Form and Function of Remnant Forests of Dong Mun, Northeast Thailand

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Abstract

Aerial photographs from 50 years ago show the Dong Mun uplands were blanketed with forests of two distinctive and sharply differentiated types. Forest with light colored reflectance predominated on the gently sloping plains where subsistence farmers grew wet rice and grazed livestock. Darker reflectance forests occurred further from settlements on sloping uplands and are thought to represent old growth forests subjected to little human disturbance. The abrupt transitions between the two types are interpreted as the boundaries of fires set by humans. In the decade of the 1970's, large tracts of both forest types underwent either conversion to dry land agriculture or degradation as a result of commercial lumbering, burning and extraction of forest products. Vegetation transects located in remnant forest fragments of both forest types showed no distinctive clustering by species composition as expected but rather a continuous gradient of variation. Forests with light reflectance clustered towards one end of the gradient and were plant communities of low species richness and biomass and with a simple structure largely lacking shrubs, low trees or climbers and result from the highest levels of disturbance. In contrast, on the other end of the spectrum, were forests with darker reflectance that have much greater species richness, biomass and structural complexity. Continued disturbance is predicted to shift forest type towards the low diversity. Although degraded forests may fulfill some ecosystem function, management must seek to protect a full range of ecotypes, particularly from fire, if maximum biological diversity is to be preserved.

Key words: vegetation, forestry, Thailand, biodiversity, conservation

I. Introduction

Forests in Thailand have been greatly decreased in extent in recent decades and the remnants often survive only as scattered fragments (Hirsch, 1987; Japan Forest Technology Association, 2001). In the distant past, forest diminution and fragmentation transformed landscapes in the moist temperate latitudes but the process continues in many parts of the tropics where large tracts of forest survived until the twentieth century. This study analyses the condition and character of one forest tract in Northeast Thailand that was left as an isolated and degraded fragment after much of the surrounding land was cleared for dryland crops in the 1970's. It considers both the changed ecological nature of the system and also addresses the new human relations to the forest.

Conspicuous landscape change frequently accompanies fast paced economic development. Old growth forests are degraded or completely replaced by agriculture, industry and its accompanying human infrastructure. Forces driving the process in Thailand include population increase and government policies promoting the growing of cash crops, which was facilitated by purposeful development of markets, the improvement of transportation networks and the availability of new technologies (Matsumura, 1994; Rigg, 1987). Mather (1990, 1997) has theorized on the changing nature of forest management as countries enter and emerge from this economic reordering. He has identified an exploitive phase during which many natural forest resources are liquidated. This is followed by an "industrial" phase of purposeful commodity management, which might include establishment of timber plantations. Eventually a "post-industrial" transition may occur to a situation where the forest is no longer viewed as just a commodity source but rather is appreciated for

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its role in the health of the larger environment. For example it may be valued as space for recreation, as a repository of biological diversity or, as forests are allowed to regenerate, an important means for carbon sequestration. Changes in attitudes and administrative policy reflecting these different stages may be precipitated by crisis. This was the case in Thailand when, in 1988, an unusually destructive flood in the southern region was attributed deforestation. This motivated the central government to institute a logging ban and also appears to have been an important event in shaping public opinion.

Forestry in Thailand has passed through its early exploitive stage and schemes for long-term management to encourage natural regeneration have been instituted along with programs to establish timber plantations. The first tree planting was done mainly with fast growing exotic species that had a high tolerance for heavily disturbed soils, but later native species have been encouraged that might be expected to function more effectively to restore natural ecosystems. Many management initiatives met with only limited success in creating new timber production forests and, in recent years, conservation programs have figured more prominently in forestry goals. Without the incentive of income from extraction of forest resources, they have had to depend on support from other quarters that has not always been forthcoming. In many areas forest management has now devolved into a local responsibility. Forests that survived the exploitation phase remain as remnants on uplands where steep slopes or remoteness limit access and make timber extraction economically unattractive and agricultural production difficult. Natural regeneration may be occurring in some areas, while others places suffer continued degradation.

Some of the consequences of the exploitive phase will not be easy to reverse. Alteration of the soil by exposure and erosion may not permit the forest to return to its former condition for very long periods of time or possible not at all. Scattered and modified forest remnants and plantations may be individually too small to support viable populations of pollinators and seed dispersers essential for successful reproduction. The elimination of key ecosystem elements by hunting, or the consequence of habitat fragmentation, may also have long-term implications for recovery. In consequence, even if the disturbing elements diminish, the ecological repercussions will be felt for many decades and genetic effects of artificial selection and population restriction may stretch over centuries, or longer. Some form of a forest ecosystem may survive, and be able to provide certain desired environmental function, but probably not all. It is in this economic and ecological context that the future of the Dong Mun forest fragment will be assessed.

A half century ago, Northeast Thailand supported the most extensive tracts of forest in the country. Although the region lacked the most valued teak of the higher and wetter Northern region, the Northeast had other hardwoods that attracted the forestry industry. Following the roads and tracks made by commercial lumber companies, farmers cleared land for agriculture for crops new to the area.

On the undulating and rapidly draining sandstone plains of the Northeast only a small proportion of the land was suitable for wet rice that was the foundation of the subsistence agricultural system (Dixon, 1987). The new cash crops like kanaf, corn, cassava and sugarcane could be grown on more steeply sloping land and their introduction into the agricultural system had the effect of increasing both the area and type of land under cultivation. Dams and large-scale water management projects further expanded the possibilities for agriculture. The result was wholesale replacement of extensive tracts of forest. Less accessible uplands, like that of Dong Mun, remained relatively little influenced by human activity until the 1970's but they then suffered major reduction.

