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GENERAL ARTICLES

THAILAND: BIODIVERSITY CENTER FOR THE TROPICS OF INDO-BURMA

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ABSTRACT

Thailand is uniquely placed to represent the fauna and flora which characterized the biogeographic province of Indo-Burma, for several reasons. This region stretches from Chittagong, Manipur, Arunachal Pradesh and Burma to Vietnam, Southern Yunnan, Guangxi and Hainan. First, Thailand is at the meeting place for elements concentrated in the west, and those confined to the east. Second, it stretches from the southward arching ranges that terminate the eastern Himalayas, a classic center of endemism, to the northern margin of the great Sunda Shelf equatorial mixed dipterocarp forests. Third, Thailand possesses the only comprehensive, adequately conserved national park system in Indo-Burma, which may by the next century represent the last surviving gene bank, in effect, of a region the size of western Europe and with more than twice the number of plant species. And lastly, Thailand's buoyant economy is coming to dominate trade in the natural resources of the region, so that Thailand's foreign policies in respect of natural resources will, literally, determine the fate of the forests and seas of Indo-Burma. However, in order to better manage such forests in a sustained manner, more long term research is required on the ecological tolerances and the dynamics of tree species and whole communities. Such research is best carried out on long term research plots of sufficient size to study tree populations and carry out manipulative or experimental field research.

The Regional Floristic Setting

Indo-Burma is a distinct tropical biogeographic province. It is bounded on the north by the temperate biota of the eastern Himalayas and the Qinghai-Tibetan plateau, and by the subtropics of south China. To the west, the Ganges Plain marks a major change in flora. The dry deciduous dipterocarp forests, which are a unique, albeit impoverished vegetational formation of Indo-Burma, are replaced by the Sal *(Shorea robusta)* forests of the sedimentary and granitic rocks of eastern India and Bangladesh.

The distinct seasonal evergreen dipterocarp forests of Indo-Burma, whose flora seems to be largely endemic to the region and to this formation, spreads no further west than Chittagong, Manipur, and easternmost Assam. Their nearest analogues, the seasonal evergreen forests of the western Ghats in peninsular India, have relatively few species in common and, now far isolated by a belt of dry climate, the two have likely been separated since the mid-Tertiary.[1]

By contrast, the formerly extensive moist deciduous forests of the region have much in common, at least among their dominant species, with those of India. There are a number of Indo-Burmese endemics, including some monotypic genera and others of exceptional interest, and the flora of this type overall is at its richest in Thailand and Indochina; but both the total flora and the species richness of individual forest communities is considerably less than the seasonal evergreen forests.

Specialized lowland vegetation formations of Indo-Burma include mangrove, seashore, limestone karst vegetation, seasonal swamp and heath forest on podsols. The mangrove and seashore vegetation, though severely affected now by human activity, are relatively poor in species compared with other kinds of regional vegetation, and particularly poor in endemics though there are a few endemic epiphytes and ground herbs.

Limestone karst is widespread in the region, particularly in peninsular Burma and Thailand, and in northern Vietnam (Tonkin) and Guangxi, but it also appears elsewhere as at Doi Chiang Dao in northern Thailand. The vegetation is a highly characteristic stunted forest. The flora is rich and distinctive, with very many endemics including a wealth of ground herbs. The isolation of the main blocks has encouraged evolution of many local endemics, particularly but not exclusively herbs.

Heath forest is a specialised dry land forest confined to white sand podsol soils.[2] A related forest occurs on similar soils above 800 m on sandstone mountains, such as in Khao Yai National Park. Classically, though, it is found on old beaches, now isolated behind the modern coast. Examples occur in south-east coastal Thailand and adjacent Cambodia west to the Bay of Kompong Som. It rarely occurs over large areas. The interest of this type lies in the large number of species in common between the heath forests of Indo-Burma and the extensive forests of this kind in Borneo. Often, species pairs exist with one in Indo-Burma, one in Borneo: *Dacrydium pierrie* and *D. beccarii* serve as an example.

