

RESEARCH

Resource Use Dynamics and Land-Cover Change in Ang Nhai Village and Phou Phanang National Reserve Forest, Lao PDR

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ABSTRACT / This study integrated aerial photographs from 1952, 1981, and 1998, and a satellite image from 2000 with oral histories and socioeconomic surveys to assess changes

in forest and land cover in Ang Nhai village, Laos. The study documents the history of resource use and changes in household access to resources in the village. Three distinctive trends were observed in terms of forest and land cover—forest degradation, deforestation, and regeneration. Project results suggest that land and forest cover change dynamically under different circumstances. The case study also points out that integration into the market economy can induce intensification of unused lowland areas, while removing pressures from upland areas previously used for supplementing agricultural production. In addition, the creation of a national reserve forest to restrict local access and forest use was an ineffective tool for regulating encroachment and logging activities.

Scientists, resource managers, policy-makers, and planners increasingly recognize that land-use change is a major driver of global change, through its impacts on climate, ecosystem processes, biogeochemical cycles, biodiversity and—even more importantly—human activities (Lambin and others 1999). To understand land-use changes, scientists and resource managers must consider a broad range of resource degradation and regeneration; include an explicit awareness of layered scales of analysis in both time and space; emphasize the mechanisms structuring and determining patterns of access to a range of resources that influence the use of the natural environment; and engage with environmental history (Batterbury and Bebbington 1999). Without understanding the human dynamics behind land-use change, we cannot understand changes in land cover, nor predict the outcomes of policy interventions.

One of the chief challenges the land-use and land-cover change community faces is developing methods

for analyzing synergistic or interactive clusters of driving forces that cannot be assessed through the use of standard regression techniques (Lambin and others 2003, Young 2002). Institutions that work under one set of biophysical or socioeconomic conditions may not work under different conditions. Combinations of factors that are useful for explaining land-use changes in some situations may explain little in other cases. The challenge is to document interactive or synergistic combinations of variables that give rise to land-use and land-cover change and that take different forms from one case to another. Lambin and others (2003) suggest that this type of integrated research requires a combination of methods—agent-based modeling, systems analysis of the organization and institutions of society, and a narrative approach. The narrative approach seeks understanding through historical detail and interpretation (Richards 1990, Crumley 1994). It tells a land-use and land-cover change story for a specific locality and attempts to grasp all the complexity of events that affect land-use and land-cover change including changing political economics, environmental feedback on land use, and external shocks (Klepeis and Turner 2001).

In this paper, we describe changes in land-cover and land-use practices in Ang Nhai village located northwest of Vientiane and adjacent to Phou Phanang National Reserve Forest (hereafter Phou Phanang), one

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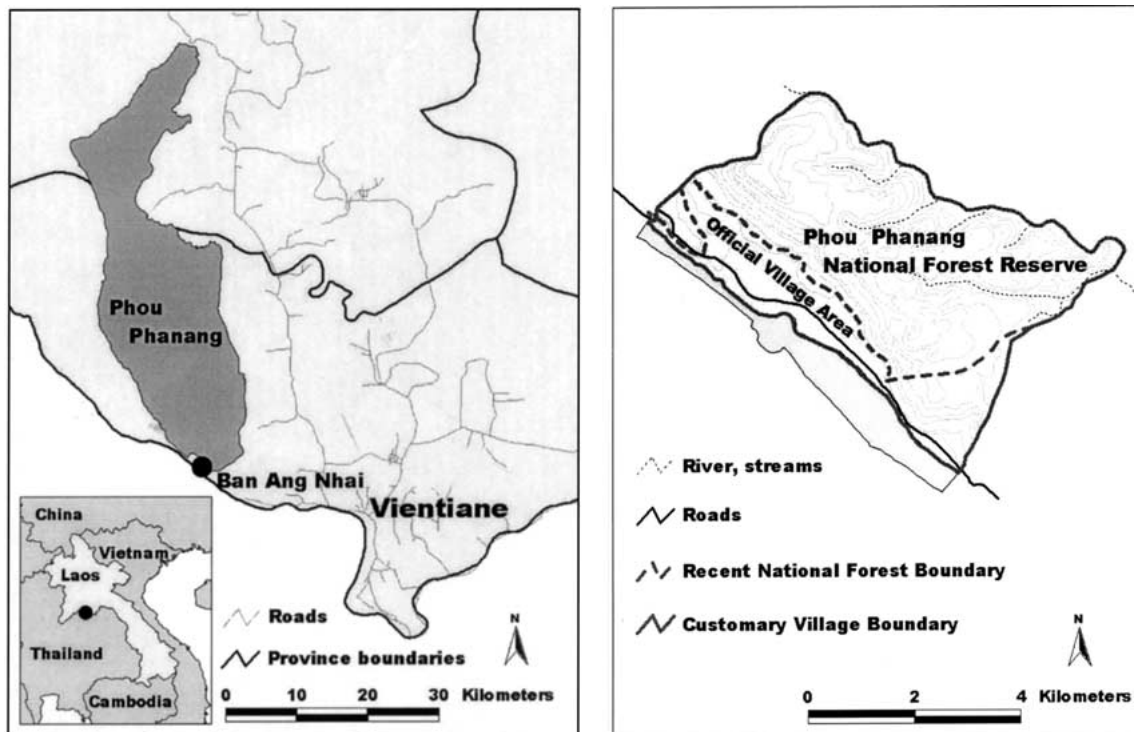


