EFFECTS OF DISTURBANCE OVER 60 YEARS ON A LOWLAND FOREST IN SOUTHERN VIETNAM

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Received January 2010

MILLET J, PASCAL JP & KIET LC. 2010. Effects of disturbance over 60 years on a lowland forest in southern Vietnam. Tropical lowland forests are some of the most threatened in the world and this is particularly the case in Vietnam. This study aimed to identify changes in species composition and forest structure in the Tan Phu lowland forest resulting from disturbance over a 60 year period. Analysis of forest composition and structure rely on data from 25 plots of 0.5-ha size established in a lowland secondary forest. The five forest stands described differed greatly from the three forest stand types described in 1943. Some long-lived shade-tolerant species had been replaced by pioneer species, such as *Cratoxylon formosum* and *Shorea roxburghii*. In addition to altering composition, forest disturbances had resulted in large changes in forest structure. While in the past, forest stands had a large number of exploitable trees, current forest stands have few trees in the diameter class > 50 cm and sometimes no trees in the diameter class > 80 cm. This paper provides notable results on forest tree ecology, forest dynamics and on the state of secondary forests in Vietnam. This is particularly important as future goods and services will increasingly have to come from such forests.

Keywords: Lowland tropical forest, disturbance impact, floristic composition, forest structure, Tan Phu forest

MILLET J, PASCAL JP & KIET LC. 2010. Kesan gangguan selama 60 tahun terhadap hutan tanah pamah di selatan Vietnam. Hutan tanah pamah tropika merupakan antara hutan yang paling terancam di dunia dan begitulah juga keadaannya di Vietnam. Kajian ini bertujuan untuk mengenal pasti komposisi spesies serta struktur hutan di hutan tanah pamah Tan Phu yang terjadi akibat gangguan selama 60 tahun. Analisis komposisi serta struktur hutan dijalankan berdasarkan data yang diambil daripada 25 plot yang setiap satunya bersaiz 0.5 ha di hutan sekunder tanah pamah. Lima dirian hutan yang dikaji sangat berbeza daripada tiga jenis dirian hutan yang dilaporkan pada tahun 1943. Sesetengah spesies yang hidup lama dan tahan naung telah diganti dengan spesies perintis seperti *Cratoxylon formosum* dan *Shorea roxburghii*. Selain daripada komposisi yang berbeza, gangguan hutan juga telah menyebabkan perubahan besar dalam struktur hutan. Pada masa dahulu, dirian hutan mempunyai banyak pokok yang boleh dieksploitasi. Namun dalam dirian sekarang, hanya terdapat beberapa pokok yang mempunyai diameter > 50 cm dan kadangkala tidak ada satu pokok pun yang mempunyai diameter > 80 cm. Kajian ini memberi keputusan penting tentang ekologi pokok hutan, dinamik hutan dan keadaan hutan sekunder di Vietnam. Ini sangat penting lebih-lebih lagi kerana pada masa hadapan pelbagai barang dan khidmat terpaksa diperoleh dari hutan sedemikian.

INTRODUCTION

In recent decades, tropical forests have been highly disturbed and primary forests continue to decrease (Janz & Persson 1997, Asner *et al.* 2005, Ashton 2008). Secondary forests and overlogged forests cover an area of 600 mil ha and an average of a further 9 mil ha is created every year (Brown & Lugo 1990, Emrich *et al.* 2000). Lowland forests are some of the most threatened in the world because their accessibility places them under the greatest pressure from anthropogenic disturbances (Curran *et al.* 2004, Hansen *et al.* 2009), including agriculture, logging, wildfires or warfare. This is particularly true in Vietnam, where most forests have either been deforested or degraded in the last 60 years (Le & Vo 1994, Roche & De Koninck 2002).

Many studies have shown direct damage to residual forest stands after logging (Cannon *et al.* 1994, Jackson *et al.* 2002, Hall *et al.* 2003), and such disturbance is known to exist over a large area and persists for many years (Sist & Nguyen-Thé 2002). In particular, it is recognised that forest logging promotes a change in floristic composition favouring the regeneration of pioneer species (Van Gardingen *et al.* 2006). Repeated logging over short time periods will compromise both natural regeneration and commercial tree regrowth (Whitmore 1990, Huth & Ditzer 2001). Removal of as few as 3.3% of trees in an area can reduce canopy cover by 50% (Johns 1988, Uhl & Viera 1989) and disturbance of 75% of the canopy is not uncommon (Pereira *et al.* 2002). It has been reported that 11 years after clear cutting, 60% of basal area removed had recovered with growth mainly in the smaller stem diameter classes, i.e. < 20 cm (Parrotta *et al.* 2002). In central Vietnam, a higher frequency of trees in the diameter class 10–20 cm was observed after two years logging compared with 12 years logging in an upland secondary forest (Tran *et al.* 2005).

