Introduction

The practice of fallowing (leaving the land 'idle' for one or more years between cropping period) is one crucial component in traditional shifting cultivation but this aspect is often ignored as part of the management system (Spencer, 1966; Santisuk, 1988; Conklin, 1957 and Ruddle, 1974). Above all, clearing and burning of fallow regrowth are negatively seen as the major cause of deforestation and degradation of ecosystem as a whole. This has led many governments to impose policies to suppression of shifting cultivation and promote settled agriculture with intensive productions. At the same time, increasing population also increase intensity of land use in shifting cultivation with shortening the fallow periods and that improved technology could help to intensify land use (Boserup, 1965). In northern Thailand, shifting cultivation is commonly practiced by ethnic minority groups, i.e., Karen, Hmong, Lisu, Lahu, Akha, Lua and Yao, but there is also non-traditional shifting cultivators on the uplands (Kunstadter and Chapman, 1978). I am interested only in those groups who traditionally actively manage the rotational bush fallowing for the production of subsistent crops, especially the upland rice. In the traditional systems, as long as fallow is left long enough to allow natural vegetation to regenerate and reach maturing stage without any interruption, clearing and burning of the above ground biomass would release adequate nutrients necessary to maintain yield of upland rice. In the humid tropic, nutrient cycling is more dependent on above ground biomass rather than accumulation in the soil (Ovington, 1962). When the length of fallow decreases, natural regeneration may proceed to younger stages of vegetation succession with less biomass and hence nutrient accumulation, the subsequent yield of upland rice declines (Nye and Greenland, 1960; Kunstadter *et al.*, 1978 and Trenbath *et al.*, 1990). Further intensification without external inputs from chemical fertilizer could eventually lead to the collapse to degraded shifting cultivation (Andreae, 1980; Sanchez, 1976; Ruthenberg, 1978 and Greenland and Okigbo, 1983). Since 1960s, fallow period of shifting cultivation in northern Thailand has been decreasing from a length of 10-15 years to 7 years and less (Rerkasem and Rerkasem, 1994). Permanent and continuous cropping is rapidly replacing shifting cultivation. The remaining shifting cultivation is being practiced with shorter rotational period.

Both internal and external pressures are impinging on traditional shifting cultivation, e.g., population, migration, commercialization as well as government policies (Rerkasem and Rerkasem, 1994 and Rerkasem, 2001). As long as population density is low and the pressure to produce large surpluses of crops is also low, management of shifting cultivation may be productive and unlikely to be resulted in any significant degradation (e.g. Kunstadter *et al.*, 1978; Rambo, 1990 and Lovelace, 1991). This situation is difficult to be met in the real world of today. Examples from northern Thailand show that, under increasing population density, restriction of land use and government policy to encourage sedentary settlement, traditional shifting cultivation with long fallow has currently shifted to shorter rotation with increasing cultivation. Total transformation of land use to permanent cash cropping is also common in many areas. Where shifting cultivation remains and external inputs are unaffordable, rice yield declines. Planted fallow offers an alternative to long rotational shifting cultivation. The idea is to plant exotic tree and other useful shrub species to improve the fallow (e.g., Tarawali, 1991; Kwesiga and Coe, 1994; Mafongoya and Nair, 1997 and Kaya and Nair, 2001). Fast growing trees and shrub (N-fixation), e.g., *Luecaena leucocephala, Cajanus cajan, Flemingia congesta, Gliricidia sepiun* have been promoted in Southeast Asia but evidence of successes are limited (Schmidt-Vogt, 1995). Little is known about the dynamic of shifting cultivation and regeneration of forest fallows to restore the degraded systems. In theory, it is suggested that the dynamic of shifting cultivation is dependent on multiple equilibrium with stable and unstable domains of attraction (Trenbath *et al.*, 1990). Failure to maintain stable equilibrium with forest fallow could result in the collapse of the shifting cultivation when it passes the unstable domain of equilibrium. Beyond this point, yield of upland rice is very poor without chemical fertilizers and the system is regulated with the dominance of grasses and herbaceous weeds.

