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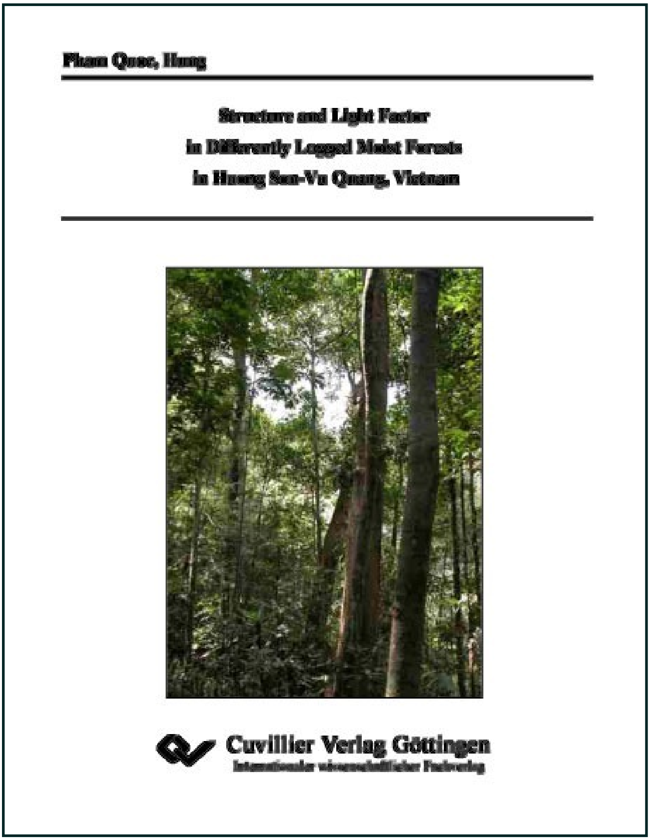
# Structure and Light Factor in Differently Logged Moist Forests in Vu Quang-Huong Son, Vietnam

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# 1 Introduction

## 1.1 Forest and forestry in Vietnam

Forests are crucial for the well-being of humanity. However, today, because of the pressure of human population growths, the forests have suffered substantial losses due to their degradation or conversion into other unsustainable forms of land use. Each year, about 13 million hectares of the world's forests are lost because of deforestation (FAO, 2007). This process is particularly severe in South East Asia, where by 2100 three-quarters of the original forests and up to 42% of the biodiversity are expected to be lost (Sodhi *et al.*, 2004).

Located in South East Asia, Vietnam is a moderately forested country with about 30% forest cover (FDP, 2005). The forest types are so diverse, comprising conifer and broadleaves forests, deciduous and moist evergreen forests, and mangrove and montane forests (Thai Van Trung, 1998). Conifers are the major component of the forests in the highlands, of which *Dacrydium pierrei, Fokienia hodginsii, Cunninghamia lanceolata,* and *Pinus* spp. are common species, whereas evergreen broadleaf forests are frequently found on hilly sites. The evergreen broadleaf forests are characterized by three or four distinct layers of woody species and a layer of shrubs and regeneration vegetation. Some species dominating the upper layer are *Hopea* spp, *Dipterocarpus alantus, D. costatus, D. dyeri* and *Shorea vulgaris*. Other families such as Ebenaceae and Leguminosae are also found there. Another forest type is the deciduous moist forest. In the dry season, some deciduous species drop all their leaves in just a few days (for instance *Dipterocarpus dyeri* and *D. turbinatus)*, some take longer (for instance *Sterculia* spp.) and others take several months (for instance *Bombax* spp. and *Tetrameles nudiflora*). In the extreme South of Vietnam, Mangrove forests cover a large area with the most typical species being the Rhizophoracae and Bruguieraceae families. Montane forests grow in high mountainous regions. They are not characterised by any particular dominating trees species, but there are epiphytes in abundance. These forests gradually replace lowland forests when elevation levels increase above 700 m a.s.l. in the North and 1000 m a.s.l. in the South. Lauraceae *(Lindera* spp., *Litsea* spp., and

*Cinnamomum* spp.), Fagaceae (*Quercus* spp., *Castanopsis* spp., and *Lithocarpus* spp.), Juglandaceae, Magnoliaceae and conifers are the major components.

