TROPICS Vol. 15 (1) Issued March 1, 2006

Land-use patterns and plant use in Lao villages, Savannakhet Province, Laos

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ABSTRACT Land-use patterns and plant use were recorded at two neighboring villages in central Laos. Bak village is located upland and surrounding land includes an extensive forest area, fallow fields, shifting cultivation fields, grassland, waterside, and paddy fields. During the study period the forest area supplied the largest number of useful plants. Nakhou village is, by contrast, in a lowland area and utilized land included small areas of remnant forest, grassland, waterside, and extensive paddy fields. Paddy fields contained the largest number of useful plants, followed by forest. Villagers compensated for the lack of forest resources in Nakhou village by maintaining and managing a diversity of trees within the paddy field land-use class. In addition, residents of the surrounding villages made the most of locally available plant resources and supplemented each other's resources through trading. Analysis of local plant use at different geographical scales showed that the relationship between humans and plants at this study site was flexible and influenced mainly by topography and land-use and partly by socio-economic conditions and invasion of naturalized species. Species inventories and descriptions of the external factors influencing plant use at different geographical scales within a spatially heterogeneous landscape, will form an important basis for management and conservation of the plant resources of local communities.

Key words: human management, landscape, land-use, plant resource, geographical scale

INTRODUCTION

In conjunction with the recent heightened concern for biodiversity, indigenous people have been identified as an important source of knowledge on useful plants (e.g., Jain, 2000; Etkin, 2002). Culturally appropriate conservation can be achieved only by understanding the complexities of indigenous knowledge of the landscape and the principles of resource utilization (Etkin, 2002).

In Laos, 83% of people aged 10 years and above are engaged in agriculture and/or fishing/aquaculture activities for subsistence (MAF, 2000) and 97% of households use wood or charcoal as a cooking fuel (LWU, 2001). In addition, numerous timber and non-timber forest products are collected and play a key role in the daily life of local communities (Lehmann *et al*., 2003; Xaydala, 2003). However, the rate of deforestation is estimated to be 70,000 ha per year, mainly due to shifting cultivation, logging, and the collection of firewood (NOFIP, 2000). Accordingly, several conservation programs have prepared local natural resource inventories (UNEP, 2001).

Earlier descriptions of plant use in Laos generally fall into one of three types: (1) inventories of the useful plants of particular regions (e.g., Vidal, 1962; Xaydala, 2003), (2) inventories of useful plants of particular land-use classes (e.g., Lehmann, 2003), and (3) full descriptions of particular useful plants (e.g., Ankarfjard & Kegl, 1998; Evans & Sengdala, 2002). However, the use of plants in subsistence livelihoods is influenced by several factors, such as the location and environmental conditions of the village (e.g., Pieroni, 1999), previous land-use (e.g., Fu *et al*., 2003), and socio-economic conditions (e.g., Wezel, 2003). Thus, descriptions of the factors influencing plant use in local communities will support conservation and rural development in Laos, especially when reinforced by previous inventories of useful plants.

The study of natural resource use and conservation is well suited to landscape and regional spatial scales (Zimmerer & Young, 1998). In central Laos, where this field survey was carried out, there is a mosaic land-use pattern on undulating terrain. This landscape, in turn, joins with others to form regions on a broader spatial scale. The purposes of this study were: (1) to describe land-use and plant use at the landscape level, (2) compare

land-use and plant use at the regional level, and (3) examine the factors influencing plant use in Lao villages.

SITE DESCRIPTION AND METHODS

Site description

The field survey was conducted at Bak village (16° 27' N, 105° 09' E, 160 m ASL: BK village) and Nakhou village (16° 29' N, 105° 09' E, 140 m ASL: NK village), Champhone District in Savannakhet Province, Laos (Fig. 1). Savannakhet Province is located in central Laos, the mean annual temperature is 26.5°C. The mean annual rainfall is 1473 mm, the rainy season (May-October) and dry season (November-April) rainfalls are 1299.2 mm and 173.8 mm, respectively.

Fig. 1. Map of the study site in Savannakhet Province, Laos.

Statistics for Savannakhet Province suggest that the proportions of the area composed of various land-use classes are: 55.5% in current forest land; 23.8% in potential forest land (including shifting cultivation fields and fallow forests in early successional stages); 8.8% in other wooded areas (mainly open woodlands); 9.1% in permanent agricultural land (mainly paddy fields); and 2.8% in other non-forest land such as urban areas, grassland, or wetland (NOFIP, 1992). A total of 80% of households are engaged in paddy cultivation (UNDP, 1998).

Forest resources are declining rapidly in Laos. During the 1940s, the forest cover represented about 70% of the total area, but this has fallen to 47% at present (UNEP, 2001). In order to control public access to land and forest resources, the government has reformed its natural resources management policies several times since 1989. In November 1993, the government issued The Prime Ministerial Decree on Management and Use of Forest and Forest Land. Subsequently, in November 1996, the government promulgated a new Forestry Law, which integrated the contents of the former Decree (UNEP, 2001). The reform of the mechanisms of forest management includes community control of forestlands, zoning and provision of incentives to manage forests sustainably within the concession (UNEP, 2001). In this study site, forest demarcation was applied in Bak village in 2000 according to the Forestry Law, but not in Nakhou village because it only has small areas of forest.

Bak village is believed to have existed for more than 200 years and has a population of 1,852 people in 327 households. Most residents are Lao-Lum people belonging to the Tai-Kadai ethno-linguistic family (Sisouphanthong & Taillard, 2000). Within the 1,405 ha of village land, forest occupies 454 ha, 274 ha of which were designated as protected forest by the Forestry Law. In a protected forest agricultural and forestry activities are prohibited. Ninety percent of households are engaged in paddy cultivation and 10% of households, consisting mainly of older people, are engaged in shifting cultivation. Nakhou village, which is adjacent to Bak village, was established more than 100 years ago. Nakhou has a population of 1,594 people, mostly Lao-Lum people, in 252 households. The village has only several hectares of forest and all households are engaged in paddy cultivation.

Methods

Field surveys were conducted in the following periods: May and June 2002; June, July, September, October, and December 2003; and March 2004. Land-use was classified for both villages by analysis of aerial photographs and field observation. Data collection on plant species occurrence and their use was conducted separately for each land-use class.

