Southeast Asian Studies, Vol. 47, No. 3, December 2009

Dynamics of Land Cover and Land Use Changes in the Upper Ca River Basin of Nghe An, Vietnam

Stephen J. Leisz*

Abstract

This paper draws on four hamlet case studies and a broader three district study to identify land cover and land use changes in the upper Ca River Basin of Nghe An Province and the possible trigger events that are influencing land cover and land use changes. The study uses two chronosequences of Landsat TM and ETM+ imagery, from 1989 to 1993 and from 2000 to 2003, to classify the land cover and land use for the larger study area and for the hamlet study areas. This information is combined with socio-economic data that was collected at the district and hamlet level in a series of field studies carried out from 1997 to 2003. Results show that areas of mature tree cover have expanded, the area devoted to long-term swidden/fallow land use has decreased and the area under permanent agriculture and short fallow swidden systems have increased, across both of the scales studied. The analysis indicates that a forest transition is taking place at the broader three district level and also within the four hamlet case study areas. Two trigger events are identified that may have helped initiate the forest transition. One is the agriculture and forest land allocation programs that were initiated in the districts and in three of the four hamlets during the 1990s and early 2000s and the second is market influences that appear to be linked to the increase in cattle and pig raising in the case study hamlets.

Keywords: land cover, land use, forest transition, deforestation, swidden/fallow, Vietnam, land allocation

Introduction

Deforestation in Vietnam

Official statistics and maps of Vietnam suggest that from 1943 to the mid-1990s Vietnam had some of the highest deforestation rates in the world and lost much of its forest cover. Officially, in 1943 43.2% of Vietnam was covered by forest [Nguyen 1999; Vo and Le Thac 1994]. By 1990 government statistics show that forest cover in the country had shrunk to 28.8%. Statistics show that deforestation continued into the mid- and even late 1990s [De Koninck 1999], but by the late 1990s and early 2000s forest

* Department of Anthropology, Colorado State University, Fort Collins, Colorado, U.S.A.
e-mail: steve_leisz@yahoo.com

cover started to recover. During this time statistics show forest cover expanding at annual rates of up to 2% [De Jong *et al.* 2006]. However, while statistics show forest cover recovering overall, not all forest cover types are recovering to the same extent or even expanding. The Global Forest Resources Assessment 2005 [FAO 2005] shows that overall, Vietnam's forests have increased in size from 9,363,000 ha in 1990, to 11,725,000 ha in 2000 and 12,931,000 ha in 2005. In contrast, the area under primary or natural untouched forest has continued its decrease from 384,000 ha in 1990 to 187,000 ha in 2000, to 85,000 ha in 2005. This suggests that all of the forest transition taking place in Vietnam is in the form of planted forest, or human managed forest, and that primary or natural forest is under increased pressure.

The government places almost all of the blame for deforestation in the mountains, where most of the remaining primary forest is, on the swidden/fallow farming system that is found there [Dang 1991; Do 1994; Morrison and Dubois 1998; Tachibana *et al.* 2001; Castella *et al.* 2006]. Others question this and suggest that the blame for deforestation rests with certain state policies that have encouraged the migration of lowland people to the uplands and with other state supported practices in the past, such as logging, and in the present, such as the promotion of tree plantations for pulp, and promoting plantation tree crops such as coffee, tea, pepper plantations, and other fruit trees [Poffenberger *et al.* 1997; De Koninck 1999; Lang 2001; 2002; D'haeze *et al.* 2005]. In contrast, the forest transition that is observed to be taking place is believed to have been triggered by government policies, most notably the agriculture and forest land allocation policies that were promulgated in the uplands during the 1990s and early 2000s [Sikor 2001; Tachibana *et al.* 2001; Castella and Quang 2002; Meyfroidt and Lambin 2008]. This paper investigates land cover and land use changes in three mountainous districts of Nghe An Province during the reported forest transition period (from 1989 to 2003). It investigates patterns of both land cover and land use change at two scales: at the broad district level scale in three districts, and at a fine, hamlet level scale, in four hamlet case studies. The paper also attempts to identify the trigger events that have led to the changes in land cover and land use that are identified.

The mountains in the upper Ca River Basin offer a good proxy for the overall situation found in Vietnam's uplands during the late 1980s through the early 2000s. The dominant land use system in the uplands, including Nghe An's uplands, has historically been based on medium to long rotation swidden/fallow systems. The study area has been the home to a number of state forest enterprises since the 1960s. The area has also been the focus of recent land allocation and reforestation programs. Finally, the area is the home to one of the largest remaining areas of primary forest in Vietnam. Focusing on the upper Ca River Basin, this paper overviews the land cover and land use situation in the three districts, and then focuses on four specific case studies. The changing socio-economic and legal situation

vis-à-vis the dominant farming systems and land use management systems is reviewed. Land use/cover changes are documented through interviews with key district level and hamlet level informants and through the analysis of satellite imagery for eight of the fifteen years studied. Finally, the trends in driving forces behind, and trigger events of land use changes for each case study, are identified as well as for the larger three district area.

Study Area and Case Study Sites

Study Area: Con Cuong, Tuong Duong, Ky Son Districts

The upper Ca River Basin runs through Nghe An Province in north central Vietnam. Nghe An is one of the poorest provinces in the country and the three districts of Con Cuong, Tuong Duong, and Ky Son in the upper reaches of the Ca River, in western Nghe An along the border with Laos, are the poorest districts within the province. These districts also encompass some of the best remaining forest area in northern Vietnam and are home to a variety of ethnic minorities including H'mong, Thai, and Kho Mu. Fig. 1 shows the location of the province, the three districts focused on in this article, and the four case study site locations.

The topography of the districts varies from flat valley plains to steep mountains. In Con Cuong and Tuong Duong the valley plains change progressively to rolling hills and steeper mountains as one travels south and north of the river. The annual mean temperature is between 22 and 24 degrees Celsius with highs of 40 degrees during the months of June, July and August and lows of 5 degrees during the months of December, January, and February. These temperatures vary significantly as one travels away from the river and climbs into the mountains. Average yearly rainfall is 1,500 mm, and average humidity is between 80% and 85%.

The transportation network in the study area is dominated by one all-season, paved, road, National Highway 7, which runs parallel to the Ca River, and by the river and stream system. Besides the national highway there are many all season, paved and gravel covered roads that run north and south away from the river. Many of these have been either upgraded from seasonal roads, or newly built from the mid-1990s to present. The river and stream system is also used extensively for transportation. Some of the hamlets north of the river are only accessible by walking paths or by river travel. In these areas river travel via motorized boats has been increasingly popular since the mid-1990s.

The livelihood systems found in the study area are dominated by agriculture. Farming systems vary in the province from subsistence long rotation swidden/fallow systems (fallow periods greater than 10 years) in the uplands near the Laos border, to medium rotation swidden/fallow systems (fallow periods

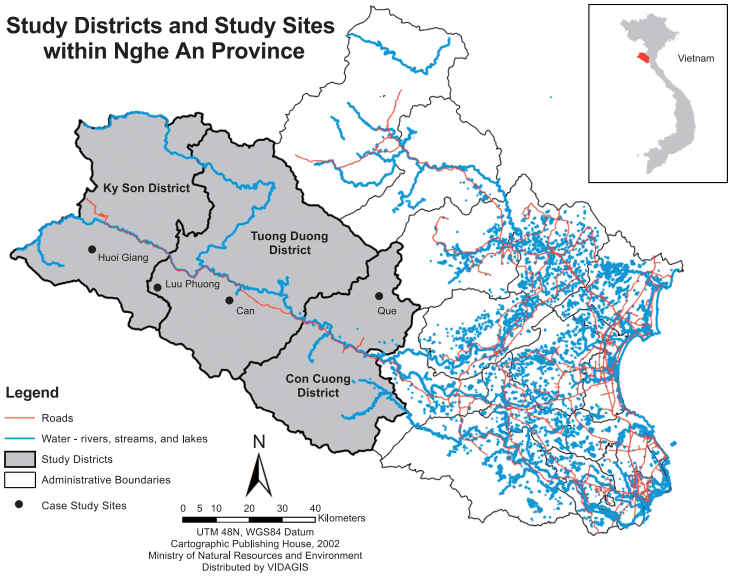

Fig. 1　Case Study Districts and Locations within Nghe An Province

between 5 and 10 years) further east in the study area. Intensive irrigated paddy and agriculture and plantation forestry is also found in the lowland parts of the river basin in the study area, mainly in Con Coung District.

