THE IMPACTS OF WARMING ON TROPICAL LOWLAND RAINFORESTS

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Before the end of this century, tropical rainforests will be subject to climatic conditions that have not existed anywhere on Earth for millions of years. Given their crucial role in preserving global biodiversity and in regulating carbon and water feedbacks in the global climate system, it is important that the likely impacts of anthropogenic climate change are understood. However, the recent literature shows a striking range of views on the vulnerability of tropical rainforests, from least to most concern among major ecosystems. Two main potential impacts are of concern with tropical rainforest: the relatively robust predictions of pantropical rising temperatures and the highly uncertain predictions of increasing drought frequency and intensity in some areas. I will focus mainly on the impact of rising temperatures, examines the evidence for and against high vulnerability, identifying key research needs for resolving current differences and suggesting ways of mitigating or adapting to potential impacts.

Optimistic views of the future of tropical rainforests generally rely on the fact that the absolute increases in temperature are expected to be less in the tropics than in other areas. Pessimists, in contrast, point out that these changes will be large relative to present variability, on daily, seasonal and longer timescales. Why would rainforest organisms retain expensive adaptations to high temperatures that they have not experienced in recent evolutionary time? Currently the evidence either way is weak. Some lowland tropical plant and animal species do seem to be approaching their thermal limits, but their representativeness, and their capacity to acclimate over longer timescales and to adapt over multiple generations is largely unknown.

We urgently need more information on the thermal tolerances of tropical lowland species, making use of both existing spatial and temporal variation in temperature, as proxies for future climate change, as well as controlled experiments on various scales. We also need rigorous, quantitative, long-term (multi-decadal) monitoring, so that impacts will be detected if and when they occur. In the meantime, while hoping for the best we need to prepare for the worst and start to plan future ‘thermal refuges’ for tropical lowland biodiversity, for example by extending existing protected areas to higher altitudes or latitudes wherever possible. Even where habitat continuity is preserved however, the ‘velocity of climate change’ is predicted to be so high in the tropical lowlands that only the most mobile of species will be able to keep up.

THREE APPROACHES FOR PLANT DIVERSITY ASSESSMENTS IN ASIAN TROPICAL FOREST

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Forest areas are being rapidly lost in tropical Asia, especially in Cambodia, Indonesia and Myanmar. However, it remains uncertain how rapidly plant species are being lost. To assess the rate of species loss, the species number-area curve has been used, but this method has some drawbacks. To obtain more reliable estimates of the rate of plant species loss in Asian tropical forest, we are employing specimen-based, plot-based and transect-based approaches. Specimen records and plot data provide key resources for assessing plant diversity at various scales, and distribution modeling based on these records provides key methods for assessing states and trends of plant diversity. However, specimen records are limited in tropical areas and plots cover only a limited number of tree species. Thus, we need to carry out new field surveys in candidate hotspots of plant diversity and its threats. We propose that transect-based approach is an efficient way for quantitatively assessing plant diversity in candidate hotspots. Since 2012, we are carrying out plant diversity assessments in Asian tropical forest using the above three approaches, and here I introduce our early achievements. One of the major difficulties in this assessment is the identification of many sterile plants in plots and transects. We could successfully overcome this difficulty by determining DNA sequences for those plants. Another difficulty we are facing is that the majority of plant species have too few distribution records to model their ranges using ordinary approaches of niche modeling. This difficulty can be overcome by coordinating collaborations of local herbaria and by developing a new modeling approach in which phylogenetic relationships between common and rare species are taken into consideration.

HOW TROPICAL FOREST SCIENTISTS CAN CONTRIBUTE TO CONSERVATION

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If scientists are to improve the fates of tropical forests, they need to pay greater attention to the diverse drivers of deforestation and degradation while they explore ways to enhance the potential synergies between conservation interventions in place and planned. Among the on-going and related interventions are certification of natural forest management operations, assurance of the legality of marketed forest products, and climate change mitigation. The success of all of these interventions depends on improvements in governance by state and non-state actors. These improvements are emerging from unprecedented levels of involvement in open global and local discussions of tropical forest issues by a diversity of often newly empowered stakeholders including representatives of civil society and government, environmental groups, scientists, forestry firms, and the retailers and purchasers of forest products. Continued disregard of this diversity of stakeholders and the overall complex contexts in which tropical forest conservation happens or fails to happen, as exemplified by advocates of complete protection (=”fortress preservation”) as the only viable and acceptable conservation strategy, damages the mixed-portfolio approach needed to maximize the overall efficiency, effectiveness, and equity of conservation interventions.

Despite the obvious resilience of the tradition of natural resource misuse by forest industries, the obvious alignment of potentially synergistic local, national, and international conservation endeavours provides hope that tropical forestry is finally primed for rapid improvement. One pillar supporting this hope is devolution of control over forest lands to indigenous groups and other rural communities that, coupled with increased transparency of decision-making, reduces deforestation and forest degradation and promotes sound, multiple-objective forest management. Also helping to motivate responsible forest management is recognition by some governments that they are failing to capture substantial forest rents due to corruption and inefficiency in their ranks. In response, they are stepping up law enforcement efforts to the point of penalizing perpetrators. Improvements in remote-sensing techniques are also helping them to detect and curb illegal logging. Working in conjunction with these national and subnational efforts to improve governance, international programs designed to control the trade in illegal timber are advancing, which benefits silviculture by making responsible forest management more financially attractive. Legality assurance facilitates an aligned step towards responsible management, international, voluntary, third-party certification of forest management operations. From management certification it is a small step towards verification of the substantial short and long-term carbon benefits of improved forest management. If the carbon connection is made, funds for reduced emissions of atmospheric heat-trapping gases could be used to reduce the direct and indirect costs of certification until markets expand for certified products and green premia increase. Forest scientists can contribute to the realization of the conservation benefits of these and other potential synergies if they focus on solving the real world problems confronted by the various responsible actors.