II. Physical setting

The Dong Mun uplands lie across the Khon Kaen-Kalasin border. They are eroded fragments of an old fold complex that rises to a maximum elevation of about 500m at Phu No in the northwest corner of the upland. Part of the original surface of the structure is evident as a south dipping cuesta whose steep north-facing cliff exposes the sandstone bedrock that underlies the whole region. To the south, the more gently sloping flank has been partly dissected by erosion to produce steep sided, flat-floored valleys separated by long narrow ridges (Fig. 1).

The area receives approximately 1200 mm of precipitation annually with a distinct seasonal distribution. In 1945 the hills were largely cloaked with forest that remained at least until the 1960's (Wester and Yonvanit, 2005). At elevations below 500 meters, under these climate and soil conditions, a deciduous forest would be expected in which dipterocarp and oak species are important elements. Maxwell (2004) has cataloged many names that have been applied to vegetation communities in Thailand and the confusion that results from imprecise definition and inconsistent use. International conventions of naming plant communities were based on the expe-

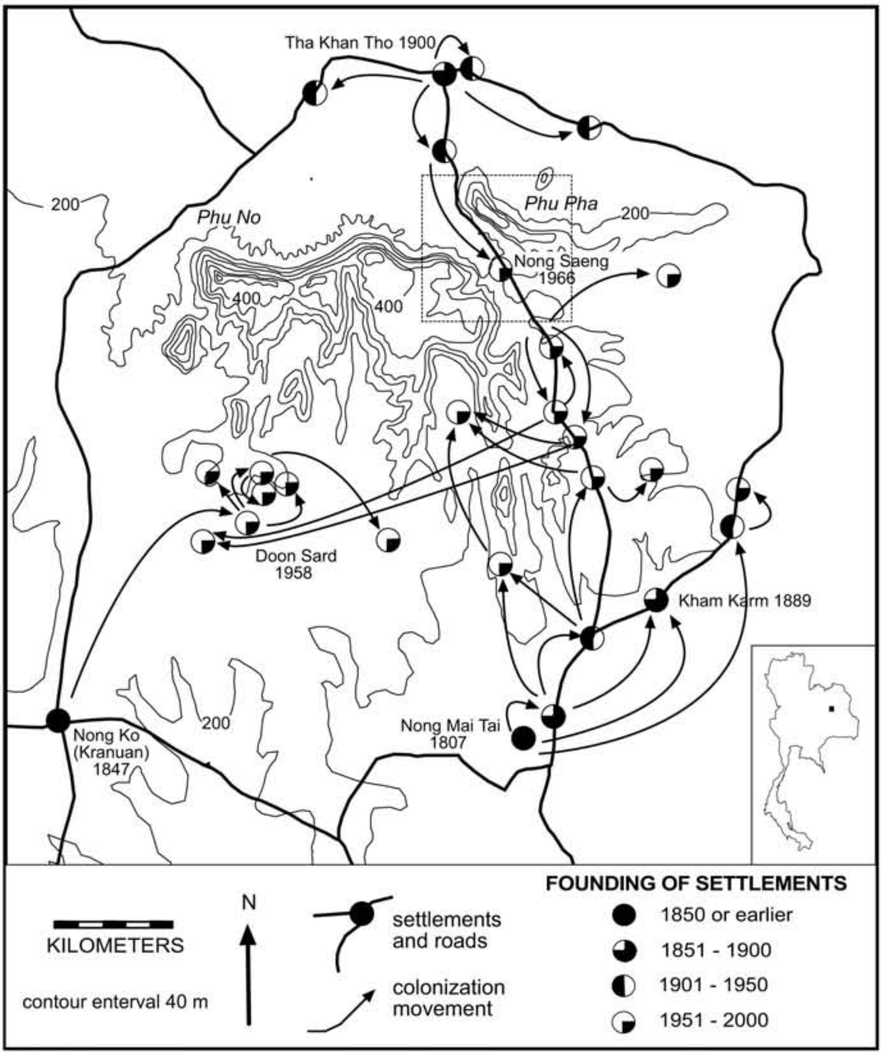


Fig. 1. Colonization and settlement of Dong Mun uplands
The area depicted in the dashed rectangle indicates the location of photographs in Fig. 2.

rience of floristically simpler ecosystems of the temperate latitudes but even here, the terminology includes a confusing mixture of descriptive terms that refer to species composition, growth patterns, community structure and as well as non-biotic factors like elevation, topography, climate and substrate. The problems are only compounded in the ecologically far richer tropical systems. Superimposed on complex natural patterns is the manner and degree to which humans have disturbed the communities by selective extraction and planting or modifying the environment most particularly by changing the fire frequency. Applying a specific name to this vegetation without increasing confusion is no easy task and will be avoided in this paper.

