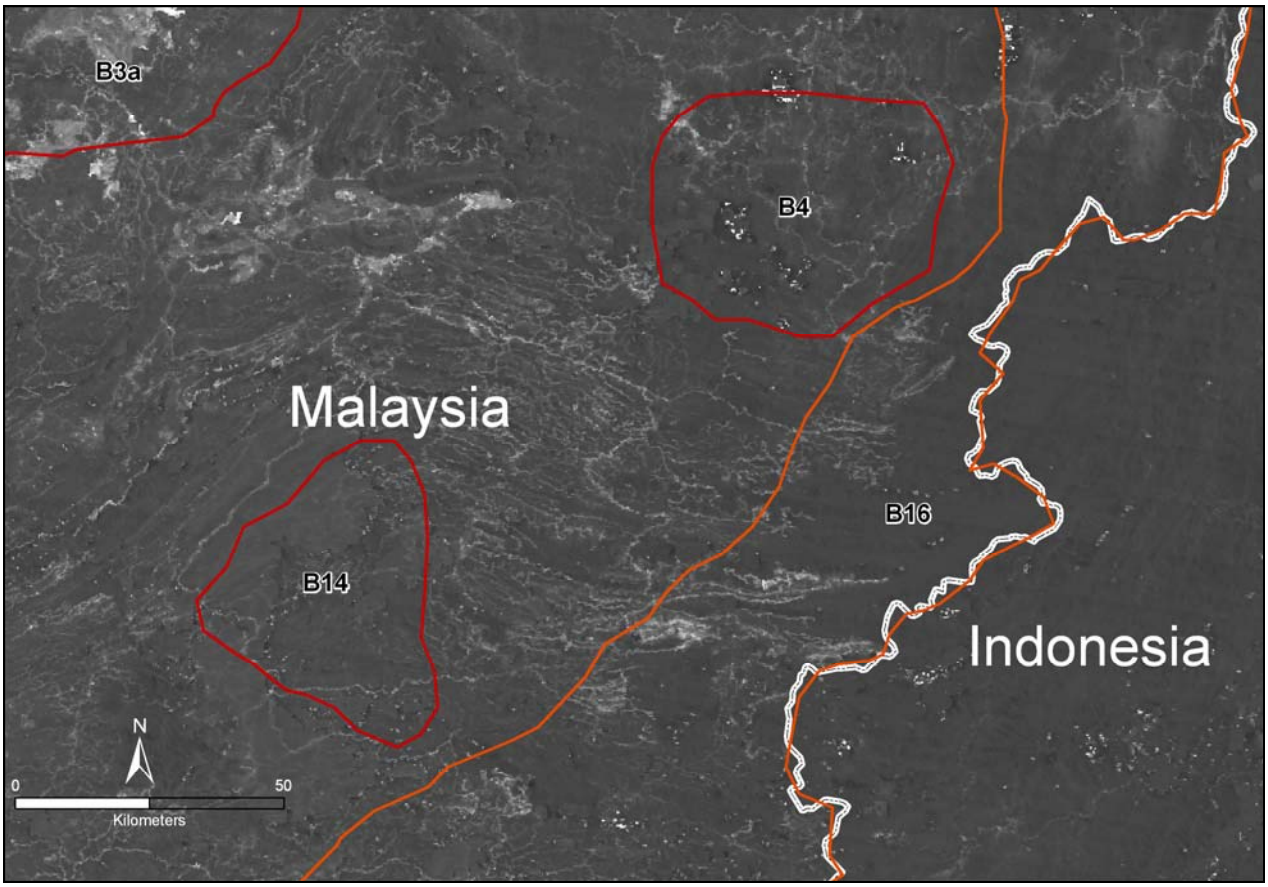

Figure 11: Network of roads and logging roads in forests in Sarawak. MODIS satellite image, 2004, 250m resolution, red band (B&W), forest cover = dark grey; non-forest = light grey and white.