During the late 1980s and early 1990s forestlands and upland management were reformed across the nation and upland/forestland allocation was carried out. In 1993 the government extended the 1988 land law into the uplands [Ahlback 1995; MAFI 1993; Sikor 1995; De Koninck 1999] allocating forestland in the same manner as agricultural land was allocated both in the lowlands and in the uplands. In 1993 the government implemented the Law for the Protection and Development of Forests, formalizing a new process for allocating rights to forestland based on the willingness of households to plant trees [Gomeiro *et al.* 2000]. The 1993 law was modified by Decree No 85/1999/ND-CP in 1999 [Socialist Republic of Vietnam 1999], allowing, according to some interpretations, for the allocation of sloping land for agricultural purposes if the land had been used for agriculture in the past. In the three district study areas and in each of the case study sites, however, similar to other reports [Sikor 1995; 2004; Sowerine 2004; Vien *et al.* 2005], local variability in the application of forestland and upland allocation at the district, commune, and hamlet levels were analyzed and one is thus not able to generalize regarding the amount of land that was allocated for use per household.

Case Study Sites: Que, Can, Luu Phuong, and Huoi Giang Hamlets

Que hamlet is located within the buffer zone of Pu Huong Nature Reserve and is accessible year-round by motorcycle and four-wheel drive vehicles via hard-pack dirt road. There is little flat land in the hamlet and traditionally a rotational swidden system was practiced. In 1998 4 ha of flatland were converted to paddy area with support from district officials. Allocation of both paddy and upland areas was done in 1998. Rather than allocate upland areas to individual households the upland area was allocated to the hamlet and the hamlet authorities then re-allocated it to households based on calculated household cultivation needs. Upland agricultural fields are officially limited to the southeast section of the hamlet's territory where the commune authorities stipulated 16 ha should be cultivated yearly with a rotation cycle of five years. However, the hamlet leader stated that the area cultivated each year is closer to 60 ha, since most households need to plant approximately 1.5 ha of land in order to produce enough rice for consumption [Jakobsen *et al.* 2007]. Today, with the development of paddy fields and the limitation on upland agriculture the farming system has started to move towards a composite swidden system [Rambo 1998]. Animal husbandry is practiced, but is limited in the hamlet.

Can hamlet is located within the Pu Mat National Park buffer zone and accessible from the main road via a 2 km all-season hard-pack dirt road. It is located in an open valley surrounded by hills that turn to mountains as one moves south towards the National Park. The farming system is a composite swidden system that has both irrigated paddy and upland rotational swidden fields. Land allocation of paddy fields was first done in 1987/88. Upland forest and field areas were allocated in 1996/97. Paddy and upland fields were reallocated in 1999 and 2002/03 respectively. Each land allocation exercise has been externally funded by the European Union's "Pu Mat National Park Social Forestry and Nature Conservation Project." The allocation of upland forest and field areas included the delineation of areas in the uplands that can officially be used for upland cultivation purposes. Animal husbandry is practiced and district extension officers support the hamlet's pig raising efforts. Following land allocation, the raising of cattle is limited due to conflicts over cattle damage to crops, a situation that led to a hamlet regulation limiting cattle raising. Buffalo are mainly raised as draft animals although some are raised for the market. Due to proximity to Pu Mat National Park, and inclusion in an European Union funded project, the hamlet has drawn attention from both national and local officials resulting in environmental and land allocation/tenure regulations being implemented at an earlier date than has been the case in surrounding hamlets. The regulations have also been strictly enforced.

Luu Phuong hamlet is located on an all season hard-pack dirt road. The hamlet's center is in a wide valley surrounded by rolling hills. The valley has been transformed into bunded rice paddies. For as

Table 1 Basic Information for Each Hamlet Studied for 2003/04

Hamlet Name	Que	Can	Luu Phuong	Huoi Giang
Commune/District	Binh Chuan, Con Cuong	Tam Thai, Tuong Duong	Luu Kien, Tuong Duong	Tay Son, Ky Son
Population	409 (69 households)	835 (183 households)	751 (147 households)	891 (103 households)
Ethnicity	Thai	Thai	Thai	H'Mong
Year of land allocation	1998	1987–88 (rice paddy, periodically re-allocated by family need); 1996/97 Pu Mat buffer zone established —— limitations on upland fields near core area. 1999 green book for forest land; 2002/03 upland areas (agriculture and forest land) reallocated	2001/02 (upland agriculture land); 1996 (rice paddy area to 110 households)	No land allocation
Area allocated	80 ha uplands; 4 ha rice paddy	80 ha uplands; 27.5 ha rice paddy	50 ha uplands; 47 ha rice paddy	N/A
Distance from district town/main market*	35 km	10 km	15 km	12 km
Transportation route	Improved-unpaved hard-pack road	Improved-unpaved hard-pack road (2 km); asphalt road (8 km)	Improved-unpaved hard-pack road (8 km); asphalt road (7 km)	Improved-unpaved hard-pack road
Type of transportation between hamlet and district town	Motorcycle	Motorcycle; bicycle; walking	Motorcycle; small truck; walking	Motorcycle; walking
Travel time to district town (minutes)	60–120	20–60	30–120	45 minutes (motorcycle); 2 to 3 hours (walking)

Source: fieldnotes

Note: * The main market is in the district town.

long as anyone can remember a composite swidden farming system has been practiced. In 1996 land allocation of the paddy area took place. Reallocation of paddy fields was redone in 2000/01, when upland field areas were also allocated. The upland area that can officially be used for swidden farming is restricted to two small valleys that enter the main valley from the north. It is reported that fallow periods have decreased. In 2000/01 the road was improved and connection to the market improved. Families with paddy land raise two rice crops when water is available. Both pig raising and cattle raising are popular in the hamlet. Pigs are generally raised in pig sties, while cattle are left to wander in the forests. Cattle owners leave salt out at their houses to encourage their cattle to return every few days to their house to lick the salt. In recent years cattle raising for the market has increased.[1)]

Huoi Giang hamlet is divided into upper, middle, and lower hamlet sectors based on their distribution along the road. The district recognizes these as three separate administrative hamlets with separate administrative officials, but locally there are no recognized borders between the hamlets, agriculture land is intermixed, and the three share customary hamlet leaders. The hamlet is located on a hard-pack dirt road in the mountains about 12 km south of, and 1,000 m higher than, Muong Sen, Ky Son's district town. The livelihood system of the hamlet is based on a long-fallow rotational swidden system. Corn and rice are the main crops. Fields are cultivated for three years, the first in rice, the second with rice or corn, and the third with cassava. Fields are fallowed for up to 20 years, but often for only 10 years. The hamlet was a nomadic hamlet until approximately 55 years ago when the French administrators built the road and the households started to move to roadside locations. Livestock raising is popular. Some pigs are raised, but the main livestock activity is cattle rearing for market. Cattle are left to wander in the forests until three to six months before they are to be sold, and then they are penned and fed forage that is especially raised in fields. Some households have taken advantage of the availability of district funds to hire lowland *Kinh* laborers, who are familiar with wet paddy cultivation and terrace construction, to build terraces for them. However, the terraces are not cultivated as water resources are not sufficient for wet paddy cultivation.