Aerial photographs of Dong Mun dating from 1954 show two forest types with of dramatically different reflectance with almost no transition zone between them (Fig. 2). On the lowlands, small patches cleared for rice cultivation by residents of the village of Tha Kan Tho located a few kilometers to the north, are evident only along stream banks, where water could be collected for wet fields. The adjacent higher terraces remained under forest cover with a distinctly lighter reflectance. Stott (1991) noted that the character and composition the forest predomi-

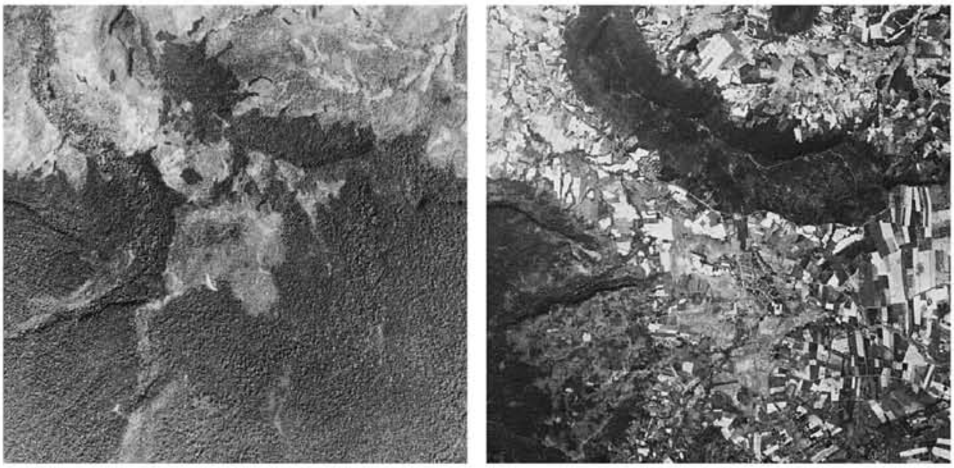


Fig. 2. Aerial photographs of the Phu Pha/Nong Saeng region from 6 February 1954 (left) and 15 November 1996 (right)

In the earlier photograph, two distinct forest types with light and dark reflectance are particularly evident. Small wet rice fields along stream channels are the most obvious witness of human occupation. By 1996 much of the forest of both types has gone and the land in their place is now occupied by the village of Nong Saeng and the rectilinear fields used for dry crops.

nating over the plains was strongly influenced by purposeful burning. Fires tend to consume the thin-stemmed shrubs and small trees and, with the onset of rains, encourage a flush of grasses and herbs that would provide food for livestock. Cattle and water buffalo and their hides were one of the traditional exports of the region. Livestock were taken to the forest to graze during the rice-growing season so they would not damage crops. These forest-grazing areas would also be the source of wood and other gathered and hunted forest products. The lighter reflectance in aerial photographs is likely the result of the opening of the tree and shrub canopy to expose more soil to direct sunlight, and the unnaturally sharp vegetation transitions, where no natural ecological disjunction exists, are best explained as fire boundaries. It is to be noted that one seasonal grazing area later became the site of the village of Nong Sang founded by immigrants from Tha Kan Tho.

In contrast to the lighter reflectance forest were those with much darker coloring that covered most of the uplands and areas less accessible from settlements. The photos suggest the canopy is much denser. The texture displayed on the image also indicates the community was structurally more complex and supported large emergent trees that stood above the main shade canopy. Very large specimens of *Hopea ferrea* were the main objective of the lumber industry that advanced into the area in the 1960's.

III. Human settlement

Ethnic Lao from Mahasarakam founded the first modern settlements in the area on the plains surrounding the Dong Mun uplands in the early nineteenth century. A second wave of colonists, displaced from their land by floods in Khon Kaen Province, followed in the mid century and settled in the southwest. Finally, around 1900, another group from Ubon Ratchatani and Roi Et settled in the north (Fig. 1). Each group in turn spawned new villages as populations increased (Yongvanit and Homnetra, 1993), but very rapid population growth occurred the 1960's and 1970's as a result of immigration from other provinces in the Northeast and elsewhere. This was the result of two factors. The government gave lumbering concessions in Dong Mun and, at about the same time, launched a program to encourage dryland agriculture as a motor for development in the agricultural sector. Loggers built roads and tracks into the more steeply sloping uplands opening gaps in the forest canopy as they extracted timber. Following these tracks farmers took advantage of the openings created by foresters and cleared land for their new cash crops.

Although the Dong Mun uplands were declared to be a forest reserve in 1964, and placed under the control of the Royal Forest Department, farmers exercised traditional rights to clear space for agriculture thus creating a conflict for control of the land. A compromise was achieved in the face of mounting demographic and political pressure that allowed the first settlers to remain but attempted to limit further colonization (Lohmann, 1991, 1993). The effect, however, was to attract even more settlers lured by the hope of acquiring free land. Ultimately large tracts of the forest were converted to agriculture and the only forest remaining was on the steepest, least accessible land, and these ecosystems were also degraded by timber cutting, hunting, collecting forest products, and generally opening the forest canopy. The dense forests of the uplands had not formerly been subject to frequent burning, but now gaps created by lumbering and clearing created more forest edges. These admitted more sunlight that promoted the growth of ground layer herbs and shrubs that provided fine fuel for fires. The desiccating effect of airflow in the cleared gaps increased flammability and, as people penetrated more deeply into the forest, there were more opportunities for ignition (Kemp, 1981; Hafner, 1990; Hafner and Apichatvullop, 1990).

Early attempts to stem the retreat of the forest by the Royal Forest Service focused on replanting with rapid growing eucalyptus. More recently higher value trees, such as pradu (*Pterocarpus macrocarpus*), native to this area, and *sak* or teak (*Tectona grandis*) native to the Northern region, have been planted. In some cases the planting of native trees was done by local populations before the Royal Forest Department began propagating and distributing them. The tracts of forest that escaped conversion to cropland or management as plantations have nevertheless been significantly changed over the last 50 years by a variety of human activities. The purpose of this study was to survey and characterize the composition and structure of these forests.

IV. Methodology

1. Aerial photograph analysis

Sets of aerial photographs were obtained from the years 1945, 1954, 1967, 1968, 1977, 1983 and 1996 and were analyzed for evidence of land use change and as a basis to plan sampling of the forest community.