Table 4: Tabular overview of forest change processes in Southeast Asia

ID	ICC	LOCATION	CHANGE				FOREST STATUS							TIME SCALE				TYPE			CAUSES											REMARKS
	Int. Country Code	Abbr. used for *'Change'*: A =afforestation; R = reforestation; G =protected for natural regrowth; P =Fo→Fo. Plant.	Fo -NoFo	No Fo > Fo	Decrease CC./ Fragm.	Other	Primary	Secondary	Degraded	Other	Production	Non-Production	Protected (PA or NP)	Last 3-5 Years	Ongoing-fast	Ongoing-moderate	Within 3 Years	Other	Controlled	Un-Controlled	In formerly unused Fo	> Agriculture	> Oil Palm	> Rubber	> Coffee Tea	> Infra /Settlement	Shifting Cultivation	> Forest Plantation	>Clear Cut & Regrwoth	Selective Logging	Fire	Aqua Culture / Shrimp	Other	Abbr. used for *'Causes'*: a = *Acacia mangium* plantations d = dam construction (hydropower) e = *Eucalyptus* plantations i = illegal logging; m = Mining; p = *Pinus* plantations; r= resettlement v = vegetables plant. & fruit orchards; o (other) = see remarks Fo = forest; Ag = agriculture; Rd = road
I1	IND	W-Dalfa Hills	x		x		x	x						x		x				x		x										o	o = land occupation by local people
I2	IND	E-Dalfa Hills	x		x		x	x						x		x				x		x										o	o = land occupation by local people
I3	IND	E- Mira Hills	x		x		x	x						x		x				x		x										o	o = land occupation by local people
I4	IND	Mikir-Rengma H.	x		x		x	x						x		x				x						x							shifting cultivation ('Jhum')
I5	IND	Naga Hills	x		x		x	x						x		x				x						x							shifting cultivation ('Jhum')
I6	IND	E-Meghalaya	x		x		x	x						x		x				x						x							shifting cultivation ('Jhum')
I7	IND	W-Meghalaya	x		x		x	x						x		x				x						x							shifting cultivation ('Jhum')
I8	IND	Khamits	x		x		x	x						x		x				x												o	o = land occupation by local people
Y1	CHN	S-Yunnan			x				x							x			x			x			x								plantations expansion
D1	BGD.	Sundarbans			x		x									x				x													mangroves, local use, flood vulnerable
D2	BGD	Chittagong	x		x		x	x						x		x			x	x		x					x	x					o	pop. pressure; o= fuel-wood harvesting
M1	MMR	Rakhine Yoma			x				x	x						x			x			x						x		x			o	mosaics & fragmented Fo; o = tourism
M2	MMR	Irrawaddy Delta	x		x		x				x		x		x	x			x	x		x							x		x	x	x	mangroves; other = fuel wood
M3	MMR	Upper Bago R.	x		x	P	x		x		x			x	x	x			x			x					x			x				D	Ag expansion & urbanisation,
M4	MMR	Bago Yoma			x	P	x							x					x			x					x	x		x				d	Greening Project
M5	MMR	Northern MMR			x		x							x						x											i				illegal logging & transport to CHN
M6	MMR	Shan Plateau			x				x							x			x			x					x	x						shifting cultivation main reason
M7	MMR	South Myanmar	x		x				x							x			x			x	x				x							oil palm plantation
M8	MMR	South Myanmar	x		x				x							x			x			x	x				x							oil palm plantation
M9	MMR	South Myanmar	x		x				x							x			x			x	x				x							oil palm plantation
M10	MMR	Myanmar Border	x						x							x				x		x					x		x					ethnic group migration
T1	THA	Nak.S.Thammarat			x		x						x			x			x				x	x		x								small & dispersed; intense management
T2	THA	Kratei-Phangnga	x				x						x	x					x				x									x	o	o = resort, Tsunami
T3	THA	Ranong			x		x									x			x			x	x											weak control (*Patoh* WSC)

ID	ICC	LOCATION	CHANGE				FOREST STATUS							TIME SCALE					TYPE			CAUSES											REMARKS
	Int. Country Code	Abbr. used for *'Change'*: A =afforestation; R = reforestation; G =protected for natural regrowth; P =Fo→Fo. Plant.	Fo -NoFo	No Fo > Fo	Decrease CC./ Fragm.	Other	Primary	Secondary	Degraded	Other	Production	Non-Production	Protected (PA or NP)	Last 3-5 Years	Ongoing-fast	Ongoing-moderate	Within 3 Years	Other	Controlled	Un-Controlled	In formerly unused Fo	> Agriculture	> Oil Palm	> Rubber	> Coffee Tea	> Infra /Settlement	Shifting Cultivation	> Forest Plantation	>Clear Cut & Regrwoth	Selective Logging	Fire	Aqua Culture / Shrimp	Other	Abbr. used for *'Causes'*: a = *Acacia mangium* plantations d = dam construction (hydropower) e = *Eucalyptus* plantations i = illegal logging; m = Mining; p = *Pinus* plantations; r= resettlement v = vegetables plant. & fruit orchards; o (other) = see remarks Fo = forest; Ag = agriculture; Rd = road
T4	THA	Phet Buri			x		x							x					x			x				x						o	In buffer zone, o = resort
T5	THA	Kanchana Buri			x	P	x									x			x			x						x					small & dispersed
T6	THA	Tak	x		x	P	x									x			x	x		x				x			x				
T7	THA	Mae Hong Son	x		x		x									x			x	x		x			x			x					coffee, tea
T8	THA	Chiang Mai	x		x		x		x				x			x			x	x		x			x	x		x			i	x		coffee, tea, oranges, illegal log.
T9	THA	Chiang Rai	x		x		x		x				x			x			x	x		v		x	x	x		x			i	x		vegetables; illegal logging
T10	THA	Naan	x		x		x									x			x	x		x		x	x			x			i			illegal logging, WSC
T11	THA	S-North. Region	x		x		x	x	x				x			x			x	x		x	x			x		x			i	x		encroachments for a decade
T12	THA	Petchaboon	x		x		x		x				x			x			x	x		x			x			x			i			corn, encroachments for a decade
T13	THA	Phupan Range	x		x	P	x	x	x				x			x			x	x		x	x			x		x	e		i	x		Eucalyptus plant., illegal logging
T14	THA	Khao Yai	x		x	P	x	x					x			x			x			x				x			e		i			corn, cassava, dispersed in buffer zone
T15	THA	Kao Soi Dao	x		x	P	x									x			x	x		x		x	v	x			e		i			fruit orchards, in buffer zone
L1	LAO	Attapeu / VN	x			P	x						x	x	x			x	x	x		x							e	x				RD 8b, comm. logging by VN companies
L2	LAO	S-Champasak	x		x		x							x						x							x			x				logging local/enterprise; state logging
L3	LAO	Xekhaman 1-Attapeu	x				x		x							x			x					x								d	rubber & hydropower
L4	LAO	Dong Phongvieng	x		x		x						x			x				x							x			x				degradation due shifting & sel. logg.
L5	LAO	Khammuan NT2	x				x	x							x				x							r				x		d	hydropower, resettlement, logging
L6	LAO	Khammuan	x		x		x						x			x				x							x			i				illegal log., shifting, NTFP collection
L7	LAO	Pakading	x		x		x	x	x		x				x				x			x		x										rubber+ coconut plantations
L8	LAO	Phouphanang	x		x	P	x	x	x				x	x		x				x							x	e		i				
L9	LAO	Phoukhaokhuay	x		x		x	x	x				x			x				x			x				x			x				
L10	LAO	Paklai-Xaiyabouli	x		x	P	x	x	x			x				x				x			x	x					x		x			
L11	LAO	NamPui-Xaiyabouli	x		x		x	x	x				x	x		x				x							x			i				logging in protected area
L12	LAO	ThaBok-Bolikhamxay	x		x	P	x	x	x		x					x			x	x			x				x		x		x			
L13	LAO	NTheun1-Bolikhamx.	x		x	P	x	x	x				x	x	x				x	x			x						x			d		dam & resettlement
L14	LAO	Ngeun/ Hongsa	x		x		x				x		x			x			x	x									x	x				export timber logging