While many environmentalists are justifiably leery of making further investments in improving tropical forest management, in light of the resilience and biodiversity of even ruthlessly exploited tropical forests contrasted with the environmentally bleak alternatives of plantations and pastures, such improvements remain critical. To reveal how conservation interventions that seek to improve forest management should be designed to avoid the pitfalls exposed by earlier efforts (e.g., the Tropical Forestry Action Plan), well-informed theory of change models are needed. In this talk, a generic theory of change model is described that captures the actors and actions needed to improve forest management by promoting carbon retention (i.e., reduced forest degradation). To illustrate the complicated and complex nature of this and related conservation interventions, the seemingly simple example is developed of a chainsaw operator in a timber concession in Borneo who needs to decide whether to fell a tree that he suspects to be hollow. This example is of general relevance insofar as interventions designed to mitigate climate change, certify responsible forest management practices, or assure the legality of forest products all need to influence this and related decisions. These sorts of shared needs provide clear motivation for communication and collaboration among forest workers, managers, auditors, certifiers, policy-makers, and researchers.

THE SENSITIVITY OF TROPICAL CARBON CYCLE TO CLIMATE CHANGE: A MULTI-MODEL ANALYSIS

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The human caused perturbation of the carbon cycle is often recognized as a major factor controlling climate change, directly through emissions of greenhouse gases and indirectly via climate feedbacks on natural carbon sources and sinks. Current coupled-climate-carbon models used in the IPCC 4th and 5th Assessment Reports generally project a positive feedback between global warming and the reduction of terrestrial carbon sinks in the 21st century, which has important implications for mitigation policies designed to stabilize greenhouse gas levels. The magnitude of this positive feedback varies markedly among models. For example, by 2100 the climate-carbon cycle feedback is estimated to cause an excess of CO2 going from 20 ppmv to 200 ppmv among the models, which corresponds to an additional global temperature increase of 0.1◦C–1.5◦C (Friedlingstein et al., 2006). Such a large uncertainty in carbon-climate feedbacks is associated with the different sensitivities of simulated terrestrial carbon cycle processes to changes in climate and atmospheric CO2

A decrease in the tropical land carbon sink driven by climate change has been found previously to be the main process explaining the positive climate-carbon cycle feedback found in future projections (Cox et al., 2001; Friedlingstein et al., 2006). Its causes have to be found in a combination of reduced photosynthesis due to a warming, generally combined with an increase in soil aridity, as well as an increase in soil oxidation, due to the warming. Hence, it is crucial to better assess, using available long-term observations, the sensitivity of the tropical carbon cycle to climate. In this study, we evaluate the sensitivity of tropical carbon cycle to climate change using ten process-based terrestrial carbon cycle models used for the IPCC 5th Assessment Report. The simulated gross primary productivity (GPP) distribution and its sensitivity to climate change are compared with flux-tower based estimates by Jung et al. (2011) (JU11). The simulated net biome productivity (NBP) is compared with the long atmospheric CO2 record from Mauna Loa observatory.

MANAGING TROPICAL FORESTS FOR TIMBER, CARBON, AND BIODIVERSITY CONSERVATION

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Tropical forests that are managed sustainably provide a continuous flow of wood products and many long-term employment opportunities in forests and along the forest product market chain while they maintain biodiversity and retain or even enhance carbon stocks. Although most projects associated with the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program being developed for climate change mitigation focus on avoided deforestation and reforestation, the substantial carbon and other benefits from application of improved forest management deserves more attention from researchers and policy-makers. To motivate this consideration, we used available data on logging practices, damage and logging and wood waste in the 403 million ha of production forests in International Tropical Timber Organization (ITTO) producer countries to calculate the annual production of end-use wood, logging damage, and wood waste. We then estimate the reduction of carbon emissions that could be achieved by switching from conventional logging (CVL) to reduced-impact logging (RIL) practices. We also compare the impacts of three selective cutting cycle durations (25, 40, and 50 years) on carbon stocks and wood production, and to propose an appropriate cutting cycle for under the REDD+ scheme.

Data of forest carbon stocks from 28 production forests across the tropics were used to assess timber harvests and associated waste, timber supply, and forest carbon stocks with RIL and CVL. In addition, inventory data were analyzed to assess how commercial tree species may be selectively harvested under RIL and CVL.

With the application of a cutting cycle of 25 years to the 403 million ha of production forests (with 50% operable area) in ITTO's timber producing countries, both RIL and CVL generated an average of 200 million m^3 $year^{-1}$ (182–217) of end-use wood product between 2010 and 2070, declining about 2.3 million m^3 $year^{-1}$ (2.0–2.7) (0.9%). The short cutting cycle resulted in a higher harvest than forest growth could sustain and therefore it results in rapid degradation of the forests. As only highly valued timber species are targeted under CVL, biodiversity loss is unavoidable. In terms of wood waste (logging damage and waste in the forest plus wood waste in processing facilities), CVL produced 371 million m^3 $year^{-1}$ (338-403) over the 2010-2070 period, whereas RIL produced only 170 million m^3 $year^{-1}$ (155-185), an average reduction of about 201 million m^3 $year^{-1}$. Wood waste under CVL resulted from sawmill wastes and a huge amount of logging wastes, especially wastes caused by employment of untrained and poorly supervised workers in tree felling, log skidding, bucking, and transport.

To determine the sustainable and financially acceptable cutting cycle for maintaining wood supplies and reducing carbon emissions, timber and carbon revenues for managing 403 million ha were analyzed. Without incentives such as the REDD+ scheme, the shortest cutting cycle (25 years) is financially the most attractive.