In most cases, the long-term impact of disturbance remains unknown due to lack of historical data records. This is often the case in Vietnam. Lowland forests in the south of Vietnam have been described in the past (Maurand 1943). More recently, the forest structure and composition of the lowland rainforest in Cat Tien National Park, which had been disturbed until the 1970s, were described and interpreted by Blanc *et al.* (2000). However, we have found no study which has attempted to examine floristic changes after disturbance over long periods. This results in a lack of information on the change in forest composition and structure of the lowland forest and also on the response to disturbance.

Tan Phu forest is representative of the general situation in Vietnam, having undergone decades of disturbance and lacking in historical information. Logging is the main cause of disturbance and a few records of dates or details of the extent of this exist. This historical disturbance has resulted in a mosaic of different types of forest stands which remain undescribed. Only general information on floristic composition of the regional forest stands was recorded 60 years ago.

The questions addressed in this study are

(1) What is the floristic composition and structure of Tan Phu forest after disturbance?
(2) Is there any link between composition and structure in this forest?
(3) What are the light and soil preferences of the most common tree species?
(4) Is it possible to estimate the disturbance effect on the forest composition over 60 years with few historical data?

This study focused on the description and analysis of different degraded forest stands in Tan Phu forest and compared results with historical forest description.

MATERIALS AND METHODS

Study area

Tan Phu forest covers an area of 13 970 ha. It is located in Dinh Quan district, Dong Nai province, Vietnam (Figure 1) and extends from 11° 2' to 11° 10' N and 107° 20' to 107° 27' E. This area is subject to a tropical monsoon climate with two distinct seasons, namely, a rainy season from April till November and a dry season from December till March. The mean annual rainfall is 2715 mm measured at Talai with a minimum of 12 mm in January and a maximum of 511 mm in August. The mean annual temperature is 26 °C.

Tan Phu forest is one of the last remaining forests in southern Vietnam. Several disturbances have occurred in the past. The forest was bombed during the Vietnam War (1959–1975). Some parts had been cleared for agriculture but later abandoned. Besides this, Tan Phu forest has been extensively logged. Based on records from the Indochina forestry services, this area was logged in the 1940s. Logging continued after this date but, because of the war, it was not documented. It was only since 1978 that the forest was placed under the management of the Tan Phu forest state enterprise and that data became available. During the period 1978–1996, logging operations were conducted in two phases on exploitable species that can potentially reach 50 cm diameter at breast height (dbh). From 1978 till 1986, logging of trees in ≥ 60 cm dbh included *Anisoptera costata, Dipterocarpus alatus, Dipterocarpus dyeri, Heritiera cochinchinensis, Hopea odorata, Lagerstroemia calyculata, Litsea pierrei, Shorea roxburghii, Shorea thorelii, Sindora cochinchinensis* and *Xylia xylocarpa.* From 1987 till 1996, trees logged were ≥ 40 cm dbh and these comprised *Cratoxylon formosum, Combretum parviflorum, Elaeocarpus tectorius, Irvingia malayana, Parinari annamensis, Syzygium grandis, Syzygium tinctorium* and *Syzygium chanlos.*

Soil parameters

Soils at Tan Phu are ferruginous and, according to the FAO classification, the three main soil conditions present are epilithi-chromic acrisoils, epihyperferric acrisoils and veti-arenic acrisoils.