Little remains of the freshwater swamps, because this is where rice is grown, except for the permanently water-logged deltaic *Lepironia* reed swamps which are important habitat for wildlife but botanically uninteresting; and the back-mangroves, which are open woodlands principally of *Melaleuca leucadendron.* These second are characteristic of this biogeographic province but poor in species. From what little remains of the inland riverain swamps it would appear that they bore a forest of variable composition, in which deciduous trees including *Bombax ceiba, Tetrameles nudiflora* and *Lagerstroemia* spp. dominated the canopy. Endemism may never have been high.

The hill forests, that is the forests which come in above 800 m and extend to the forest line and to the temperate forest to the north, are also characteristic of the

biogeographic province. Particularly distinctive is the dominance of Fageceae and Lauraceae, many of whose species are endemic to the province, and several species of conifers, including species of *Pinus, Keteleeria,* and also *Podocarpus* and cycads, many of which are endemic within the province and may form dense gregarious stands.

Whereas the lowland forests of Indo-Burma have been very statisfactorily classified by Smitinand and Nalanphun[3], following the well established system of Champion[4] which was designed for Pakistan, India, Bangladesh and Burma, the hill forests remain inadequately understood. Their land is fractured into mountain masses with different climates, but also different histories. In the subtropical north in particular, they harbor ancient relic genera, even families, of importance to world science.[5] The floristic classification of these forests is a major challenge, and should be an important priority for Thai botanists, because much still needs to be done before conservation planners and managers have all the information they need.

The Regional Significance of Thailand's Vegetation

Thailand, being geographically central in Indo-Burma, possesses a particularly comprehensive representation of its vegetation and flora.

Though Thailand lacks the snowy mountains and true alpine vegetation of northern Burma and Yunnan which are strictly not part of the Indo-Burmese province, a surprising number of the eastern Himalayan temperate elements penetrate south into the northern mountains.[5, 6] This region, where the Himalayan ranges curve round to the south, is one of the richest floristic regions in the world. Perhaps because the north-south trending valleys contain major rain shadows, the upper elevation of the ranges are rich in endemism, particularly in herbs and shrubs, while the temperate and montane tropical evergreen forests harbor a rich flora of exceptional interest.

Thailand represents the true heartland of the lowland Indo-Burmese forest flora, which is the principal characteristic of the province (Fig. 1).

Of the three main forest types, seasonal evergreen dipterocarp forest (including dry evergreen dipterocarp forest), dry deciduous (dipterocarp) forest and moist deciduous forest. I would like here to pay particular attention to the seasonal evergreen dipterocarp forest because it is by far the richest in species, including endemics, and because all major regional types occur in Thailand. There are four main types with some variants.

1. Northern forests (Northern Tropical Wet Evergreen forests of Champion) distinguished by a cool dry season with much precipitation and dew, occurring on oxisolic soils. Relatively poor in species, *Dipterocarpus retusus* and *Shorea assamica* ssp. are characteristic. There is a high point endemism, particularly in Tonkin and South China where a distinct subtype occurs. This probably was always the least well represented type in Thailand, its main distribution being in Arunachal Pradesh, northern Burma, south China and Tonkin.

2. The Peninsular and South-eastern seasonal wet evergreen forests (Evergreen Dipterocarp and Eastern Tropical Evergreen forest of Champion) occur in a region with less