By switching from CVL to RIL under a 40-50 year cutting cycle, ITTO producer countries could prevent the carbon emissions due to forest degradation by about 1.5-2.1 billion tCO_2 $year^{-1}$ while still producing about 82.5-140.5 million m^3 of end-use wood under a 50-year carbon project cycle, with the results being dependent on the chosen cutting cycles. Furthermore, as socially and environmentally sensitive areas are excluded from logging under the RIL, biodiversity conservation could also be achieved with the right incentives and enforcement.

This study suggests that switching from destructive CVL logging practices to RIL can substantially reduce carbon emissions while still producing wood for commercial use and protecting biodiversity. Longer cutting cycles maintain higher carbon stocks but reduce wood production, whereas short cycles increase wood production at the expense of carbon stocks, long-term timber availability, and biodiversity. Longer cycles than 40 years would discourage investors as well as project developers because of political and financial uncertainty, thus also discouraging long-term political commitment in developing countries. Nevertheless, without the right incentives, developing countries are likely to continue to allow the use of destructive logging practices because of the high short-term returns. It is therefore important that the REDD+ agreements explicitly include RIL and sustainable forest management (SFM) as key components along with appropriate guidelines, and SFM projects should be promoted. Forest product certification and payments for ecosystem services in addition to carbon will likely reduce illegal logging, thereby increase government revenue from timber royalties and taxes, and create more jobs in the legal logging industry.

A COMMON CHARACTER OF FOREST EVAPOTRANSPIRATION IN RESPONSE TO CLIMATE CHANGE

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Although terrestrial ecosystems support a sound environment necessary for our human life, we are now facing a serious risk of crossing the threshold into ecosystem declination in response to the climate change. Evapotranspiration (ET) decreasing due to limited moisture supply has been already detected particularly in the Southern Hemisphere. It is important to examine such influences of climate on ET from a resilience and threshold perspective. Among the terrestrial ecosystems, forest has a striking character on ET derived from a long life of tree individuals. This paper first describes the character, a strong resistance against dryness with a dependency on climate change, obtained from an analysis of annual water budget in a temperate small catchment in Japan where a long-term hydrological observation with high accuracy is conducted by Forestry and Forest Products Research Institute. Secondly, we have a discussion that such a character on ET is commonly detected under both tropical and boreal forests.

A 69-year record (1937-2005) of the precipitation and runoff in a small catchment Japan was analyzed to evaluate effects both of the vegetation and climate changes on ET. Although natural pine forest covered the catchment, ET decreased after a pine death by insect damage around 1943. After 1959, when a broad-leaved forest grew up, ET has a clear positive relationship to the annual air temperature. The ratio between them became large for the recent years with high temperature after 1991 compared to the previous period. Increase or decrease of the annual loss in each year was highly correlated with a difference in the catchment water storage between the beginning and end of year when the catchment was covered with forest, but no correlation was found for periods of 1944-58 with a poor vegetation after the pine death. This result shows that ET from a forest was maintained constant by reducing the soil water even in dry years but that this character disappeared in case of a forest absence.

The remarkable character of forest ET was also found in a strong ET resistance during dry seasons under tropical climates. Flux studies conducted in tropical rain forests in Amazonia and in Malaysia and in seasonal forests in Thailand and Cambodia commonly revealed this character. This sustainability of ET was supported by a deep root system and clayey soil with a low hydraulic conductivity, as revealed in hill evergreen forest in Thailand. Additionally, ET from boreal forests with permafrost was maintained even in an unusual dry summer using water supplied in the previous wetter summer through the freezing/melting process during winter, as demonstrated in Siberia and Alaska. These evidences clearly demonstrate a homeostatic mechanism of forest against a dry spell. We may have to recognize that forest can cover the land surface only when it can access water by a sophisticated mechanism even in dry spells which often appear during a long year of tree life.

Finally, we should emphasize a different impact of forest ET on the water resources conservation in each geographical region. Because forest ET is not only large but also resistant against dryness, this effect may contribute to a sustainability of humid climate in an inland region of a continent through a constant water supply necessary for a valuable source of precipitation. In an island or a peninsular, however, such a character of forest ET may only result in a decrease of river water because precipitation is brought from the ocean ET. Forest clearing in a small area of a catchment is rather efficient for using water particularly in a dry spell. The normal forest operation to get the same timber harvest every year should be reminded in geographical regions surrounded by ocean like Japan. If such a common character of forest ET is not carefully considered in both forest and watershed managements, positive interactions between poor forest managements and highly-fluctuating water cycle will lead us into an environmental devastation.

PRODUCTION AND CONSUMPTION OF METHYL HALIDES IN SOUTHEAST ASIAN TROPICAL FOREST

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Plants emit a variety of biogenic volatile organic compounds (BVOCs) into the atmosphere. Major BVOCs, such as isoprene and monoterpenes, are extremely reactive and play an integral part in atmospheric chemistry by modulating the oxidation capacity of the atmosphere and providing the formation of organic aerosols. In addition to the reactive compounds, certain tropical plants are known to emit long-lived compounds such as methyl chloride (CH_3Cl) and methyl bromide (CH_3Br). Their atmospheric lifetime (~ 1 year) is long enough for them undergo long-range transport from source regions to the stratosphere, where they play an important role in the halogen-catalyzed destruction of stratospheric ozone. Currently, they are responsible for ~25% of total halogen related ozone depletion and hence important in the global climate system.