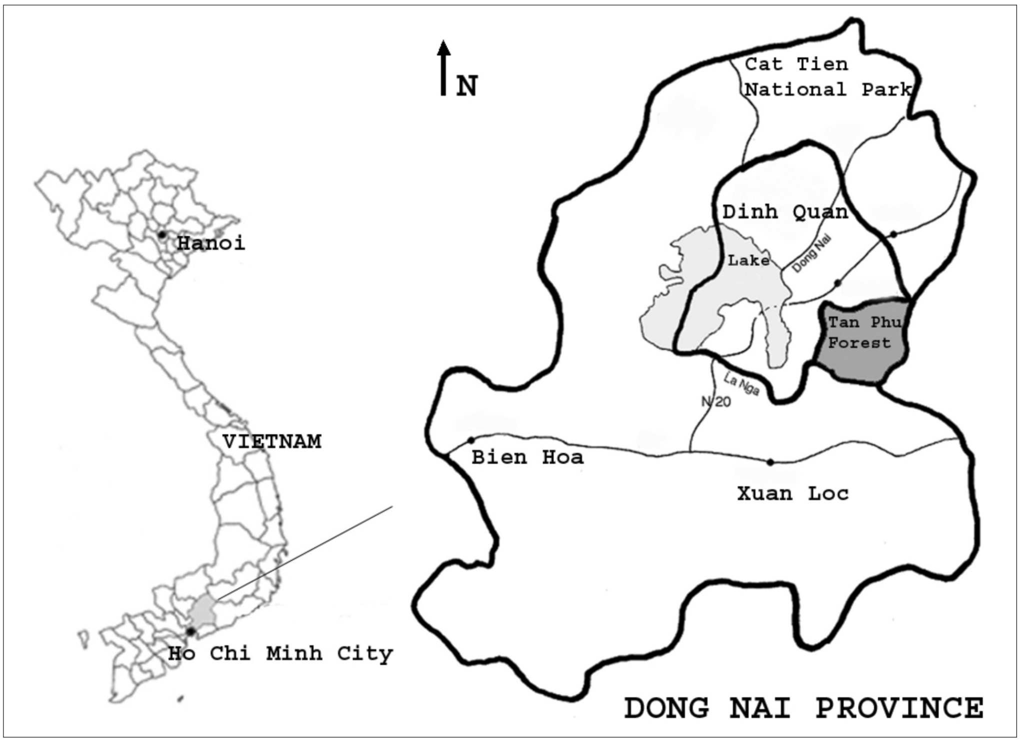

Figure 1 Location of the study area in Dong Nai Province, Vietnam

In each plot, two soil samples were taken from the depth of 50–80 cm. Analysis took into account the following criteria: maximum retention capacity (MRC), cation exchange capacity (CEC), iron (Fe^{2+}), aluminium (Al^{3+}) by extraction with ammonium acetate, organic matter (OM), pH, sand percentage (Sand), silt percentage (Silt) and clay percentage (Clay).

Botanical context

The lowland forests are characterised by a large number of species belonging to Dipterocarpaceae and Fabaceae, developing in a complex mixture, and some trees belonging to Lythraceae and Clusiaceae (Maurand 1943). Maurand (1943) has classified lowland forests according to the three soil conditions:

(1) Type α: on clayey and siliceous alluvial soils, forest stands are clearly dominated by Dipterocarpaceae—*D. dyeri, Shorea vulgaris, Vatica odorata, A. costata* mixed with some *Mesua ferrea* and *Heritiera cochinchinensis*—and Meliaceae

(2) Type β: deep soil containing humus are the favourite habitat of *V. odorata, H. odorata, D. alatus, D. dyeri* and some Clusiaceae

(3) Type γ: On red basaltic soil, *L. calyculata* with large proportions of *X. xylocarpa* mixed with some disseminated *Afzelia xylocarpa, S. cochinchinensis, D. alatus, Dalbergia bariensis* and *M. ferrea* have been found.

Sampling

Vietnamese foresters usually classify forests in four stages, i.e. medium, poor, young regenerated and aged regenerated forests, based on structural characteristics. As this method does not use floristic composition, we developed a new sampling strategy incorporating both the structure and floristic composition of forest stands. First, we conducted a preliminary survey to identify different types of forest and to locate replicate stands of each forest type. Based on this survey, forest inventory plots were established. The classic method using square subplots was tested but the high density of lianas and shrubs in the undergrowth made setting up subplots slow and difficult. We found an alternative method employing circular subplots, which does not require delimitation of the area (Figure 2) to be more appropriate. Distance between subplots was 10 m and trees were sampled if the distance from the centre of the circle was ≤ 4 m. This was a systematic method of sampling that covered close to 50% of the area and was less time consuming. Sampling size was determined by the stabilisation of specific richness curves. In total, 25 plots of 100 circular subplots with a total area of 0.5 ha were established in Tan Phu forest.

In each subplot, data were collected on trees (dbh > 10 cm), including names of species following Ho (2000), dbh and height of the highest tree. In addition, we measured forest canopy cover using a point-intercept method (Brockelman 1998). In the centre of all 100 subplots (10 × 10 m grid points), one was attributed if vertically, over shrubs (height > 5 m), sky was visible and zero was given if a tree crown was present. Therefore, the sum of the measurement provided the canopy opening percentage. Structural parameters chosen for this study were density, basal area (m^2), tree frequency in two classes (10–20 cm and > 50 cm), height and canopy opening (%).