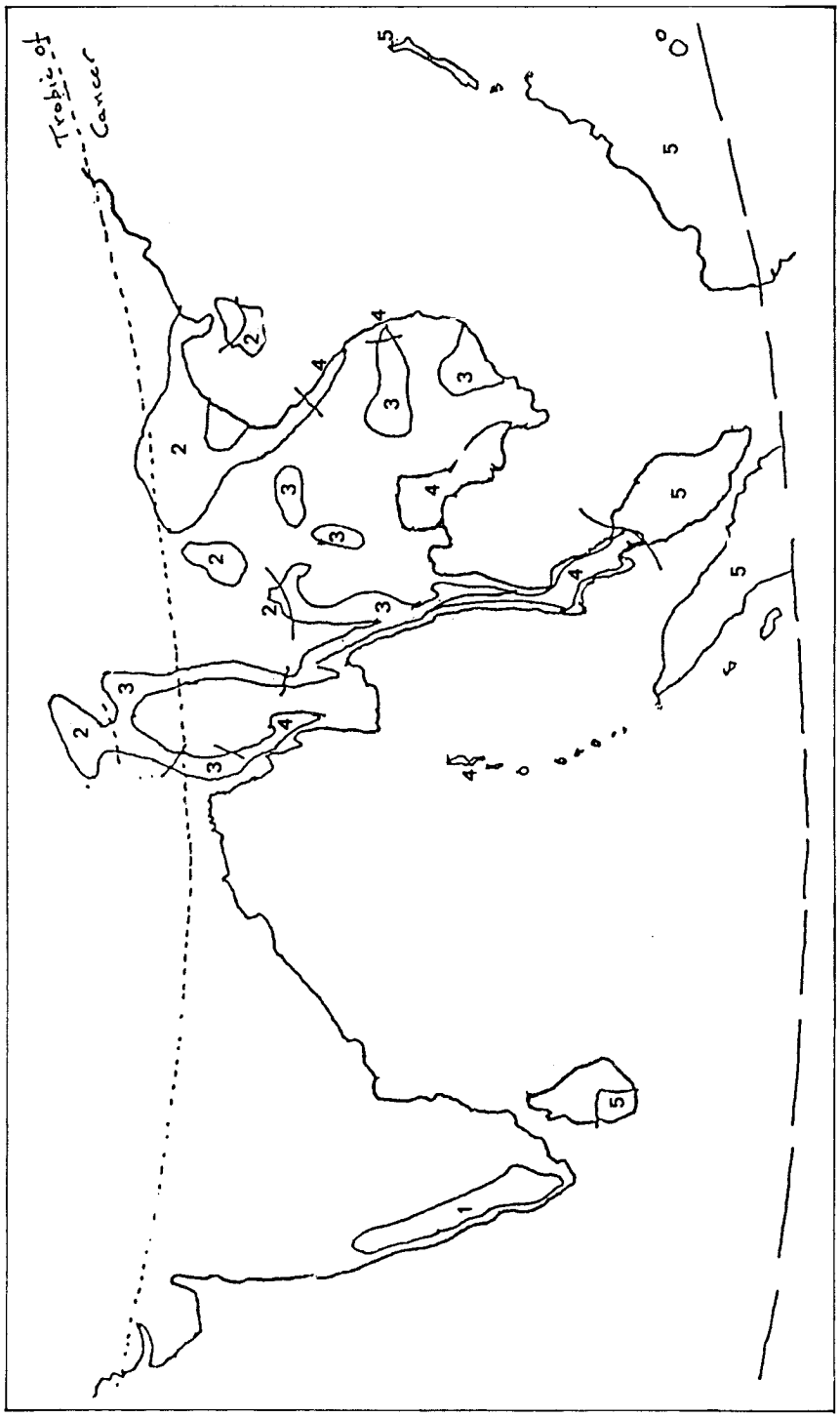

Fig. 1. Tropical lowland evergreen forests in Asia: Probable original distribution, based on climate and soil.

1-4. Seasonal evergreen forest of lowlands.
1. Western peninsular forest.
2. Northern, *S. assamica* forest.
3. Dry evergreen forest.
4. Wet seasonal evergreen forest.
5. A seasonal mixed dipterocarp forest, and edaphic and montane associates.

than four dry months and, generally, at least 2000 mm mean annual rainfall. They are richest in their total flora and also have a high proportion of endemics (55% in the case of *Dipterocarpaceae,* for instance). There are two major subtypes, which differ substantially (though details are unknown) in composition and dynamics: predominantly (but not exclusively) southern forests on predominantly clay-rich oxisols, characterized by the presence of a variety of species including *Parashorea stellata, Shorea gratisisima, Dipterocarpus kerrii, Amesiodendron chinense* (also in type 1), *Litsea pakabenica* and *Dipterocarpus baudii;* and predominantly (but not exclusively) south-eastern forests on predominantly sandy ultisols, characterized by *Dipterocarpus costatus.* The most evergreen of Thai lowland forests, this sybtype is the best represented in Cambodia. Other species include *Dipterocarpus dyeri, Hopea ferrea, Hopea pierrei, Vatica cinerea,* and *Heritiera javanica.* Regeneration of this subtype is particularly difficult owing to the freely draining soils on which it grows. A form of this subtype occurs at middle altitudes in northern Thailand. There Fagaceae, Lauraceae, and other hill elements are also well represented.