The atmospheric budgets of the methyl halides remain highly uncertain, but natural sources are believed to play major roles in the budget of the compounds, especially CH_3Cl. Among a variety of the natural sources, tropical forest ecosystem is now considered as major source of CH_3Cl. In the tropical forest ecosystem, there are both sources and sinks; plants (as well as fungi) and soil bacteria are known to be responsible for production and consumption of CH_3Cl, respectively. Recently, we observed the consumption of CH_3Cl by tropical plant leaf samples, but it is not known to what extent the identified uptake process affect net emission rate of CH_3Cl from tropical plants. The tropical terrestrial source for CH_3Br is less well studied, despite modeling studies suggested that there are unidentified sources of CH_3Br in the tropics. Only a few studies demonstrated that certain tropical trees and tree ferns produce CH_3Br substantially (Blei et al., 2010; Saito and Yokouchi, 2006). Plant leaves uptake of CH_3Br when exposed to high concentrations (Jeffers et al., 1998), but it is unknown if such processes occur at ambient levels.

In this study, we conducted field studies to determine gross production and consumption of CH_3Cl and CH_3Br for some tropical-tree species. Field studies were conducted at the Pasoh Forest Reserve in Peninsular Malaysia. To simultaneously determine production and consumption rates of methyl halides, a stable isotope tracer technique (Rhew et al., 2003) was applied for tropical plants. Branches of tropical plants were enclosed in a Teflon bag. Immediately after enclosure, 2 ml of a standard gas mixture containing $^{13}CH_3Cl$ (5 ppm), $^{13}CH_3Br$, and CFC-113 (5 ppm) in nitrogen was injected into the bag through the injection port, and then air samples in the bag were collected at 3, 13, 23, and 33 min after enclosure. The air samples were analyzed by preconcentration/gas chromatography/mass spectrometry (GC/MS, HP 6890/5973) with the same experimental setup described in elsewhere (Saito et al., 2008).

Of the 9 plant species examined, five consumed CH_3Cl with an average uptake rate of 3 ng g(leaf dry weight)$^{-1}$ h^{-1}. However, gross production rates of CH_3Cl (31 ± 58 ng g(leaf dry weight)$^{-1}$ h^{-1}) mostly exceed the gross consumption rates, leading to large net source overall. The net CH_3Cl emission rates were similar to those reported for dipterocarp trees (Blei et al., 2010; Saito et al., 2008; Yokouchi et al., 2002). In contrast to CH_3Cl, gross uptake rates of CH_3Br (0.2 ± 0.1 ng g(leaf dry weight)$^{-1}$ h^{-1}) were almost balanced against gross production rates (0.2 ± 0.3 ng g(leaf dry weight)$^{-1}$ h^{-1}). The low net emission rates of CH_3Br are consistent with previously reported values of 0.4 (range: <LOD to –2.9) ng g(leaf dry weight)$^{-1}$ h^{-1} for dipterocarp trees in Borneo island (Blei et al., 2010). The measured uptake rates of CH_3Cl and CH_3Br are correlated with each other, suggesting that CH_3Cl and CH_3Br may be consumed by a similar mechanism in or on the leafing branches. The molar ratio of CH_3Cl to CH_3Br (43) is similar to gross uptake rates reported in the boreal forest soil (CH_3Cl:CH_3Br molar uptake ratio: ~39; (Rhew et al., 2003)); microorganisms (such as methylotrophic bacteria) are known to be responsible for at least part of methyl halide consumption in soils (Miller et al., 2004). Considering that a variety of microorganisms dwell in the surface of plant leaves (Leveau, 2009), and that methyl chloride-degrading bacteria present on the leaf surfaces of a CH_3Cl emitting plant (Arabidopsis thaliana)(Nadalig et al., 2011), our observations may be evidence for the consumption of methyl halides by the plant-associated microorganisms.

SOIL CARBON DYNAMIC AND REDD CREDIT OF SE TROPICAL ECOSYSTEMS

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The tropical ecosystems have been estimated to be a large carbon source (1.3 Pg C yr^{-1}) due to deforestation and forest degradation, even the global terrestrial carbon sink has been large (1.1 Pg C yr^{-1}) in recent decades. Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for tropical region to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. The ultimate goal of this study is to update REDD mechanism through improved forest management by evaluation of effects of logging and land-use change on soil carbon emission of tropical forests.

This study was conducted in a lowland primary forest at Pasoh Forest Reserve (2º58’ N, 102º18’ E; 75~150m a.s.l.) and a mountainous tropical forests at Temenggor concession area (5º33’ N, 101º36’ E; 800~900m a.s.l.) in Peninsular Malaysia. About 50~65% biomass was harvested and soil temperature increased about 3ºC with SMS, resulting value of the carbon stock lost about 247 US$ ha^{-1}following the first year of logging. On the other hand, under low-impact harvest condition, only about 124 US$ ha^{-1} was lost following the first year of logging. Result suggests that this low-impact harvest system would achieve about 123 US$ ha^{-1} of REDD credit partially contributed from mitigating soil degradation of about 55 US$ ha^{-1}.

FRAGMENTATION, RESTORATION AND CLIMATE CHANGE: SEEING GREEN IN A SEA OF REDD

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Tropical deforestation and fragmentation continues to be the major driver of biodiversity loss and a major contributor to climate change. Increasing numbers of forest-dependent rural poor rely on degraded forest for their livelihoods. The lowland forests of Southeast Asia are unique in that they are dominated by a single family of tree species, the Dipterocarpaceae. These forests are economically and ecologically vital to the region, providing valuable timber resources, are habitat rich in biodiversity and among the most important terrestrial carbon sinks in the world. Surprisingly, relatively little is known about the implications of forest fragmentation for the reproductive ecology of these foundation tree species.