2. Vegetation sampling and analysis

Vegetation was sampled to determine species composition, as well as the structure of the communities. Samples consisted of transects each 8 meters wide by 50 meters long. All plants over two meters tall were recorded. A total of 22 transects were completed, being spread widely through the Dong Mun uplands. The forests of both light and darker reflectance were included. Samples were also taken in eucalyptus and *sak* (teak) plantations for comparison. Locations of samples are indicated in Fig. 3. Although, the general location of transects was determined by accessibility within a site, the starting point of all transects were arbitrarily determined. In thirteen of all transects, the height, diameter at breast height and bole length were measured. A biomass index was calculated using the diameter at breast height (DBH) and the total height of the plant using this formula:

$$\text{Biomass index I} = \frac{\text{DBH} \times \text{Height}}{2}$$

Plant identification and recording in the field was done with the assistance of a forester and an experienced local hunter and herbalist. Common names were recorded and specimens were collected and identified with reference to specimens in the Royal Forestry Herbarium Bangkok and Chiang Mai University Herbarium. Assistance and advice was provided by botanists at the Royal Forestry Department and J. F. Maxwell at Chiang Mai University Herbarium. Species were classified as tree (T), shrub (S), shrub or small tree (S/ST), small tree (ST) and climber (C) following Smitinand (2001). For the purposes of calculating richness, abundance and biomass values, the low growing plants classified as shrub (S), shrubs or small trees (S/ST) and small trees (ST) where lumped together as shrubs.

3. Ordination of transects

An index of similarity was calculated using the Sorenson method (Sorensen Index of Similarity: (IS) (Mueller-Dombois and Ellenberg, 1974). It is expressed as a percentage and takes the following form.

$$\text{IS} = \frac{2c}{a+b} \times 100$$

where: c = number of species common to both samples
a = total number of species in sample A
b = total number of species in sample B

The similarity index was computed for each pair of transects (Appendix). A multidimensional ordination procedure was applied to these calculated similarity indices. This requires selection of a pair of transects with high degrees of dissimilarity to act as reference for each axis. A reference transect is discarded if it shows a high level of dissimilarity to all

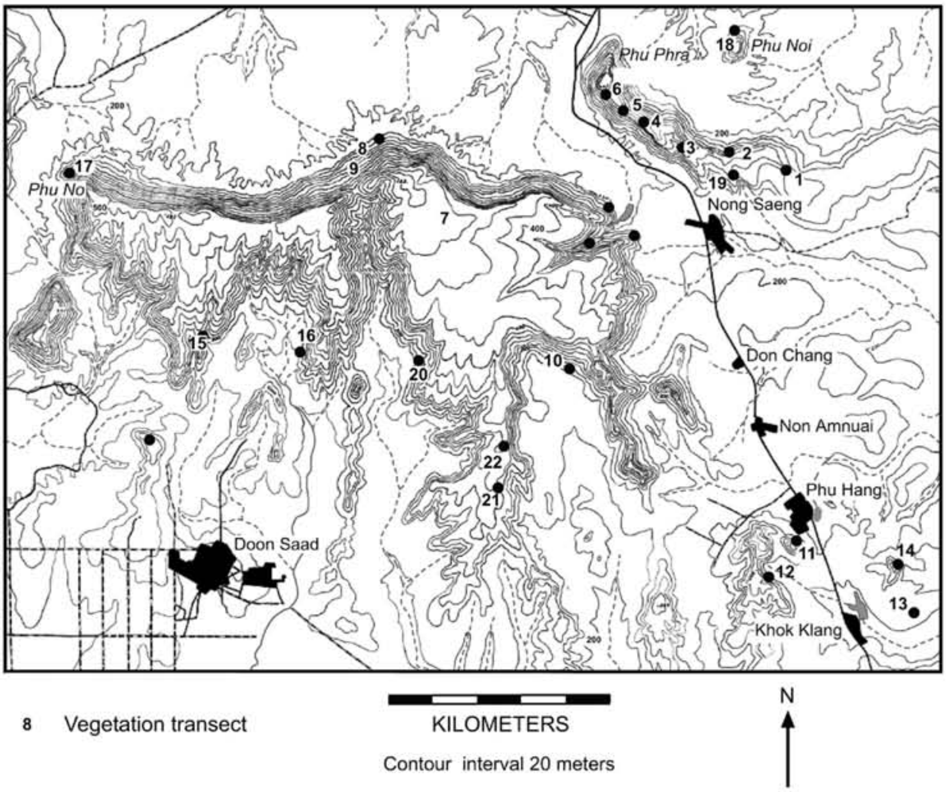


Fig. 3. Location of vegetation transects

other transects, that is to say, if it has a high level of uniqueness. Transects 3, 10 and 6, 11 met all criteria and were used as the reference pairs. The method for constructing the ordination is described in detail by Muller-Dombois and Ellenberg (1974). It should be noted that samples falling close together in the ordination indicates only that have approximately equal dissimilarity to the reference pairs. It does not necessarily mean that they have high similarity to each other, although this is often the case.

V. Results

1. Landscape change

Air photo analysis from imagery shot between 1945 and 1967 of a sample section of the Dong Mun uplands depict large tracts of dense forest. The only evidence of disturbance was near the settlements of present day Phu Hang and Nong Saeng (Fig. 1). These tracts of lighter vegetation are interpreted to be those that were partly cleared and burned. Interviews with old residents confirmed that these areas were used for grazing cattle during the dry season.