Understanding the key processes of the dynamics of shifting cultivation will lead to the restoration of upland rice productivity and rehabilitation of degraded shifting cultivation systems and preventing them from irreversible collapse. Therefore, the productivity of upland rice and associated crops can be maintained to support rural livelihoods on a long-term basis. This study was undertaken in Tee Cha village of Sop Moei district, Mae Hong Son province. It is a Pwo Karen village which has been settled for > 200 years. Despite social and economic changes, traditional shifting cultivation remains the major agricultural system in the village. In spite of the fallow period that has been shortened to only 6 years, with cropping in the 7 years, farmers maintained that their system of shifting cultivation is sufficiently productive, provided that there are dense stands of a particular tree called Pada (*Macaranga denticulata*) in the fallow. This study site provides opportunity for examination and identification the key processes associated with the maintenance of productivity of a shifting cultivation system with such a shortened fallow period, and the role of the fallow enriching tree.

The objectives of the present study are

1. to examine farmers' management of fallow and crop diversity in the face of change and their efforts to encourage *Macaranga denticulata* in shifting cultivation fields,
2. to evaluate variation in fallow vegetation in different succession stages and determines the dominance of *Macaranga denticulata* in various stages of the shifting cultivation cycle, and
3. to determine the effects of *Macaranga denticulata* on yield of upland rice.

Chapter 1

Literature review

1.1 The uplands of Northern Thailand

Northern Thailand, located between latitude $16^0\ 20'$ and $20^0\ 30'$ N and longitude $97^0\ 30'$ and $100^0\ 30'$ E, has a predominantly mountainous terrain, mountain ranges aligning north - south. The larger, and central, part of Northern Thailand is drained by the main head water of the Chao Phraya southwards into the Gulf of Siam, the northeastern sector into the Mekong, and the northwestern sector into the Salween and so through Myanmar into the Andaman Sea. The area is known historically associating with other civilizations in the Southeast Asia region (Penth, 2000). With exception of Phichit, Phitsanulok and Suklothai, the rests of the provinces are dominated by mountainous area with steep slope (Department of Land Development, 1989). The total area is approximately 171,000 km^2, covering 12 provinces (Figure 1.1). The climate of the region is monsoonal and characterized by three distinct seasons: the wet season from mid-May to October when the region comes under the influence of the southwest monsoon; the cool dry season from November to the end of February during which time the northeast monsoon bring dry cold air south from continental Asia; and a hot dry summer from the end of February until mid-May when the region comes under the influence of the southeast monsoons. Common soil is acrisols (poor fertility especially phosphorus) on slope with an inclination of 20^0 to 40^0, cambisols on steeper slopes, and ferralsols on more gentle (Schmidt-Vogt, 1999). In 2001, it was estimated that a population of one million people lived in the forests and protected areas of this mountainous region, occupying 400,000 ha of land under shifting cultivation (Rerkasem, 2001) and the Karen populations are biggest group of the total population of lived in the forest and protect area.

1.2 Extent, distribution and forms of shifting cultivation

Shifting cultivation was once the most widespread cropping system in South and Southeast Asia, is now predominant in Borneo and the hills of Thailand, Laos, Myanmar, Vietnam, Cambodia and Southwestern China (Spencer, 1966; Warner, 1991; Thrupp, 1996; Banerjee, 1995 and Ramakrishnan, 1984). Conklin (1961) defined the term 'shifting cultivation' as an agricultural system in which fire is commonly used to clear fields and the period of cropping is normally shorter than the fallow period. The term has been widely adopted among many research scholars and development personals (e.g. Izikowitz, 1951; Keen, 1972 and Sutthi, 1996). The current extent of shifting cultivation in Asia is not accurately known but it was estimated with a wide range of 70-120 million ha (Banerjee, 1995). The countries of mountainous mainland Southeast Asia varied in the extent of shifting cultivation in both actual area and percentage of forest occupied by shifting cultivation (Table 1.1). Thailand has about 0.4 million ha of shifting cultivation, which accounts for 3.14 % of the country's forest area. The practice of shifting cultivation is well known among the ethnic minorities who live on the mountains along the border of Northern and Western parts of Thailand (McKinnon and Bhruksasri, 1983 and NRC, 1987). The highland population has more than tripled from 217,000 in 1960