Methods

A variety of methods were used in this research to collect socio-economic data. Semi-structured and

1) Informants report that lowland cattle buyers from Vinh City, Hanoi, and Ho Chi Minh City started visiting hamlets in the late 1990s. They contract with farmers to bring cattle to the district capital on a fixed date and give the farmer a down payment for the cattle. The farmers drive the cattle to district capital on the agreed date and the buyer pays the remainder for the cattle.

structured interviews at district, commune and hamlet level with a focus on hamlet-level livelihoods, farming systems, land tenure rules and forest tenure rules were carried out. Land administration and forest protection personnel were interviewed at the district level; commune chairmen, vice chairmen, and land administration personnel were interviewed; and hamlet leaders and farmers were interviewed regarding land allocation procedures, reliance on customary tenure systems, hamlet and household livelihood systems, and farming systems. A structured questionnaire covering these topics was administered to 30 randomly chosen households in each hamlet. Historical socio-economic and demographic data were collected from records kept at the district and commune headquarters and from focused interviews with hamlet informants who were chosen for their knowledge of specific subjects (e.g. hamlet headmen and party leaders regarding hamlet history, boundaries, demography, administration, tenure systems, conflict resolution, farming systems, land cover and land use; agriculture officers regarding farming systems, agricultural crops, soil conditions, land cover and land use; older residents for their knowledge of hamlet histories; traditional healers for their knowledge of forest products and changes in plant communities over time, etc.).

Land cover and land use information, as well as information for ground truthing the satellite image interpretations, was collected in the following ways. Transects were walked to better understand the types and distribution of land cover and the land use in each hamlet. Field and hamlet boundaries were measured using GPS receivers, tape measures, and compasses. Detailed information on agriculture field productivity was gathered through interviews and measurements in the field. Post-fieldwork Landsat TM and ETM+ images were classified into upland agriculture fields, paddy, and fallow regrowth land cover types for the years 1989, 1991, 1992, 1993, 1998, 2000, 2001, 2002, and 2003. This was done by first level slicing normalized differential vegetation indexes and infra-red indexes for each year and then setting thresholds that most accurately delineated the upland fields and wet paddy areas from areas that were covered with other types of vegetation. Fallow and forest land cover types were derived from year-on-year chronosequence analysis of images combined with a supervised classification of the images. All results were checked against a total of over 400 ground truth points collected in 1998, 1999, 2000, 2001, 2003, and 2004. Classification accuracy for the upland fields and paddy areas are greater than 90% for each year. Fallow areas were mapped at greater than 80% accuracy. A full discussion of the methods used is found in Leisz [2007].

Results

Study Area Socio-economic Changes

From the early 1990s to the early 2000s the socio-economic situation in the three district study area changed in many ways. According to the national census records available population grew overall in the study area from the 1989 to the 1999 census by 5.27% (Table 2). This rate of population increase is lower than for the province of Nghe An and for the nation as a whole, which for the same period were 18.62% and 17.60% respectively [Socialist Republic of Vietnam 2001]. However, when the increase is looked at by district, it is clear that the two districts with the best road access, Con Cuong and Tuong Duong, are also those districts that appear to have had the lowest population increase over this time period, 1.53% and 0.42%, while the most remote district, Ky Son, has the highest population increase, 17.04%, and is roughly at the national average for this time period.

There are several possible reasons for the low population growth rate in Con Cuong and Tuong Duong. One may be that during this time there were some dramatic changes in these two districts that influenced people to move away from the districts or that allowed them to more freely leave the districts. One of these was that the forest enterprises closed down, and many of the workers associated with those industries, who were of Kinh ethnicity, appear to have left. Second, the government stopped its policy of sponsoring the resettlement of Kinh lowlanders to the uplands, and indeed there is anecdotal evidence that some of those who had been resettled in Con Cuong and Tuong Duong in the 1970s and 1980s left the uplands and returned to the lowlands, or even migrated to the central highlands. Finally, there is the possibility that the 1989 census numbers are just wrong. During the 1989 census there were not many resources available for carrying out the census and it is plausible that some remote areas where not actually counted in the estimate, but rather were estimated.

An examination of the population data on a commune by commune basis shows that there are a number of communes in Con Cuong and Tuong Duong District that lost large amounts of population. Some of these are easily explainable. Examples are Kim Tien Commune in Tuong Duong, which is

Table 2 Population Change in the Study Area Districts

District	1989 Pop	1999 Pop	Pop Change	% Change
Con Cuong	61,747	62,691	944	1.53
Tuong Duong	68,769	69,061	292	0.42
Ky Son	47,881	56,042	8,161	17.04
Overall	178,397	187,794	9,397	5.27

Source: Socialist Republic of Vietnam, General Statistics Office, 2001

going to be flooded when a dam is constructed there and people were already being resettled from the commune as early as the late 1990s; and Tam Thai Commune, also in Tuong Duong, which is in the buffer zone of Pu Mat National Park and had hamlets resettled out of the buffer zone, and out of the commune. Others, such as Cam Lam Commune in Con Cuong, which is on a good road with a large amount of agriculture land, are not as easily explainable, but may have lost population due to rural to urban migration, which has been seen in other parts of Vietnam [Pham and Hill 2008].

Other changes which have taken place in the study area include changes in land tenure laws, which were described in the previous section describing the study area and case study sites. Land titling of lowland areas was undertaken during the period between 1993 and 2003 and forestland and agricultural allocation in the uplands was started, and in many cases completed, during this time. Transportation routes were improved and new roads were built: National Route 7 was repaved and widened, but only through Tuong Duong District, and small feeder roads north and south of the river were paved and turned into all season roads, again mostly in Con Cuong and Tuong Duong districts. Water transportation also became more reliable as motorized boats started to ply the river in greater numbers. Market forces for certain agricultural products were also felt in the districts as livestock traders from the lowlands started to come into the districts to source and buy cattle, and in some cases pigs, for the growing beef and pork market in the lowland. As a result livestock raising expanded in all of the districts studied.

Study Area Land Cover and Land Use Changes

Fig. 2 visually illustrates how land cover in the study area changed during the period from 1993 to 2003. The quality of the tree cover increased from 1993, when there were 107,488 ha of mature (near primary) trees, to 2003, when 267,531 ha of mature trees where identified, an increase of 160,043 ha. However, overall natural tree cover decreased from 493,544 ha to 450,162 ha (Table 3) between 1993 and 2003, a decrease of 43,382 ha. The reason for the overall decrease in natural tree cover area is that from 1993 to 2003 there was a decrease in transitional tree cover area, a land cover that is usually associated with fallow land use. While some of this area became mature tree cover, a large amount of the area that had been transitional tree cover became covered with bush, grass and small tree land cover in 2003 as this land cover category increased in size by 18,363 ha. Also a large area of the 1993 transitional tree cover was converted to new agriculture field area in 2003. The area covered by the cultivated crop land cover class increased by 24,239 ha between the 1993 and 2003 land cover maps. Residential and built up land cover areas increased in spatial extent by 780 ha between 1993 and 2003.