The wet rice fields adjacent to streams can be traced over long periods of time with little change in their shape or extent. There is no evidence of increase in clearing between 1945 and 1967 although the first logging concessions were granted in 1963. Selective logging was the planned method of exploitation and it was hoped that natural regeneration would allow the timber to be harvested again in thirty years. By 1977 however, photographs show spidery traces of logging trails, well-defined roads and settlements. The rectilinear shapes of clearings suggest they are the agricultural fields of farmers who used the logging trails and gaps to gain access to land for their crops.

Evidence of extremely rapid change is clear by 1983 by which time most of the forest cover has been removed. Fragments of the dark reflectance forest remained only on the steep northern escarpment of the cuesta and sites farthest from settlements and roads. A surveyed road and new villages, with a formal grid pattern of streets, are conspicuous. These were the direct result of government action providing infrastructure as part of various land distribution programs. The settlement frontier in effect passed through between 1977 and 1983 and most of the land suited to cropping was cleared.

2. Forest form and composition

A total of 1480 plants were recorded and represented 255 taxa. We could not assign a scientific name to a number of the species as they lacked flowers or fruits needed for identification. In these cases we preserved the entity so as to be defined by our local informant. As he may have recognized more variety than is formerly described in the scientific literature, this may have inflated the number of taxa slightly. The ordination diagram (Fig. 4) shows the samples align along an axis without distinct clusters. This would suggest a continuum of variation rather than a sharp discontinuity between discrete types that we expected from the sharply contrasting light and dark reflectance patterns visible on aerial photographs.

To investigate the variation in more detail, the gradient was divided into three sub types identified as A, B and C. Group. The A Group of transects (1, 2, 3, 5 and 6) were found to cluster on Phu Pha, which is a comparatively dry ridge isolated from the main upland. Aerial photographs indicate this area supports a mosaic of forests with both light and dark reflectance values (Figs. 2 and 3) and the site is now designated a national recreation area for which access is provided by a sealed all weather road. It is subject to management and frequent fires that effectively removes much of the groundcover except fire resistant bamboo (*Arundinaria pusilla* Cheval. and

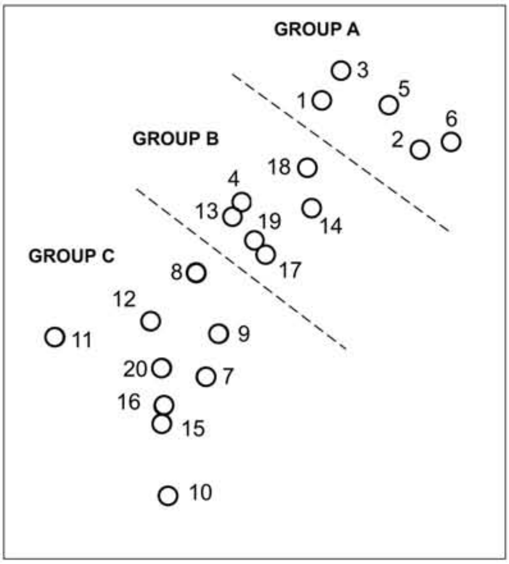


Fig. 4. Ordination of transects

Camus) and annual species.

In contrast, Group C transects (7, 8, 9, 10, 11, 12, 15, 16 and 20) are mostly located on the main Dong Mun upland in areas that formerly supported dark reflectance forest and were selected for sampling in part because they were still well vegetated and in many cases received some protection by proximity to forest temples. Group B transects (4, 13, 14, 17, 18 and 19) also occurred on Phu Pha ridge, adjacent to the Group A cluster, as well as on isolated small hillocks to the east of the main Dong Mun upland. This was an area dominated by dark reflectance forest in 1967 but today only a tiny tattered fragment remains barely visible at all on aerial photographs. One of the transects was located on the dry lower slopes at Phu No, a promontory in the extreme north west of Dong Mun proper.

3. Species richness

Of the 255 taxa, ten occurred in all transect groups (Table 1). These wide ranging plant types include some of the more abundant species so are ecologically important, but are least useful as indicators of subtle differences in conditions over the study site.

A comparison of taxa that are shared by the three transect groups show that Groups B and C have the greatest number of shared species but this, in part, reflects their greater richness (Table 2). Species richness is also illustrated in Fig. 5, which shows further that the greater richness in Groups B and C transects is due to a much greater number of climbers and shrub and small tree species.

Of the species that occur in more than 50% of the transects in each group, the dipterocarps (*Dipterocarpus* and *Shorea*) are most evident along with *Xylia* and *Pterocarpus* that occur commonly in all the transects (Table 3). These species were found with much lower frequency in the Group C transects where a variety of other species take their place including another dipterocarp species, *Hopea odorata*.

4. Species abundance

If the number of individual plants is considered, the greater abundance of climbers, shrubs and small trees is also evident in transect groups B and C (Fig. 5). Perhaps the most marked feature of the abundance data is the anomalously large numbers of plants encountered in transect (#10) in which 529 trees, shrubs and vines were counted representing 50 species and also making it the most species rich transect. Furthermore, this transect had three times more of each structural type than any other sample. It was located in the grounds of the largest temple

Table 1. Commonly occurring species found in all transect groups

SPECIES	LIFEFORM	FREQUENCY			
		A	B	C	TOTAL
Xylia xylocarpa (Roxb.) Traub	T	4	6	2	12
Grewia eriocarpa Juss.	S/ST	2	6	4	12
Pterocarpus macrocarpus Kurz	T	3	5	3	11
Hymenodictyon orixense (Roxb.) Mabb.	T	3	3	4	10
Haldina cordifolia (Roxb.) Rids.	T	2	3	3	8
Terminalia mucronata Craib & Hutch.	T	1	6	1	8
Vitex quinata (Lour.) F.N. Williams	ST	1	5	2	8
Pavetta tomentosa Roxb.	S	1	3	2	6
Irvingia malayana Oliv. ex Benn.	T	4	1	1	6
Bombax sp. (Lit)	T	1	3	2	6