Useful plants were collected as voucher specimens with the help of three key informants, one at Nakhou village and two at Bak village, all of whom were men in their early forties. The informant at Nakhou was a paddy cultivator who is knowledgeable about plants. Of the two

Bak village informants, one was a village soldier who is knowledgeable about plants of the forest, fallow fields, shifting cultivation fields, and grassland. The other was a paddy cultivator who is knowledgeable about plants from paddy fields, waterside, and homesteads. At both villages, other villagers were also consulted while they were collecting, processing, or using plant resources. These people were also interviewed about the history and current status of land-use classes, agricultural activities, local names and uses of plants, and trading of plant resources between neighboring villages. Useful plants were ranked in importance according to a three-level classification: (1) species essential for livelihood or as a source of cash income (this category included several timber species and other species of economic value, i.e., those sold in local markets or to traders); (2) species sometimes used for self-consumption, but not essential to livelihood; and (3) species recognized as useful, but rarely used at present.

Vegetation surveys conducted to describe the general floristic characteristics of each land-use class highlighted the fact that a mosaic of vegetation types existed within individual villages. The surveys carried out for each land use class were as follows:

1. In forest and fallow fields, every tree was measured (> 1.5 m in height or > 3 cm DBH) by recording DBH and height in plots (20 m × 20 m). Plots were selected within typical forest types, such as dry evergreen forest (DEF), *Peltophorum dasyrrhachis* dominant forest (PTF), and swamp forest with *Syzygium* spp. (SWF) at Bak village, and gallery forest (GLF) with *Dipterocarpus alatus* and PTF at Nakhou village. At Bak village there were two plots in DEF, three in PTF, and one in SWF; in Nakhou village there was one plot in GLF and two in PTF. Forests were defined to include shifting cultivation areas that had been left to regenerate for at least 10 years, in addition to current protected forests. Fallow areas were defined as former shifting cultivation fields that had been left dormant for four to nine years since burning; this time frame was adopted because a three-year cropping cycle for shifting cultivation fields was common in Bak village.

2. In shifting cultivation fields, the names of both cultivated and wild species present were recorded in several fields in Bak village. Shifting cultivation was not practiced in Nakhou village.

3. In grassland, only the names of species observed were recorded, since the number of species was very small.

4. In waterside land, only species names and their habitats were recorded, since the number of species was very small. Water bodies beside which the waterside class existed included irrigation dams, small marshes around paddy fields, ditches, ponds, and streams.

5. In paddy fields, methods used for recording herbaceous species were different than those for recording woody species. For herbaceous species, species names and their habitats (field or levee) were recorded during the rainy season (June, July, September, October 2003) and the dry season (December 2003 and March 2004) at both villages. At Bak village, only the names of observed woody species (>1 m height, including shrubs and woody lianas) and their habitats (field, levee, or termite mound) were recorded because the number of individuals and species was very small. At Nakhou village, where many trees were observed, the species name, habitat, DBH, and height were recorded in a belt-transect survey plot that was 3 km long and 200 m wide.

6. In the homestead land-use class, species names were recorded when observed at both villages. This class is a general category of land-use consisting of homes and adjoining land occupied by families.

The collected plants were identified at the Faculty of Forestry, National University of Laos, Vientiane, Laos, and in the Forest Herbarium, Royal Forestry Department, Bangkok, Thailand (BKF). Nomenclature of sampled plants followed Ho (1999–2000), Santisuk and Larsen (1997–2002), and Smitinand and Larsen (1970–1996).

RESULTS

History and current status of vegetation

Fig. 2 shows current land-use patterns in Bak village and Nakhou village. Both villages are located on different parts of a contiguous slope, with shifting cultivation being conducted on the higher land of Bak village and paddy fields widespread over the lowlands beginning in central Bak village and extending to Nakhou village. Some springs were found in Bak village on the boundary between the shifting cultivation and paddy field zone.

Bak village

In Bak village, both shifting cultivation and paddy cultivation have been the main sources of subsistence since village establishment. However, most households have become devoted to paddy cultivation since the revolution in 1975. Late successional forests, with large trees such as *Afzelia xylocarpa, Anisoptera costata, Dipterocarpus alatus, Pterocarpus macrocarpus*, and *Xylia xylocarpa* var. *kerrii*, were distributed all over the

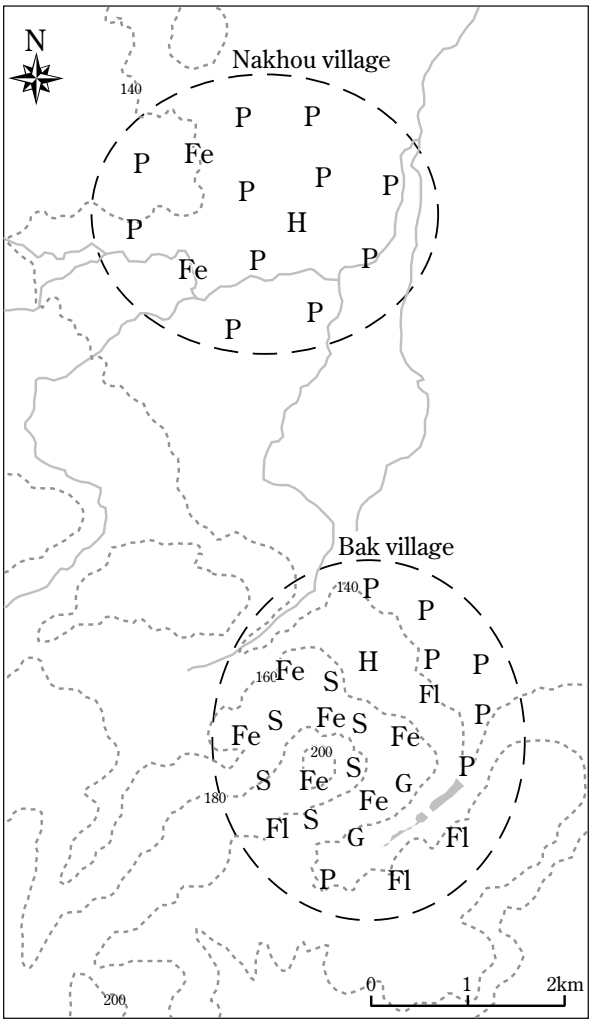

Fig. 2. Current land-use patterns in Bak village and Nakhou village.
Fe:Early successional forest and fallow fields, Fl:Late successional forest, G: Grassland, H:Homestead, P:Paddy fields, S: Shifting cultivation fields.

higher land in the past. The trees were logged by the government to generate revenue in 1976 and 1977. The current landscape of Bak village is a mosaic of late successional forest (DEF and SWF), early successional forest (PTF), shifting cultivation fields, grassland, waterside, paddy fields, and homesteads.

In our surveys, DEF was observed in sacred forests, crematory forests, and some protected forests. The main species of the canopy layer were *Dipterocarpus alatus* and *Hopea odorata*.

PTF mainly occurred in fallow fields and other early successional forest. The main species of the canopy layer were *Dialium cochinchinense* and *Peltopholum dasyrrhachis*. Those of the understory layer were *Amomum villosum, Calamus* sp., *Holarrhena pubescens*, and *Streblus taxoides*.