First, I provide a brief review of our current understanding of how forest fragmentation influences the reproductive ecology and population genetics of dipterocarps. Using examples from our work in Borneo, the Seychelles and India, I argue that variation among species in their vulnerability to fragmentation is likely to impact not only community dynamics and forest tree species assembly, but also the patterns of genetic biodiversity in tree populations. Experimental work in Borneo examines how variation in flower size, pollinator body size and pollen dispersal vary across dipterocarp species, coupled with limited seed dispersal, this suggests some dipterocarps may be especially vulnerable to habitat fragmentation. In highly fragmented landscapes species of dipterocarp may become genetically isolated due to a limited capacity to disperse pollen among fragments. In addition, most dipterocarps are unlikely to be able to disperse seed to new sites amenable to colonization in a fragmented landscape. Work using genotyped dipterocarp seedlings in a nursery experiment provides evidence of a heterozygosity fitness correlation in the early stages of seedling establishment. In contrast, an endemic dipterocarp species in the Seychelles appears to be relatively insensitive to an extreme genetic bottleneck. The rapid rate of land use change across Southeast Asia and increasing forest fragmentation necessitates that we integrate our scientific understanding of the reproductive ecology of these trees into future land use and forest management policies. This will impact on levels of biodiversity, ecosystem function and critical ecosystem services such as carbon storage.

Second, I present the results of a comprehensive review conducted to evaluate masting phenology, seed storage and seed dispersal distances across important tropical timber tree families. This information is synthesized to identify the implications of these seed-related traits for ecological restoration of tropical forests and its integration into REDD+ with a focus on Southeast Asian forest. Reversing the current trend towards highly fragmented forest landscapes will require conservation and restoration of Southeast Asia forests. I propose a framework upon which forest restoration could be established to conserve forest biodiversity, help mitigate climate change and support rural livelihoods.

Finally, I will summarize the gaps in our knowledge of how current and future land use change is likely to influence the resilience of lowland forest in Southeast Asia and suggest new research that will be essential to scientifically informed sustainable forest policy.

PLANT CONSERVATION EFFORTS IN MALAYSIA

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Malaysia has a rich flora with about 15,000 species of vascular plants. Conservation efforts in Malaysia are now guided by the Malaysian National Strategy for Plant Conservation. The strategy includes documenting the flora of Malaysia which is included in two projects, the Tree Flora of Sabah and Sarawak and the Flora of Peninsular Malaysia. Since 1990, the Tree Flora of Sabah and Sarawak has published seven volumes covering 2,055 species. The Flora of Peninsular Malaysia which initiated in 2005 has published four volumes, covering 991 species. The flora projects formed the basis of plant conservation projects. Conservation assessments for plants in Peninsular Malaysia were started in 2005. Currently, about 500 species have been assessed. From the assessment about 47% of the taxa were found to be in some conservation concern categories. The assessments provide the prioritisation for conservation work on the most threatened species in Malaysia. Currently, 33 species are subjected to detail studies for conservation actions; these are mainly in the Endangered or Critically Endangered categories. The project is also looking into identification of the Important Plant Areas (IPA) for Malaysia.

HOW WILL REDD+ SATISFY BIODIVERSITY CONSERVATION AND LOCAL BENEFIT? -- A CASE STUDY IN EAST KALIMANTAN, INDONESIA --

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UNFCCC COP16 at Cancun in December 2010 referred to the 'safeguards' in its Annex I, such as transparent and effective national forest governance, respect for the knowledge and rights of indigenous peoples and members of local communities, full and effective participation of relevant stakeholders, and consistency with the conservation of natural forests and biological diversity. It is, however, unclear how those provisions will be effectively operationalized. In order to ensure the safeguard substantially, principal stakeholders such as governments and project initiators/ managers are required to know the reality of the local peoples' livelihoods and land use systems in terms of their preference in the near future as well as the status quo.

The authors selected Indonesia for the study, because of having the most developed REDD legislation among the initial nine member countries of UN-REDD as well as being one of the countries experiencing a large forest loss between 2000 and 2010. The province of East Kalimantan was selected for the research sites because the province is the center of timber production and forest cover in Indonesia.

The objective of the study is to explore local people's near-future preferences in terms of income source and land use, and to get policy implications for feasible implementation of REDD+ policy. Four villages resided by different ethnic groups, such as the Bahau, the Kenyah, the Benuaq, and the Tonyooi accounting for the majority of the indigenous people, known generally as the 'Dayak', in West Kutai district were selected as research sites.

The authors presented 13 income options to respondents and asked them to choose the most, second-most, and third-most important ones for the year 2013: (1) Sale of timber: Meranti (*Shorea* spp.), Kapur (*Dryobalanops* spp.), Ulin (*Eusideroxylon zwageri*), Sengon (*Albizia* spp.), and other species, (2) sale of NTFPs: rattan, aloes-wood, Damar resin, deer, wild boars, birds, monkey gallstones, swallow nests, and honey, (3) sale of gold dust and white sand, (4) oil palm plantations, (5) other perennial crops: rubber, coffee, and cacao, (6) rice, etc.

The authors also presented 11 land-use options in accordance with present land-use categories: (1) swidden agriculture, (2) traditional rubber gardens, (3) commercialised rubber plantations, (4) rattan gardens, (5) orchards, (6) oil palm plantations, etc.

In forestlands, the questionnaire survey revealed that people still somewhat prefer the income generated from selling timber and NTFPs such as swallow nests, aloes-wood, resin, and forest game. This finding implies that it is possible for them to use these resources as livelihood assets, even though forestlands are usually far from their residences. At the same time, they do not expect opportunities for work of logging and planting trees in the concession areas held by private companies. In addition to the group management of plantation forests (*Hutan Tanaman Rakyat: HTR*), we recommend incorporating the management of timber and NTFPs by local people into the programs approved as REDD-plus activities.