Like other countries in the region, Vietnam's forests have declined significantly in direct proportion with the economic development of the country. In 1945, Vietnam had 14.2 million hectares of forests but this figure dropped to 9.3 million hectares in 1996 (FIPI, 1997). There are several reasons for the forest decline during this period. Under French colonialism (1858-1954), large tracts of natural forests were cleared for cultivating coffee and rubber trees and other tropical cash crops. During the war between Vietnam and the United States of America (1956-1975), about 2 million hectares of forest were destroyed due to bombardment with defoliant chemicals. After the reunification of Vietnam in 1975, forest management and reforestation were primarily carried out by State Forest Enterprises, which achieved only limited success. In the early 1990s, policy objectives focused on managing forestlands primarily for production purposes, and this led to the overexploitation of forests. In addition, shifting cultivation and forest fires accelerated the deforestation process in Vietnam even further.

In order to deal with the situation, the Government of Vietnam with the support of International Organizations launched various reforestation programmes, for example PAM in period of 1976-2000 (World Food Program supports reforestation in Vietnam), National Programme for Upland Development from 1993 to 1998 (known as the 327 Programme), and more recently, the 5 Million Hectares Reforestation Programme ("5MHRP") was implemented in 1998 and will be completed by 2010. The goal of the 5MHRP is to establish a forest cover rate for the country of 43% (14 million hectares), which was the level in 1945, by the year 2010. As a result of this programme, in 2005 Vietnam possessed 12.6 million hectares of forests (FPD, 2006), which is 3.3 hectares more than in 1996. To date, these programmes have been successful in restoring forests in part of the bareland and have contributed to the stabilization of the livelihood in rural areas.

Forest and forest industry play an important role in the national social economy. In 2005, the total value of non-wood forest products was USD 289 million (FAO, 2006), the export turnover of the forestry sector reached USD 1.5 billion, ranking it fifth among the other export sectors of Vietnam (Anh, 2006). In the first 6 months of 2006, the revenue from woody products export was USD 922 million and it was expected to be USD 1.8 billion at the end of the same year (MARD, 2007). In addition, forests are essential to the livelihood of the rural population, in that they supply most of the energy used and act as an economic safety net for the poor in these areas. In Vietnam, it is estimated that about 24 million people live off forests and forest products (Trieu Van Hung, 2006). These people collect food, vegetables, poles and medicinal plants from the forests either for their own use or for sale. However, it is recognised that the greatest value of forests is their role in maintaining the Earth's Ecosystem, particularly now with the worldwide concern about "climate change". The critical environmental functions of forests include cycling of essential nutrients such as nitrogen, phosphorous, absorbing carbon dioxide from the atmosphere, regulating temperature and precipitation, protecting watershed from soil erosion and supplying water for downstream communities.

## 1.2 Rationale

There is growing interest in many parts of the world in the use of stand management regimes that will increase the structure and species diversity of forests and so achieve multipurpose forest management (O'Hara, 1998; Lähde *et al.*, 2001) vs. classical silviculture geared to wood production and its mature phase (Gómez-Pompa *et al.*, 1991). Also there is a tendency among some experienced tropical foresters to dismiss natural forest management as unrealistic, unworkable or impractical, or with another scenario that let plantations eventually supply all timber produced in the tropics (Gómez-Pompa *et al.*, 1991). In Vietnam, forest management has become a major issue in every national reforestation programme as well as in its conservation strategy.

In Vietnam, during the last two decades, about 3 million hectares of forests/plantations have been established. The applied management regimes of these forests/plantations may cause nature bias because of insufficient knowledge of trees' physiology character and their environment. Among the different applied management systems in Vietnam, the conversion from plantation to close-to-nature forest is currently drawing much attention from foresters, e.g. the KfW projects implemented on the plantations in Lang Son, Bac Giang and Quang Ninh provinces. For the rehabilitation of young forests, mostly watershed protection forests, the most widely accepted method is strict protection in association with "naturally facilitated regeneration". These management systems, with or without enrichment, have the aim of increasing the number of desirable tree species. Both conversion of plantation into close-to-nature forest and strict protection for improving natural regeneration, require information about the ecology and specific site requirements of the desirable tree species in order to provide the proper treatments at the right time.