Lifeform abbreviations: T=tree, S=shrub, ST=small tree, S/ST=shrub or small tree, C=climber

Table 2. Floristic affinity of transect groups

TRANSECT GROUPS	A	B	C	UNIQUE TAXA	NUMBER OF TRANSECTS	TAXA PER TRANSECT
A		10	3	4	6	11.6
B			31	61	5	31.8
C				136	9	37.4

in the area extending over 3500 rai (560 ha) of land and supporting 18 monks. Interviews revealed that the temple was established in 1987 and the abbot was instrumental in promoting a successful program of forest protection (Wester and Yongvanit, 2005). According to the abbot, when he arrived in 1987, the land had been logged and there were large areas of grass. The richness and denseness of the forest is largely a product of natural regeneration when a site is afforded appropriate protection. The abundance of climbers in the closed canopy forest may also be a response to regeneration (Roberts, 2001).

5. Biomass

Data was not collected to estimate biomass for all transects and Group B is poorly represented in this data. However the contrast between Groups A and C is very evident with most Group C transects having much greater presence of shrubs, small trees and climbers and much greater total biomass in all cases (Fig. 6). Transect 10, which was earlier noted for its unusually high abundance values, does not have in the highest biomass. Instead transect 9 has the higher biomass because it contains two very large trees over 30 m tall. It too is near a temple that may have afforded some protection against the felling to these unusually large specimens.

VI. Conclusions

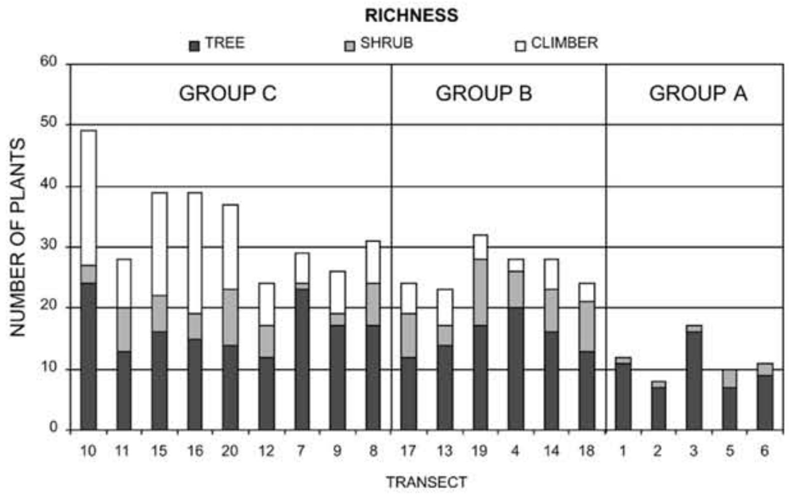
The forests of Thailand, and Dong Mun in particular, experienced severe reduction in area and degradation particularly in the decade of the 1970s. This was in part the result of commercial logging but also by cutting and clearing of forests by subsistence farmers or landless laborers. The force of economic, political and demographic pressures brought to bear on forest resources were far greater than government's capacity to resist.

The situation now has somewhat stabilized. Most of the easily accessible forests have been cut or converted to agriculture and the population pressure on agricultural land is diminished. A logging ban was enacted in 1989 but had relatively little effect in this area because the valuable timber had already been cut and it is very difficult to police the small-scale cutting done by local people for their domestic use. The Royal Forest Department, with its hierarchical

Table 3. Comparison of common species in each transect group

GROUP A	LIFEFORM	FREQUENCY
Dipterocarpus turbinatus Gaertn.	T	5
Xylia xylocarpa (Roxb.) Traub	T	4
Irvingia malayana Oliv. ex Benn.	T	4
Canarium sp.	T	4
Shorea siamensis Miq.	T	4
Quercus kerii Craib	T	3
Pterocarpus macrocarpus Kurz	T	3
Hymenodictyon orixense (Roxb.) Mabb.	T	3
GROUP B		
Terminalia mucronata Craib & Hutch.	T	6
Grewia eriocarpa Juss.	S/ST	6
Xylia xylocarpa (Roxb.) Traub	T	6
Vitex quinata (Lour.) F.N. Williams	ST	5
Pterocarpus macrocarpus Kurz	T	5
Cassia garrettiana? Craib	T	5
Canarium sp.	T	4
Dipterocarpus turbinatus Gaertn.	T	3
Leea indica (Burm f.) Merr.	S	3
Apocynaceae ?	T	3
Hymenodictyon orixense (Roxb.) Mabb.	T	3
Olax scandens Roxb.	C	3
Shorea siamensis Miq.	T	3
Hibiscus sp. ?	ST	3
Bombax sp.	T	3
Buchanania glabra Wall ex Hk. f.	T	3
Haldina cordifolia (Roxb.) Rids.	T	3
Pavetta tomentosa Roxb.	S	3
Cissus adnata Roxb.	C	3
Atherolepis pierrei Costa	C	3
GROUP C		
Olax scandens Roxb.	C	8
Apocynaceae ?	T	8
Sampantaea amentifolia (Airy Shaw) Airy Shaw	S	6
Rubiaceae ?	T	6
Millettia sp.	C	6
Tinospora crispa (L.) Miers ex Hook. f. & Thompson.	C	5
Suregada multiflora (A. Juss) Baill.	S/ST	5
Zanthoxylem sp.	T	5
Hymenopyramis cana Craib	C	5
unknown	T	5
Memecylon sp.	S/ST	5
Polyalthia evecta (Pierre) Finet & Gagnep.	T	5
Hopea odorata Roxb.	T	5
Polyalthia sp. ?	C	5

Lifeform abbreviations: T=tree; S=shrub; ST=small tree; S/ST=shrub or small tree; C=climber.