Change in land cover can also be displayed as a change in land use for the study area. This article

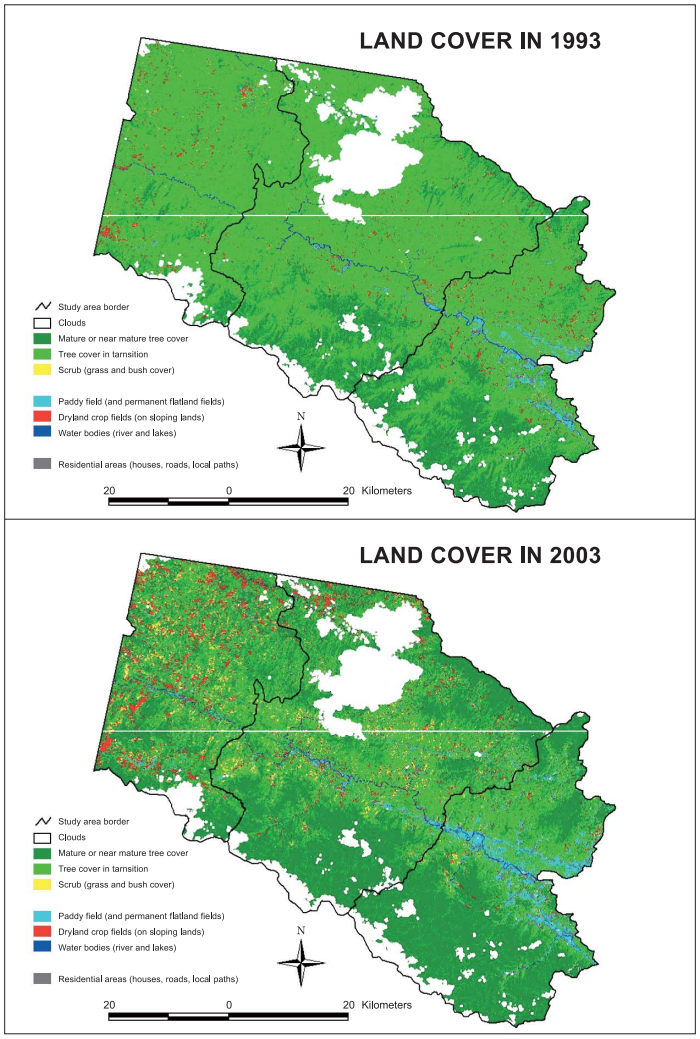

Fig. 2 Land Cover in the Study Area 1993 and 2003

Source of imagery [before analysis]: www.usgs.gov/pubprod/aerial.html

Note: The land cover analysis does not cover all of the three districts due to limitations of the Landsat Imagery that is available.

attempts to graphically differentiate between land use and land cover. Land cover as described in the previous section is the type of vegetation or other natural covering (e.g. water, rocks, bare dirt) or manmade cover (e.g. pavement, built structures) covering the surface of the study area. Land use considers if the land has been used by humans for agriculture regardless of whether agriculture is currently being practiced on it; if the land is not actively managed by humans, e.g. natural water areas or non-managed natural forest areas; or used as residential land by humans. Land use is mapped by

Table 3　Land Cover Changes in the Study area 1993 to 2003 Land Cover Maps

Land Cover Category	Land Cover in 1993 (ha)	Land Cover in 2003 (ha)	Change: 1993 to 2003 (ha/%)
Total Natural Tree Cover	493,544	450,162	–43,382/–9%
Tree cover: Natural, Mature (or near mature; possibly including trees regrowing in long-fallow areas)	107,488	267,531	160,043/149%
Tree cover: Natural, in transition from herbaceous to tree dominated	386,056	182,631	–203,425/–53%
Total Herbaceous Cover	4,143	22,506	18,363/443%
Herbaceous dominated: Scrub (grass, bush, few small trees)	4,143	22,506	18,363/443%
Total Agricultural Crop Cover	21,463	45,702	24,239/113%
Human planted: Paddy fields/cultivated flat land	7,580	20,445	12,865/170%
Human planted: Sloping cultivated fields	13,883	25,257	11,374/82%
Other Land Cover	10,379	11,159	780/7.5%
Water	2,057	2,057	0
Other —— human (residential/built land)	8,322	9,102	780/9%
Total area	529,529	529,529	0

considering the type of land cover and whether that land cover is associated with human activities or not, and if so, what type of activities it is associated with. For the purposes of this analysis the following land cover types indicate human land use: residential land cover indicates residential land use; land cover indicating that an area was cultivated during at least one of the years when the image classifications were done indicates either permanent cultivated agricultural land use (e.g. land is cultivated on a yearly basis) or intermittent cultivated agricultural land use (e.g. swidden/fallow land use); and land cover consisting of vegetation that is known to be associated with fallow land indicates swidden/fallow land use. Water and tree cover, which was not cleared during the respective five year image chronosequence classifications, are considered non-human land use areas (e.g. natural water areas and natural forest areas). Table 4 details the relationship between the land cover categories and the land use types and Fig. 3 illustrates the results of mapping the study area for land use.

As indicated in the previous section on land cover, mature natural forest areas increased in size, indicating that natural forest area land use increased in size (Table 5). From 1993 to 2003 natural forest area land use expanded into parts of the study area that had previously been used as fallow land in the rotational swidden/fallow agriculture system found in the study area. Area devoted to agriculture land use correspondingly decreased. However, indications are that shorter term swidden-fallow land use systems expanded, indicated by the increase in areas where there was at least one-year of an active field identified during the second five year image chronosequence. Also, areas of permanent cultivated

Table 4 Land Use Categories and the Associated Land Cover Types

Associated Land Use	Land Cover Type	Comment
Forest land use	Mature or near mature tree cover	This land cover type is only classified as forest land use if it is mature or near mature tree cover during the whole chronosequence of the satellite images.
Agricultural land use: swidden/fallow system land	Tree cover in transition Scrub Dryland crop fields (on sloping lands)	Tree cover in transition and scrub (grass and bush) are synonymous with vegetation growing back in areas that have been cleared for upland fields; dryland crop fields are indicative of swidden/fallow systems if they are not cleared in all of the chronosequence images for each time period.
Agricultural land use: permanent agriculture land	Dryland crop fields (on sloping lands) Paddy fields	Dryland crop fields are considered permanent if they are classified as cleared land in all of the chronosequence images for each time period; paddy is considered permanent agriculture land.
Other land use: residential land use	Residential areas	Areas with land cover associated with residential land use (buildings, roads, etc.)
Other land use: water	Water	Lake, river, and stream areas.

Table 5 Land Use Change in the Study Area during the Chronosequence Periods: 1989 to 1993 and 2000 to 20003

Land Use Type	Period: 1989 to 1993 (ha)	Period: 2000 to 2003 (ha)	Change (ha/%)
Forest land use: mature tree cover on the area for the chronosequence period*	224,419	266,740	42,175/19%
Agricultural land use	294,653	251,366	43,287/–15%
Swidden/Fallow System Land: fallow field during chronosequence period	261,296	160,508	–100,788/–39%
Swidden/Fallow System Land: active swidden field during at least 1 year of chronosequence period	25,855	70,486	44,631/173%
Permanent Agriculture Land (classified as paddy or other cultivated flat land for all years of chronosequence period)	7,502	20,372	13,202/174%
Other land use			
Residential Land	8,322	8,956	780/9%
Water	2,135	2,467	0
Total area	529,529	529,529	0

Note: * Does not include all areas of 'near mature' trees that are included in mature tree land cover.

fields (e.g. areas cultivated at least one time per year on a yearly basis), in other words, permanent agriculture land use, increased from the 1989–93 period to the 2000–03 period. Residential land use also increased between the two time periods.