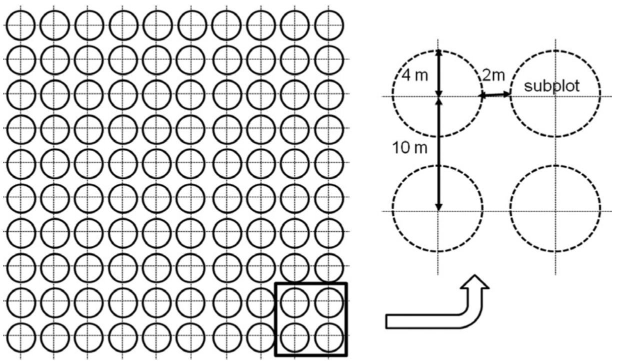

Figure 2 Sampling methodology using circular subplots

Statistical analysis

A non-symmetric correspondence analysis (NSCA) was used to establish a typology based on floristic composition of plots. NCSA was preferable because it avoided an overemphasis on rare species in the analysis (Gimaret *et al.* 1999). Here, only potential logging species, with diameters that can reach 50 cm, were taken into account. Understorey species were not considered. A principal component analysis (PCA) was used to establish typology of plots based on structural and soil parameters. Co-inertia analysis, which seeks to maximise covariance between two systems, was used to compare the contingence table with soil analysis table. It was also used to find any correspondence between structural parameters, floristic composition and soil criteria. Multiple variable analyses were performed using ADE-4 (Thioulouse *et al.* 1997) under R software.

RESULTS

Floristic composition

In total, 90 potential logging species were found in the 25 plots. A representation of 14 of the most abundant species is given in Figure 3. Following the NSCA analysis, five groups of species composition were identified.

Group A was represented by plots P7, P12, P18 and P19. These were characterised by *S. roxburghii* (which represented 10 to 22% of the total abundance of species) and *P. annamensis* (6 to 9%). P7 and P18 were further characterised by *I. malayana* (7 and 9% respectively), *Vitex tripinnata* (7 and 3%) and *C. formosum* (6 and 3%). P19 was more mixed with *L. calyculata* (7%), *V. odorata* (4%) and *D. dyeri* (4%).

Group B was represented by P3, P5, P8, P9, P10, P11, P17 and P20. These were characterised by *V. odorata* (3 to 15% of species abundance, notably in P9 and P11) and *S. chanlos* (3 to 16% except in P11 where it represented 1%). Plots P5, P8, P9, P10 and P20 were also characterised by *D. dyeri* (2 to 10%) and by *E. tectorius* (4 to 7%). *Hopea odorata* (3%) was represented in plot P11.

Group C was represented by P2, P6, P14, P15, P16, P23 and P25. These plots were characterised by *S. chanlos* (3 to 7%) and *V. tripinnata* (2 to 8%). There were also some other species such as *C. formosum* (6 to 7% in P14, P15 and P23), *D. alatus* (4 and 10% respectively in plots P2 and P23), *D. dyeri* (2 to 8% in P2, P6, P15 and P25), *H. odorata* (2 to 6% in P2, P16 and P23), *L. calyculata* (3 to 7% in P2, P6, P15, P16 and P25), *Metadina trichotoma* (4 to 13% in P2, P6, P14 and P25), *V. odorata* (3% in P6) and *Xerospermum noronhianum* (2 to 8% in P2, P14, P15, P16 and P25).

Group D was represented by P4, P13, P21 and P24. These were characterised by *L. calyculata* (8 to 18% of the total abundance of species), *V. tripinnata* (4 to 6%) and *C. formosum* (1 to 7%). *Xerospermum noronhianum* represented 2 to 25% in plots P4, P13 and P21, *D. alatus* 13% in P4 and *X. xylocarpa*, 7% in P24.

Group E was represented by P1 and P22. These plots were characterised by an abundance of *C. formosum* (22 and 15% in P1 and P22 respectively), *V. tripinnata* (8 to 6%) and *P. annamensis* (3 to 5%). P22 was also characterised by *M. trichotoma* (3%) and *L. calyculata* (2%).