Figure 1. Location of Ang Nhay village and Phou Phanang National Forest Reserve.

of 18 original national reserve forests, or *pā saguan*, established in 1993 following the promulgation of Prime Minister Decree No. 164 (Figure 1). We combined aerial photographs and satellite image interpretation with oral histories of the village and household socioeconomic surveys to map changes in natural resource-use patterns between 1952 and 2000 and to explore factors driving these changes including war, population movement, markets, and government policies. The study emphasized the importance of understanding the historical dimension of resource-use patterns, and the necessity of combining different methods of analysis for furthering our understanding of the dynamic processes that affect forest and land-use change.

Research Methods

Researchers and students from the Faculty of Forestry at the National University of Laos conducted the project. The research team was divided into two subgroups: one led by the first author that focused on spatial analysis, and the other led by the second author that focused on socioeconomic analysis. The two subgroups joined together in fieldwork to document and understand customary resource use boundaries and village resource use histories through group

interviews in the village. This was followed by separate activities including ground-truthing and household interviews.

Spatial Data Analysis

The spatial analysis group analyzed aerial photographs from three dates (1952, 1981, 1998) to elucidate forest cover and land-use patterns. The first set of aerial photographs was produced in 1952 (Mission Number 35) at a scale of 1:40,000 during the French-Indochina War. The second set was produced in 1981 at a scale of 1:30,000 by the National Geographic Department and the former USSR. The final set of photographs was produced in 1998 at a scale of 1:50,000 by the National Geographic Department and the Japan International Cooperation Agency (JICA) as part of a project to collect spatial data for inclusion in a nationwide geographic information system database in Laos.

Aerial photographs were scanned digitally at a resolution of 300 dpi (dots per inch). The scanned images were geometrically registered to the UTM projection, zone 48 and WGS84 datum. An orthographic correction using a digital elevation model for the area was applied to the images to create orthophotos (photomaps). The digital orthophotos were interpreted in order to identify land-cover and land-use types.

Table 1. Land-cover change in Ang Nhai

| Class | Year | Number of patches | Mean size of patches (to nearest ha) | Total area (ha) | % of Area |
|--|------|-------------------|--------------------------------------|-------------------|-----------|
| Dense forest (≥70% canopy cover) | 1952 | 2 | 1223 | 2446 | 91 |
| | 1981 | 1 | 1469 | 1469 | 55 |
| | 1998 | 6 | 64 | 386 | 14 |
| | 2000 | 0 | 0 | 0 | 0 |
| Degraded forest (10–70% canopy cover) | 1952 | 0 | 0 | 0 | 0 |
| | 1981 | 20 | 24 | 474 | 18 |
| | 1998 | 10 | 159 | 1594 | 59 |
| | 2000 | 112 | 9 | 1001 | 37 |
| Grassland | 1952 | 0 | 0 | 0 | 0 |
| | 1981 | 0 | 0 | 0 | 0 |
| | 1998 | 1 | 3 | 3 | <1 |
| | 2000 | 255 | 1 | 323 | 12 |
| Shrubland ^a | 1952 | 11 | 20 | 219 | 8 |
| | 1981 | 70 | 9 | 618 | 23 |
| | 1998 | 92 | 5 | 473 | 18 |
| | 2000 | 245 | 5 | 1149 | 43 |
| Rice paddy | 1952 | 1 | 7 | 7 | <1 |
| | 1981 | 4 | 7 | 28 | 1 |
| | 1998 | 12 | 6 | 68 | 3 |
| Swidden | 1952 | 14 | 1 | 12 | <1 |
| | 1981 | 36 | 2 | 70 | 3 |
| | 1998 | 38 | 1 | 42 | 2 |
| Garden | 1952 | 0 | 0 | 0 | 0 |
| | 1981 | 3 | 8 | 23 | <1 |
| | 1998 | 13 | 8 | 105 | 4 |
| Agricultural land ^b | 1952 | 15 | 1 | 19 | <1 |
| | 1981 | 43 | 3 | 121 | 5 |
| | 1998 | 63 | 3 | 215 | 8 |
| | 2000 | 74 | 3 | 187 | 7 |
| Other ^c | 1952 | 2 | 1 | 3 | <1 |
| | 1981 | 1 | 5 | 5 | <1 |
| | 1998 | 3 | 5 | 15 | <1 |
| | 2000 | 46 | 1 | 37 | 1 |
| Total | 1952 | 30 | 90 | 2687 | 100 |
| | 1981 | 135 | 20 | 2687 | 100 |
| | 1998 | 175 | 15 | 2686 | 100 |
| | 2000 | 732 | 4 | 2697 ^d | 100 |

^aShrubs include tall and short shrubs in 1952, 1981, and 1998 and also bamboo in 2000.

^bFor 2000 satellite image classification, rice paddy, swidden, and garden aggregated into agricultural land. Aggregate values for rice, swidden, and garden over 1952, 1981, and 1998 are included in this row only to facilitate comparison over time.