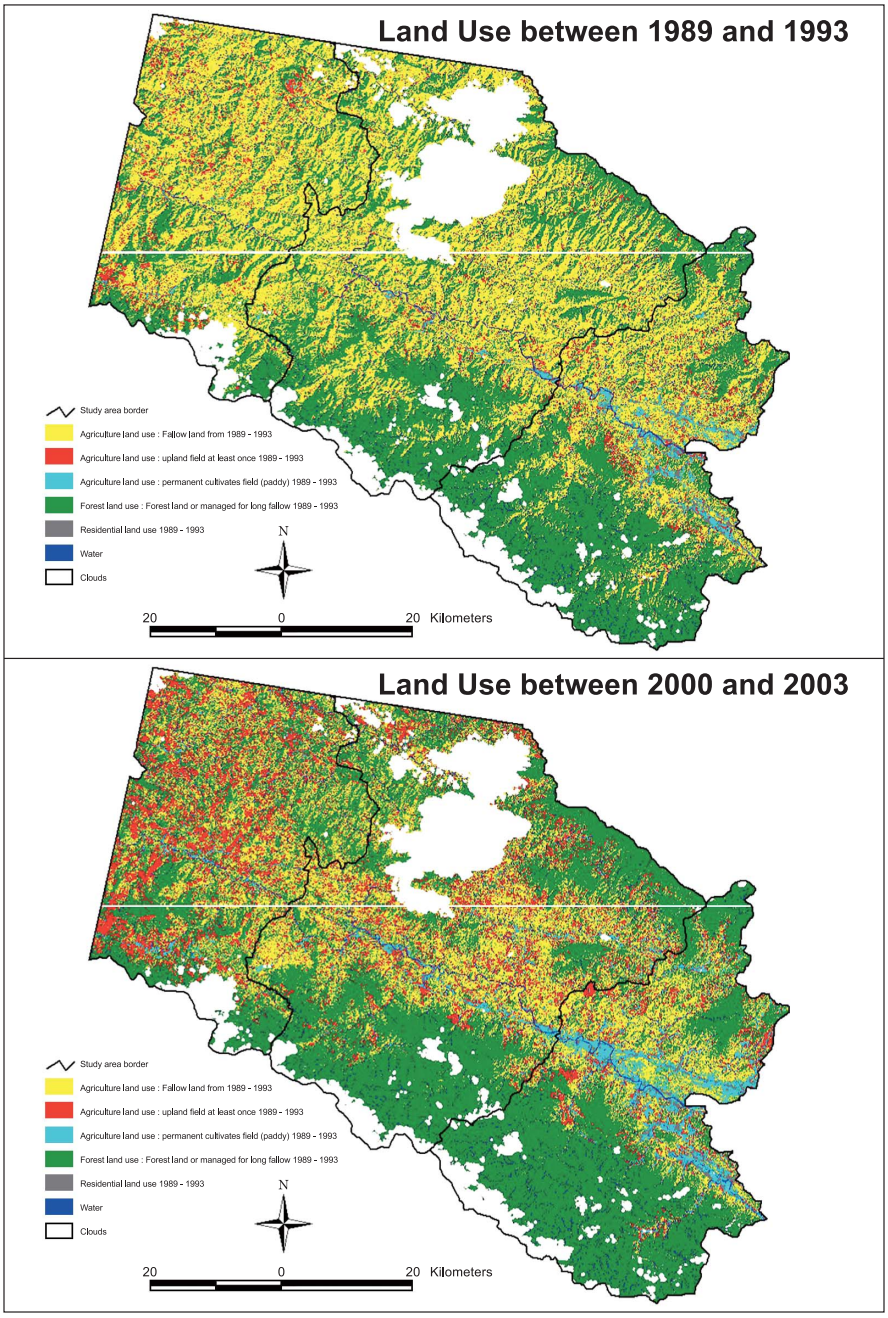

Fig. 3　Land Use in the Study Area 1989 to 1993 and 2000 to 2003

Source of imagery [before analysis]: www.usgs.gov/pubprod/aerial.html

Note: The land use analysis does not cover all of the three districts due to limitations of the Landsat Imagery that is available.

Table 6 Population Changes in Case Study Hamlets

Hamlet	Population 1993 (at or around)	2003 (at or around)	% Change
Que	320	409	27.8
Can	675	835	23.7
Luu Phuong	554	751	35.6
Huoi Giang	832	891	7.1

Source: Fieldnotes/hamlet interviews.

Case Studies: Socio-economic, Land Cover and Land Use Changes

In general, the socio-economic changes in each of the case study hamlets mirror the overall three district study area's changes. Population in each hamlet increased during the 10 year study period, but to different extents (Table 6). Transportation routes between National Route 7 and each of the hamlets were improved, but none of them are connected to the main market by paved road. Changes in land tenure and in the way land allocation was implemented in the hamlets are the most varied. Three of them, Que, Can, and Luu Phuong, all had land allocation of both paddy fields and upland areas (forestland allocation and upland agriculture land allocation) take place by 2003. However, Huoi Giang has had no land allocation done within its territory. Two of the hamlets, Luu Phuong and Huoi Giang, report that they have expanded their cattle rearing efforts and attribute the expansion to market demand. One, Can hamlet, has expanded pig raising, but not cattle raising. Que hamlet originally expanded cattle raising, but in the early 2000s had to scale back on these efforts due to the scarcity of financial resources within the hamlet that are needed to start, or in their case, replenish, a herd.

Land cover and land use changes in each of the hamlets mirror the broader, smaller scale, changes in the three district study area. Fig. 4 shows the changes in land cover for each hamlet and Fig. 5 shows changes in land use for each of the hamlets.

All of the hamlets' exhibit land cover changes and land use changes that reflect the overall changes in the three district study area (Tables 3 and 4). In general land cover in each shows a pattern of decreased area under transition tree cover, while mature, or near mature tree cover has increased and land cover associated with both permanent and swidden agriculture has increased (Table 7).

Land use change patterns in each of the hamlets also mirror the larger study area's patterns. Areas of land cover associated with natural forest area land use have increased. Long-term fallow areas have decreased, while shorter-term fallow, permanently cultivated areas, and residential land use areas have increased in size (Table 8).