Among 12.6 million hectares of forests in Vietnam, more than 2 million hectares have been set aside for National Parks, Nature Reserves and Biosphere Reserve Sites for the purpose of conservation. Most of these protected areas had been assigned to productive forest; and as a result, they have been now covered by secondary vegetation. Instead of silvicultural management, strict protection is often applied in these areas. A lot of research on the vegetation of the areas has been conducted, such as the works of Tran Xuan Thiep (1995), Le Van Cham (1995), Nguyen Thanh Men (2004), Dinh Huu Khanh (2004), Pham Quoc Hung and Nguyen Quoc Dung (2005), and Pham Xuan Hoan (2005). However, these authors paid limited attention to the variation in structure and composition of the forests. Meanwhile, the possible changes in structure as well as species composition (compared with primary stand) of the secondary vegetation may cause the un-sustainability of the forest in the future. This is the reason this research partly focuses on the forest structure and tree species composition of different conditions of secondary forest.

Forests in different states vary significantly in canopy structure, and there is a close relation between the canopy structure and light illumination inside forests (Capers and Chazdon, 2004; Dube *et al.*, 2005; Houter and Pons, 2005). Among other ecological factors, light becomes an essential factor because plants grow as a result of their ability to absorb light energy and convert it into reproductive chemical energy (Attridge, 1990). In a tree community, the light availability influences many important biological processes, for example plant growth and succession (Cannell and Grace, 1993). In forests, transmitted irradiance to the understories is a crucial environmental factor governing many processes, such as microclimate (Dai, 1996; Clinton, 2003), tree regeneration, seedling and tree survival and growth (Vazquez-Yanes *et al.*, 1990; Lieffers *et al.*, 1999; Bloor and Grubb, 2003; Mason *et al.*, 2003), species succession and diversity (Beudet *et al.*, 2002), biomass allocation and crown morphology (Messier and Nikinmaa, 2000), soil biological activities, water and mineral resources use (Phares, 1971). Hence, the assessment of available light in forest understories is important for better understanding of a wide range of different processes.

Light is often a limited factor in moist evergreen forests and the performance of trees in these forests is much influenced by the light regime. However, tropical tree species vary widely in their light requirements (Whitmore and Burnham, 1975; Richards *et al.*, 1996). It is known that light-demanding trees need more light for their survival and growth, whereas the shade-tolerant require less. Most research, conducted in shadehouses, has been done on the relationship between light and mortality and growth of seedlings of tropical species, (Augspurger, 1984; Lee *et al.*, 1996; Mostacedo and Fredericksen, 1999; Davies, 2001; Bloor and Grubb, 2003; McLaren and McDonald, 2003; van Rheenen *et al.*, 2004). These works mainly experimented on the development of a single or a group of species under different light environments; however, few considered developing a key tool for identifying light requirement magnitude of species.

Conventional classification of shade tolerance in tree species is based on a species' ability to withstand low light conditions using indirect field observations (Kennedy *et al.*, 2006). As far as this indirect method is concerned, among many authors, Richards *et al.*, (1996) has realized that the size-class distribution of light-demanding, shade-tolerant and semi-shade-tolerant (opportunist) species is different from each other. He recommended that the size-class distribution of a single species is a tool for classifying trees with respect to their light requirements. However, this method is time and labour consuming, and most of all, it requires a rather intact stand (primary forest) for collecting basic data.

Another way of classifying shade tolerance is direct assessment of either plant performance in different light environments (mentioned above) or photosynthetic performance. The assessment of plant performance in different light environments is time consuming and costly. Meanwhile, the other assessment based on gas exchange or chlorophyll fluorescence to provide a useful means of monitoring the response of trees to different light environments is often difficult to integrate over time or to relate them to tree growth (Kennedy *et al.*, 2006).