^cIncludes residential land, rock, and sand classes for all years.

^d10-ha discrepancy attributed primarily to raster data structure of satellite image classification vs. vector data structure of land categories digitized from aerial photographs and differences obtained when subsetting and calculating areas in each data type.

Boundaries were digitized on-screen using ArcView software augmented with stereoscopic manual interpretation of the original photographs.

The minimum mapping unit used in the aerial photo interpretation was 1 rai (1600 m²). Land-cover categories were identified (Table 1) based on a hierarchical classification scheme established for the region. Aerial photographs were analyzed in the same manner for the three dates. Results were then cross-checked with GPS field measurements and further corrected and verified with input from villagers.

Changes in land use were calculated using ERDAS Imagine software. Overall changes for 12 categories of land cover were computed, and then the amount of land conversion occurring during the periods 1952–1981 and 1981–1998 was calculated for three categories—forest degradation, deforestation, and forest regeneration (Table 2).

A Landsat 7 Enhanced Thematic Mapper plus (ETM+) satellite image (03 July 2000) was obtained and rectified to the UTM projection, zone 48 and WGS84 datum. We collected more than 150 GPS points

Table 2. Summary of land and forest area transition

| | 1952–1981 | | 1981–1998 | | 1998–2000 | |
|-----------------------------|-----------|-----|-----------|-----|-----------------|-----|
| | Area (ha) | % | Area (ha) | % | Area (ha) | % |
| Areas deforested | | | | | | |
| Forest to swidden (hai) | 70 | 60 | 43 | 26 | 11 ^a | 3 |
| Forest to paddy (na) | 21 | 19 | 34 | 21 | — | 0 |
| Forest to garden | 21 | 18 | 79 | 49 | — | 0 |
| Forest to grass | — | 0 | — | 0 | 288 | 87 |
| Forest to others | 4 | 4 | 8 | 5 | 30 | 9 |
| Total | 116 | 100 | 164 | 100 | 329 | 100 |
| % of Study area | | 4 | | 6 | | 12 |
| Areas degraded | | | | | | |
| to Shrubs | 463 | 49 | 379 | 30 | 900 | 77 |
| to Degraded Forest | 475 | 51 | 866 | 70 | 256 | 22 |
| to Others | — | 0 | — | 0 | 13 | 1 |
| Total | 938 | 100 | 1245 | 100 | 1169 | 100 |
| % of Study area | | 35 | | 46 | | 44 |
| Areas regenerated | | | | | | |
| Agricultural land to forest | 12 | 42 | 54 | 13 | 104 | 48 |
| Shrubs to forest | 15 | 54 | 354 | 87 | 109 | 50 |
| Others to forest | 1 | 5 | — | 0 | 5 | 2 |
| Total | 28 | 100 | 408 | 100 | 218 | 100 |
| % of Study area | | 1 | | 15 | | 8 |

^aForest to agricultural land.

of representative land-cover types with relevant information on elevation, height, and basal area of forest trees, and land-use history, as well as photographs of current land use for each GPS point. These data were entered into a database and used as a reference for identifying training sets in the satellite image. A maximum likelihood classifier was applied to the image using ERDAS Imagine software. A 3×3 filter was applied to the final classification to help eliminate single, isolated pixels from the image. The accuracy of the image classification was assessed using a separate subset of GPS ground-truth points. Results indicated an overall classification accuracy of 95.5%.

Socioeconomic Data Collection

The socioeconomic group conducted a group interview with village leaders and members of *pā mai bān*, or village foresters, in order to understand resource management issues (village foresters were introduced to villages across Laos in the 1980s to monitor forest-use practices). A separate interview was conducted with a group of village elders including both men and women to ascertain the history of Ang Nhai and any significant changes that have occurred in terms of resource use since the 1950s. Questions regarding village history focused on demographic changes and their causes; changes in land cover and land use; and the villagers' assessments of the causes of environmental change. The information collected from these interviews was used to support the results of

the spatial analysis, and in particular, to understand the processes of forest and land-cover change that occurred during the three major time periods.

The socioeconomic subgroup also conducted semi-structured interviews with 59 randomly selected households (45% of the total households) to assess existing household discrepancies in land and forest resource use and to understand individual household land-use histories. This information was used to understand the effects of the recent boundary demarcation at the household level.

Results

Ang Nhai Village

Ang Nhai village is located in Sikhotabong District, Vientiane Municipality, along the Mekong River approximately 30 km northwest of Vientiane (Figure 1). The study site ranges in elevation from 180 to 460 m above sea level and receives an annual rainfall of approximately 1700 mm. According to village elders, the village was established 200 years ago by members of a Tai-Kadai ethno-linguistic group that migrated from the area of Kengtao in present-day Xayaburi Province as a result of the Ho or Chinese invasion. The Pavie Mission to Laos in the late 1880s (Pavie 1903) mapped Ang Nhai in its current location.