3. Dry evergreen dipterocarp forest is widespread in Thailand, north of the peninsula occurring in regions with four or more dry months and as little as 1200 mm rainfall. Confined to yellow-red clay rich oxisols lacking a laterite pan, it is variable in species composition but specifically poorer than other types. *Dipterocarpus turbinatus* is characteristic, *Hopea odorata* frequent. It grades into mixed deciduous forest on well drained sites; and deciduous canopy species of *Dalbergia, Afzelia, Sindora cochinensis* (all rosewoods) and *Lagerstroemia* are widely present. At the most seasonal extremes of its range this type forms a characteristic gallery forest, following the river valleys into the region of deciduous forests.

An extreme edaphic variant of this subtype is the heath forest, which is very local in Thailand along the east coast of the southern peninsula, and also in the extreme south-east.

By contrast, the moist and dry deciduous forests which covered the greatest area of the low hills of Thailand are relatively poor in species, and these species are mostly widespread in the region.

Of the remaining regional vegetation types the best represented in Thailand is that on karst limestone. In the peninsula and on islands, and also scattered elsewhere, mainly in the north, are superb examples of this unique vegetation, so rich in relicts and also in endemic species.

Of the freshwater swamps, little remains.

Degrees of Endangerment

Thailand has witnessed one of the greatest rates of deforestation of any nation during the last forty years. Even so, the process had begun centuries back, and had accelerated in the nineteenth century with the draining of the great southern plains for irrigated rice cultivation. As far as I am aware, the mangosteen and durian, among other domesticated trees, are now unknown in the wild. I suspect that this is because their

habitat was the valley forests and seasonally swamped alluvium which was the first to be used for cultivation. Should we not regret the loss of the genetic variation of these species that must have existed in the wild, particularly in the case of the mangosteen where the very possibility of recombination is lost through extinction of the male tree?

But all Thai vegetation is now threatened. The hill tribes, themselves expanding, yet under pressure from immigrants from the plains, are leaving the mountain regions bare. The lowlands have been almost universally logged and converted, and often abandoned again. Of all dry land vegetation types, the seasonal evergreen forests on clay soils and the moist mixed deciduous forests have suffered most as they are on the best soils.

Here again, though, I want to make special mention of the wet seasonal evergreen forests, so rich in species. These forests were confined to climates with a 1-3 month dry season, or exceptionally moist valley habitats, and yellow-red soils. Though almost no primary forest of this type remains outside the national parks system, degraded forest still apparently occurs in many areas.

Wet seasonal evergreen dipterocarp forest is not easy to regenerate following disturbance. The critical importance of phenological differences between tropical forests for conservation and management strategies is not yet widely appreciated. The most celebrated and successful silvicultural procedure for regenerating logged rain forest, the Malayan Uniform System, was designed for forests in which fruiting is irregular and supra-annual (at 5-10 year intervals), but in which seedlings and saplings have high survivorship due to shade tolerance and infrequency of soil water stress. Clear cutting of the overstory is precribed. Regeneration depends on established seedlings and pre-existing saplings because conditions for successful establishment may not return for quite a number of years following logging and because seed is poorly dispersed. To rely on seed produced after logging would require that an uneconomically large fraction of mother trees would have to be left uncut to guarantee adequate seed distribution.

The Malayan Uniform System is generally (though not always) inapplicable in seasonal evergreen forests, for the following reasons.

1. Though fruiting is generally annual in seasonal evergreen forest, seedling establishment is not so, partially on account of predation but particularly because there is high mortality during the dry season. On most sites, establishment therefore occurs only in unusually favorable years and little or no early regeneration exists on the ground in most years.[7] Regeneration of emergent timber species must therefore depend on a generally rather low stocking of established pole-sized juveniles and saplings.