(Young, 1961) to 750,000 in 1993 (Rerkasem and Rerkasem, 1994). It is widely thought that this type of cultivation is simple and primitive and involves cutting and clearing of primary or secondary forests followed by burning and cropping until the soils are exhausted, after which they move to new patches of forest. With this reason the Thai term "Rai Luen Loi" is still commonly used to refer to shifting cultivation without any classification of different types. This terminology conveys the management of shifting cultivation that is exploitative, unsustainable and uniform. Shifting cultivation is, however, not uniform but it is a diverse system of natural resource management providing many products and services to the landholders and communities as a whole (Thrupp, 1996).

Table 1.1 Extent of land under shifting cultivation in mountainous mainland Southeast Asia region.

Country	Total Land Area	Total Forest Area	Shifting Cultivation Area	% Forest under Shifting Cultivation
		(10^3 ha)		
Cambodia	17,652	12,163	n.a.	n.a.
Laos	23,080	13,173	400	3.04
Myanmar	65,774	28,856	181	0.63
Thailand	511,770	12,735	400	3.14
-Northern Thailand	16,966	7,523	400	5.32
Vietnam	32,536	8,312	3,500	42.11
China (Yunnan Province)	39,410	9,533	130	1.36
Total	229,629	84,772	>4,611	5.44

Sources: Rerkasem (2003)