The oral history suggests that approximately 30 households totaling 195 inhabitants occupied the village in the 1960s. Over the next 10 years, during the

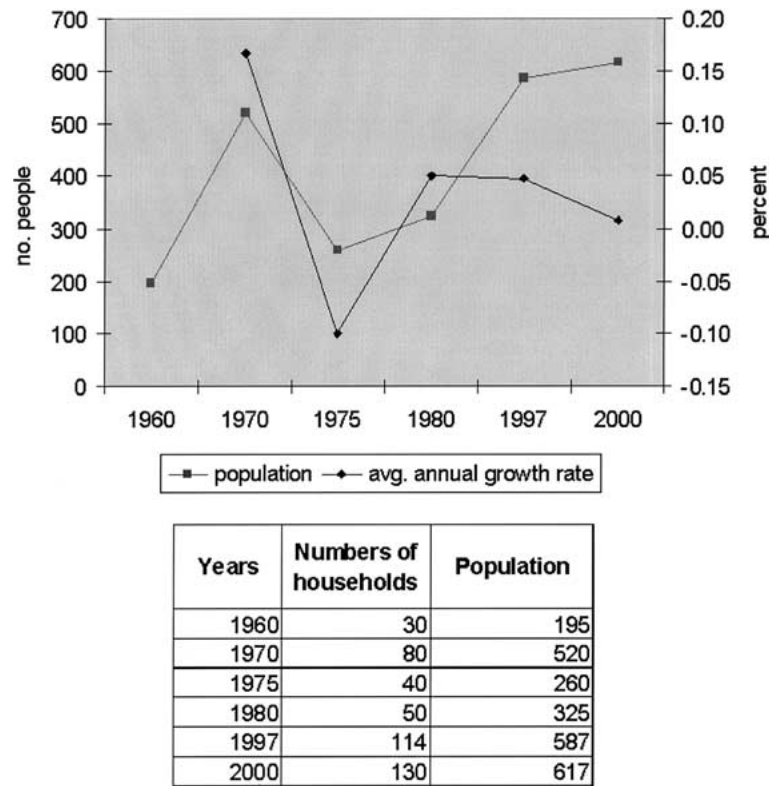


Figure 2. Ang Nhאי village population between 1960 and 2000.

Indochina war, the village population more than doubled to 520 people (Figure 2) due to a large influx of migrants escaping wartime disruption and U.S. bombings in northeastern areas of Laos, including Houaphan and Xieng Khouang provinces. A second wave of population migration occurred between the early and mid-1970s when the village population decreased to approximately 40 households as numerous migrants as well as long-time village residents fled across the Mekong River to Thailand in fear of political persecution. Wartime migrants that remained after the war were resettled to nearby villages following the establishment of the socialist government in 1975.

In the early 1980s, the population in Ang Nhאי began to gradually increase with the spontaneous repatriation of refugees. Approximately 10 former village members returned to Ang Nhאי during this period. Since then, total village population has increased to 130 households and 617 people with a relatively stable annual population growth rate of 1% per year.

Although the majority of Ang Nhאי residents currently have family roots in the village, population movements in and out of the village in the last two decades had been dynamic due to the occurrence of war and political change (Fujita *in press*). As we will see, these events had significant impacts on forest and

land cover in Ang Nhאי village, together with other factors including commercial logging, government policies on natural resource management, and changes in agricultural market.

History of State Forest Management in Ang Nhאי

State control over forest resources was initiated in Ang Nhאי in the post-1975 period when the government asserted control over resources and restricted shifting cultivation (Figure 3). This was accompanied by resettlement of upland communities and encouragement to convert their agricultural practices to more permanent forms (Souvanthong 1995). Villagers in Ang Nhאי, however, continued to practice shifting cultivation in upland areas, because they had no other viable alternatives for supplementing low and unstable rice production. This finding is supported by the interpretation of the 1981 aerial image (Figure 4B) and from village interviews. Concurrently, the government initiated commercial logging in the early 1980s when Phou Phanang was incorporated into a 420,000-ha state production forest managed by the military-owned State Forestry Enterprise (SFE) Number 9 (Persson 1983). Although the forest area was never demarcated nor were forest resources reserved exclusively for SFE No. 9, widespread logging occurred

| Time Period | Paddy | Swidden | Agriculture | Logging | External Factors |
|--|---|---|---|--|---|
| 1960 <i>American Period</i> (Indochina War) | | | | Logging by royal government and private companies | USAID intervention 1969-1976 |
| | Paddy rice cultivation in lowland | Swidden rice cultivation (villagers and migrants) | Subsistence gardening | | |
| 1970 <i>Political Transition</i> (Ceasefire and New Political Regime) | | | | | Logging road is improved |
| | | Shifting cultivation continues | | | Establishment of new socialist state |
| | | | | Logging by private companies | Government ban on shifting cultivation |
| | | | Beginning of cash cropping | | Rehabilitation of plymill and sawmill |
| 1980 <i>Economic Transition</i> (Planned to Market) | Construction of irrigation (agricultural cooperative) | Shifting cultivation gradually decreases | Sales of agricultural products to Thailand (Tobacco, Peanuts, Tomato, etc.) | Logging by state enterprise | Logging road improves |
| | | | Sales of agricultural products burgeons (Tobacco, Eggplants, Chili, etc.) | | |
| 1990 <i>Institutional Transition</i> | | | | Logging by private companies are banned. | |
| | Increased paddy rice cultivation in lowland | Encroachment by Champa and Vientiane. | Sales of cash crops to Thailand as well as to Vientiane | Logging is based on quota issued by different offices | Phou Phanang becomes national protected forest area |
| 2000 | | | Sales of cash crops and livestock (cattle, pigs) to Thailand as well as to Vientiane. | Illegal logging persists often with military intervention. | Phou Phanang is transferred to the military. |

Figure 3. History of Ang Nhאי village and Phou Phanang Forest.

during the 1980s, as a concession was given to the Japanese furniture company Otsuka Kagu to extract commercially valuable species for export including *Mai Dū* (*Pterocarpus marcocarplus*) and *Mai Tē Khā* (*Azelia xylocarpa*) (Thapa 1998).