2. The species of forest gaps in seasonal evergreen dipterocarp forest include a number of invasive species which out-compete mature-phase tree regeneration following logging and canopy opening, leading to the effective elimination of the latter and a deflected succession. Notable are several bamboos which are synchronously monocarpic[8] and thus periodically permit tree regeneration to occur, but also the introduced vine *Micania scandens,* shrub *Lantana camara* and herb *Eupatorium odoratum.*

3. Logged forest and dry evergreen gallery forest are highly susceptible to fire during the dry season. The species of the mature-phase forest are fire-sensitive, and burning replaces this forest with a floristically impoverished version of the forest types normally associated with a drier, more seasonal climate or drier soils: mixed moist deciduous forest and dry (semi-deciduous) dipterocarp forests, which occur on more and less fertile soils, respectively. An understanding of the dynamic relationship between the evergreen and deciduous forests, which often exist side by side, is fundamental to the conservation and sustainable management of both.[9-11]

Seasonal evergreen forest once occupied a no-man's land between great civilizations that were based on lowland irrigated rice culture, and the minority upland nations dependent on swidden agriculture. The fact that forest apparently identical to primary seasonal evergreen dipterocarp forest now again covers ruins at Angkor and Phnom Kulen in Cambodia suggests that its capacity for self-repair is greater than the immensely species-rich mixed dipterocarp forests to the south, although the recovery may take several centuries. While silvicultural techniques for sustaining production of the principal dipterocarp hardwoods have been devised for forests on mesic oxisols[12-22] the sensitivity of the ultisols to water stress and topsoil disturbance has so far prevented success for the species-rich *Dipterocarpus costatus* subtype. Often, forests on dry sites become more or less permanently converted to moist deciduous forest through poor management, thereby losing the principal component of their species richness which comprises evergreen trees of the mature phase and their associated epiphytes. In no case is the impact of logging, managed sustainably or not, on plant biodiversity known.

Particularly disastrous at present is the almost universal abandonment of forest management in seasonal evergreen forests and the ubiquity of illegal logging and swidden within the residual stands. Specifically I know of only three preserves where primary forest of species-rich types are conserved, and then only in a vegetational mosaic with individual areas of less than 10,000 ha. These are Khlong Saeng Wildlife Sanctuary, where most of the forest has been submerged under the new Chiew Larn Reservoir, Khao Yai National Park and Tung Yai/Huai Kha Khaeng Wildlife Sanctuaries where the lowland evergreen forests are restricted to major valleys in a dry climate and where these would also be inundated were it not for public pressure. The pressure to log all residual forests nevertheless remains intense.

It is truly fortunate, therefore, that Thailand has a strong and growing constituency among the public who understand the consequences of environmental degradation and are determined to reverse the trends of the last half century. The superb national park system of Thailand is in significant measure a consequence of their efforts. Its future integrity will certainly depend on the public political will.

But now, Thailand has become the dominant economic power in Indo-Burma. The future of the natural resources of the whole region is in a very real sense in its hands. Determined efforts will certainly be needed to ensure that Thai foreign policy is brought to bear on commercial interests which certainly, without restaint, will indirectly cause the destruction of the remaining lowland forests of the region.

Priorities for the Future

Land use policy cannot be well informed without the knowledge that can only come from further research. Formulating a nation-wide policy and plan for sustainable use and conservation of Thailand's natural forests requires the following.

1. Completion of the documentation of the flora.

Documentation of the plant species of the country is basic to every decision. This entails not only the description of all species, and preparation of a flora which will enable their identification. It also entails compilation of information concerning distribution. Critically important is information concerning the distribution of species in each major vegetation type. How many species occur in seasonal evergreen dipterocarp forest, and how many are endemic to this type? We have no data base which can provide this information, yet it is essential for establishing conservation priorities.

2. Complete the classification of the vegetation types of Thailand.

Here, the work of Smitinand and others has been seminal for the lowlands, but the hill forests in particular require further research.