In non-forestlands, the questionnaire survey reveals that the continuation of swidden agriculture, developing and extending traditional rubber gardens and modern rubber plantations, and developing cacao gardens will constitute an important basis for their livelihood in the near future. Furthermore, the fact that people have a preference for rattan gardens and orchards, which look like forests, implies the importance and effectiveness for landscape conservation of sustainably managing non-forestland resources. It is recommended that Indonesia introduce programs to support, as REDD+ activities, the sustainable management of remaining forest and forest-like land uses such as orchards, rattan gardens, and traditional rubber gardens.

Fortunately, Indonesia has a national program called “Forest and Land Rehabilitation” (*Rehabilitasi Hutan dan Lahan: RHL*), which is, however, not formally connected to REDD-plus activities. The program supports various activities initiated by local people: (1) reforestation activity on protected forestland, (2) re-greening activities on non-forestland including “individual forestry”; “individual agroforestry” in which trees are intercropped with rice, maize, or other crops; “forest-related activities”, including the management of NTFPs such as rattan, aloes-wood, and sugar palm; and “individual gardens” of rubber and cacao. Actually some people in West Kutai district have received government support to start such activities, and their approval as REDD+ activities by the government even on non-forestland might provide an excellent incentive for local people to contribute to carbon sequestration as well as to biodiversity conservation.

In order to satisfy the biodiversity conservation and local benefit, we should not confine our perspective on the REDD+ policy framework determined by the government, but evaluate it by checking actual conditions in the field, especially grassroots preferences in terms of income sources and land-use type.

RESEARCH ON TROPICAL FORESTS IN SARAWAK, MALAYSIA: TOWARD UNDERSTANDING THE ECOSYSTEMS AND SOCIAL-ECOLOGICAL SYSTEMS

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The mixed dipterocarp forest in Sarawak, Borneo may be characterized by four dimensions of ecosystem complexity. The first is species richness; The forest is one of the richest tropical rain forests in the world, in particular with quite a high species diversity of trees. The second is attributed to complex interaction networks among these species. For example, most flowering plants depend on animals for pollination. Although majority of the plant-pollinator interactions are diffuse, some plants have evolved very tight relationships with a particular group of pollinators. The third and forth are heterogeneity in space and time. The forest canopy of 20-40 m with emergents reaching up to 70 m creates various microenvironments and habitats, which support different flora and fauna. For temporal heterogeneity, irregular fluctuation of precipitation plays an important role. For example, a dry period of about 40 days is known to trigger general flowering at irregular intervals of 3-10 years. During general flowering, most dipterocarp species, together with species of other families, come heavily into flower, while flowering is rarely observed in non-general flowering periods.

We have studied the ecosystem complexity in Lambir Hills National Park, Sarawak, Malaysia since 1992. Monitoring of forest dynamics and reproductive phenology for 20 years have revealed drastic changes in mortality and regeneration of the forest under relatively aseasonal climate. Facilities such as tree towers, areal walkways and canopy crane have greatly enhanced our researches in the canopy, and our understanding of spatial heterogeneity of the forest. In the former half of the talk, I will introduce some of the results of the studies.

In the latter half of the talk, I will focus on the studies about the cause and consequences of recent rapid decline of the forest conducted as part of the RIHN project “Collapse and restoration of ecosystem networks with human activity”. In Sarawak, human activities have changed ecosystems dramatically in the last 50 years; land use has shifted from small-scale agriculture in the forests by indigenous people to logging in natural forests by enterprises as a source of timber for export, and then to the development of oil-palm plantations.

The decrease and degradation of forests due to human activities inevitably result in considerable loss of forest organisms and biodiversity. Our studies demonstrated that a major proportion of species were only found in primary forests, while a lower level of biodiversity can be maintained in secondary forests after swidden cultivation. In comparison, species loss is much greater when forests are converted to oil palm plantations. In addition, the effects of loss of primary forests are not always simple. The effects are strongly depending on the group of the organisms, and they sometimes have repercussions on biodiversity in the surrounding area. The changes in the species composition and forest structure alter biological interactions and ecosystem functions. These observations suggest that loss of biodiversity and ecosystem services following reduction of forest area do not proceed linearly but show abrupt decline a certain point ("tipping point"). Once a majority of the forests are lost or become degraded on a large scale, and re-colonization of the organisms becomes difficult, recovery of the forests may be impossible.

Drastic changes in land cover are considered responsible for many negative changes in the lives and society of indigenous peoples. To investigate the effects of such changes quantitatively, we conducted interview surveys in the Baram and Rajang river basins. We also collected data on aspects of their environments; forest cover was evaluated based on the land cover maps based on the satellite data, and available infrastructures of the villages were recorded based on the interview to the village leaders. The data indicate that loss of forests is one of the major factors explaining a decline in the use of various non-timber forest products and swidden agriculture. Such changes in the livelihood may also affect social capital of the villages.

LEARNING FROM MALAYSIAN FORESTS; TOWARDS AN UPGRADED REDD+ INCORPORATING BIODIVERSITY

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Reducing Emissions from Deforestation and Forest Degradation (REDD+) and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries are topics being discussed in the United Nations Framework Convention on Climate Change as methods for mitigating global warming. No less than 20% of anthropogenic CO^2 emissions arise from changes in land use or deforestation (IPCC, 2007). Furthermore, tropical developing countries such as Brazil and Indonesia are rapidly losing forested areas, and this loss has accounted for the majority of the carbon emissions from land use change worldwide (Houghton, 1999). These facts make it obvious that reducing deforestation in developing countries is an effective way of reducing emissions of greenhouse gases.