SWF was distributed around water sources and are the village's traditionally conserved forests. The main species of the canopy layer were *Syzygium* spp. Those of the understory layer were *Ardisia* spp.

In shifting cultivation fields, *Ananas comosus* (pineapple), *Carica papaya* (papaya), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Morus alba* (mulberry), *Musa* sp. (banana), *Oryza sativa* (rice), and *Sesamum indicum* (sesame) were cultivated. Seedlings of *Calamus* sp., *Peltophorum dasyrrhachis*, and other forest tree species were found growing among these crops.

Grassland was distributed in patches between the shifting cultivation zone (including fallow fields) and waterside. This vegetation occurred where shifting cultivation had been abandoned due to the invasion of *Imperata cylindrica* var. *major*. In this vegetation, *Imperata cylindrica* var. *major* dominated, and some shrubs, such as *Helicteres hirsuta, Melastoma malabathricum* ssp. *malabathricum*, and scattered forest tree seedlings were observed.

Waterside was classified into three separate habitats based on the type of water body: irrigation dams, small marshes around paddy fields, and ditches. They harbored different species compositions as follows: *Nelumbo nucifera* and *Nymphoides indica* were predominant in irrigation dams; Blyxa japonica, *Neptunia oleracea*, and *Utricularia aurea* were predominant in small marshes around paddy fields; and *Monochoria vaginalis* and *Polygonum* sp. occurred in ditches.

In the paddy field land-use class, the herbaceous species composition varied with habitat. In field habitat, *Blyxa japonica, Cyperus haspan, Fimbristylis miliacea, Limnophila villifera* ssp. *gracilipes*, and *Monochoria vaginalis* were dominant, in addition to paddy rice. In levee habitats, *Chrysopogon aciculatus, Desmodium heterophyllum, Fimbristylis pauciflora, Limnophila villifera* ssp. *gracilipes, Lindernia parviflora*, and *Sacciolepis indica* were dominant. The few woody species observed included trees such as *Lepisanthes rubiginosa* and *Syzygium gratum* var. *gratum* on termite mounds, and a shrub, *Melastoma saigonese*, on some levees.

In the homestead land-use class, wild vegetation could not be seen except for some weeds, but many useful trees, shrubs, lianas, and herbs had been planted.

Nakhou village

In Nakhou village, paddy cultivation has been conducted since village establishment. A late successional forest consisting of *Dipterocarpus alatus, Lagerstroemia* sp. and *Pterocarpus macrocarpus* existed in the past. However, it

was converted to paddy fields. The current landscape of Nakhou village is a mosaic of early successional forest (GLF and PTF), grassland, waterside, paddy field, and homestead land-use classes.

GLF was occupied the private forest along streams. The main species observed in the canopy layer was *Dipterocarpus alatus*. In the understory layer, the main species were *Cratoxylum cochinchinense* and *Memecylon scutellatum*. *Bambusa bambos* was also widespread.

PTF was sacred forest, crematory forest or private forest. The presence of several stumps and large gaps in the canopy implied intensive human disturbance. The main species of the canopy layer were *Dialium cochinchinense, Peltopholum dasyrrhachis,* and *Xylia xylocarpa*. In the understory layer, the main species were *Dipspyros filipendula* and *Oxyceros horridus.* Bamboos, such as *Bambusa bambos* and *Gigantochloa albociliata*, were also widely observed.

Paddy fields were surrounded by grassland with scattered trees, such as *Peltopholum dasyrrhachis*. The herbaceous species composition was similar to that of paddy levees mentioned below. Although this grassland is currently used as pasture during the rainy season, it may be converted to paddy field, pond, or homestead in the future.

Waterside was classified as one of three habitats: stream, pond, or small marshes around paddy fields. These habitats harbored different species as follows: *Combretum quadrangulare, Pandanus* sp., and *Phyllanthus taxodiifolius* predominated along streams; *Ipomoea aquatica* and *Nymphaea pubescens* were the most abundant species in ponds; and *Cyperus pilosus* in small marshes around paddy fields.

In paddy fields, the herbaceous species composition varied with habitat. In field habitat, *Fimbristylis miliacea, Limnophila geoffrayi, Lindernia viatica, Ludwigia hyssopifolia,* and *Rotala indica* were dominant, in addition to paddy rice. In levee habitat, *Adenosma javanica, Adenosma elsholtzioides, Chrysopogon aciculatus, Corchorus aestuans,* and *Desmodium heterophyllum* were dominant. In addition, many woody species were observed, such as *Azadirachta indica* var. *siamensis, Diospyros mollis,* and *Streblus asper* on termite mounds and, both in fields and on levees, *Irvingia malayana* and *Peltphorum dasyrrhachis*.

Around homesteads, wild vegetation could not be seen except for some weeds, but many useful trees, shrubs, lianas, and herbs had been planted.

Plant use in respective land-use patterns

The characteristics of plant use in Bak village and Nakhou village were compared for each land-use class separately (Table 1). Useful species were placed into the following use categories: food, timber, fuel (fuel wood and charcoal), material for handicrafts, medicine, and others. The total number of species placed into these categories exceeded the overall number of useful plants recorded because many species were utilized in multiple ways and therefore counted more than once. The habitat, its importance, and uses of the major useful plant species are listed in Table 2. It was noted that both villages had traditional rules on the collection of useful plants. Wild

Table 1. Number of useful plant species in each land-use class in Bak village and Nakhou village

Village	Land	No. Used	Plant.	(%)	Econ.	(%)	Food	(%)	Timber	(%)	Fuel	(%)	Hand.	(%)	Medic.	(%)	Others	(%)
BK	Forest	104*	7	(7)	25	(24)	47	(45)	39	(37)	52	(49)	3	(3)	4*	(4)	7	(7)
	Fallow	31	1	(3)	11	(35)	18	(58)	11	(35)	13	(42)	1	(3)	2*	(6)	1	(3)
	Field	16	16	(100)	13	(81)	15	(94)	0	(0)	0	(0)	0	(0)	0	(0)	2	(13)
	Grass	5	0	(0)	1	(20)	1	(20)	0	(0)	0	(0)	2	(40)	0	(0)	2	(40)
	Water	5	1	(20)	2	(40)	3	(60)	0	(0)	0	(0)	0	(0)	0	(0)	2	(40)
	Paddy	18	9	(50)	12	(67)	17	(94)	0	(0)	0	(0)	0	(0)	0	(0)	5	(28)
	Home	39*	39	(100)	27	(69)	27	(69)	1	(3)	0	(0)	2	(5)	2*	(5)	15	(38)
NK	Forest	48	0	(0)	9	(19)	20	(42)	8	(17)	25	(52)	1	(2)	6*	(13)	6	(13)
	Grass	3	0	(0)	0	(0)	0	(0)	1	(33)	1	(33)	0	(0)	2*	(67)	0	(0)
	Water	4	1	(25)	3	(75)	2	(50)	0	(0)	0	(0)	2	(50)	0	(0)	0	(0)
	Paddy	116	40	(34)	40	(34)	62	(53)	24	(21)	26	(22)	8	(7)	20*	(17)	34	(29)
	Home	31*	31	(100)	19	(61)	21	(68)	2	(6)	0	(0)	6	(19)	4*	(13)	9	(29)

Useful plant species were placed into use categories by the authors.