Note: n.a. designates data not available

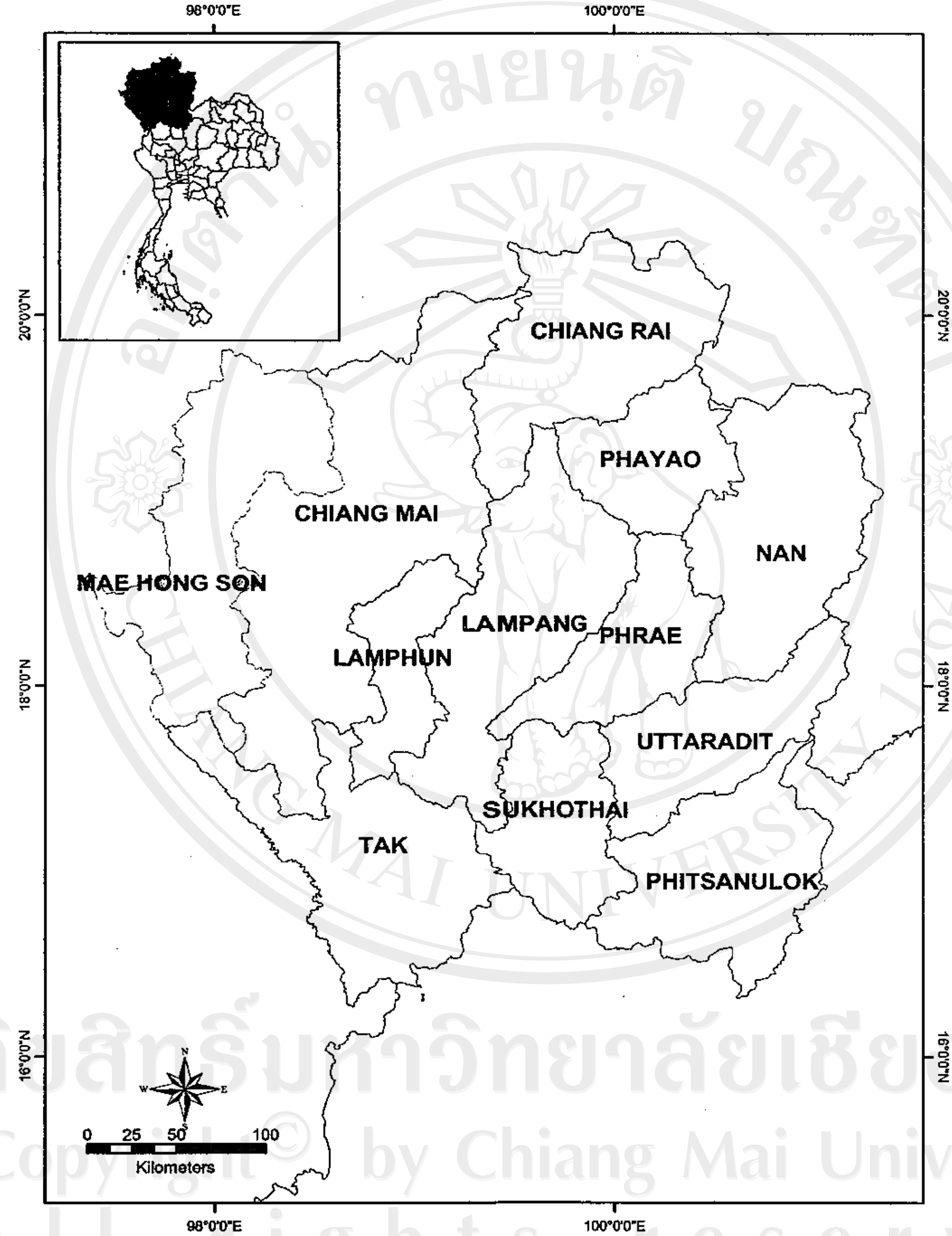

Figure 1.1 Provincial boundaries of Northern Thailand.

Many types of shifting cultivation have been cited in the literature (Warner, 1991), but three major types have been distinguished according to the management of fallow periods (Kunstadter *et al.*, 1978). These are 1) short-cropping and short-fallow periods (often used by Northern Thai), 2) short-cropping and long-fallow periods (often used by upland Karen and Lua), and 3) long-cropping and long-fallow periods (often used by Hmong and other opium-growing hill tribe groups). Lowlanders who recently encroached and/or transmigrated to the upland are sometimes counted as practicing another type of shifting cultivation, but they are not traditional shifting cultivators and their practices are destructive to natural vegetation and the environment (Rerkasem, 2001). This type of shifting cultivation is not considered here. Neither will the first type of shifting cultivation by lowland Thais be considered here because it has largely been replaced by permanent cropping of corn and other cash crops.

In principle, short cropping and long fallow cycles managed on permanent fields, around the established village allowing local households to rotate their crop and fallow fields, (Nakano, 1978 and Zinke *et al.*, 1978) are characterized as rotational shifting cultivation (Kunstadter *et al.*, 1978). In northern Thailand, some ethnic minorities, especially the Karen or Lua, would clear a large tract of land by slashing undergrowth and weeds, and lopping big trees of secondary forests for drying and burning before the onset of the wet season. Burning of vegetation releases nutrients previously stored in the forest biomass onto the soil surface and makes it available for the crops during cultivation period. Burning also helps to neutralize acid soil. The fields may be in crops for 1-2 years to avoid intensive use of land leading to severe soil fertility depletion and increasing weed infestation. The community then decides collectively to choose the next field in rotation, leaving the first field to lie fallow and naturally regenerate. After fallow regeneration reaches a mature stage providing sufficient biomass to enable productive re-cultivation, the full cycle of shifting cultivation is complete and this may take 10-15 years, depending the degree of land scarcity. In contrast to rotational shifting cultivation, the pioneer system usually involves non-permanent villages that move into the primary forest for a longer period of intensive cultivation, perhaps 10-15 years (Kunstadter *et al.*, 1978 and Rerkasem and Rerkasem, 1994). When the soil fertility is severely depleted, the fields are ready for abandonment for natural regeneration. However, vegetation succession may proceed to grass or herbaceous weed climax. By this time farmers have already moved to new location in another area and open up primary forest for cultivation. The practice of pioneer shifting cultivation is said to be unsustainable and destructive to natural vegetation and environment. Shortening fallow period or intensive cultivation during the cropping phase could give rise to grass or weedy climax with the dominance of *Imperata cylindric* or *Chromolaena odorata* in Southeast Asia and elsewhere.