3. Develop sound means to manage natural forests for goods and services, and also for conservation.

The present status of seasonal evergreen dipterocarp forests, in particular, is so critical that a rescue operation is mandatory. This must involve both active management of residual stands and, where possible, restoration of adequate representative tracts of degraded forest both in terms of biodiversity and also timber productivity. In most cases, past silvicultural methods have failed because the basic scientific understanding to accomplish these objectives does not exist. The following set of questions address the major issues arising in the management of these seasonal evergreen forests. In particular, the invasion of these forests by bamboos and exotic weeds, and the increase of secondary moist deciduous forest, are major management problems that are connected to the problem of fire management.

These issues will need to be addressed in the near future.

1. What are the overall characteristics of forest including its dynamics, phenology, species composition, and degree of endemicity?

2. What correlations exist between the spatial patterns of variation of forest composition and the gradient of annual soil water deficits?

3. What influence does an annual dry season, and its year-to-year variability in length and intensity, have on forest dynamics, demography of juveniles and phenology?

4. What are the conditions which favor survival and growth of juveniles of the mature-phase canopy tree species?

5. What conditions permit or, alternatively, restrict the invasive increase of bamboos and exotic weeds?

6. What conditions permit or, alternatively, restrict the invasion of moist deciduous forest into evergreen forest in the absence of fire?

These issues include most of those considered crucial in the sustainable management of lowland evergreen forests elsewhere in the tropics.[23]

Understanding the conservation and management needs of these Far Eastern seasonal evergreen forests will therefore necessitate study of their structure and dynamics, and the demographic characteristics of the tree species, in relation to seasonal water stress. Needed most are sites safe for long-term research, including manipulative field experiments to better explain survival and distribution patterns. The long-term objectives must include monitoring the growth, survival, and recruitment of species. This must include rare as well as common species, many of which are of economic importance, and which may be important for the continued functioning of the ecosystem. Large census plots are therefore essential for additional research, including ecophysiological studies of the light and water relations of the trees along moisture gradients. Such plots would be suitable for a wide range of basic research, including both ecosystem and environmental as well as population experiments. I, and other colleagues abroad, stand ready to work with Thai colleagues in finding the means for completing these studies, so critical in the continued survival and sustained utilization of your unique indigenous ecosystems.

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บทคัดย่อ

ประเทศไทยถูกจัดให้เป็นตัวแทนของแหล่งพรรณพืชและสัตว์ที่เป็นเอกลักษณ์ของสิ่งมีชีวิตในเขตอินโด-พม่า ซึ่งมีเนื้อที่ตั้งแต่เมืองจิตตากอง มานิปัวร์ อรุณาฉานประเทศ และพม่า ถึงเวียตนาม ยูนานใต้ กวางสี และไฮนาน ทั้งนี้ด้วยเหตุผลหลายประการ ประการแรก ประเทศไทยเป็นที่รวมของพรรณพืชและสัตว์ที่มีมากในแถบตะวันตก และที่มีเฉพาะในแถบตะวันออก ประการที่สอง มีอาณาเขตจากเทือกเขาใต้ที่เป็นเขตสิ้นสุดของหิมาลัยตะวันออก ไปจนถึงทางเหนือของสันเขาซันดาที่อุดมไปด้วยป่าที่มีพันธุ์ไม้พวก Dipterocarp ประการที่สาม ประเทศไทยมีเขตอนุรักษ์ในรูปอุทยานแห่งชาติแห่งเดียวในเขตอินโด-พม่า ที่คาดว่าในศตวรรษหน้า อาจจะเป็นแหล่งพันธุกรรมสุดท้ายที่ยังเหลืออยู่ โดยมีขนาดประมาณยุโรปตะวันตก แต่มีพันธุ์พืชมากกว่าเป็นสองเท่า นอกจากนี้ ภาวะเศรษฐกิจลอยตัวของประเทศ จะมีอิทธิพลต่อการค้าทรัพยากรธรรมชาติของถิ่นนี้ นโยบายด้านต่างประเทศในส่วนที่เกี่ยวข้องกับทรัพยากรธรรมชาติ จะเป็นตัวกำหนดอนาคตของป่าไม้และทะเลของเขตอินโด-พม่า