Land**:* Land-use class (field: shifting cultivation field; grass: grassland; water: waterside; paddy: paddy field; home: homestead); ***No. Used**:* Number of species used in the village; ***Plant.**:* Number of planted (cultivated or transplanted) species, ***Econ.**:* Number of species with economic value (sold in local markets or to traders); ***Food, ***Timber***, ***Fuel***, ***Hand.***, ***Medic.***, ***Others**:* Number of species used for food, timber, fuelwood and charcoal, material for handicrafts, medicine, and for other purposes. Number with an asterisk indicates only main species.

Table 2a. Major Plant Species Used in Bak village

Species	Local	Habitat		I	Use	Note
Diptererocarpus alatus Roxb. ex G. Don	Mai nyang	W	DEF	3	T, O	Formerly, oleoresin was main income source.
Nephelium hypoleucum Kurz	Mak ngeo	W	DEF	3	Fo, T, C	Fruits eaten raw.
Syzygium gratum (Wight) S. N. Mitra var. *gratum*	Phak samek	W	DEF, SWF	3	Fo	Essential vegetable for popular Lao dish.
Tinospora crispa (L.) Hook. f. & Th.	Kheua khao ho	T	DEF, Home	3	M	Medicine for lumbago. Transplanted to homesteads.
Amomum villosum Lour.	Mak neng	W	PTF	3	M	Medicine for stomachaches. Thai traders came to buy.
Baccaurea ramiflora Lour.	Mak fai	W	PTF	3	Fo	Fruits eaten raw.
Cratoxylum formosum (Jack) Dyer	Phak tiu	W	PTF	3	Fo	Essential vegetable for popular Lao dish.
Dialium cochinchinense Pierre	Mai kheng	W	PTF	3	Fo, T	Fruits eaten raw. Producing high quality timber.
Irvingia malayana Oliv. ex Benn.	Mai bok	W	PTF	3	C, Fo, T	Seeds eaten raw. Best quality charcoal.
Peltophorum dasyrrhachis (Miq.) Kurz	Kok aran (safang)	W	PTF	2	T, C	Fast growing pioneer tree.
Tiliacora triandra (Colebr.) Diels	Kheua ya nang	W	PTF	3	Fo	Essential ingredient for popular Lao dish.
Dendrocalamus strictus (Roxb.) Nees	Mai sang phai	C	PTF	3	Fo, H, O	Planted in forest as living fence. Shoots edible.
Calamus sp.	Waai	W	PTF	3	Fo, H	Shoots cooked as vegetable. Fruits eaten raw.
Ananas comosus (L.) Merr.	Mak nat	C	Field	3	Fo	Fruits eaten raw.
Morus alba L.	Kok moon	C	Field, Home	3	Fe	Leaves used for sericulture.
Imperata cylindrica (L.) Beauv. var. *major* (Nees) Hubb.	Nya kha	W	Grass	3	O	Used for roofing.
Thysanolaena maxima (Roxb.) O. Ktze.	Kok khem	W	Grass	2	H	Spikes used as material for broom.
Nelumbo nucifera Gaertn.	Dok boua	W	Dam	3	Fo	Young seeds eaten raw.
Pandanus sp.	Kok teuy	T	Dam, Marsh	2	O	Transplanted from marsh for dam protection.
Neptunia oleracea Lour.	Phak kaset	W	Marsh	3	Fo	Cooked as vegetable.
Limnophila geoffrayi Bonati	Phak ka nyeng	W	Paddy	3	Fo	Essential herb for popular Lao dish.
Lygodium sp.	Phak kout kapon	W	Paddy	2	Fo, O	Edible fern. Stems used as string.
Marsilea crenata Presl	Phak ven	W	Paddy	3	Fo	Eaten raw as vegetable.
Mentha aquatica L.	Phak suumlao	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Ocimum basilicum L.	Phak i tou	C	Paddy	3	Fo	Cultivated in paddy levees. Important herb.
Oryza sativa L.	Khao	C	Paddy, Field	3	Fo, Fe	Staple diet. Straw and husk was feed for livestock.
Annona squamosa L.	Mak khiap	C	Home	3	Fo	Fruits eaten raw.
Chrysophyllum cainito L.	Mak nam nom	C	Home	3	Fo	Fruits eaten raw.
Pentace burmanica Kurz	Kok si siet	T	Home, DEF	3	O	Used for betel chewing. Transplanted to homesteads.

Local: Local name; Habitat (C: Cultivated, E: Cultivated and escaped, W: Wild, T: Transplanted, DEF: Dry evergreen forest, PTF: *Peltophorum* dominant forest, SWF: Swamp forest, Field: Shifting cultivation field, Grass: Grassland, Home: Homestead, Paddy: Paddy field); I: Importance (3: Essential for daily livelihood or source of cash income, 2: Sometimes self-consumed but not essential, 1: Recognized as useful but rarely used at present); Use (C: Charcoal, Fe: Feed, Fo: Food, Fr: firewood, H: Material for handicraft, M: Medicine, O: Other uses, T: Timber).