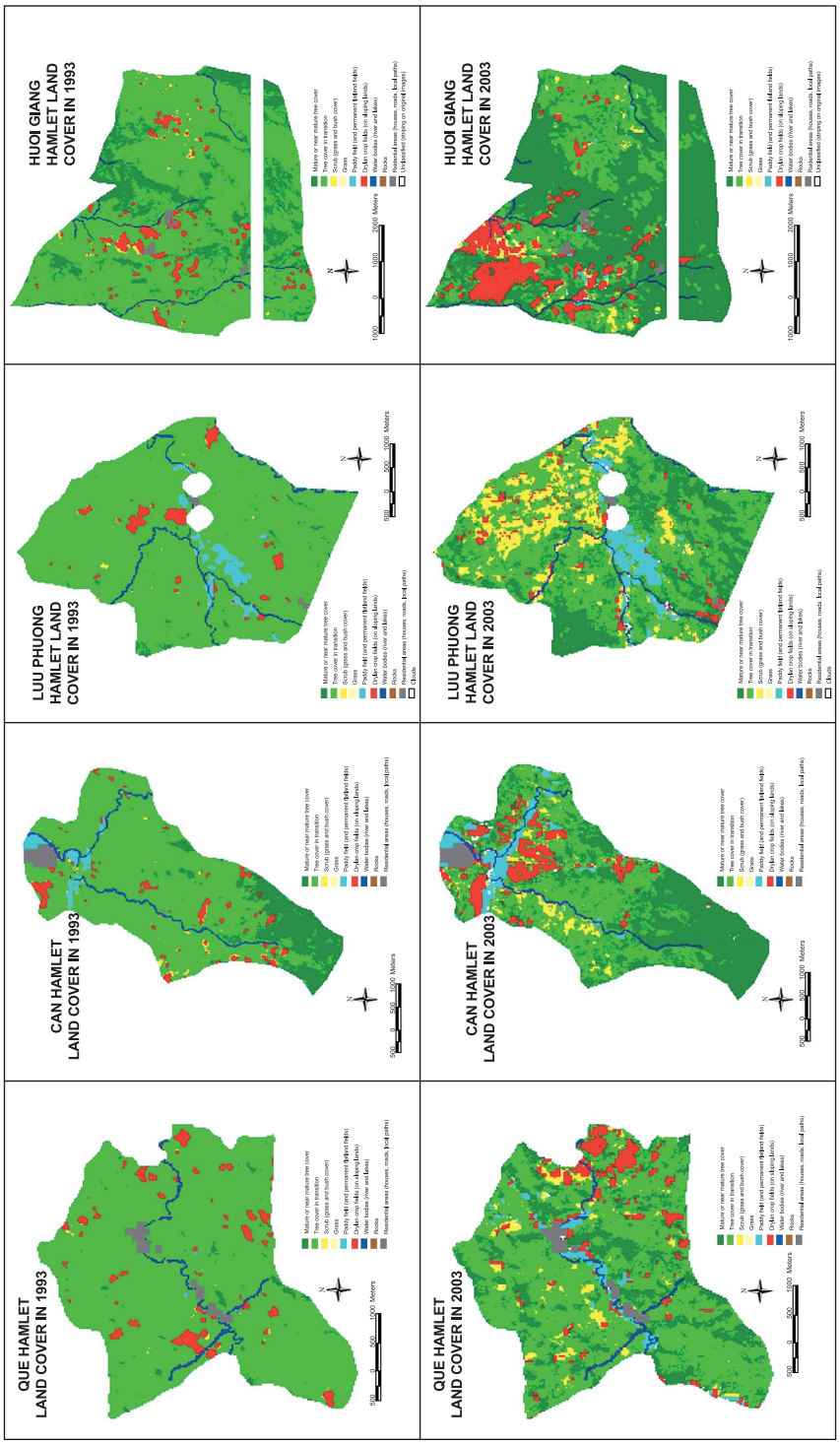

Fig. 4　Land Cover in Four Case Study Areas 1993 and 2003

Source of imagery [before analysis]: www.usgs.gov/pubprod/aerial.html

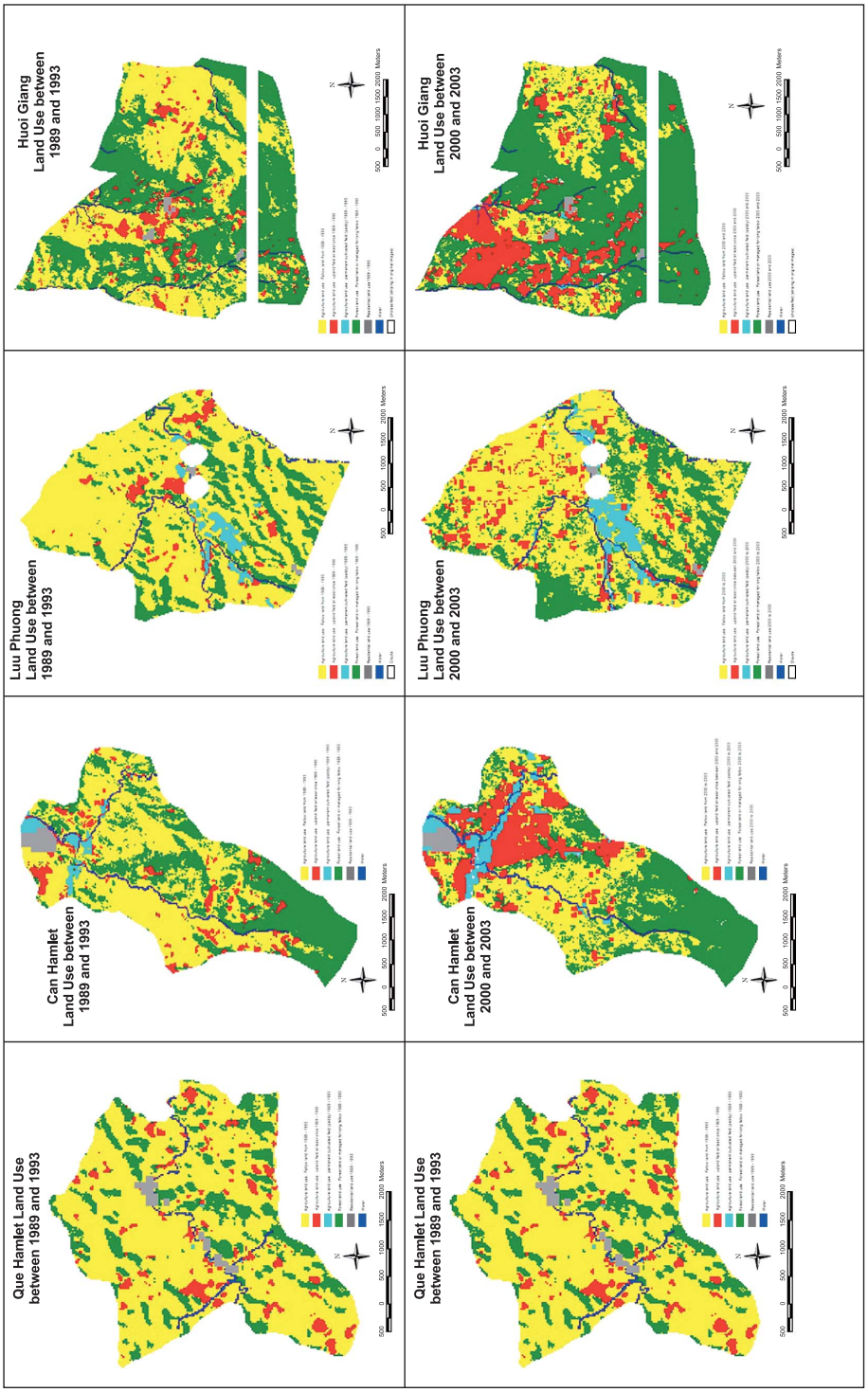

Fig. 5 Land Use in Four Case Study Areas 1993 and 2003

Source of imagery [before analysis]: www.usgs.gov/pubprod/aerial.html

Table 7 Hamlet Case Study Land Cover Change from 1993 to 2003 Land Cover Maps

Land Cover Category	Que Hamlet			Can Hamlet			Luu Phuong Hamlet			Huoi Giang Hamlet		
	1993 (ha)	2003 (ha)	Change (ha)	1993 (ha)	2003 (ha)	Change (ha)	1993 (ha)	2003 (ha)	Change (ha)	1993 (ha)	2003 (ha)	Change (ha)
Tree cover: Natural, Mature (or near mature; possibly including trees regrowing in long-fallow areas)	23	354	331	260	646	386	23	519	496	686	2,286	1,600
Tree cover: Natural, in transition from herbaceous to tree dominated	1,478	1,000	–478	1,289	704	–585	1,859	1,016	–843	2,935	1,013	–1,922
Total Natural Tree Cover	1,501	1,354	–147	1,549	1,350	–199	1,882	1,535	–347	3,621	3,299	–322
Herbaceous dominated: Scrub (grass, bush, few small trees)	3	63	60	19	80	61	6	291	285	29	102	73
Total Herbaceous Cover	3	63	60	19	80	61	6	291	285	29	102	73
Human planted: Paddy fields/cultivated flat land	1	36	35	39	97	58	61	110	49	0	14	14
Human planted: Sloping cultivated fields	69	109	40	68	156	88	56	63	7	169	418	249
Total Agricultural Crop Cover	70	145	75	107	253	146	117	173	56	169	432	263
Other —— human (residential/built land)	28	31	3	32	31	–1	7	8	1	25	27	2
Unclassified (clouds, striping)							43	48		228	212	
Total	1,602	1,593		1,707	1,714		2,055	2,055		4,072	4,072	