A second period of state control over forest occurred during the 1990s. This time all state-owned forestry enterprises were dismantled and commercial logging was restricted. Furthermore, in 1993 the government established national reserve forests, or *pā saquan hēngxāt*, to protect biodiversity and prohibit all human intervention (Prime Minister's Decree No. 164). Phou Phanang was included among the original national reserve forests totaling 70,000 ha. In 1995, the new state forest boundaries were announced to all the villages surrounding Phou Phanang including Ang Nhאי.

It was not until 2000, when the village formalized its official village boundary through the Land and Forest Allocation process, that the official village area was reduced from 2690 ha to 729 ha, a strip of land stretching along the Mekong River (Figure 1). Phou Phanang was no longer part of the village's customary territory, and villagers no longer possessed rights to access the area for resource extraction or to reclaim forests for agricultural use.

The management of Phou Phanang was formally transferred from the Centre for Protected Areas and Watershed Management under the Department of Forestry to provincial and municipal forestry and agricultural offices in 1997. To date, however, no discussions have taken place among local authorities and villagers to develop a management strategy to conserve the national reserve forest. Lack of trained staff and limited budgets for provincial and district governments have further precluded an assessment of local resource-use practices, and inhibited the development of an active management scheme.

Customary Resource Use and Changes

Prior to the delineation of Phou Phanang as a national reserve forest in 1993, villagers in Ang Nhאי accessed forest in Phou Phanang freely to collect both timber and nontimber forest products. Families that required supplementary rice for household consumption also pioneered the forest for agricultural use. Resources were not exclusive to Ang Nhאי villagers but were also accessed and used by neighboring villages. Households customarily occupied lowland paddy fields (*nā*), forests (*pā* or *pā khok*), swidden fields (*hai*), and fallow swidden areas (*pā lao*) in addition to their residential land (*bān*) and home garden (*suan khua*). Ang

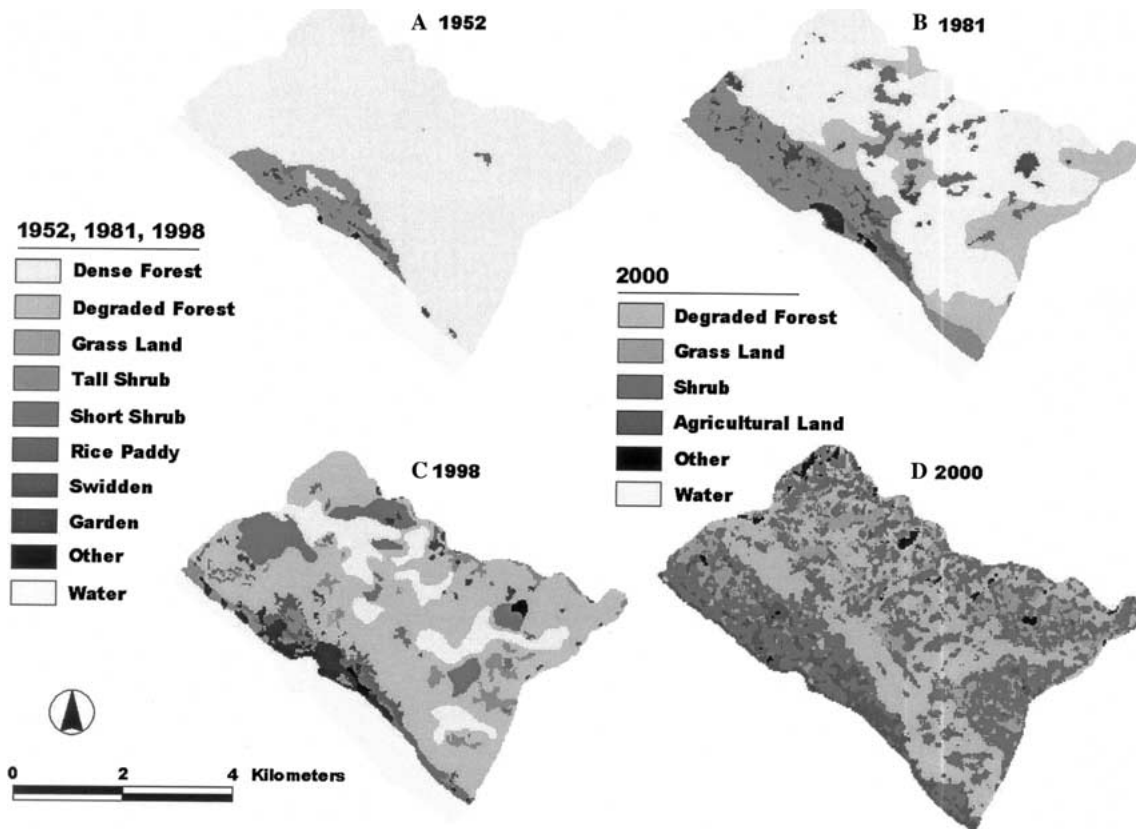


Figure 4. Land cover in Ang Nhai in 1952, 1981, 1998, and 2000.