Table 2b. Major plant species used in Nakhou village

Species	Local			I	Use	Note
Bambusa bambos (L.) Voss	Mai phai paa	W	PTF, Paddy	3	Fo, O	Shoots edible.
Gigantochloa albociliata (Munro) Kurz	Mai lai	W	PTF	3	Fo, H	Shoots edible. Also used as a material for handicrafts.
Lepisanthes rubiginosa (Roxb.) Leenh.	Mak houat	W	PTF	3	Fo	Fruits eaten raw.
Croton crassifolius Geisel	Kan khii	W	Grass	2	M	Medicine for stomachaches.
Alloteropsis sp.	Nya phek	W	Marsh	3	O	Used for roofing.
Cyperus pilosus Vahl	Pheu nong	W	Marsh	3	H	Material for mat weaving.
Ipomoea aquatica Forssk.	Phak bong	W	Pond	3	Fo	Cooked or eaten raw as vegetable.
Nymphaea pubescens Willd.	Dok boua nooi	C	Pond	2	Fo	Flower stalks eaten raw.
Azadirachta indica A. Juss. var. *siamensis* Valeton	Kok ka dao	W	Paddy	3	Fo, T, M	Essential vegetable for popular Lao dish.
Careya arborea Roxb.	Kok ka don	W	Paddy	3	Fo, M, O	Essential vegetable for popular Lao dish.
Diospyros mollis Griff	Mak keua	W	Paddy	1	O, Fo	Formerly, fruits were used for dyeing.
Elephantopus scaber L.	Khi fai nok khoum	W	Paddy	2	M	Medicine for stomachaches.
Glinus oppositifolius (L.) DC.	Phak dang khom	W	Paddy	3	Fo	Cooked as vegetable.
Limnophila geoffrayi Bonati	Phak ka nyeng	W	Paddy	3	Fo	Essential herb for popular Lao dish.
Mitragyna rorundifolia (Roxb.) O. Ktze.	Kok thom	W	Paddy	3	C, T	Pollarded every two years for fuelwood.
Peltophorum dasyrrhachis (Miq.) Kurz	Kok aran (safang)	W	Paddy, PTF	3	T, C, Fr	Pollarded every two years for fuelwood.
Pterocarpus macrocarpus Kurz	Mai dou	W	Paddy, PTF	3	T	Producing best quality timber.
Streblus asper Lour.	Kok som pho	W	Paddy, PTF	2	Fr, Fe, M, Fo	Dominant tree in paddy field, used in multiple ways.
Ipomoea batatas (L.) Lam.	Man dang	C	Paddy	3	Fo	Tubers eaten cooked.
Oryza sativa L.	Khao	C	Paddy	3	Fo, Fe	Staple diet. Straw and husk was feed for livestock.
Zea mays L.	Mak sa li	C	Paddy	3	Fo	Fruits eaten cooked.
Borassus flabellifer L.	Kok taan	E	Paddy, Home	3	Fo, T, O	Young seeds and inner stem edible.
Cassia fistula L.	Mai khoun	E	Paddy, Home	2	T, O	Flowers for ornamental.
Leucaena leucocephala (Lam.) de Wit	Kok ka thin	E	Paddy, Home	3	Fo, C	Fruits and young shoots eaten raw.
Millingtonia hortensis L. f.	Kok kang khong	E	Paddy, Home	2	M, O	Medicine for a cough.
Tamarindus indica L.	Mak kham	E	Paddy, Home	3	Fo	Fruits eaten raw.
Ziziphus mauritiana Lam.	Mak ka than	E	Paddy, Home	3	Fo	Fruits eaten raw.
Ceiba pentandra (L.) Gaertn.	Kok ngiu	C	Home, Paddy	3	H	Cotton-like aril was used as stuffing of pillow.
Cyperus corymbosus Rottb.	Pheu itok	C	Home, Paddy	3	H	Material for mat weaving.

Local: Local name; Habitat (C: Cultivated, E: Cultivated and escaped, W: Wild, T: Transplanted, DEF: Dry evergreen forest, PTF: *Peltophorum* dominant forest, SWF: Swamp forest, Field: Shifting cultivation field, Grass: Grassland, Home: Homestead, Paddy: Paddy field); I: Importance (3: Essential for daily livelihood or source of cash income, 2: Sometimes self-consumed but not essential, 1: Recognized as useful but rarely used at present); Use (C: Charcoal, Fe: Feed, Fo: Food, Fr: firewood, H: Material for handicraft, M: Medicine, O: Other uses, T: Timber).

fruits, shoots or greens could be collected anywhere in the villages, except protected areas. On the other hand, wild trees were only allowed to be cut with the traditional owner's permission. In addition, no parts of cultivated plants were allowed to be collected by anyone other than their owners.

Forest

In Bak village, forest supplied the largest number of useful plants. Of the 104 species used by villagers, seven species were planted and 25 species had economic value (sold in local market or to traders). The useful plants were mainly used as food (47 spp.), timber (39 spp.), or fuel (52 spp.). Plant products that were often sold as food in local markets were *Dendrocalamus strictus* shoots, *Nephelium hypoleucum* fruits, *Syzygium gratum* var. *gratum* shoots. Late successional trees, such as *Dipterocarpus alatus* and *Pterocarpus macrocarpus*, produce high quality timber, but they were found to be largely unavailable at present because their main habitats are designated as protected areas. Instead, *Dialium cochinchinense* and *Peltophorum dasyrrhachis* were indicated as the main timber species. Charcoal made of *Irvingia malayana* had the best quality. Abundant *Calamus* sp. and *Dendrocalamus strictus* were utilized as raw materials for basketry. Formerly, oleoresin from *Dipterocarpus alatus* had been one of the main income sources. It had been sold to traders as a raw material for varnish, lacquer, and paint. However, currently only small amounts were observed to be collected owing to the decreasing population, and its main use is now for making traditional torches. *Amomum villosum* and *Tinospora crispa* were important medicinal plants. *Amomum villosum* seeds were used for stomachache in the village and Thai traders occasionally came to buy them. Alcohol in which *Tinospora crispa* stems had been steeped was used as a medicine for lumbago. This species was sometimes collected and transplanted within homestead areas.

In Nakhou village, forested land that is neither sacred forest nor crematory forest hosts a total of 48 useful plants. However, the amount of plant resources was small, owing to the limited area of forest. The useful plants were mainly used as food (20 spp.) and fuel (25 spp.). *Bambusa bambos* and *Gigantochloa albociliata* shoots were important foods. *Lepisanthes rubiginosa* produced popular fruits. *Gigantochloa albociliata* was also used as a raw material for making handicrafts.

Fallow fields

Fallow fields in Bak village harbored 31 useful species, including several of the most popular edible species, *Baccaurea ramiflora, Calamus* sp., *Cratoxylum formosum, Dialium cochinchinense*, and *Tiliacora triandra*. The leaves of *Tiliacora triandra* leaves are the main ingredient of a popular Lao dish, *keng noomai* (bamboo shoot soup), and *Cratoxylum formosum* shoots are an essential companion vegetable to another popular Lao dish, *laap* (spicy salad of pork, beef, or fish). Pineapple plants persisted in fallow fields and their fruit continued to be harvested through the fallow.

Shifting cultivation fields

In Bak village, 16 cultivated species were recorded, including 13 species with economic value. Fifteen of the 16 species were used for food crops. Although upland rice had previously been the primary crop, pineapples have become the most popular crop and income source since the 1990s. Mulberry trees were planted for sericulture in Bak village, but not Nakhou. Regenerated seedlings of *Peltophorum dasyrrhachis*, a fast growing pioneer tree, were preferentially retained in the field to promote vegetation recovery during the fallow period.