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L15	LAO	Nam Ha	x		x		x	x					x	x	x					x	x			x			x						rubber small & medium scale
L16	LAO	ViengPhongkha (LN)	x		x		x	x	x			x			x					x	x		x					x				m	logging & mining along Rd 3 Thai-CHN
L17	LAO	Phong Yeny	x		x	P	x	x	x		x	x			x					x		x					x		x				logging & plantations
L18	LAO	Ou Nua -Phongsaly	x		x		x	x	x			x		x						x	x		x			x							sugar cane & rubber, CHN invest.
L19	LAO	NamBak-Oudomxai	x		x		x	x	x			x		x		x				x	x		x		x				x				rubber plantations
L20	LAO	N. Phonleng- Huapan	x		x		x	x	x				x			x				x						x			x				shifting cult & logging
L21	LAO	Phon Bia-Xieng K.	x		x		x	x	x			x				x				x						x			x				extraction of high-value timber
L22	LAO	Nam Ngum II	x				x	x	x			x			x				x													d	hydropower
L23	LAO	Nam Ngum III	x				x	x	x			x			x				x													d	hydropower
L24	LAO	Xekong	x		x	P	x	x	x		x	x	x		x				x	x					x			x	x				d	rubber & hydropower
L25	LAO	Boloven	x	x	x	P	x	x	x			x			x					x		x	x			x	x	x					fruit trees, live stock
L26	LAO	Border	x				x	x				x	x			x				x										i			illegal logging for sawmills
L27	LAO	Savannakhet	x		x	P	x	x	x		x	x		x	x					x		x	x			x	x			x			pulpwood; Rd 9, foreign invest.
L28	LAO	Patomphone	x					x			x			x						x								x					heavily logged
L29	LAO	Border LAO/VN/CBD			x		x	x				x		x	x					x									i				illegal logging along borderline
C1	KHM	Virachey Rattanakiri	x				x							x						x								i					
C2	KHM	Roniem Daun Sam	x				x	x						x	x					x		x											
C3	KHM	Kampong Thom	x				x	x						x	x				x	x				x									
C4	KHM	Kamphong Cham	x					x	x					x	x				x	x		x		x									
C5	VNM	Tây Ninh / S-VNM	x					x	x							x	x			x		x		x	x								rubber, coffee
C6	VNM	Dak Nong C-Highl.	x					x								x				x		x		x	x								rubber, coffee
C7	VNM	Gia Lai C-Highl.	x					x								x				x		x		x	x								rubber, coffee
C8	VNM	Quâng Nam C-VNM		A												x			x														A & R of barren hills, Gvmt. program
C9	VNM	Son La N-VNM			x			x						x		x	x			x										i			sel. logging, partly Illegal, high demand
C10	VNM	Hong Lien Son N-VN			x			x						x		x	x			x										i			sel. logging, partly Illegal, high demand
C11	KHM	Mondulkiri (PA)			x		x						x			x	x		x	x													proposed. conversion of 50k ha

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C12	KHM	Snoul (Wildlife S.)	x					x					x	x	x				x	x		x							x				de-gazetted - illeg. logged in past
C13	VNM	Tuyên Quang N-VN		A		P				x	x			x					x									x					on barren land & severely deg. forest
C14	KHM	Quang Binh C-VNM	x		x		x	x								x			x											x			new highway to Saigon
C15	KHM	Phnom Kulen N.P.	x		x		x	x						x						x		x								x			concession
C16	KHM	Botum Sakor PA	x				x						x	x					x				x										
C17	VNM	Thua Tien, Huê		R		P				x		x				x	x		x									e					plantation& enrichment, landscape apr.
C18	VNM	Dâk Lâk	x				x							x	x				x	x		x			x	x							Yok Don dry forest
C19	KHM	Mondolkiri	x				x						x		x				x	x							x						highway Mondolkiri – Ratanakiri
C20	KHM	Preah Vihear	x		x	P	x	x								x	x			x	x	x						x	x				dry Fo conv., landmine clear., sh. AG
C21	VNM	So'n La N-VNM		x		G			x					x		x			x														40'000 ha., density increase, also shrubl.
C22	KHM	Mondolkiri Plateau		A	x	P		x	x				x	x		x	x		x									p				m	a)Fo-Grassl.>Pinus plant b)Bauxit
C23	VNM	Ban Lôm N-VNM				G			x					x					x														density incr., 30'000 ha protected
C24	VNM	Thanh Hóa N-VNM				G		x	x					x					x														density incr., 30'000 ha protected
C25	VNM	Lang S'on N-VNM		x		G		x	x	x				x		x			x														density incr., also shrubland →forest
C26	VNM	Ca Mau S-VNM	x	R			x		x					x		x			x			x						x				x	mangrove (destruction + plantations)
C27	VNM	Sre Quang S-VNM			x		x	x						x		x				x									x				
C28	KHM	Tonle Sap	x				x							x		x				x		x											seasonally flooded forest → paddy
S1	IDN	Mt. Lembu Aceh			x		x				x							x	x										x				big change 1990s, then little, regrowth
S2	IDN	Lqangsa Aceh	x			P	x				x							x	x				x					x					big change 1990s, then little
S3	IDN	W Aceh	x				x				x							x	x				x										big change 1990s, then little
S4	IDN	Takenong Aceh	x			P	x				x		x					x	x									x					big change 1990s, then little
S5	IDN	Singkil Barat	x				x				x		x					x	x				x										big change 1990s, then little
S6	IDN	DanauToba	x			P	x				x							x	x									x					big change 1990s, then little
S7	IDN	Riau	x			P	x				x		x		x			x	x				x					x					also in 1990s comm.. log.; Peat Swamp
S8	MYS	Pekan & Nenasi			x		x				x			x					x											x			peat swamp forest
S9	MYS	Ibam	x					x			x			x					x				x										state land forest