Nhai households often acquired paddy and residential lands by inheritance or by purchasing the land. Property rights for productive agricultural land and residential land plots were defined customarily prior to the implementation of the Land and Forest Allocation Act in 1996, and these private lands were customarily traded without legal land certificates.

Households gained temporary access to forest, swidden, and fallow areas through occupation or *chap chong*. Villagers acknowledged someone's access to these lands through consensus and mutual respect. On these lands, households possessed exclusive rights to reap the benefits of their own labor, but access to other food and firewood resources was open to members of the village and neighboring villages. Once these lands were abandoned or remained unused for a long period of time, new users could re-occupy the land with the consent of its former occupant(s). The boundaries of these lands were indefinite, loosely defined by natural landmarks, and flexible, based on family needs for land and the availability of household labor. When conflicts over land use occurred, the parties affected generally resolved them through discussion and mutual agree-

ment. In some instances, mediation by a village authority was sought.

Since the 1980s, agricultural land use in the lowland areas has become increasingly intensive. Paddy fields were expanded, and unused lowland areas were converted into permanent agricultural land in response to increased interests in cash cropping. This facilitated privatization of land in lowland areas as households concentrated their labor on surplus agricultural production. The recognition of private property gained importance as an increasing number of families began to purchase and rent land for cash cropping. Implementation of the Land and Forest Allocation Act in 1996 further formalized private ownership of land, as households were required to register land plots and pay land taxes accordingly. At the same time, the traditional practice of *chap chong* declined as the Land and Forest Allocation Act prohibited the practice and as forest areas in lowland areas decreased due to their conversion to permanent agricultural land.

Meanwhile, household access to swidden plots and fallow lands, particularly in the uplands, was restricted following the designation of Phou Phanang as a na-

tional reserve forest. Although Prime Minister Decree No. 164 and the Forest Law officially restricted access to Phou Phanang Decree, these rules were not enforced, so villagers as well as outsiders continued to access Phou Phanang on a de facto basis. The delinication of Phou Phanang created what Sato (2000) calls “ambiguous land,” where customary resource access and use persists within state property. Sato (2000) contends that ambiguous property status often attracts other resource users and promotes further competition over limited resources, thereby aggravating the livelihood basis of marginalized rural populations. In Ang Nhai, the creation of “ambiguous land” invalidated customary resource management practices. During a group interview, Ang Nhai villagers noted that neighboring villages continued to encroach into Phou Phanang; however, because of Decree No. 164, Ang Nhai villagers no longer held any formal or informal authority to manage this territory.

Creation of “ambiguous land” also allowed logging activities to continue, for it created a management vacuum in which no party was able to effectively regulate the access and use of resources. Similar to the problems of logging pointed out in a report by the Tropical Rain Forest Programme (2000), logging in Phou Phanang represented a complex web of local resource users as well as outsiders. In the case of Ang Nhai, not only were local villagers involved in logging, but also others including neighboring villagers, timber merchants, as well as local government officials were involved. These parties were involved in combinations of ways that allowed continued timber extraction from Phou Phanang. Thapa (1998), who conducted a study in Sangthong District, which lies to the west of Phou Phanang, also noted the difficulty of controlling illicit logging practices, which involve economically and politically influential individuals as well as government offices.

In order to halt the persisting degradation of Phou Phanang, management of the preserve was transferred in 2001 to the Ministry of Defense. The Ministry of Defense was chosen because of Phou Phanang’s strategic location near the Thai–Lao border and because of the ministry’s perceived ability to patrol the forest regularly. Today, Ang Nhai villagers recognize that forest patrolling has begun, and “ambiguous zones” are beginning to disappear as forest boundaries become clearer.

Forest and Land-Cover Change in Ang Nhai

Analyses of the remotely sensed images of Ang Nhai’s customary territory support the stories told through the oral histories and household interviews. The remotely sensed data show significant reduction in

dense forest with notable increases of both degraded forest and shrubland over the 48-year period (Figure 4). In 2000, patches of dense forest were no longer discernible from the satellite imager (Figure 4D and Table 1). Forest changes can be categorized into three general trends—forest degradation, deforestation, and forest regeneration.

The Food and Agriculture Organization defines deforestation as “the transfer of forestland to non-forest uses” including the conversion of forestland to shifting cultivation land, permanent agricultural land, mining land, human settlements, and other infrastructure developments (Rao 1989). By distinguishing between forest degradation, which is defined as a reduction in forest quality, and deforestation, which is a loss of forest area, we sought to identify the chief causes of forest deterioration. Furthermore, by distinguishing a trend of forest regeneration, we sought to uncover the factors causing some forest areas to regenerate despite years of widespread forest resource exploitation.