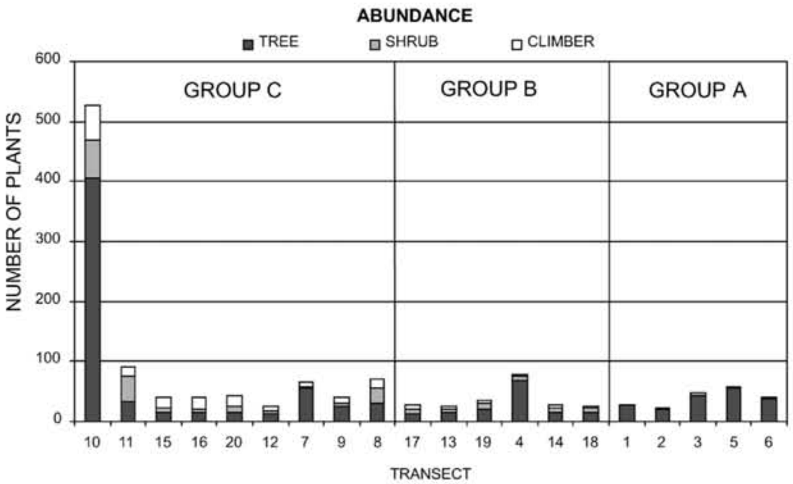


Fig. 5. Abundance and richness in transects

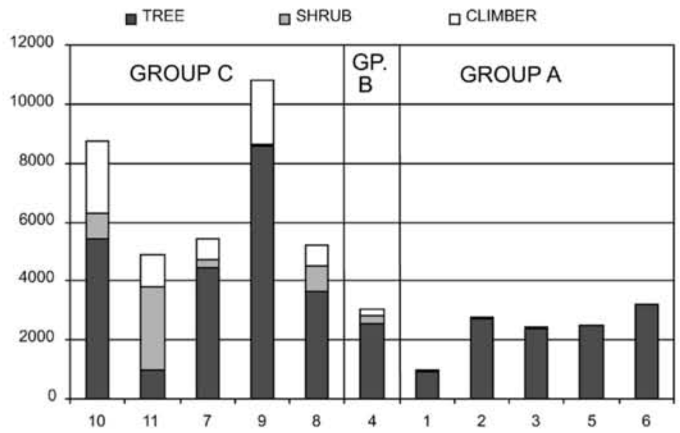


Fig. 6. Biomass of transects

and bureaucratic structure, has had very limited success in gaining the cooperation of local populations that today pose the greatest threat. Much of the management has been turned over to local authorities where religious figures and educators have a role in shaping local practices. The selective cutting or wood and charcoal producing, hunting of wildlife still continues. Those attempting to protect the forest feel that burning is the most serious threat.

Contrary to expectations based on appearances from aerial photographs, floristic analysis did not show two very distinct communities. Instead a gradient of variation was found which, for convenience, was dived into three categories. At one end of the gradient were communities of low biomass and species diversity and the simplest structure with few shrubs, low trees and climbers. These best represent the forest communities recognized on aerial photographs with light reflectance and are sites subjected to the highest intensity of human disturbance. These are typically open canopy forests lacking large emergent trees and are dominated by dipterocarps species generally associated with degraded habitats and the driest conditions.

A vegetation term frequently found in the Thai literature is "dry deciduous dipterocarp" which generally refers to the driest phases of lowland seasonal forest such as might be expected in Dong Mun. Gardner *et al*. (2000) describes the community as dominated by four species in the family Dipterocarpaceae namely *Shorea siamensis*, *S. obtusa*, *Dipterocarpus turbinatus and D. obtusifolius*. The forest is typically structurally simple with few tall emergent trees and poorly developed understory. Tree species richness may be less than half that of adjacent communities but might include members of the Rubiaceae family and species of *Quercus* as well as *Gardenia sootepensis* and *Morinda tomentosa* and a number of others. This description fits most closely the Group A transects. According to Gardner *et al*. (2000), under natural conditions, the "dry dipterocarp" community may have formerly had a very limited distribution and was probably confined to the driest ridges. However, human disturbance has greatly expanded its range and it can invade moist sites if species with higher moisture requirements are excluded by annual burning. The fact that the community is particularly susceptible to burning means that it can become stalled at an early stage of ecological succession and not advance to a more complex and species rich ecosystem.

At the other end of the spectrum are communities with much greater species diversity, biomass and structural complexity. They retain some relicts of their old growth character in the form of some very large trees in excess of 30 meters tall. Certain logged sites, with a documented history of protection from cutting and burning for the last 20 years in a temple, display vigorous regeneration with a dense understory development of trees and an abundance of climbers. This shows the capacity of the forest to regenerate at least in some well-watered sites if proper protection is applied. A significant reservoir of biological diversity resides in the dark reflectance forest and not in the light reflectance communities represented by the Group A transects. Most effort should be concentrated on preserving and protecting the fragments of this dark reflectance forest particularly from fire, if the maximum amount of diversity is to be preserved. Although the degraded light reflectance forest may fulfill some ecosystem functions, they have lower diversity, biomass and structural complexity and probably least capacity to regenerate.