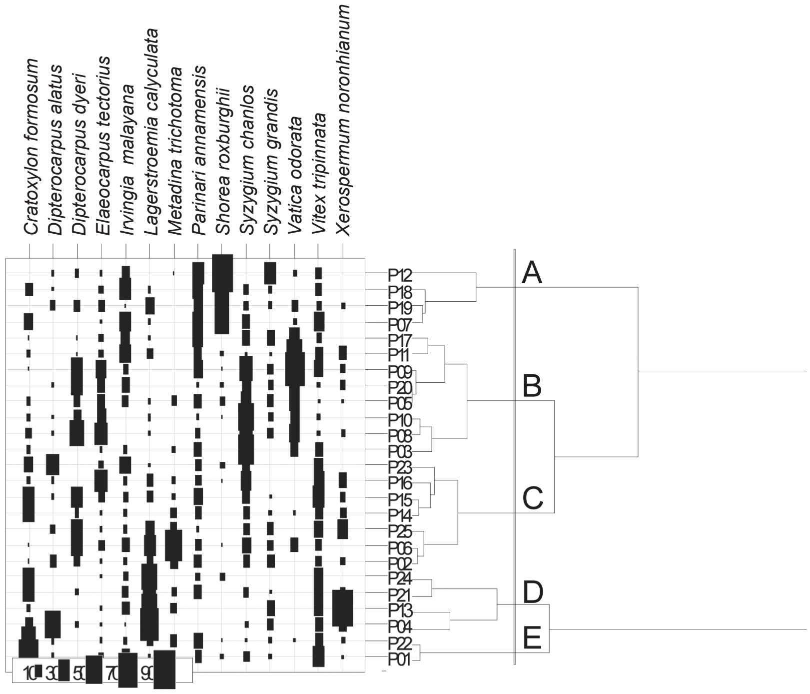

Figure 3 Representation of the contingency table (14 of the most abundant species) and plot hierarchic classification according to a non-symmetric correspondence analysis

Relationships between soils and floristic composition

Results of co-inertia analysis between the tables for soil characteristics and contingence are presented in Figure 4. A relationship existed between the two tables (total inertia = 0.049). In particular, *S. roxburghii* was attached with sandy soil. Abundance of *L. calyculata* was linked with soil acidity. This species occurred on 80% of plots but its abundance was higher when pH was over 5. The effect of pH in explaining the presence of *L. calyculata* was not shown clearly in Tan Phu forest since the pH changed within a narrow range, i.e. from 4.4 to 5.4. *Syzygium chanlos* and *D. dyeri* had links with sandy-clay soils while *C. formosum* showed relationships with high organic matter and soils with high water retention.

Typology on structural parameters

Results of PCA on structural parameters are presented in Figure 5. The first axis represented 38% of the total inertia. Seven main groups could be identified based on the hierarchic classification. In order to classify these groups, the average of the factorial value on axis 1 for each plot of the group was used to determine the value of the group. A high value indicates high disturbance. The classification from the most disturbed group to the least disturbed was as follows: II > IV > V > III > VI > VII > I. Co-inertia analyses between structural parameters and floristic composition and those between structural and soil parameters showed no linking ($p > 0.05$).

Data on the structural parameters are presented in Table 1. Average density was 587 (variation coefficient 25%). Average basal area was 26 m^2 ha^{-1} (46%). The average percentages of trees with diameters < 20 cm was 63% and those with > 50 cm was 3.8%. A third of the plots had no trees in the diameter class > 80 cm. The average height was 18 m (28%) and the average forest opening was 12% (100%).

DISCUSSION

Effect of disturbance on floristic composition

Based on comparison of floristic compositions, relationships between forest stands of the past (α, β and γ) and current forest stands were established (Figure 6). On sandy soil, *A. costata, D.*

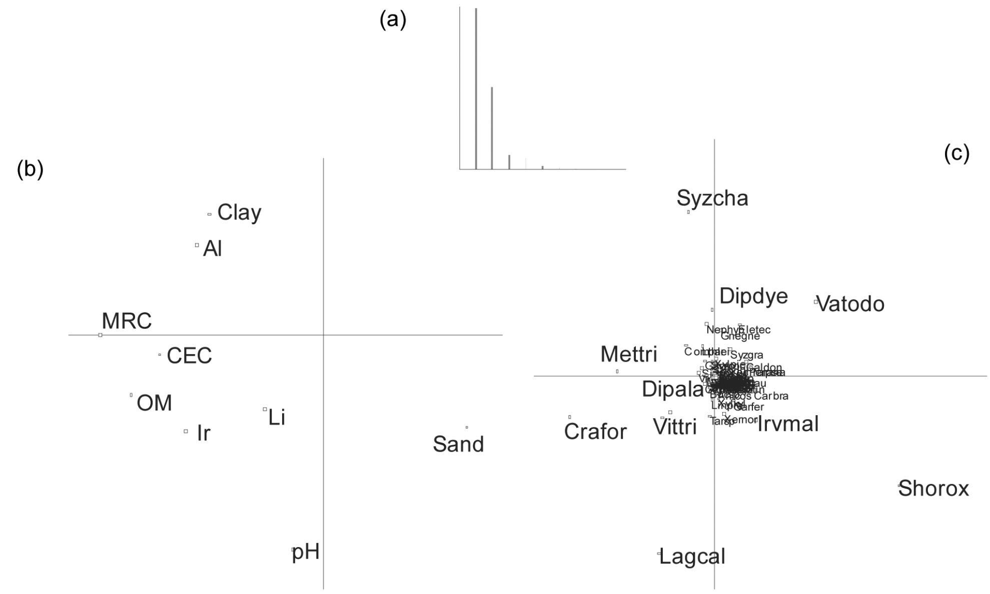

Figure 4 Co-inertia analysis between soil criteria and floristic composition: (a) Eigen value graph, (b) factorial plan 1–2 for soil parameters and (c) species factorial plan 1–2