Table 8 Hamlet Case Study Land Use Change during the Two Chronosequence Periods

Land Use Type	Que Hamlet			Can Hamlet			Luu Phuong Hamlet			Huoi Giang Hamlet		
	1989 to 1993 (ha)	2000 to 2003 (ha)	Change (ha)	1989 to 1993 (ha)	2000 to 2003 (ha)	Change (ha)	1989 to 1993 (ha)	2000 to 2003 (ha)	Change (ha)	1989 to 1993 (ha)	2000 to 2003 (ha)	Change (ha)
Forest land use: mature tree cover on the area for the chronosequence period	309	353	44	628	631	3	412	520	108	1,849	2,300	451
Agricultural land use	1,265	1,209	–56	1,047	1,052	5	1,593	1,479	–114	1,970	1,533	–437
Swidden/Fallow System Land: fallow field during chronosequence period	1,154	903	–251	896	624	–272	1,440	1,189	–251	1,703	837	–866
Swidden/Fallow System Land: active swidden field during at least 1 year of chrono-sequence period	110	290	180	112	331	219	92	180	88	267	681	414
Permanent Agriculture Land	1	16	15	39	97	58	61	110	49	0	15	15
Other land use												
Residential or built up land	28	31	3	32	31	–1	7	8	1	25	27	2
Unclassified							43	48		228	212	
Total	1,602	1,593		1,707	1,714		2,055	2,055		4,072	4,072	

Discussion and Conclusion: Driving Forces, Trends, and Trigger Events

The socio-economic trends in the three district study area and in the case study sites all point in the same direction. Overall the population is growing and the hamlets are becoming more connected to the market. Correspondingly, the market is having an effect on what the hamlets produce, as all the hamlet case studies indicate that there has been an increase in the production of livestock, either pigs or cattle, for the market at the hamlet level. Land allocation of both agricultural land and forest land has been carried out in three of the case study hamlets, and district officials in all three districts report that this policy will continue to be implemented.

Changes in land cover and land use across the three district study area and within the case study hamlets show similar, though complex, trends. Older, mature, tree cover is increasing in extent of area covered, while transitional tree cover is decreasing, herbaceous land covers are increasing in area extent, and agricultural crop cover is increasing in areal extent. Land use patterns mirror these trends. Area devoted to natural forest land use, shorter-rotation swidden/fallow land use, and permanent agriculture land use have all increased, while areas devoted to longer duration fallow land use have decreased in size. These trends in observed land cover changes versus observed land use changes send a mixed signal. If the land cover changes are only considered, then one is led to believe that a forest transition [Mather 1992] is not taking place in Vietnam. If the land use changes are considered one is led to the opposite conclusion, a conclusion that is in line with other researchers [Meyfroidt and Lambin 2008], since land use changes indicate that more land is being devoted to natural forest land use than in the past, e.g. land use in the study area is transitioning to forest land use. A detailing of the evidence for the forest transition hypothesis in the study area follows:

– An increase in the incidence of shortened fallow periods, or no fallow periods, associated with upland agriculture land use for all of the hamlets. This is seen in the change in the size of upland areas that are cleared for at least one year during the respective chronosequence of images. For the study area overall there is a 173% increase in this land use category from the first to the second period. For the case study sites increases are: Que 180 ha increase; Can 219 ha increase; Luu Phuong 88 ha increase; Huoi Giang 414 ha increase.

– An increase in the area devoted to permanent agriculture land use. For the overall study area this category of land use increased by 174% from the 1989–93 period to the 2000–03 period. For the case study sites changes in this land use category are: Que 15 ha increase; Can 58 ha increase; Luu Phuong 49 ha increase; Huoi Giang 15 ha increase.

– An increase in the area devoted to forest land use. For the study area overall this category of land use increased by 19%. For the case study sites changes in this land use category are: Que 44 ha increase; Can 3 ha increase; Luu Phuong 108 ha increase; Huoi Giang 451 ha increase.

– A decrease in long-term fallow land use. This decrease is indicated by the change in the amount of land found in the land use category "swidden/fallow system land: fallow field during chrono-sequence," which is a category that would include mostly, or wholly, long-term fallow lands. For the overall study area this land use category decreased 39% from the first to the second chrono-sequence of images. For the case study sites changes in this land use category are: Que 251 ha decrease; Can 272 ha decrease; Luu Phuong 251 ha decrease; Huoi Giang 866 ha decrease.

– An increase in the land cover category of "mature tree cover." For the overall study area this land cover category increased by 149% from the first to the second time period. For the case study sites changes in this land cover category are: Que 331 ha increase; Can 386 ha increase; Luu Phuong 496 ha increase; Huoi Giang 1,600 ha increase.

The trigger events associated with a forest transition are considered to be a broad set of factors that can include economic, political, institutional and cultural practices [Mather *et al.* 1999]. In the case of Vietnam it has been suggested that the forest land allocation policies are the triggers that have initiated the forest transition, as these policies have been broadly credited with decreasing, or reversing, the deforestation trends [Sikor 2001; Tachibana *et al.* 2001; Castella and Quang 2002]. The results of this study provide some support for the hypothesis that land allocation is influencing the movement towards increased forest land use. However, only three of the case study hamlets have experienced allocation of forest and agriculture land. Huoi Giang, where neither agricultural land allocation nor forest land allocation have taken place, has experienced the biggest increase in mature tree cover, the biggest increase in forest land use, and the biggest decrease in land used for long-term fallow. In association with these changes Que, Can, and Luu Phuong have all increased the amount of land they devote to permanent agriculture. Huoi Giang, though, has not responded in this way, increasing their permanent agriculture land by only 0.4%.

These results suggest that while land allocation may be one of the trigger events leading to a change in land use practices that ultimately leads to land cover change and increased forest land cover, another trigger event may be the increased connection with the market. All of the hamlets have increased their production of livestock for sale in the market. Increased livestock production, especially the production

of cattle, requires that pasture land be available for cattle raising. In the uplands of Vietnam pasture land can be grass and bushland, but it can also be tree covered, e.g. forest, land. In the past forest cattle have been raised by the hill tribes in Southeast Asia, and the H'mong are well-known for their skill in raising forest cattle. The increase in livestock, especially cattle, production, and the increased revenues that are associated with this production, provide another, complementary, explanation for the change in land use, and associated change in land cover, that lead towards a forest transition. By leaving more land tree covered, and allowing the land use to revert to "forest land use," upland residents are also providing more pasture land for their cattle. As demand for cattle increases, and it becomes even more lucrative to raise cattle as opposed to cultivating upland rice, it can be expected that forest land use will increase at the expense of swidden or upland cultivated fields. This trigger has not been identified in other studies looking at upland land cover changes in Vietnam, but may play an important role in the forest transitions that are taking place.