1.3 Restoration of upland rice yields in degraded shifting cultivation

The idea of restoration was introduced by ecologists in the middle of 1970s (Cairns, 1980). In the early years, it was used to describe degraded ecosystems such as polluted rivers and lakes to strip mined land as well as disturbed ecosystems, e.g., logging area or recreation sites. The extensions of the concept and idea to agro-ecosystems have been fairly recent (Hobbs, 2001) and this has significant implications to the area of shifting cultivation where this managed systems is being degraded.

1.3.1 Concepts and ideas of restoration

"Ecological restoration" covers a wide range of activities involved with the repair of damaged or degraded ecosystem and is usually carried out for one of the following reasons (Hobbs, 2001):

1. To improve productive capability in degraded production land. Degradation of productive land is increasing worldwide, leading to reduced agriculture, range, and forest production. Restoration in these cases aims to return the system to a sustainable level of productivity, e.g., by reversing or ameliorating soil erosion or nutrient problems in shifting cultivation system.

2. To enhance nature conservation values in protected landscapes. Conservation lands worldwide are being reduced in value by various forms of human induced disturbance, including the effects of introduced stock, invasive species (plant, animal, and pathogen), pollution, and fragmentation. In theses cases, restoration aims to reverse the impacts of theses degrading forces, for example by removing an introduced herbivore from a protected landscape.

3. To restore ecological processes over broad landscape-scale or regional area. In addition to the need for restoration effects within conservation land, there is also a need to ensure that human activities in the broader landscape do not adversely affect ecosystem processes. There is an increasing recognition that protected areas alone will not conserve

biodiversity in the long term, and that production and protection land are linked by landscape scale processes and flows (e.g., hydrology, movement of biota). Methods of integrating conservation and productive use are thus required, as for instance in the biosphere reserve and core buffer matrix models (Hobbs, 1993; Morton *et al.*, 1995; Noss and Cooperrider, 1994). Restoration in this case entail (1) returning conservation value to portions of the productive landscape, preferably through an integration of production and conservation value and/or (2) ensuring that land uses within a region do not have adverse impacts on the region's ecological processes.

1.3.2 Dynamic of restoration

Ecological restoration occurs along a continuum from the rebuilding of totally devastated sites, to the limited management of relatively unmodified sites (Hobbs and Hopkins, 1990 and Hobbs and Norton, 1996). Ecosystem restoration seeks to return some aspects of the natural ecosystem to the treated area. Characteristics of natural ecosystem can be summarized as follow (Hobbs and Norton, 1996):

1. Composition: species present and their relative abundances.
2. Structure: vertical arrangement of vegetation and soil components (living and dead).
3. Pattern: horizontal arrangement of system components.
4. Heterogeneity: a complex variable made up of components 1-3.
5. Function: performance of basic ecological processes (energy, water, nutrient transfers).
6. Species interaction: includes pollination, seed dispersal.

7. Dynamics and resilience: succession and state-transition processes, recovery from disturbance.

Higgs (1997) similarly suggested that restoration goals should focus on three elements; namely structure/compositional replication, functional success and durability. Much of restoration ecology is backwards looking, seeking to recreate ecosystems with properties, which were characteristic of the system at some time in the past. There has been increasing debate as to whether this is either desirable or possible, due to the dynamic nature of ecosystems, and the irreversibility of some system changes (Pickett and Parker, 1994 and Aronson *et al*., 1995).