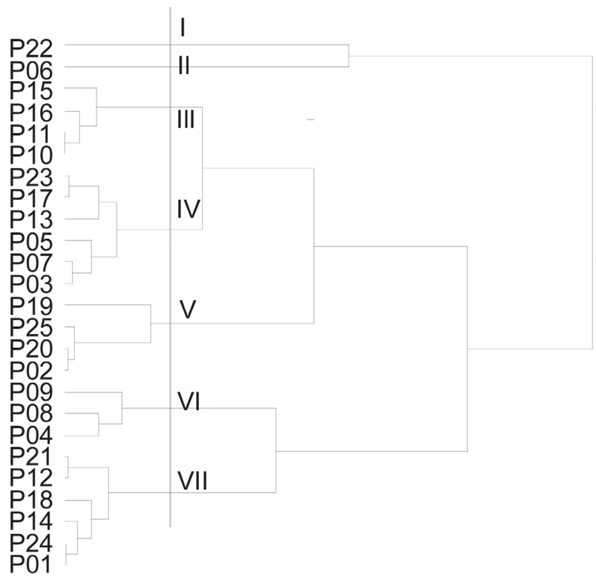

Figure 5 Plot hierarchic classification according to principal component analysis on structural parameters

alatus, D. dyeri and *V. odorata* had few individuals. The forest was mainly composed of *S. roxburghii* and *P. annamensis* (forest stand A). It may be assumed that on sandy soil, large openings in the forest cover which occurred after intense logging have reduced the water capacity of the soil. Hence, high water-demanding species have been disadvantaged. Once the water capacity was higher, *E. tectorius, S. chanlos, V. odorata* and *D. dyeri* became more abundant (forest stand B). This forest stand could be linked with type α or β forest stands as described by Maurand (1943). *Vatica odorata* and *D. dyeri* could withstand disturbance and even strong disturbance. In P8 and P9, disturbance seemed to be heavy (few trees in the diameter class > 50 cm) but there were 32 and 50 numbers of trees respectively belonging to these two species, their dbh class 10–20 cm. When water capacity was even higher (Figure 4), *V. odorata* disappeared in the profit of *D. alatus* and *H. odorata* (forest stand C). It appeared that *D. alatus* and *H. odorata* could not regenerate intensively after disturbance. This was the case in P14 where only six trees, which belonged to the Dipterocarpaceae family, were found. Only in P23, presumably due to less intense logging, *D. alatus* and *H. odorata* had 10 and 12 trees respectively in dbh class 10–20 cm. In this situation, perturbation was followed by regeneration of others species including *C. formosum, L. calyculata, M. trichotoma, S. chanlos, V. tripinnata* and *X. noronhianum* according to soil conditions. *Lagerstroemia calyculata* occurred more frequently (forest stand D) if the pH was over 5. This stand may be compared with type γ comprising *L. calyculata, X. xylocarpa* mixed with some disseminated *A. xylocarpa, S. cochinchinensis, D. alatus* and *D. bariensis.* In this case, disturbance was unfavourable to Fabaceae and trees belonging to this family were scattered.

Table 1 Value of structural parameters (density, basal area, frequency, height, canopy opening) for each structural groups

Structural group	Density	Basal area (m^2 ha^{-1})	Frequency of trees in the diameter class 10–20 cm	Frequency of trees in the diameter class 20–50 cm	Height (m)	Canopy opening (%)
I	620	14	0.77	0	16	19
II	706	36	0.6	0.054	23	2
III	614–664	24–27	0.58–0.64	0.016–0.032	18–20	1–11
IV	504–608	25–29	0.52–0.64	0.04–0.058	19–22	5–18
V	496–550	23–28	0.54–0.67	0.055–0.075	14–18	3–13
VI	644–734	23–34	0.59–0.72	0.011–0.036	17–20	14–24
VII	542–584	18–27	0.58–0.68	0.007–0.036	16–18	12–23
Average	587	25.8	0.63	0.038	18.1	11.9