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S10	MYS	Gna Musang	x					x						x					x				x										state land forest
S11	IDN	W Lampung	x				x				x		x			x				x					x		x						small scale coffee gardens
S12	IDN	Lubukjering C-Jambi			x		x				x							x	x										x				1990s com. logging, now conservation
S13	IDN	Jambi Berbak	x		x		x				x		x					x	x				x							x				massive 1990s, presently?
S14	IDN	Dusunmudo Jambi	x			P	x				x							x	x				x					x						massive 1990s, presently?
S15	IDN	Padangsidempuan	x		x		x				x		x					x	x	x									x					massive 1990s, presently?
S16	IDN	Bangko C-Jambi	x				x									x				x		x												
S17	IDN	N-Bengkulu	x			P	x									x			x	x		x						x						
S18	IDN	S-Bengkulu	x				x									x				x		x												
S19	IDN	Gunung Leuser	x		x		x				x	x	x			x	x		x	x						x			x					high timber demand, illegal logging
B1	IDN	Tanjung Puting	x				x				x		x			x			x				x						i	x				oil palm at boundary, encroachm., peat
B2	IDN	Gunung Palung	x		x	P	x		x		x		x			x			x	x		x	x					x		i				around NP, oil p. on former concession
B3	MYS	Mukah-Bintulu SW	x						x		x					x			x			x	x											large scale oil palm on swamp forest
B4	MYS	Belaga-Sarawak	x			x	x				x				x				x				x					x						long-term forest plantations (non-indig.)
B5	IDN	U-Kapuas/Danau	x		x		x		x		x		x	x		x			x	x		x	x				x			i				illegal log. in inactive concess., oil palm
B6	IDN	C-Kalimantan	x		x	P		x	x		x			x	x				x	x		x	x						x		i				Forest on alluvial terraces, oil palm
B7	IDN	Sangkulirang	x		x	P	x		x		x			x		x	x		x	x		x	x						x		i	x			important Karst area
B8	IDN	Nunukan/Sembakung	x		x	P	x		x		x				x				x				x						x						timber plantations
B9	IDN	Berau / Malinau	x		x	P	x		x		x			x	x	x			x	x			x						x		i			m	m=coal mining, large pulp & paper mill
B10	MYS	Bengoka Sabah				P		x						x					x										x		x				formerly logged Fo > plantation Fo
B11	MYS	Niah/Suai Sarawak	x					x						x					x				x												large scale oil palm plantation
B12	MYS	Tatau Sarawak				P		x	x							x			x									a						plantations, pulp & paper ~ 275'000ha
B13	IDN	Lore Lindu	x		x		x		x				x			x	x			x		x					x								changes in NP boundary, land claims
B14	MYS	Belaga	x				x	x			x				x				x														d	hydro power ~ 66'000ha
B15	IDN	Weda / Halmahera	x				x				x					x			x			x				x								large Ag & settlements, no details
B16	MYS	E-Sarawak Mts.			x		x				x					x			x										x					concessions, lack of enforcement

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B17	IDN	Sambas/NW-Kali.	x		x			x	x		x			x	x				x			x	x							x			large scale oil palm, burnings
B18	IDN	Kalimantan Hill Forest	x		x		x	x	x		x	x	x	x		x			x	x		x								x			legal & illegal logging, forest frontier
B19	IDN	Kapuas (Pontianak)	x		x	P	x		x		x			x	x				x	x			x				x	x		x			peat forest in Kapuas Delta
B20	IDN	Pasir	x		x	P		x	x		x			x	x				x	x		x	x					x		i	x			timber plantations and oil palm
B21	IDN	Kutai NP	x		x		x	x	x				x	x		x				x			x							i	x		m	land claims
P1	PNG	W-Sepik			x		x				x					x			x											x				concession 230'000 ha, + adj. area
P2	PNG	Wewak			x		x				x					x			x								x			x				2 concessions active
P3	PNG	Madang		x	x		x			x	x					x			x									x	x	x				prim.FO <90, plant. ≥80, now rot. logg.
P4	PNG	Lae			x		x				x					x			x											x				3 concessions in Morobe province
P5	PNG	Admiralty Island			x		x				x					x			x											x				W-coast Manus timber project - 2 conc.
P6	PNG	New Ireland			x		x				x					x			x	x										x				most concessions over-logged
P7	PNG	New Britain			x		x				x					x			x	x										x				concession. almost depleted (over-
P8	PNG	Milne Bay			x		x				x					x			x											x				
P9	PNG	Port Moresby	x		x		x				x					x			x				x							x				
P10	PNG	Gulf Province			x		x				x					x			x											x				
P11	PNG	Western Province			x		x				x					x			x											x				biggest concession in PNG
P12	PNG	Popondetta	x				x				x				x				x				x											
P13	PNG	New Britain	x				x				x				x				x				x											
P14	PNG	New Ireland	x				x				x				x				x				x											
P15	IDN	Bian-Kombe / WP	x				x									x			x				x					x						concession group
P16	IDN	Sorong / Papua	x				x		x		x					x			x	x			x											part. logged concession, ~ small holder
P17	IDN	Jayapura / Papua	x				x				x					x	x		x	x		x	x											small holder log. for crop, ≠ real clear cut
P18	IDN	Jayapura–Sarmi/WP			x		x									x			x	x										x				mix of legal and illegal logging
P19	IDN	Nabire / Papua			x		x				x			x		x			x	x										x				concession, possibly illegal logging,
P20	IDN	Bomberai Pen. / WP			x		x							x			x		x											x				concession
P21	IDN	Doberai Pen. / WP			x		x							x					x											x				concession, before small hold. logging