1.3.3 Degradation of shifting cultivation

When there is enough land, and enough time for the fallow to regenerate, shifting cultivation can be quite productive and sustainable. Degradation of shifting cultivation occurs when the loss of fallow biomass and crop yields could be observed and this implies that the capacity of shifting cultivation fails to regulate the system on a long-term basis.

The symptoms of degraded shifting cultivation are numerous and some the past lessons and experience may be summarized follow:

1) The yield decline, in Dong Luang, a Pwo Karen community in the Mae Sarieng, rice yield in long fallow of > 10 years was reported as high as 2.3 tons ha^{-1}, with shorter fallow period rice yield was as low as 0.91 tons ha^{-1} (Hinton, 1978). In northern Thailand, yield of upland rice was recorded above 1.5 ton ha^{-1} in late 1960s when fallow

period was maintained >15 years much longer but the figure fell below 0.8 ton ha^{-1} in late 1970s with much shorter fallow period (Grandstaff, 1980).

2) Soil fertility decline and build up of weeds disease and pest, short fallow period means the delay in natural regeneration and hence repeated practice of short fallow could lead to deterioration of shifting cultivation due to soil fertility decline and perhaps, weed disease and pest build up (Nye and Greenland, 1960; Trenbath *et al*., 1990 and Warner, 1991).

3) Loss of crop diversity, Sutthi, 1989; Santasombat, 1998 and Ganjanaphan *et al.*, 2004 suggest that, reduction of shifting cultivation cycle was said to have negative impact on these biodiversity loss of genetic resources of traditional crop species and varieties has been raised and now becomes the national and local issues in campaigning conservation of traditional practices.

4) Forest succession postponed nutrient cycle in shifting cultivation. The short fallow period induced to negative change of the ground biomass accumulation and have effect to nutrient cycle and hence to productivity decrease.

1.4 Some attempts to restore degraded shifting cultivation with fallow management.

There have been many attempts to restore the degraded shifting cultivation. Many technical recommendations have been suggested to reverse the declining trend in crop productivity with shorter fallow periods. These include construction of bench terrace and vegetative strips to support sedentary agriculture (Harper, 1986 and Enter, 1996), introducing fast growing tree species for enriched fallow or alley cropping practice with fast growing legumes such *as Luecaena leucocephala, Gliricidia sepiun, Cajanus cajan, Flemingia congesta* and others. In Africa, much effort has gone into introduction of trees and other plants as fallow-enriching species (e. g., Tarawali, 1991; Kwesiga and Coe, 1994; Mafongoya and Nair, 1997and Kaya and Nair, 2001). In 1970s a development project in Northern Thailand introduced bench terracing as alternative to short rotational shifting cultivation in Nan province (Harper, 1986). Attempts have been made with these alternatives but the scale of success is often limited with highly variable results. Some technical problems associated with the techniques; for instance, heavy infestation of Psylids after the introduction of *Luecaena leucocephala*, or poor seed germination and establishment (Rerkasem, 2001). Small holders are finding difficulties in applying these alternatives to overcoming problems arising from short fallows in shifting cultivation. Upland farmers in many areas in the region are seeking other alternatives on their own.

The fallow management strategies is one of alternatives to overcoming problems arising from short fallows in shifting cultivation, with focus on the intensification of the cropping period through the incorporation of species that enhance soil fertility restoration as the traditional fallow period is shortened (Beer, 1983, Budowski, 1987; Padoch and De Jong, 1987; Raintree and Warner, 1986 and Unruh, 1990). The context consists of changes in the biophysical, social, economic, and political environment. Three types of adaptive strategies have been distinguished: 1) improved fallows focusing on increasing the rate of restoration of soil fertility and other ecosystem properties following cropping, such as reduction in pernicious weed population; 2) enriched fallows focusing on increasing the direct economic benefits of natural fallow vegetation; and 3) focus on integrating soil fertility and economic benefits through integration of livestock.