Shifting cultivation was not being practiced in Nakhou village.

Grassland

In Bak village, the leaves of the dominant species, *Imperata cylindrica* var. *major*, were an important roofing material. This grass was harvested in December. Shrubs and saplings of forest trees were removed at the same time to prevent the grassland from reverting to secondary forest. Small groups of people harvested the plants by sickle, removed shrubs and saplings using a spade, and bound the harvested plants into bundles using twine made of *Trachelospermum asiaticum* or *Lygodium* sp. A thatched roof can last for three years. In addition, material from *Thysanolaena maxima* was collected and used for making brooms.

In Nakhou village, the medicinal plant *Croton crassifolius* was found only in grassland around paddy fields. A decoction of the roots, often mixed with *Casearia grewiaefolia* roots, was used as a medicine for stomachaches. *Eupatorium odoratum* leaves were applied externally as a styptic for wounds.

Waterside

In Bak village, among the five useful species, *Nelumbo nucifera* fruits and *Neptunia oleracea* shoots were popular foods often sold in markets. *Pandanus* sp. was transplanted from marsh to irrigation dams for the dam's

protection.

In Nakhou village, although the number of useful species was small, those that were available were essential to livelihood. *Ipomoea aquatica* shoots and *Nymphaea pubescens* flower stalks were major foods often sold in markets. *Alloteropsis* sp. was harvested in December for use as a roofing material. The thatch from this species is regarded as being of better quality than that from *I. cylindrica*, lasting as long as five years. *Cyperus pilosus* was used as material for mat weaving.

Paddy fields

In Bak village, of the 18 useful species recorded in paddy fields, 14 were herbaceous species and four were woody species. The majority, 17 spp., was edible. *Limnophila geoffrayi* and *Marsilea crenata* were the major greens often sold in local markets. *Limnophila geoffrayi* has a particularly fragrant smell, and is an essential herb for *keng noomai* (bamboo shoot soup). Plants were dried and kept for the dry season, when it was otherwise not available. *Monochoria vaginalis*, one of the dominant paddy weeds, is also edible. *Mentha aquatica* and *Ocimum basilicum* are essential culinary herbs and were cultivated in small vegetable gardens on paddy levees in the rainy season.

In Nakhou village, paddy fields contained the largest number of useful plants. Of the 116 useful species found in paddy fields, 30 were herbaceous species and 86 were woody species. Among them, 40 species had been planted, and 40 species had economic value. They were mainly used as food (62 spp.), timber (24 spp.), and fuel (26 spp.). Regarding herbaceous species, besides *Limnophila geoffrayi* and *Marsilea crenata* mentioned above, *Glinus oppositifolius* was used as an edible green. This species was collected in the dry season when other wild edible plants were scarce. *Ipomoea batatas* (sweet potato) and *Zea mays* (corn) were cultivated after the harvesting of paddy rice in lowland paddy fields, where nearby water was available, even in the dry season. *Elephantopus scaber* growing on paddy levees is used as a medicinal plant. A decoction of leaves and roots are prepared and consumed orally for stomachaches. The major foods sold in local markets derived from woody species included shoots and flower buds of *Azadirachta indica* var. *siamensis*, fruits of *Borassus flabellifer*, shoots of *Careya arborea*, fruits and shoots of *Leucaena leucochephala*, fruits of *Tamarindus indica*, and fruits of *Ziziphus mauritiana*. *Mitragyna rotundifolia* and *Peltophorum dasyrrhachis* were recognized as fast growing species and were pollarded for fuel wood at a height of 2–3 meters every two years. *Pterocarpus macrocarpus*, a remnant tree of original forest, was recognized as providing the highest quality timber of all the local species. *Diospyros mollis* fruits were once used for dyeing. Alcohol or water in which the bark of *Millingtonia hortensis* had been soaked was used as a medicine for coughs. A decoction of *Streblus asper* roots was consumed orally for stomachaches or as an antifebrile.

Moreover, almost all plants in paddy fields had indirect, secondary utility in both villages. Cattle and buffaloes grazed in the paddy fields after rice harvesting. Trees in paddy fields provided shade for both humans and livestock. Villagers in Nakhou village said that shade from the trees protected rice plants from strong sunshine and that fallen leaves from the trees fertilized paddy soil.

Although the average rice yield was 1–3 t/ha in both villages, the yield varied considerably with land quality, amount of fertilizer input, and weather. Most of the grain produced was for self-consumption.

Homestead

In Bak village, mulberry leaves were used for sericulture and *Pentace burmanica* bark was used for betel chewing. Although *Pentace burmanica* was previously extracted from the forest, it had become scarce and was planted around homesteads in recent years. *Annona squamosa* (sugar apple) and *Chrysophyllum cainito* (star apple) were also planted in Nakhou village, but more frequently in Bak village.

Special products of Nakhou village are mats woven from culms of *Cyperus corymbosus*, which was planted in small pools dug within homestead areas and harvested twice a year. *Ceiba pentandra* was also planted in Bak village, but more frequently in Nakhou village. The cotton-like aril of this species (kapok) was used for stuffing pillows and as an income source.

In addition, many common species were planted in both villages. For example, *Mangifera indica* (mango) and *Psidium guajava* (guava) were planted for their fruit; *Bambusa blumeana* for edible shoots and handicrafts; *Cocos nucifera* (coconut palm) for fruit and handicrafts; *Alpinia galanga* (great galangal), *Capsicum frutescens* (bush red pepper), *Citrus hystrix* (kaffir lime), and *Cymbopogon citratus* (lemon grass) for essential spices; *Jatropha curcas* as a fence; *Muntingia calabura* for shade; *Hymenocallis littoralis* for medicine and Buddhist ceremonies; and *Plumeria rubra* as an ornamental.

Plant use on a regional scale

Plant use in Bak village and Nakhou village was also

influenced by plant resource production in surrounding villages. Fig. 3 shows production and distribution of plant resources in the region around Bak village and Nakhou village. Kenkok village is the center of Champhone District and has a local market every morning and evening. Fresh vegetables, fruits, fish, meat, and other products are brought from nearby villages and sold. In Fig. 3, however, the "market" designation for Kenkok village is nominal, indicating only that resources were distributed; sometimes plant resources were exchanged or traded directly between villagers.