Carbon storage is not the only ecosystem service forests provide. Forests provide various other ecosystem services such as timber production, water purification, and slowing runoff by acting as natural dams. Providing the structure necessary for high levels of biodiversity is another important ecosystem service of forests. In particular, tropical forests are well known for their high levels of biodiversity. Many biodiversity hot spots occur in tropical developing countries (Myers et al., 2000) and these include most of the mega-diversity countries (World Bank, 2006).

Data reveal that forests with high carbon stock do not always contain high levels of biodiversity. Therefore, if we concentrate on producing or maintaining forests with high carbon storage capabilities, which can have a high economic value using REDD+ mechanisms, we may lose some level of biodiversity. Clearly, we need to consider biodiversity and avoid impacting biodiversity negatively when conducting REDD+. With this in mind, we explored forest management techniques that both maintain and produce high levels of forest carbon stock as well as high levels of forest biodiversity in two Malaysian forests.

One study site is the Pasoh Forest Reserve, Negeri Sembilan, in peninsular Malaysia. Within the reserve, a forest originally logged under the Malayan Uniform Systems method from 1954 to 1959, is located adjacent to unlogged primary forest. We compare the ecological aspects of an unlogged forest and a forest selectively logged 50 years ago. Our results show that the forest structure, light regimes, tree performance, demography and species composition in the selectively logged forest were different from those in the primary forest. These results suggest that logging cycles shorter than 40–50 years are not advisable in terms of conservation of biodiversity in Malayan tropical forests. More frequent logging may negatively impact biodiversity in tropical forests.

The other study site is the Temengor Forest Reserve, Hulu Perak, also in peninsular Malaysia. In this reserve, a logging operation was ongoing. We investigated impacts of the logging operation on mammalian and insect biodiversity. Based the results, logging roads have a high negative impact both on mammalian and insect biodiversities. Reducing logging road density and length can help mitigate the loss of biodiversity caused by logging operations. Because logging roads are easily monitored and measured, logging road density and length can be a good indicator of negative impacts to biodiversity caused by logging operations. Finally, we discuss how to incorporate biodiversity into REDD+.

ASSESSING THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON DIPTEROCARPUS SPECIES AND CONSERVATION ADAPTATION IN PENINSULAR THAILAND

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The objectives of this research were to evaluate the consequences of climate change on potential shifts in distribution of Dipterocarpus species, to assess species at risk and to adapt protected area networks to cope with future climate change in Peninsular Thailand. A sub-scene of the predicted climate in 2100 of the Hadley Centre Coupled Model, version 3 (HadCM3), was extracted and calibrated with topographic variables. A machine learning algorithm or Maxent was employed to generate ecological niche models of 31 Dipterocarpus species from eight genera. In addition, a risk assessment matrix and the gravity model & GIS were employed to determine species at risk and priority areas to cope with future climate change, respectively. According to the global climate data, the temperature in Peninsular Thailand will increase from 26.6 °C in 2008 to 28.7 °C in 2100, while the annual precipitation will decrease from 2,253 mm in 2000 to 2,075 mm in 2100. The model predicted that six species have a turnover rate greater than 50 percent of the current distribution range and 13 species will be listed as high to extreme risk species. The studied Dipterocarp species were predicted to assemble in large and contiguous protected areas. However, such concentration areas are likely to decrease from 12.03 percent in 2008 to 9.35 percent in 2100. If the government expands the existing protected areas from 19 percent to 25 percent in priority areas, this conservation effort will significantly mitigate future climate change in the peninsular Thailand.

DEFORESTATION & SPECIES CONSERVATION IN INDONESIA

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Indonesia has been acknowledged as a mega-diversity country. It is home of thousands species of world's flowering plants, mammals, amphibians and reptiles, birds, and fish. Unfortunately, their habitat has been facing a problem of forest conversion due to agricultural & settlement expansion, illegal encroachment, mining & illegal logging, which resulted in habitat loss and fragmentation that lead to species extinction. Another problem arose from habitat loss and fragmentation was conflict between animal and human, such as Orangutan, Sumatran Tigers & other key species. Some facts finding and cases study would be presented.

SAFEGUARD ISSUE ON CLIMATE CHANGE AND TROPICAL FOREST MANAGEMENT

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Since late 1970s, forest management policies in developing countries have been promoted local people participation as one of main actors of forest management. Aid agencies from international organization and developed countries had promoted the support on the condition that developing countries would introduce participatory forest management such as social forestry, community forestry and community based forest management. These movements supported the introducing participatory forest management in developing countries and the devolution of forest resource use to local people had been accelerated.

Recently, REDD-plus mitigating climate change through reducing emission deforestation and forest degradation in developing countries has been discussed under UNFCCC (United Nations Framework Convention on Climate Change) and other initiatives such as FCPF (Forest Carbon Partnership Facility), UN-REDD programme which consist of FAO, UNDP and UNEP and other voluntary initiatives. Under the agreement of UNFCCC, REDD-plus should be implemented in national or sub-national level. In this situation, REDD-plus can create pressure for re-centralization of forest management and consequently devolution of forest use to local people have the possibility of retrogression.

Under the UNFCCC, securing local people livelihood of REDD-plus has been discussed as a terminology of "*Safeguards*". In the end of 2010, the decision of COP16 under UNFCCC mentioned "*the Safeguards …… should be promoted and supported***"**. While REDD-plus scheme drafting in each countries, local people livelihood are expected to officially consider. Under these situations, international organizations and donors have tried to develop guidelines and standards regarding safeguards on REDD-plus. In this presentation, we are analyzing main initiatives of safeguards on REDD-plus.