Improved fallows have been proposed as a management alternative to shifting cultivation in the tropics (Nye and Stephens, 1962). The shifting cultivators, by encouraging the presence of certain species in fallows, have traditionally used this practice to restore soil fertility, suppress weeds, and increase economic yields (Beer, 1983; Budowski, 1987; Padoch and De Jong, 1987; Raintree and Warner, 1986 and Unruh, 1990).

Van Keen *et al.* (1996) suggested that the fallow land has mainly an agriculture function towards the subsequent crop. Indeed, the main reason why a swidden farmer leaves a plot fallow is that he expects to obtain a yield in the first year after a fallow that is higher than the yield in the last cropping year before the fallow started. Therefore, a fallow is expected to perform 2 main tasks: 1) to rebuild soil fertility, i.e. to raise the physical, biological and chemical soil condition to levels that are more favorable than those at the end of the last cropping cycle. And 2) to clear the land of a wide range of crop pests (weed, soil-borne pests and above-ground pests).

Koutika *et al.* (2002) suggested that the fallow management plays a key role in supplying nutrients to the growing crop, suppressing weeds, reducing pests and diseases, and improving the sustainability of cropping systems in the humid forest. These included nutrient availability and storage (Russell, 1973 and Woomer and Ingram, 1990), and an increase in buffering capacity and water-holding capacities (Swift and Sanchez, 1984). Soil organic matter plays an important role in nutrient cycling in the tropical systems

(Sanchez and Miller, 1986; Woomer *et al.*, 1994; Myers *et al.*, 1994 and Barrios *et al.*, 1996). Moreover, fallows may also supply a source of cash income for the farmers through the existence or planting of specific economic valuable species. In addition, fallows may provide products that serve as agricultural inputs, such as fodder, construction materials, fencing materials and utensils for domestic use for farms with a livestock component (Dennis *et al.*, 2000).

In practice, three types of traditional enriched fallow can be identified by Kass *et al.* (1993): (1) multi species fallows similar to natural secondary vegetation but enriched with certain species; (2) less diverse fallow in which one species dominates the regenerating vegetation after burning and clearing; and (3) planted fallow in which one or more species with biological or economic value are introduced in order to shorten the fellow's regeneration period or increase its economic worth.

The strategies depend upon the length of fallow period available and this determines suitable management regimes for fallow succession, i.e., weed succession, bush fallow and secondary forest succession (Rerkasem, 2001). For example, farmers in Sepone district of Laos are producing upland rice intensively and cultivate the land for 2-3 crops before leaving the fields for fallowing. Length of fallow periods also determines the dominant species in fallows; i.e., either a broadleaf weed *(Chromolaena odorata)* or a mixture of bamboo species. Farmers recognize the contribution of *Chromolaena odorata* as soil builder. After 4 years of regrowth, solid stands of *Chromolaena* could improve soil fertility and soil structure substantially. Production of upland rice in the area may vary between 600-1500 kg of output per 50-60 kg of seed sown (Chansina, *et al.,* 1991).

In Northern Vietnam, the introduction of leguminous trees such as *Tephrosia candida* has enabled a decrease in fallow length from to 10-15 to 4-6 years. Farmers in northern Thailand are also finding other weed species useful for soil building in the 1-3 years of fallow regeneration, e.g., *Ageratum conyzoiddes, Euphatorium adenopphorum and Blumea balsamifera* (e.g., Schmidt-Vogt, 1995). In the Hmong village of Chiang Mai province in northern Thailand, they are managing the fallow succession for a climax of a weedy species (*Mimosa invisa*), which is being used to build soil fertility of former highly degraded land and forest (Rerkasem *et al.*, 2002).