References

Ahlback, A. J. 1995. *On Forestry in Vietnam, the New Reforestation Strategy and Assistance*. UNDP/FAO Project VIE/92/022. Hanoi.

Castella, J. C.; and Quang, D. D., eds. 2002. *Doi Moi in the Mountains. Land Use Changes and Farmers' Livelihood Strategies in Bac Kan Province, Vietnam.* Ha Noi: The Agricultural Publishing House.

Castella, J. C.; Boissau, S.; Hai Thanh, N.; and Novosad, P. 2006. Impact of Forest Land Allocation on Land Use in a Mountainous Province of Vietnam. *Land Use Policy* 23(2): 147–160.

Dang, N. V. 1991. La culture sur bruˆ lis et le nomadisme. *Etudes Vietnamiennes* 1: 16–28.

De Jong, W.; Sam, D. D.; and Hung, T. V. 2006. *Forest Rehabilitation in Vietnam: Histories, Realities and Future*. Center for International Forestry Research (CIFOR), Bogor, Indonesia.

De Koninck, R. 1999. *Deforestation in Vietnam*. International Development Research Center (IDRC), Ottawa.

D'haeze, D.; Deckers, J.; Raes, D.; Phong, T. A.; and Loi, H. V. 2005. Environmental and Socio-economic Impacts of Institutional Reforms on the Agricultural Sector of Vietnam: Land Suitability Assessment for Robusta Coffee in the Dak Gan Region. *Agriculture, Ecosystems and Environment* 105(1–2): 59–76.

Do, D. S. 1994. *Shifting Cultivation in Vietnam: Its Social, Economic and Environmental Values Relative to Alternative Land Use.* International Institute for Environment and Development, London, UK.

FAO (Food and Agriculture Organization). 2005. *Global Forest Resources Assessment 2005: Progress Towards Sustainable Forest Management*. Food and Agriculture Organization of the United Nations Rome.

General Statistics Office. 2001. *Results of the 1999 Population and Housing Census*. Ha Noi: Statistical Publishing House.

Gomiero, T.; Pettenella, D.; Giang, P. T.; and Maurizio, P. 2000. Vietnamese Uplands: Environmental and Socio-Economic Perspective of Forest Land Allocation and Deforestation Process. *Environment, Development and Sustainability* 2: 119–142.

Jakobsen, J.; Rasmussen, K.; Leisz, S.; Folving, R.; and Quang, N.V. 2007. The Effects of Land Tenure Policy on Rural Livelihoods and Food Sufficiency in the Upland Village of Que, North Central Vietnam. *Agricultural Systems* 94: 309–319.

Lang, C. 2001. Deforestation in Vietnam, Laos and Cambodia. In *Deforestation, Environment, and Sustainable Development: A Comparative Analysis*, edited by D. K. Vajpeyi, pp. 111–137. Praeger, Westport, Connecticut and London,

————. 2002. *The Pulp Invasion: The International Pulp and Paper Industry in the Mekong Region*. Technical report, World Rainforest Movement, Uruguay.

————. 2007. Reinterpreting the Uplands of Vietnam: Towards Understanding and Correcting a Misreading of Its Land Cover, Land Use, and Resource Management System. Ph.D. Dissertation. Geography Department, University of Copenhagen. Copenhagen, Denmark.

Leisz, Stephen J. 2007. Reinterpreting the Uplands of Vietnam: Towards Understanding and Correcting a Misreading of Its Land Cover, Land Use, and Resource Management System. Ph.D. Dissertation. Geography Department, University of Copenhagen, Copenhagen, Denmark.

MAFI (Ministry of Agriculture and Forest Industry). 1993. *Bare Lands in Vietnam: The Existing Situation and the Improving and Using Orientation Up to the Year 2000*. MAFI. Hanoi.

Mather, A. S. 1992. The Forest Transition. *Area* 24(4): 367–379.

Mather, A. S.; Fairbairn, J.; and Needle, C. L. 1999. The Course and Drivers of the Forest Transition: The Case of France. *Journal of Rural Studies* 15(1): 65–90.

Meyfroidt, P.; and Lambin, E. 2008. The Causes of the Reforestation in Vietnam. *Land Use Policy* 25: 182–197.

Morrison, E.; and Dubois, O. 1998. *Sustainable Livelihoods in Upland Vietnam: Land Allocation and Beyond*. Forestry and Land Use Series 14. International Institute for Environment and Development (IIED), London.

Nguyen M. C. 1999. Information Technologies for Forest Management in Vietnam. Workshop Proceedings: Application of Resource Information Technologies GIS/GPS/RS) in *Forest Land & Resources Management*. October 18–20, 1999. Hanoi, Vietnam.

Pham, B. N.; and Hill, P. S. 2008. The Role of Temporary Migration in Rural Household Economic Strategy in a Transitional Period for the Economy of Vietnam. *Asian Population Studies* 4(1): 57–75.

Poffenberger, M.; Walpole, P.; D'Silva, E.; Lawrence, K.; and Khare, A. 1997. *Linking Government and Community Resource Management: What's Working and What's Not.* Report of the 5th Asia Forest Network Meeting, Surajkund, India, 2–6 December 1996. Research Network Report No. 9, Asia Forest Network.

Rambo, A. T. 1998. The Composite Swiddening Agroecosystem of the Tay Ethnic Minority of the Northwestern Mountains of Vietnam. In *Land Degradation and Agricultural Sustainability: Case Studies from Southeast and East Asia*, edited by A. Patanothai, pp. 43–86.

Sikor, T. 1995. Decree 327 and the Restoration of Barren Land in the Vietnamese hHghlands. In *The Challenges of Highland Development in Vietnam*, edited by A. T. Rambo, R. R. Reed, Le Trong Cuc and M. R. DiGregorio. Honoulu. U.S.A.: East-West Centre.

————. 2001. The Allocation of Forestry Land in Vietnam: Did It Cause the Expansion of Forests in the Northwest? *Forest Policy and Economics* 2(1): 1–11.

————. 2004. Conflicting Concepts: Contested Land Relations in North-western Vietnam. *Conservation & Society* 2(1): 75–95.

Socialist Republic of Vietnam. 1999. "Decree No. 85/1999/ND-CP," in D. Tran, 2003. *The Farm Economy in Vietnam*. Hanoi: The Gioi Publishers.

————. 2001. *Nien Giam Thong Ke* [Statistical Yearbook] *2000*. Statistical Publishing House, Hanoi, Vietnam. 599 pp.

Sowerine, J. C. 2004. Territorialisation and the Politics of Highland Landscapes in Vietnam: Negotiating Property Relations in Policy, Meaning and Practice. *Conservation & Society* 2(1): 97–136.

Tachibana, T.; Nguyen, T. M.; and Otsuka, K. 2001. Agricultural Intensification versus Extensification: A Case Study of Deforestation in the Northern-hill Region of Vietnam. *Journal of Environmental Economics and Management* 41(1): 44–69.

Vien, T. D.; Nguyen Vinh Quang; and Mai Van Thanh. 2005. *Decentralization of Forest Management and Impacts on Livelihoods of Ethnic Minority Groups in Vietnam's Uplands*. The Agriculture Publishing House. Hanoi, Vietnam.

Vo Quy; and Le Thac Can. 1994. Conservation of Forest Resources and the Greater Biodiversity of Vietnam. *Asian Journal of Environmental Management* 2(2): 55–59.