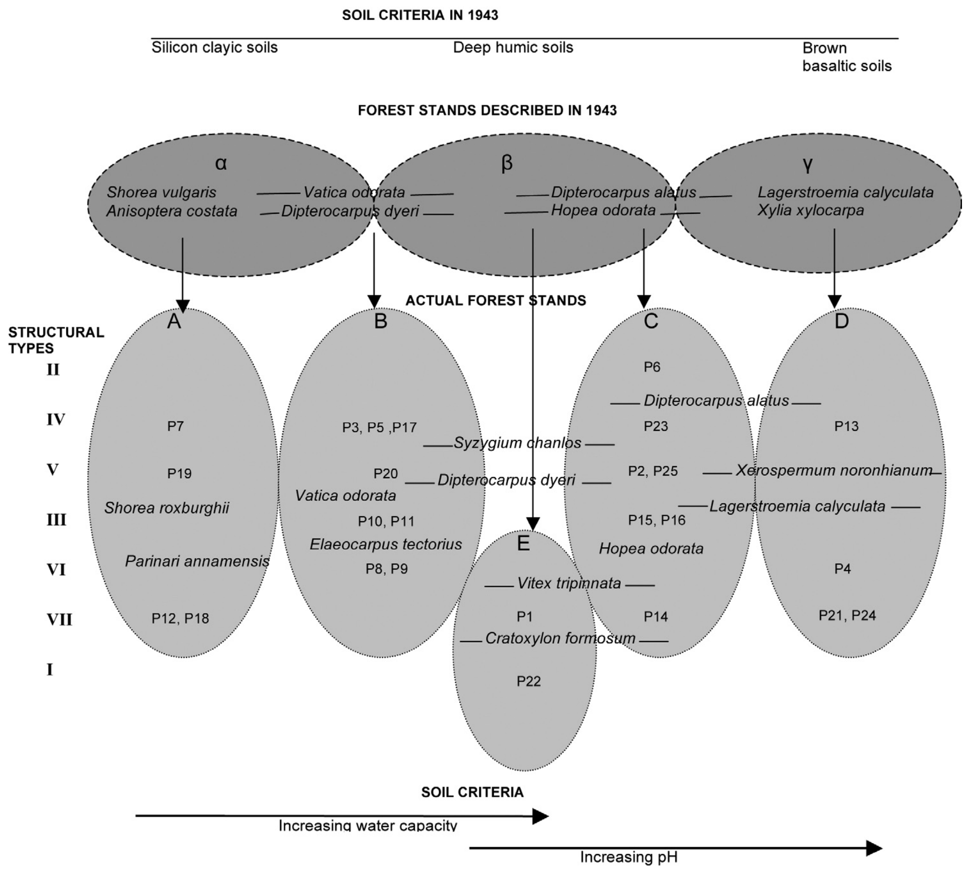

Figure 6 Tan Phu forest stands arranged according floristic composition and structural types and relationships with forest stands described in 1943 plus soil effect

The best represented species was *X. xylocarpa* in P24. *Dipterocarpus alatus* occurred only in P4. The disturbance benefited *L. calyculata* and *X. noronhianum*. Finally, in the case of a very strong disturbance, *C. formosum* and *V. tripinnata* were the main representative species (forest stand E). This was the case in P22, characterised by an absence of trees in diameter class > 50 cm, proving that clear cutting had occurred. This corresponded to the ultimate degraded forest after overlogging or agriculture. Dipterocarpaceae, Fabaceae and Lythraceae were nearly absent. Some remaining *D. alatus* and *H. odorata* indicated that this forest stand came from type β.

Globally, in dipterocarp forest (type α or β), dipterocarps are succeeded by *C. formosum*. This species is deciduous and has small seeds easily dispersed by wind. The small diameter of fallen trees on the ground shows that *C. formosum* is a short-lived pioneer species. If the disturbance is lower, *V. odorata* and *D. dyeri* can continue to regenerate. These species have a higher recruitment rate compared with *A. costata, D. alatus* and *H. odorata*. This could be a result of a more regular fruiting event and recruitment as for *Vatica cinerea* in Thailand (Bunyavejchewina *et al.* 2003). Their seeds are characterised by a lack of dormancy and a short dispersal distance. *Syzygium chanlos* is usually mixed with dipterocarps after disturbance and it can reach a big size. It is also a long-lived pioneer species. On sandy soil, with the exception of *S. roxburghii*, dipterocarps cannot regenerate after disturbance. *Shorea roxburghii* regenerates under light and can reach quite large diameters, being a long-lived pioneer species well adapted to sandy soil.

In Fabaceae forest (type γ) many of the original species cannot regenerate after disturbance. Natural regeneration of *Dalbergia* is very poor after logging (Aerts *et al.* 2009). It therefore becomes a *L. calyculata* forest. *Lagerstroemia calyculata* has small seeds, regenerates after disturbance and can reach large diameters. It is a long-lived pioneer species that develops on soil with pH > 5. Blanc (1998) described four forest stands composed of *L. calyculata* plus *A. xylocarpa* and *D. mammosa* which grow on brown shallow soil with pH 7 in Cat Tien National Park. This result confirms the preference of *L. calyculata* to less acidic soil.