Currently, three main safeguards initiatives in national and sub-national level have been developed by international organizations etc. That is, "*Strategic Environmental and Social Assessment* (SESA)" by the World Bank, "*UN-REDD's Social and Environmental Principles and Criteria* (SEPC)" by UN-REDD programme and "*REDD+ Social & Environmental Standards* (REDD+ SES)" by CCBA (The Climate, Community & Biodiversity Alliance) and CARE International (NGO). The members of CCBA consist of international NGO, research organization and private sectors.

Each SESA, SEPC and REDD+SES has components for securing local livelihood. The main target of safeguards of SESA and SEPC is prevention of negative aspect of REDD-plus like "*do not harm*". On the other hand, the main target of REDD+SES is promoted the co-benefit including improvement of local livelihoods, forest governance and biodiversity conservation.

Each initiative is still in the trial and error stage under developing process of them. In the future implementation stage, it should be necessary for them to consider effectiveness and legitimacy of securing safeguards such as transparency system and third parties audit system. In addition, the coordination of different safeguards initiatives should be discussed in the future step.

METHODOLOGIES OF TROPICAL FOREST CARBON MONITORING: DEVELOPMENT AND THE STATE-OF-THE-ART FOR REDD+

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REDD+ is the first challenge of human being to mitigate the trend of deforestation and forest degradation (DD) in a global scale. In this context of mitigating DD, the role of forestry has greatly changed. In the far past, forestry mainly worked for how to harvest forest products efficiently. Afterwards forestry was required to work for enhancing other forest functions also in particular environmental conservation, and very recently, mitigation of the climate change effects. Linking forestry to other sectors in particular agriculture, grazing, and mining should be considered among the sectors to establish forest land as an indispensable element of land use. Foresters are also required of contribution to realizing the balanced land use in economies and in resource conservation.

Contents of my speech will be "How human being changes the tropical forest?", "Methods for estimating forest carbon stock" including choices and a case study of estimating nationwide forest carbon stock in Cambodia, and "Requirements for the methods used in REDD+".

1. The balance of nature (incl. art) is a key to the REDD+. REDD+ does not only conserve forest, but also replace people's land-use systems with different systems to make GHG emission reduction/removals.

Considering requirements for carbon monitoring methods for REDD+,

2. CO_2 emissions from biomass are important in the dry land forest, while in the peat swamp forest, CO_2 emissions from drained soil organic matter are important. Estimates of such emissions with large emission potential are indispensable to reduce overall uncertainty of estimates effectively.

3. A practical method for estimating CO_2 emissions from DD is the calculation of total carbon stock change by monitoring forest land and periodically summing the forest area and its carbon stock per land area for important forest types.

4. For monitoring forest area, spaceborne optical and microwave (PALSAR) sensors are partly or partially available. In case both approaches are not appropriate, airbone media are considered to be an only alternative.

5. For monitoring carbon stock per land area, airborne media and/or ground-based measurement are the practical approaches. 6. As a feasibility study, we estimated the nationwide forest tree

biomass carbon stock and required number of sample plots in Cambodia. By repeating this calculation, we can monitor the (historical) trend of forest carbon stock on a national scale and such data are useful to make generic reference (emission) level.

6. More varied field data must be collected for improving methods.

A "Cookbook - How to measure and monitor forest carbon" compiles our latest knowledge in forest carbon measurement and is under preparation by FFPRI.

A MODEL-BASED ASSESSMENT OF THE IMPACTS OF LAND-USE CHANGE IN SOUTHEAST ASIA FOR MITIGATION AND ADAPTATION

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Rapid vanishment of tropical forests is one of the most serious global environmental issues with respect not only to biodiversity loss but also to carbon emission to the atmosphere. Therefore, the Reduction of Emission from Deforestation and forest degradation in Developing countries (REDD) should play a substantial role as a practical mitigation measure. However, total carbon budget as a result of land-use change in tropical forests, such as conversion from pristine forest to oil-palm plantation, is still difficult to evaluate at a regional scale, leading to uncertainties in implementation of REDD activities.

We have developed and applied a process-based terrestrial ecosystem model, VISIT (Vegetation Integrative SImulator for Trace gases), at both global and local scales. First, we applied the model to a landscape in Pasoh, Malaysia, which contains a natural forest reserve surrounded by oil-palm plantations (Adachi et al. 2010, Biogeosciences). As a result of land-use conversion, ecosystem carbon stock decreased apparently, even though oil-palm trees grew up and recovered biomass accumulation. The estimated long-term carbon budget was sensitive to changes in the amount of debris production. Second, the model was applied to Borneo Island in conjunction with satellite-derived maps of forest/non-forest distribution (Yamagata et al. 2011). Although the satellite-based forest detection is subject to cloud contamination, our simulation implied that the recent forest reduction in this area resulted in a considerable amount of carbon emission. Third, the model was also applied at the global scale, in which historical land-use change data were used. In addition to interannual variability related to ENSO and other climatic events (Ito and Oikawa 2000), spatial and temporal distribution of carbon emission caused by land-use change was simulated. These model-based studies are clearly effective to evaluate the broad-scale carbon budget, especially to estimate a baseline for the REDD implementation. In contrast, few studies have been done for the adaptation issue of the tropical forests, because of difficulties in considering effective adaptation options (e.g., installation of refugia and corridors, adaptive transplantation, and seeding) in these areas.

Further researches are required to develop a reliable model for discussing mitigation and adaptation of tropical forests in Southeast Asia. For example, it is still difficult to evaluate carbon accumulation and emission from tropical peat lands in this area. Total accounting of net greenhouse gas exchange, including CH4 and N2O, is also a challenge for ecological modeling. To overcome the issue of data deficiency in tropical regions, we should deepen discussion on effective data management and sharing policies.