Plant resources sold from Bak village were pineapple and *Imperata* thatching. Bananas were sold from Koangton village and watermelon from Phai village. Koangton village and Phai village are adjacent to Bak village on the upper hillside. The people of both villages were engaged in shifting cultivation as well as paddy cultivation. Although bananas and watermelons were also cultivated in Bak village, they were only used for self-consumption. The main plant resource sold from Nakhou village was kapok. Although *Cyperus* spp., were used for mat weaving in Nakhou village, the mats produced were for self-consumption. Within the general region, most mats made of *Cyperus* spp. supplied for trade came from Laonat village, and mats made of *Pandanus* sp. were from Khamsida village. Owing to the limited area of forested land in Nakhou village, fuel wood supply from village resources was insufficient, especially for the distillation of alcohol, cremation, or salt making by boiling. Therefore the Nakhou villagers bought fuel wood from Khamnoi village, which has a large forest area.

Other plant resources were distributed on a larger geographical scale by trade. From the market in a central town in Savannakhet Province about 50 km northwest of both village, Bak village bought traditional medicines, and Nakhou village bought traditional medicines, bamboo screens, and charcoal. Although some types of medicinal plant were available in both villages, others needed for the preparation of traditional medicines were not. These were obtained from other villages in Savannakhet Province or Vientiane Province (about 400 km northwest of Savannakhet Province). The best quality bamboo screens were made of *Schizostachyum zollingeri* and were used for house walls and floors. This bamboo was mainly produced in Khammouane Province (about 120 km north of Savannakhet Province), but was seldom produced in Savannakhet Province. Charcoal was also sold in the market at Kenkok village, but people preferred buying it in bulk from Savannakhet, where the price was lower.

DISCUSSION

To consider the wider applicability of the results of this case study, we discuss the factors influencing plant

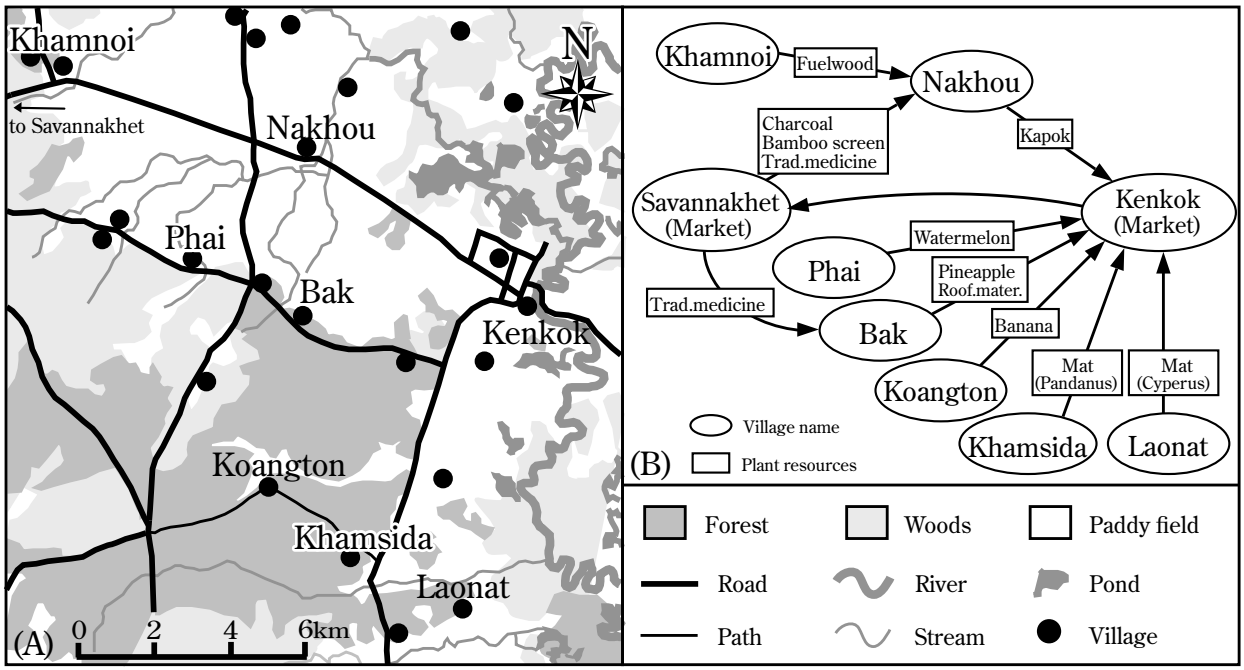

Fig. 3. Production and distribution of plant resources in the region around Bak village and Nakhou village. (A)Map of the study site (Adapted from Republique Democratique Populaire Lao: Service Geographique D'Etat 1982). (B)Production and distribution of plant resources.

use in local communities with reference to three broad categories: geographical factors, socioeconomic factors, and the role of naturalized species. Finally, we discuss the implications of our findings for management and conservation of plant resources.

Geographical aspects of plant use

In this study site, plant use is determined by the actual vegetation present, which is strongly influenced by topography and land-use patterns (Fig. 2, Table 1). This becomes more obvious when we consider the results of previous studies on topography and land-use patterns in northeast Thailand. The topography, climate, flora, and fauna of the Mekong Valley in Laos are similar to those of northeast Thailand (Heckman, 1974), as are the language and culture (Evans & Sengdala, 2002). Northeast Thailand is more densely populated and was largely deforested long before areas on the Lao side of the Mekong were (Evans & Sengdala, 2002). In northeast Thailand, pioneering farmers transformed the land from forests to cultivated fields, first in the lowland (prime areas for paddy fields) and then in the uplands (Vityakon *et al*., 2004). However, this land transformation did not lead to a rapid loss of forest until the 1950s when the economy changed from being primarily subsistence based to a more commercial one, leading to an increase in cash crops such as kenaf, cassava, or sugarcane (Vityakon *et al*., 2004). In this study, in Bak village forest cover was also found to remain in upland areas where cash crop cultivation had not yet been introduced. On the other hand, Nakhou village is located in the lowlands, so only small areas of forest had survived the past clearing for paddy cultivation. However, many trees were left or planted in paddy fields, and this compensated for the lack of forest resources. The presence of trees in paddy fields is also a characteristic of the northeast Thailand landscape (Takaya & Tomosugi, 1972; Grandstaff *et al*., 1986; Watanabe *et al*., 1990; Prachaiyo, 2000) and central Laos (Kosaka *et al*., in press).

Plant resource utilization in each village exploited the natural environment to the fullest. The results of this study suggest that the main crop species grown for income were not common in most adjacent villages (Fig. 3). It was also shown that plant resources were not uniformly distributed among surrounding villages or even provinces and, therefore, adjacent villages or provinces supplemented each other with resources that they lacked. This kind of resource distribution is important at this study site where the rice yield is unstable (Mushiake, 2002).