Disturbance effect on structure

The average density in Tan Phu forest was 587 trees ha^{-1} (range 496–734 trees ha^{-1}). Cat Tien National Park, located 20 km from the study area, has a density of 195 to 540 trees ha^{-1} (Blanc *et al.* 2000). In Malaysia, stem density of a primary forest (dbh ≥ 10 cm) is 584 ha^{-1} and in a regenerating forest, 724 ha^{-1} but for medium size trees (10–30 cm dbh), stem density in the former is much higher than in the latter (Okuda *et al.* 2003). The high stem density in Tan Phu forest can be explained by the diameter class distribution of its trees. Here, forest stands are young and more than 60% of trees are in the diameter class 10–20 cm.

The average basal area is 26 m^2 ha^{-1} (range 14 to 36 m^2 ha^{-1}). At Pasoh in Malaysia, basal area ranges between 33 and 37 m^2 ha^{-1} (Appanah *et al.* 1990, Okuda *et al.* 2003). In India, a value of close to 40 m^2 ha^{-1} has been reported for a non-exploited forest (Pascal & Pelissier 1996). In Laos, basal area is 35 m^2 ha^{-1} in natural forest (Sovu *et al.* 2009). In Cat Tien (Figure 1), where forests have been under protection since 1978 but were disturbed in the past, the basal area ranged from 29 to 69 m^2 ha^{-1} (Blanc *et al.* 2000). Our results showed that disturbance or logging in Tan Phu was very intensive, resulting in the basal area being particularly reduced. In Tan Phu, there were fewer than 4% trees with dbh > 50 cm. There can be areas where there were no trees in this diameter class (plot P22). One third of the plots had no trees in dbh class > 80 cm.

Forest opening varied from 1 to 24%. In Brazil, forest opening of an undisturbed forest is 3% and after logging of 15 trees ha^{-1}, the value rose to 21.6% (Pereira *et al.* 2002). Logging of 16 trees ha^{-1} led to forest opening of about 24–29% while logging of 8 trees ha^{-1}, 15–16% (Van Der Hout 2000). In Indonesia, opening of about 3.1–3.8% has been reported before logging and 19.2% after conventional logging of about 8–9 trees ha^{-1} (Sist *et al.* 2002). On one hand, results observed in Tan Phu forest are close to undisturbed forest but on the other, close to overlogged forest. The time span since logging plays an important role. Tree cover recovered within logging gaps by nearly 20% during the first 6–14 months after logging (Fredericksen & Mostacedo 2000)

CONCLUSIONS

Our study provides important knowledge on the effect of disturbance on lowland forests in Vietnam. In Tan Phu, five different floristic compositions have been described. In spite of different study methods, it can be assumed that all five forest stands are different from the three described in the historical data available. A large number of species that made up the forest stands 60 years ago no longer characterise them. *Anisoptera costata, D. alatus, H. odorata* and *X. xylocarpa* are scattered in the forest. Certain species such as *A. xylocarpa, D. bariensis, M. ferrea* and *H. cochinchinensis* have nearly disappeared. Only *D. dyeri, L. calyculata* and *V. odorata* are still seen in several forest stands. Disappearances of certain species offer opportunities for some others such as *C. formosum*, *S. roxburghii*, *S. chanlos*, *X. noronhianum* and also for *I. malayana*, *P. annamensis* and *V. tripinnata*. *Cratoxylon formosum* is a short-lived pioneer species that develops on poorly drained soil. *Shorea roxburghii* is a long-lived pioneer species that occurs on sandy soil. A pH effect could explain the existence of *L. calyculata* on soil with pH > 5 compared with *S. chanlos* which seems to tolerate more acidic soil. The structure of the forest has also been severely affected by disturbance. Trees in the diameter class > 50 cm are fewer than 4% and one third of the plots have no trees in diameter class > 80 cm, so basal area is generally low (14 to 36 m^2 ha^{-1}).

Seven structural forest types have been identified in Tan Phu forest. All of them are characterised by a high density of young trees, at least 52% in the dbh class 10–20 cm. The same floristic composition can be found in different forest structures. Floristic composition is a complex result of several parameters of disturbance (time, intensity and repetition) which affect regeneration according to the original floristic composition and soil condition.

Our results are particularly useful in the framework of the Vietnam National Forestry Action plan developed in an attempt to overcome losses in forest quantity and quality. In this regard, attention should be paid to *A. costata, D. bariensis, D. alatus, H. odorata* and *X. xylocarpa* which are high valued species but very sensitive to intensive and repetitive logging.

ACKNOWLEDGEMENTS

This study was carried out within the framework of the decentralised cooperation between Dong Nai Province in Vietnam and Rhône Alpes Région in France. The authors are grateful to the authorities of both communities as well as the representatives of Tan Phu forest enterprise for providing the opportunity to undertake this research. The authors also thank students of the University of Natural Sciences in Ho Chi Minh City and MM Dau and Thanh for field assistance.

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