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Bibliography

Dixon, CJ 1978. Settlement and Environment in Northeast Thailand. *Journal of Tropical Geography* 46: 1–10.

Gardner, S, P Sidisunthorn and V Anusarnsunthorn 2000. *A Field Guide to the Forest Trees of Northern Thailand*. Bangkok: Kobfai Publishing Project.

Hafner, JA 1990. Forces and Policy Issues Affecting Forest Use in Northeast Thailand 1900–1985. In: M Poffenberger ed. *Keepers of the Forest*. 69–100, West Hartford: Kumarian Press.

Hafner, JA and Y Apichatvullop 1990. Farming the Forest: Managing People and Trees in Reserved Forests in Thailand. *Geoforum* 21: 331–346.

Hirsch, P 1987. Deforestation and Development in Thailand. *Singapore Journal of Tropical Geography* 8: 129–138.

Japan Forest Technology Association 2001. *Classification of forests using remote sensing technology for the sustainable management. Eleven years of information system development project for management of tropical forests*. Tokyo: Japan

Forest Technology Association, Overseas Forest Information Center.

Kemp, JH 1981. Legal and Informal Land Tenures in Thailand. *Modern Asian Studies*, 15: 1–23.

Lohmann, L 1991. Peasants, Plantations and Pulp: The politics of Eucalyptus in Thailand. *Bulletin of Concerned Asian Scholars* 23: 3–17.

Lohmann, L 1993. Land, Power and Forest Colonization in Thailand. *Global Ecology and Biogeography Letters* 3: 180–191.

Mather, A 1990. *Global forest resources*. Portland, Oregon: Timber Press.

Mather, A 1997. South-North challenges in global forestry. *United Nations University, World Institute for Development Economics Research, Working Paper* 145, UNU/WIDER, Helsinki.

Matsumura, M 1994. Coercive Conservation, Defensive Reaction, and the Commons Tragedy in Northeast Thailand. *Habitat International* 18: 105–115.

Maxwell, JF 2004. A synopsis of the vegetation of Thailand. *Natural History Journal of Chulalongkorn University* 4: 19–29.

Mueller-Dombois, D and H Ellenberg 1974. *Aims and Methods of Vegetation Ecology*. New York: Wiley.

Rigg, J 1987. Forces and Influences behind the Development of Upland Cash Cropping in North-east Thailand. *Geographical Journal* 153: 370–382.

Roberts, SJ 2001. Tropical Fire Ecology. *Progress in Physical Geography* 25: 286–291.

Smitinand, T 2001. *Thai plant names (Revised Edition)*. Bangkok: Royal Forest Herbarium, Royal Forest Department.

Stott, P 1991. Recent trends in the ecology and management of the world's savanna formations. *Progress in Physical Geography* 15: 18–28.

Wester, L and S Yongvanit 2005. Farmers, foresters and forest temples: conservation in the Dong Mun uplands, Northeast Thailand. *Geoforum* 36: 735–749.

Yongvanit, S and T Homnetra 1993. Changes in Landuse in National Reserve Forest Northeast Thailand: A Case Study of Village Settlement in Dong Mun National Reserve Forest. *Regional Training Workshop for Technical and Extension Level Agroforestry Trainers in Asia Pacific*, 14–27 November, Khon Kaen University.

Appendix Pairwise comparison of species composition in transects

	TRANSECTS																					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
2		30	55.2	25	36.4	34.8	0	4.5	10.3	0	14.6	9.8	15	17	3.3	3.6	19.5	27.3	19.6	3.3	10	0
3			40	16.7	44.4	63.2	0	10	1	3.4	5.4	5.4	11.1	23.3	3.6	3.8	16.2	20	17	2.3	0	28.6
4				35.6	51.9	42.9	0	20.4	9.1	3	13	8.7	26.7	30.8	3.1	3.3	17.4	36.8	21.4	3.1	8	17.4
5					21.1	20.5	13.8	23.3	14.5	12.8	24.6	24.6	28.6	25.4	23.7	13.9	24.6	23.3	26.9	23.7	11.1	17.6
6						57.1	0	14.3	5.4	0	10.3	15.4	21.1	35.6	3.4	0	25.6	42.9	20.4	6.9	0	12.5
7							0	14	5.3	3.3	10	15	20.5	30.4	3.4	3.6	20	27.9	24	3.4	0	23.5
8								16.1	7	25	13.6	6.8	6.9	6.1	20.5	13.5	0	0	2.9	10.3	0	5.6
9									30.5	17.1	29.5	36.1	40	29.8	12.5	23.7	19.7	12.5	22.5	30	0	10.5
10										20.8	14.3	28.6	14.5	9.7	18.7	25.4	14.3	6.8	12.1	21.3	5.7	0
11											27.8	17.7	7.7	9.4	42.8	38.3	10.1	4.9	13.5	24.5	3.4	7.1
12												44.8	24.6	12.5	26	27.4	17.2	13.1	20.6	28.5	10.8	17.1
13													28.1	18.8	15.6	21.9	20.7	16.4	17.6	23.4	5.4	11.4
14														34.9	10.5	55.6	7	40	44.8	21.1	11.1	11.8
15															9.6	6.5	27.4	39.3	36.6	11.5	0	42.9
16																43.5	5.2	30	34.5	16.7	7.1	7.4
17																	5.5	5.3	9.6	32.6	3.8	8
18																		39.3	41.2	13	0	0
19																			42.3	10	5	5.3
20																				18.4	0	14.3
21																					7.1	11.1
22																						28.6