The use of the stable isotopes technique in plant ecological research has grown steadily in the past two decades (Dawson *et al.*, 2002), because it provides key insights into biochemical interactions between plants, soils, and the atmosphere. Recently, scientists have reviewed how isotopes measurements associate with the critical plant resources of carbon, water, and nitrogen to understand plant-resource acquisition, plant interactions with other organism, and the role of plants in ecosystems (Alessio *et al.*, 2004; Formanek and Ambus, 2004; Halaj *et al.*, 2005; Stevenson *et al.*, 2005; Brandes *et al.*, 2006; Menyailo and Hungate, 2006; Schwendenmann and Pendall, 2006; Ewe *et al.*, 2007; Oelbermann and Voroney, 2007; Tiunov, 2007). For plant ecology, the carbon stable isotope is a useful tool because this isotope is unevenly distributed among and within different compounds, and the distribution can reveal information about the physical, chemical, and metabolic process involved in carbon transformation (Farquhar *et al.*, 1989). In nature, there are three occurring stable isotopes of carbon, $^{12}C$, $^{13}C$ and $^{14}C$. In the air, the ratio of $^{13}C/^{12}C$ is about -8‰ (Peterson and Fry, 1987). Through the photosynthesis process, plants use $CO_2$ in the atmosphere to synthesize carbohydrates, the building block of plant material. Based on this process, two types of plants are grouped, $C_3$ and $C_4$. The ratio of $^{13}C/^{12}C$ varies greatly between these two types of plants, about -27‰ in the tissue of $C_3$ plants and about -12‰ in $C_4$ plants (Peterson and Fry, 1987). As a result, the difference in $^{13}C/^{12}C$ ratios can be applied to distinguish $C_3$ and $C_4$ plants. Furthermore, the carbon isotope discrimination is also characterized by genetic and environmental variability, i.e. the light condition. Kennedy *et al.* (2006) on the other hand  pointed out that leaf carbon isotope discrimination has the potential to be used as an indicator of seedling performance under shaded conditions. In other research, Juhrbandt *et al.* (2004) found that the variation in sun leaf $\delta^{13}C$ ($^{13}C/^{12}C$) is very small with no significant difference among 7 light-demanding species (range from -27.49‰ to -28.41‰). So, why does the isotopic discrimination occur? It happens obviously during two photosynthesis processes, 1) $CO_2$ enters the leaf from the air and 2) it is fixed into carbohydrate. In the first step, the heavier $^{13}CO_2$ diffuses more slowly than $^{12}CO_2$ into the leaf pore space. Thus, the air outside the leaf is slightly enriched with $^{13}CO_2$, whereas the air inside the stomata is depleted in $^{13}CO_2$. In the second step, carboxilation occurs but the process of carboxylation is different for the two major pathways of photosynthesis found in plants ($C_3$ and $C_4$). The isotopic discrimination is further influenced by the rate of photosynthesis and stomatal conductance (Farquhar *et al.*, 1989) stated that carbon stable isotope discrimination has become a tool to help understanding photosynthesis with different rates among light-demanding, shade-tolerant or semi-shade-tolerant species. Using the carbon stable isotope as a proxy indicator for light requirement of species would be new and seems to be applicable.

In this study on light factor in secondary forests it is worthwhile to examine possible differences in carbon isotope discrimination among light-demanding, shade-tolerant and semi-shade-tolerant species. The results are expected to be used to classify tree species according to their light requirements. This basic information is essential for forest management, i.e. in controlling the establishment, growth, composition, health and quality of forests.

The light regimes beneath the canopy of secondary forests in different treatment states are examined as well. The subject of this research is the moist evergreen forests in Vu Quang-Huong Son, Hatinh Province, Vietnam. Globally, the term ‘evergreen forest’ is often referred to as “tropical rain forest” (*tropischer Regenwald*), a term coined by Schimper (1898, 1903, cited by Richards, 1996). In Vietnam, this type of forest is also called the ‘closed evergreen tropical rainforest’ by Thai Van Trung (1963; 1998). Conforming to geographical character, this type of forest is dominant on altitudes below 1000 m a.s.l. in the South and 700 m a.s.l. in the North of Vietnam.