Forest degradation. Dense forest decreased from approximately 2450 ha in 1952 to 1470 ha in 1981, a loss of 36% (Table 1). During the same period, the area in degraded forest increased from 0 to 18% and shrubland increased by 15%. Table 2 indicates that approximately 35% of the study area was converted to shrubs and degraded forest from 1952 to 1981. Between 1981 and 1998 the village lost 1083 ha of dense forest, which shrank from 55% to 14% of land cover (Table 1; Figure 4B and C). During the same time, 46% of the study area, or 1245 ha, was converted to shrub and degraded forest and a similar amount of land (44%) was converted between 1998 and 2000 (Table 2). These observations coincide with villagers’ historical accounts of widespread commercial logging in Phou Phanang, particularly between the late 1980s and the early 1990s, which was conducted by SFE No. 9 in conjunction with the Japanese furniture company Otuska Kagu. Interpretation of the aerial photographs indicates that forest areas became increasingly fragmented into smaller forest patches over the last two decades in the forests of Ang Nhai.

The forest degradation and fragmentation trend continued between 1998 and 2000 (Figure 4C and D; Table 2) despite the site’s designation as Phou Phanang National Reserve Forest in 1993. These findings are supported by the villagers’ accounts of persistent logging in Phou Phanang conducted by both villagers and outsiders. It also became clear during field interviews that while few households actually considered logging to be their main occupation, logging was always a source of quick cash income. For example, male

household members will engage in logging when their households run out of rice during the rainy season and they have no other source of cash with which to buy rice.

Deforestation. In comparison to forest degradation, the area experiencing deforestation over the last five decades is small, with 4%, 6%, and 12% of the study area being deforested during the three time periods. Table 2 indicates that most deforestation occurred between 1952 and 1981, most likely as a result of swidden cultivation (*hai*), which expanded during this period due to arrival of wartime migrants from north-eastern Laos. When the new socialist government was established in 1975, shifting cultivation in the upland areas was restricted. Villagers in Ang Nhai and the migrant families, however, continued to practice swidden cultivation in Phou Phanang to supplement insufficient and unstable rice production elsewhere.

The situation changed significantly between 1981 and 1998, during the period of economic transition, because around 70% of deforestation during this period represented conversion of forest into permanent agricultural land, including paddy fields (*na*) and cash crop land (Table 2). This coincides with villagers' accounts of increased agricultural land use in the lowlands. Land-use intensification began in the 1980s as the government supported development of two irrigation canals that allowed households to engage in dry season paddy rice cultivation. In addition, political stabilization and liberalization of agricultural markets in the mid-1980s encouraged villagers to produce cash crops such as tobacco, eggplants, tomatoes, and long-beans for export to Thai markets as well as for the domestic market.

Forest regeneration. We also observed a trend of forest regeneration in Ang Nhai. Table 2 indicates that the amount of agricultural and shrublands converted to degraded forest increased between 1981 and 1998. In particular, 354 ha of shrubland were converted to forest, which is greater than the total area experiencing deforestation during the same time period. As many migrants fled to Thailand during the late 1970s, their makeshift settlements and swidden fields in Phou Phanang were abandoned. While Ang Nhai villagers continued to practice shifting cultivation during the period immediately following the political transition, land-use intensification in lowland areas gradually removed land-use pressures in Phou Phanang.

Commercialization of Agriculture and Land Use

Both the spatial analyses and the oral histories indicate that agricultural intensification in Ang Nhai

began in the mid-1980s. This occurred as a result of both market integration and the development of irrigation. Contract farming of tomatoes was first arranged via a connection of old relatives across the Mekong, as the domestic market in Laos was centrally controlled during the early 1980s. With improved logging roads connecting the village to Vientiane, and the liberalization of domestic agricultural markets in the mid-1980s, Ang Nhai villagers began to increase cash crop production. As a result, villagers who conducted shifting cultivation in the uplands to supplement lowland rice production also began to engage in cash crop production and to purchase rice from the markets. This resulted in the intensification of lowlands in Ang Nhai, which removed pressure to expand agricultural land in Phou Phanang. Studies conducted by Kono and others (1994) in Thailand and Takasaki and others (2001) in the Amazon also indicate similar effects of market integration on local peoples' land-use practices that reduce pressure on forestlands.

Out of 59 households interviewed, 46 households (78%) were engaged in tobacco production, which is produced mainly on a contract basis (Table 3). For households in all income levels, revenue earned from eggplant production is an important source of household income. Table 3 indicates that households with an annual income above 20 million kip (approximately 2105 USD; based on 2001 rate of 1 USD = 9500 kip) produced sufficient rice (from swidden, wet- and dry-fields) for household consumption. These households earned a significant percentage of their income from raising large livestock (pigs, cattle) and petty trade within the village. We observed generally diversified sources of income for households with incomes between 5 and 20 million kip (approximately 526–2105 USD) per year (Table 3). Households in this income class engaged in both agricultural (e.g., working on other people's cash crop fields) and nonagricultural labor (e.g., logging, driving trucks) within the village. Contract tobacco production was most popular among households earning 10 to 20 million kip per year (1050–2105 USD). Households with incomes below 5 million kip per year were mostly dependent on eggplant production.