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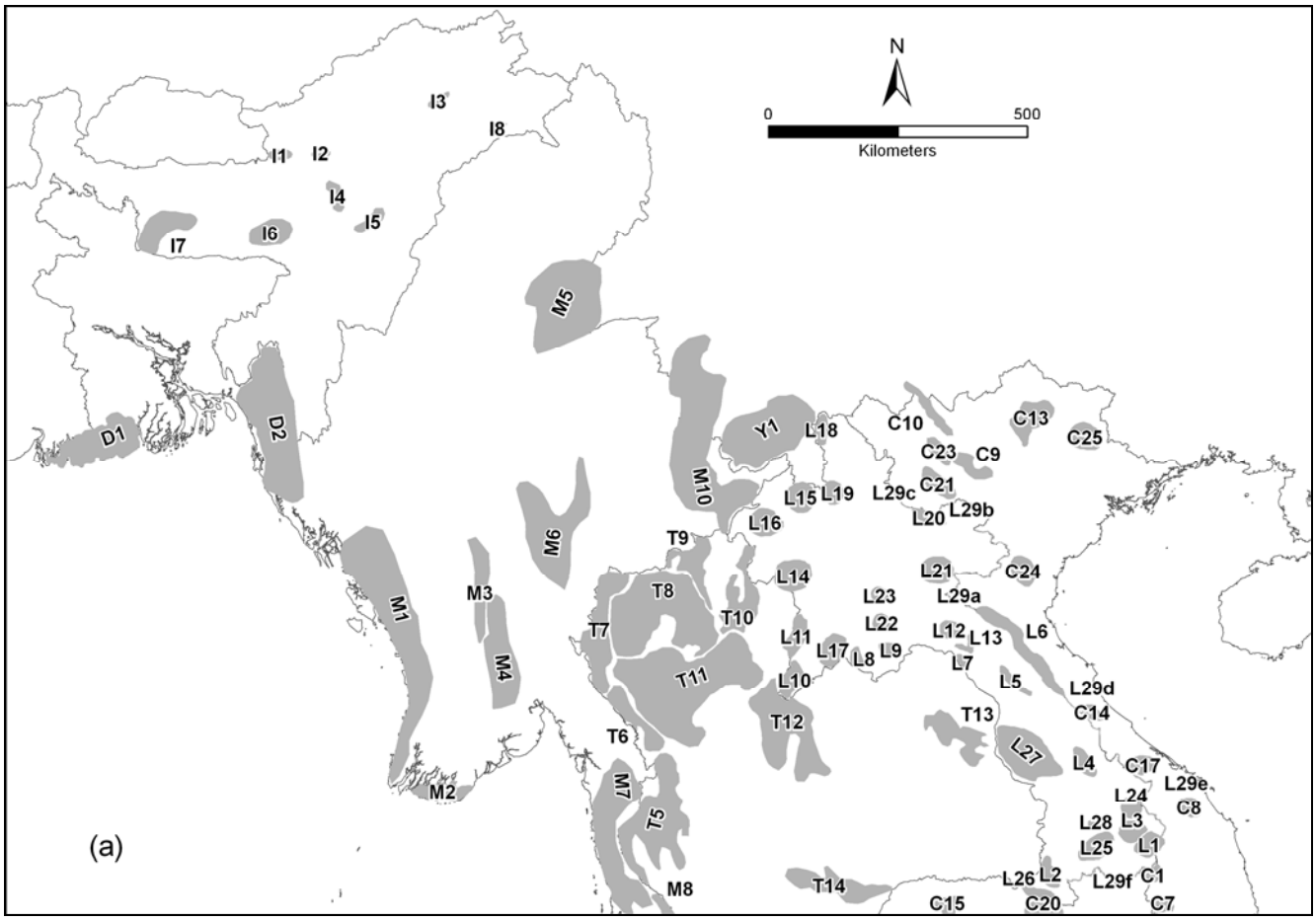
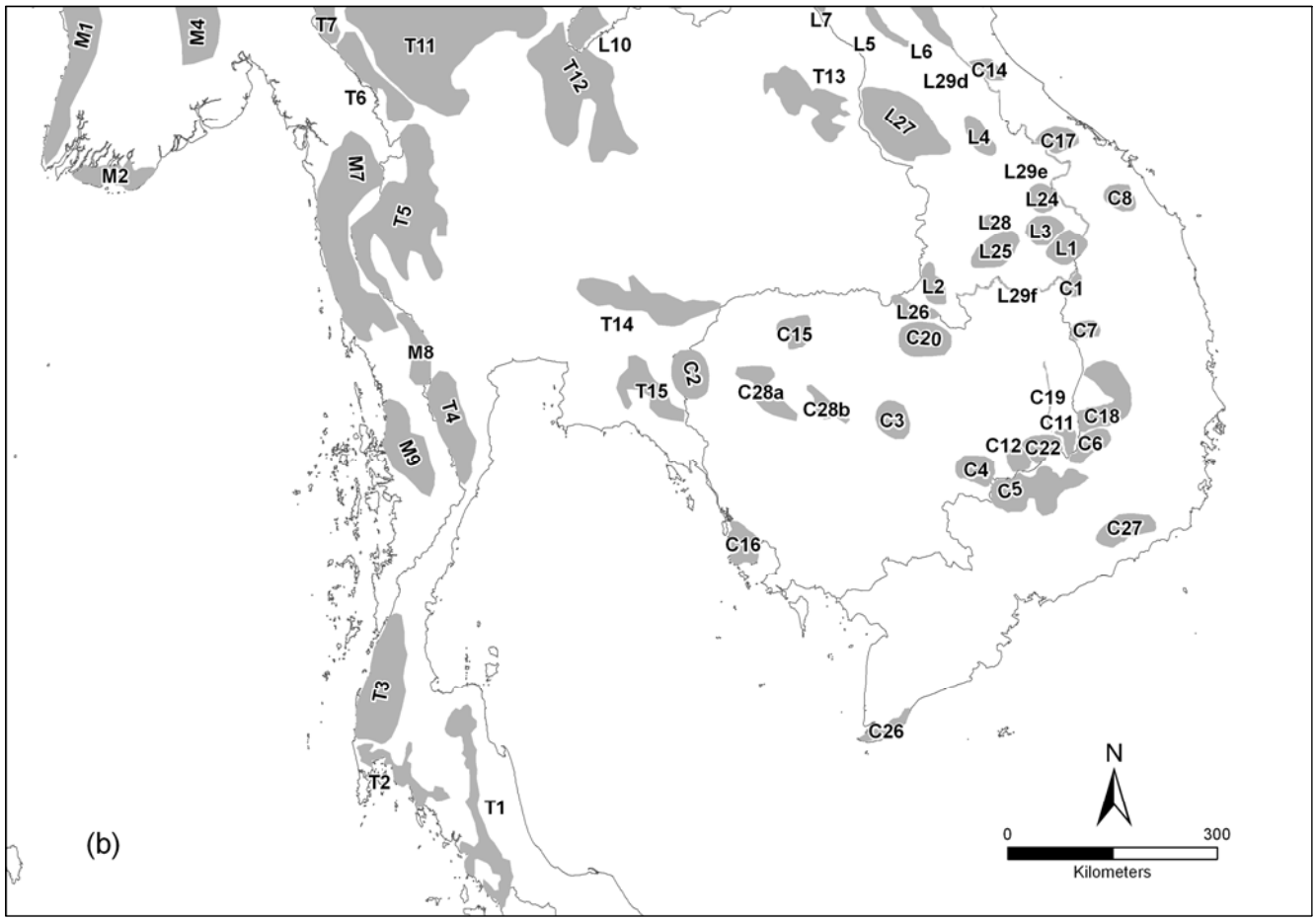
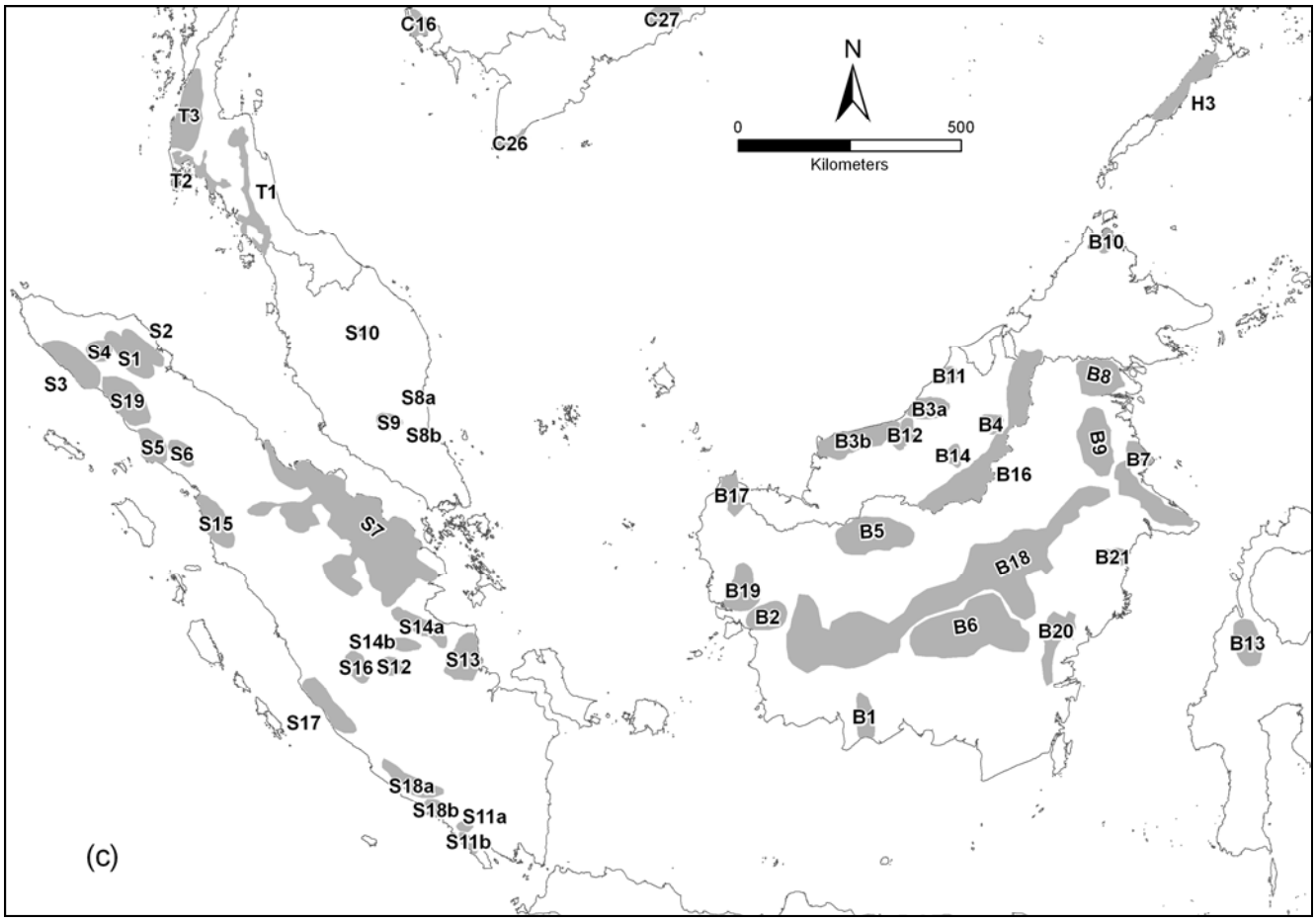
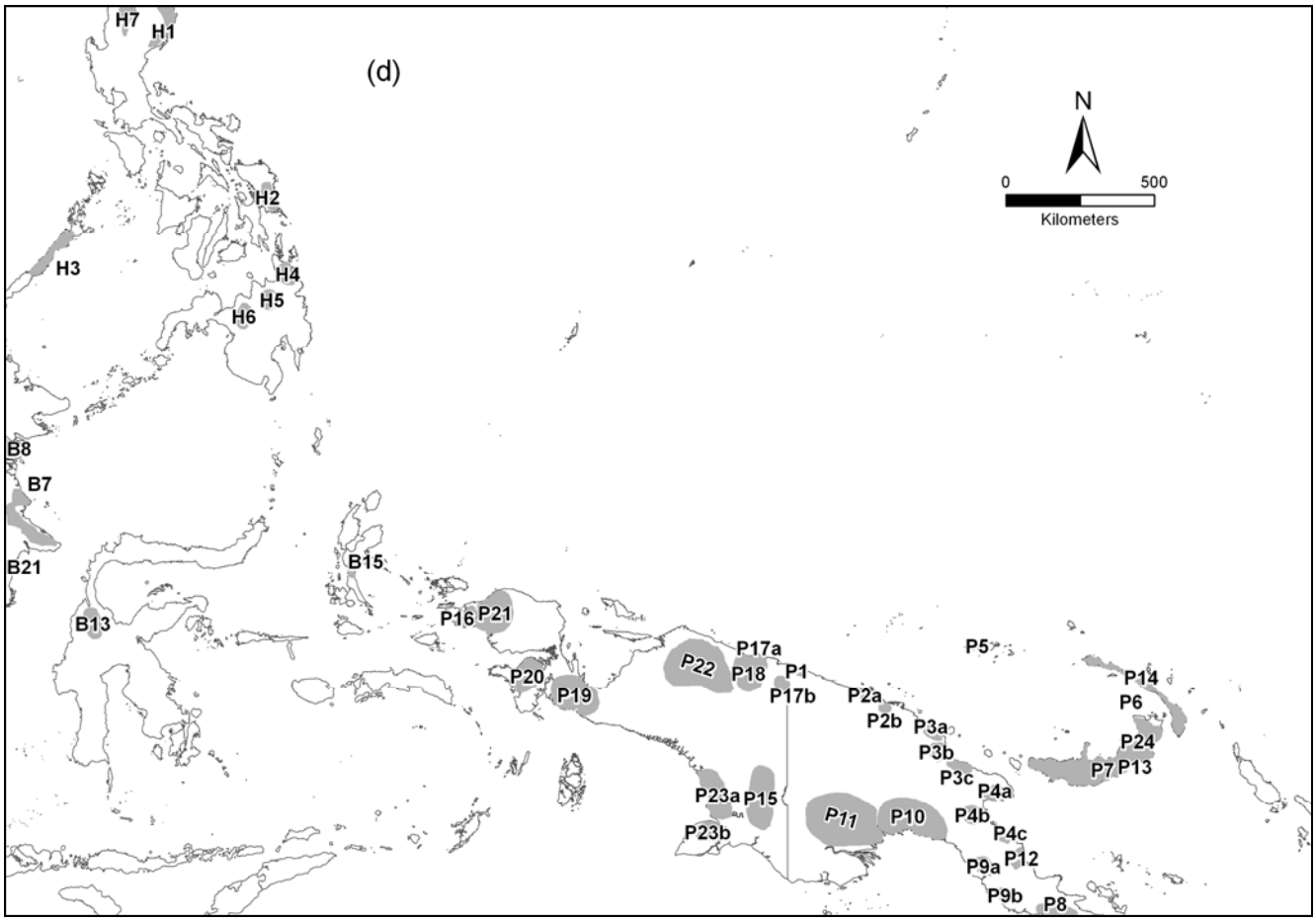
P22	IDN	Mamberano / WP				x	x				x		x				x			x									x			still intact fo, area potentially developed
P23	IDN	Mapi &vYos Sudarso	x				x	x									x			x												discussed for bio-diesel industry
P24	IDN	New Britain East				P																						x					
H1	PHL	Sierra Madre / Luzon	x		x			x	x			x				x				x						x			i			some illegal logging, followed by shifting
H2	PHL	E-Samar	x		x			x	x			x				x				x						x			i			some illegal logging, followed by shifting
H3	PHL	Palawan	x		x			x	x			x				x				x						x			i			some illegal logging, followed by shifting
H4	PHL	Surigao / Mindanao	x		x			x			x					x			x	x						x			x			concession logging, followed by shifting
H5	PHL	Agusan / Mindanao	x		x			x			x					x			x	x						x			x			concession logging, followed by shifting
H6	PHL	Bukidnon / Mindanao	x		x			x			x					x			x	x						x			x			concession logging, followed by shifting
H7	PHL	Cordillera / Luzon	x		x			x			x		x			x				x						x						highland: conv. to AG, lower: shift. cultiv.