Influence of socio-economic factors on local plant resources

Socio-economic factors not only change the general condition of land-use patterns, as mentioned above, but also directly influence the relationships between humans and individual plant species. In Bak village, the number of households engaged in oleoresin extraction from *Dipterocarpus alatus* has decreased due to the reduction in trees by logging during the revolution era. On the other hand, oleoresin is still collected in Laos, and demand for it has risen since European perfume manufacturers started to use it as a fixative in perfumes (Ankarfjard & Kegl, 1998). The adoption of dipterocarp oleoresin as a component in perfumes is an encouraging example of a long used non-timber forest product finding a new market after the importance of its traditional use has declined (Ankarfjard & Kegl, 1998).

Diospyros mollis, which grows in the paddy fields in Nakhou village, used to be used by the villagers as a dye. However, this practice has disappeared with the availability of colored clothing, cloth, and fibers at a low price at nearby markets. On the other hand, many dye plants, including *Diospyros mollis*, are still used in some area of Laos and are becoming especially important for export as the worldwide demand for natural dyes is expanding due to increased environmental awareness (Hayashi *et al*., 2002).

Plant resources in Laos occasionally become an income source through access to new external markets. However, local communities do not always receive a steady profit from such discoveries. In the past, some useful species have been over harvested. This clearly occurred in northern Laos soon after Chinese traders made a contract with villagers to buy *Coscinium fenestratum* (personal observation). Further study on useful species is necessary to investigate appropriate uses and management that contributes to rural development (Evans & Sengdala, 2002).

Remarks on naturalized species

Relationships between human and plants are also influenced by biotic factors, such as invasion by naturalized species. In Nakhou village, *Leucaena leucocephala* was not only planted on paddy levees, but was also growing wild as an escaped plant. Although this species was introduced from South and Central America (Smitinand & Larsen, 1985), the fruits and shoots are currently one of the major vegetables in Laos. *Leucaena leucocephala* has been introduced into many areas in the tropics as a feed crop or cover crop, whereas its rapid

expansion sometimes negatively affects indigenous vegetation (Yoshida & Oka, 2000).

Imperata cylindrica var. *major*, which is used for roofing in Bak village, is also a naturalized species. Although it has been locally collected and traded for use as roofing and house wall material, and other uses for centuries in Southeast Asia, it is one of the world's worst weeds (Potter, 1997).

Eupatorium odoratum, introduced into Laos in the 1930s, has become the most abundant weed and fallow species in shifting cultivation fields (Roder *et al.*, 1995). In Bak village and Nakhou village, it was observed more at the edges of forest, along roadsides, on paddy levees, and in grassland than in shifting cultivation fields. This species' use was not documented in the inventory of Vidal (1962), however, its widespread medicinal use as a styptic for wounds in Laos was recorded in our field surveys. In addition, its many favorable attributes as a fallow species were pointed out by Roder *et al.* (1995).

Care needs to be taken with the introduction of non-native species, even if they seem to be useful. The threats posed by some invasive species are so severe that reducing the rate of introduction of non-indigenous species needs to become a greater conservation priority (Primack, 2002). For example, *Mimosa pigra* was once introduced into Thailand as a cover crop for riverbank protection, but is now a serious problem along water bodies because it disrupts fishing activity (Harada *et al.*, 1996). *M. pigra* was not observed at this study site, but its distribution is spreading through many other regions of Laos (personal observation).

Human management of plant resources

The use and management of plant resources in the study area have played a role in their conservation. In Bak village, *Pentace burmanica* and *Tinospora crispa* were transplanted from forest to homestead areas owing to their population decline in forests. Over-harvesting may alter population size, growth rates, and reproductive capacity of harvested species, leading to a reduction in the quantities of non-timber forest products (Hall & Bawa, 1993). Accordingly, moving plants from the wild to protected house gardens may be a way of conserving economically important species in the region (Evans & Sengdala, 2002; Fu *et al.*, 2003). Pollarding, which was conducted in Nakhou village, has recently been reevaluated as a practice that conserves species diversity (Orians & Millar, 1992). In addition, sacred forests, crematory forests, and traditional conservation forests in the villages were also found to contribute to forest resource management. Shifting cultivation produces an extensive area of ecologically and economically valuable fallow vegetation, although it is being phased out throughout mainland Southeast Asia (Schmidt-Vogt, 2001). Moreover, several land-use classes under human management in Bak village and Nakhou village contained many unique useful plants, and surrounding villages had their own products with otherwise limited availability, resulting in a variety of available useful plant species, both at the local and regional level.

Traditional botanical knowledge is neither static nor uniform as is often assumed, but is generated, maintained and modified according to local ideology, external social or practical influences, and changing resource availability (Cotton, 1996). In Laos, uniform application of the Forestry Law will cause a conflict between traditional land-use systems and newly established forest demarcation (Namura & Inoue, 1998; Hyakumura, 2001; Yokoyama, 2004). In such cases, a reevaluation of indigenous knowledge, use, and management of natural resources may provide clues to mitigate the problem.

CONCLUSION

Plant use at this study site was influenced mainly by topography and land-use and partly by socio-economic conditions and invasion by naturalized species. Bak village is located on an upper hillside and still has a large area of forest. There were abundant forest products and specific useful plants in several other land-use classes. On the other hand, Nakhou village is located on lower flat land and has few areas of forest because of earlier conversion to paddy fields. However, the villagers coped with the lack of forest resources by using and managing trees in paddy fields in multiple ways. In addition, plant resources in surrounding villages influenced plant use in both villages. Each village utilized specific plant resources by making the most of those locally available and supplementing deficiencies through trade.

Thus, this analysis of local plant use on different geographical scales shows that the relationship between humans and plants in this study site was flexible. Moreover, it is also shown that the number of available useful plant species was enhanced at the local level with a mosaic distribution of land-use and also at the regional level by trading specific products between villages. Therefore, it is suggested that species inventories and descriptions of the external factors influencing plant use at different geographical scales within a spatially heterogeneous landscape, can form an important basis

for management and conservation of the plant resources of local communities.

ACKNOWLEDGMENTS The authors wish to express profound gratitude to Prof. H. Furukawa, Prof. K. Tanaka, Prof. S. Kobayashi, Dr. A. Iwata, Mr. E. Mushiake, and the two anonymous reviewers for their valuable advice. Gratitude is also extended to Mr. S. Soukkongseng, Mr. C. Houngpheth, Mr. P. Thavy in NUOL (National University of Laos), PAFO and DAFO (Agriculture and Forestry Office) in Savannakhet Province, Laos, and Dr. W. Eidthong in Kasetsart University, Thailand. Finally, this research would never have been completed without the generous hospitality of the villagers in Bak village and Nakhou village. The field survey was supported in part by the Toyota Foundation and the 21st Century COE Program "Aiming for COE of Integrated Area Studies" (Project of the Japanese Ministry of Education, Culture, Sports, Science and Technology).

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Received 30th June 2005
Accepted 21st Dec. 2005