The results of household economic surveys indicate that unlike in the past, villagers in Ang Nhai today have little dependence on shifting cultivation. Instead, most households in Ang Nhai have become commercial farmers. While wealthier households have been able to diversify their means of household production, cash crop production has also become an important part of household economy for poorer households. As a result, the demands placed on lowland agricultural land in-

Table 3. Source of income by annual household (HH) income (in 1000 kip) and percent of households growing different crops

| Annual HH income | <5000 | 5000–10,000 | 20,000–10,000 | >20,000 | % of HH |
|------------------|-------|-------------|---------------|---------|---------|
| No. of HHs | 23 | 19 | 8 | 5 | |
| Swidden | 57 | 136 | 613 | 658 | 100 |
| Wet | 479 | 1240 | 1453 | 1220 | 100 |
| Dry | 277 | 759 | 394 | 1332 | 100 |
| Eggplant | 1211 | 1829 | 2475 | 1935 | 42 |
| Tobacco | 232 | 532 | 1713 | 400 | 78 |
| Vegetable | 30 | 105 | 125 | 200 | 24 |
| NTPP | 113 | 279 | 50 | 320 | 8 |
| Trade | — | 507 | 1664 | 3660 | 32 |
| Livestock | 72 | 119 | 1581 | 11,530 | 15 |
| Labor | 130 | 674 | 675 | 100 | 31 |
| Others | 207 | 572 | 2,663 | 4,300 | 36 |
| Total | 2809 | 6752 | 13,384 | 25,655 | |

Source: Fieldwork (2001, 2002).

creased dramatically during the 1990s, while need for upland swidden decreased.

In addition, we observed that households with access to unused agricultural land in the lowlands are beginning to lease out these lands to different members of the village. This, in conjunction with the increased integration of the village economy with the local market, has caused less wealthy households whose livelihood previously depended on swidden to abandon their upland fields and to spend more time growing cash crops in rented lowland fields. The need for cash income played a significant role in motivating all classes of households in Ang Nhאי to transform their agricultural practices from subsistence to commercial production in the last decade.

Discussion and Conclusions

Forests in Ang Nhאי today appear more heterogeneous and fragmented compared to the relatively homogeneous forest cover present only five decades ago. Spatial analysis of aerial imagery indicates widespread forest degradation as well as fragmentation of degraded forests into smaller patches between 1952 and 2000. Incidences of increased forest fragmentation are also consistent with findings from studies conducted in other parts of montane mainland Southeast Asia (Fox and others 1995, Long and others 1999, Xu and others 1999, Fox and others 2000, Fox and others 2003, Sikor and Dao 2002).

The village's oral history suggests that forest and land-cover changes were induced by a combination of factors including war, population movement, commercial logging, government policies, and market

change. Incorporation of oral history in our research was invaluable for understanding the complex and dynamic human factors that affected the local landscape and determining how resources were used. Study results suggest that forest degradation was due not only to population increase, but also to complex factors that involve social history, economic changes, and government policies. For instance, war and government resettlement policies significantly affected the demography of the research area. Furthermore, changes in economic policies and increased integration into regional markets induced intensification of lowland use, which gradually removed pressures off upland areas.

By looking closely at the local history of resource use, the current study also offers a different view on the cause of degradation from the official view that places blame on shifting cultivation (Domoto 1997, Rasul and Thapa 2003). While shifting cultivation had been one cause of forest degradation during the 1960s and 1970s, government policies on commercial logging during the 1980s had a far more extensive effect on degradation in Ang Nhאי.

We observed that shifting cultivation in Ang Nhאי declined in the last decade. However, this was due to a combination of factors. One was the government policy that banned shifting cultivation in the upland. Second was the government support of irrigation and intensification of lowland use. Third, the factor with the most significant impact was the development of regional markets that encouraged cash cropping. All classes of households were motivated to engage in cash cropping in lowland areas. Without market integration and access to arable lowlands, declines in shifting cultivation would have been difficult to achieve in Ang Nhאי.

Finally, our study elucidated that delineation of official forest boundaries was insufficient for the protection of forests. While state definition of national reserve forests imposes a definitive boundary, local communities have a different sense of boundary, which is often nonlinear and dynamic (Fujita 2000). It is also an inclusive territory in which neighboring villages share resource use based on mutual consent. The study in Ang Nhai clearly illustrates that the new state-imposed boundaries and the communities' perception of boundaries overlap and as a result create "ambiguous lands" where neither formal nor informal institutions function to regulate resource-use practices. It is thus recommended that instead of applying a "fence and fine" approach to managing national reserve forests, it would make more sense to recognize customary resource management practices in areas beyond current village boundaries. This means allowing local village authorities to manage their former village territories, which are now defined as national reserve forests, as common property. While logging and encroachment in ecologically sensitive areas of the national reserve forest should be regulated, access to and use of resources in the national reserve forests should be decided on the basis of consensus among the villages that share the resources. Because the current forest conservation policy and village boundary demarcation process isolates villages such as Ang Nhai that overlap with state property from neighboring villages with which they shared resources in the past, it is essential to strengthen existing local institutions so that collective efforts to commonly manage resources are facilitated.

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