Figure 12 (a-d): Change area location and identification numbers






C16
C27
N
0
500
Kilometers
H3
C26
T3
T2
T1
B10
S2
S10
S4
S1
S3
S19
S8a
S9
S8b
B11
B8
B3a
B4
B3b
B12
B14
B9
B7
B16
S5
S6
B17
S15
S7
B5
B18
B21
B19
B2
B6
B20
B13
S14a
S14b
S16
S12
S13
B1
S17
S18a
S18b
S11a
S11b
(c)


(d)
H7
H1
N
0
500
Kilometers
H2
H3
H4
H5
H6
B8
B7
B21
B15
B13
P16
P21
P17a
P5
P22
P18
P1
P20
P19
P17b
P2a
P14
P6
P2b
P3a
P24
P3b
P7
P13
P3c
P4a
P23a
P15
P11
P10
P4b
P23b
P4c
P9a
P12
P9b
P8

7 CONCLUSIONS

Based on the knowledge of a team of experts it was possible to establish a comprehensive regional overview of the spatial distribution and pattern of forest change processes in Southeast Asia. Forest change processes include forest conversion and change of canopy cover (e.g. degradation), in some localities also major afforestation and reforestation activities. The boundaries and the spatial extent of the change areas are given approximately, the information is not intended to serve for local applications that would require high spatial detail and accuracy.

The regional change pattern shows, that apart from the less accessible and mostly mountainous areas, most of the remaining forest cover of Southeast Asia is affected by change, usually due to a combination of different change processes. The conversion of forests to cash crop plantations has become the primary threat to the remaining forests in many parts of the region, downgrading somewhat factors like 'logging' and 'shifting cultivation'. This is to a great extent driven by foreign demand. In the continental part of Southeast Asia plantations of rubber, coffee and other crops have become an important cause for forest loss, oil palm plantations are the most important driving force of forest conversion in the insular part of Southeast Asia.

But also the establishment of timber plantations is a major factor for the disappearance of natural forests. Commercial concession logging remains an important reason for forest change and degradation, and illegal logging activities cause damage across the region at varying intensity. Commercial logging represents the major cause of forest changes in Papua (Indonesia) and PNG, and the pressure on the forests will probably increase due to the shrinking forest resources in other parts of the region and the increasing demand for timber.

There are some sub-regional differences. For example, the construction of dams (hydropower) is at present more an issue in continental Southeast Asia (upper Mekong tributaries), less in the insular part. Fires remain an important threat to the forests of insular Southeast Asia, but are causing little change on the continent.

The frequent overlap of change areas with protected areas and national parks (illegal logging, encroachment, small scale conversion) stresses the fact that protected areas are not sufficiently respected everywhere in the region. Considering the importance of Southeast Asian forests for biodiversity this may be taken as an indication for the need to further enforce forest protection and biodiversity conservation.

The fact that many change areas stretch along country boundaries highlights the need for forest strategies at sub-regional and regional levels.

From a regional perspective, the spatial density of the change pattern indicates a high level of threat for the region's forest and forest ecosystems, confirming therefore concerns about sustainability and biodiversity conservation.

Note:
The GIS layers of the regional pattern of forest change in Southeast Asia and the regional forest cover maps displayed in this report can be downloaded from the following website: URL: *http://www-gem.jrc.it*, following the appropriate links provided.

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9 ANNEXES

9.1 QUESTIONNAIRE USED FOR DESCRIBING THE CHANGE PROCESSES

AREA NUMBER: _____

AREA NAME/ LOCATION: _____

CHANGE PROCESS:

- ☐ Forest → Non-Forest
- ☐ Non-Forest → Forest
- ☐ Decrease of Forest Density or Structure / Fragmentation
- ☐ Other (specify):

STATUS BEFORE CHANGE (if known):

- ☐ Primary Forest
- ☐ Secondary Forest
- ☐ Degraded Forests
- ☐ Other (specify):
- ☐ Production Forest
- ☐ Non-Production Forest
- ☐ Protected Forests

TIME SCALE OF CHANGE:

- ☐ in the past 3-5 years
- ☐ presently ongoing at high speed – affecting whole area within a short time period
- ☐ presently ongoing at moderate speed – affecting whole area in the long term
- ☐ will take place from now onwards (e.g. in the next 3 years)
- ☐ Other (specify):

TYPE:

- ☐ Controlled/Planned
- ☐ Uncontrolled
- ☐ New forest activity in formerly unutilized forests

MAIN REASONS (not exhaustive, please add under remarks if necessary):

- ☐ Conversion to agricultural land
- ☐ Conversion to agro-plantations (oil palm)
- ☐ Conversion to infrastructure or urban area
- ☐ Shifting Cultivation
- ☐ Other (specify):
- ☐ Conversion to forest plantations
- ☐ Clear cut and natural re-growth
- ☐ Selective logging
- ☐ Fires

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Abstract
This document provides an overview of the present pattern of forest change in Southeast Asia at a regional scale. Areas of forest change were identified and approximately delineated by a team of national and regional experts. This was done in the context of sub-regional workshops, held in Vientiane (Laos) and Jakarta (Indonesia) at the beginning of 2007. The main processes of forest change are described, providing indications on the time scale, intensity and the main causes for the change. The regional change pattern established from this information shows that most of the accessible forests in Southeast Asia, and specifically the lowland forests, are experiencing change. The most evident cause of forest loss is the conversion of forest to cash crop plantations. The establishment of timber plantations and timber exploitation, including illegal logging, are responsible for considerable change of forest canopies and structure. The geographical layer established from this information will serve for stratification of the region's forest cover, to be used for a remote sensing based sampling approach in the context of regional forest monitoring. It can also provide useful background information for regional forest and conservation strategies.

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