In the Americas (Kass *et al.*, 1993), six traditional fallow systems are 1) enriched fallow of the Amazon, 2) babassu palm (*Orbignya phalerata* Mart.) forests of central and northern Brazil, 3) bracatinga (*Mimosa scabrella* Benth) improved fallow of southeastern Brazil, 4) carbon negro (*Mimosa tenuiflora* Willd.) fallow of the wet-dry zone of Mesoamerica, 5) frijillo (*Senna guatemalensis* Donn. Smith) of high-elevation zone in southern Honduras, and 6) caragra (*Lippia torresii*) fallow of humid zone of Costa Rica. In the India, the indigenous knowledge of farmers based fallow management practice is used Nepalese alder (*Alnus nepalensis*) useful for soil building in the 5 years of fallow regeneration in shifting cultivation (Ramakrishnan and Saxena, 2005).

In Northern Thailand, previous studies of fallow succession have been carried out in rotational fields' cultivation by Lua and Karen communities' tribes (Kunstadter *et al.*, 1978; Sabhasri, 1978; Nakano, 1978 and Schmidt-Vogt, 1995, 2001). In rotational systems, the length of cropping and fallowing and shifting cultivation practices determine the development and structure of fallow regrowth in secondary forests. Sabhasri (1978) pointed out that the length of fallow periods should be at least 10 years for fallow regrowth to real maturing stage. Nakano (1978) has shown that the length of fallow period is crucial to the recovering of soil fertility through the amount stored in the vegetation. As fallow periods become shorter, weeds become dominant. Eupatorium a duration, for example, could survive abundantly under young secondary forest of five years of fallow in Karen community of Mae Tho area, Chiang Mai province. Management that allows tree stumps and roots in upland rice field are also crucial for fallow regeneration and succession (Schmidt-Vogt, 2001). Coppice shoots and root suckers can develop quickly. Large trees left during bush cleaning, referred to as "relict emergent" differ among different ethnic groups. Lua practices selective felling of trees with diameter > 15cm at an average 244 relict emergent ha^{-1}. Karen, on the other hand, does not seen to have any idea of selective cutting and apparently fall large and small tree at random. Nevertheless, their shifting cultivation field may contain 20-40 relict emergent. With exception of Nakano (1978), others studies deal with long fallow system between 9 to 17 years.

1.5 *Macaranga denticulata*

Macaranga denticulata is a relatively large genus of pioneer species (Whitmore, 1982). *Macaranga denticulata* (Bl.) Muell. Arg. is well known locally for its fallow-enriching property amongst the various ethnic groups who make a living on rotational shifting cultivation in northern Thailand. It is known as *Teen Tao* amongst the *Khamu* and *H'tin* who populate the northeastern mountains, on the border with Laos. *Pada* is the name in *Skaw Karen* (Thailand's largest minority group, now concentrated along the western border with Myanmar), while the *Pwo Karen* call it *Letha*. The *Lua* (who are believed to have been the dominant group in the region until about a thousand years ago) calls it *Tong Coab*. The *Akha* (a group not known to practice rotational shifting cultivation in Thailand) calls the tree *Loom Piah*. Amongst lowland *Thai* it is variously called *Tong Taeb, Tong Tao, Tao Maew, Por Khee Haed* or *Bai Hoo Chang*. Pada is a small evergreen tree of the Euphorbiaceae family, which can reach 19 m in height and up to 40 cm in diameter at breast height. *Macaranga denticulata* is a pioneer tree in early succession; its role in natural regeneration may be associated with other long lived species in later stages of succession such as *Castanopsis* and *Lithocarpus* species and other climax species. Youpensuk *et al.* (2004) found 30 species of arbuscular mycorrhizal (AM) fungi in the rhizosphere of *Macaranga denticulata* growing in the farmers' fields. The colonization rates in *Macaranga denticulata* roots were recorded as being as high as 75-90%. Numbers of spores around the root systems of *Macaranga denticulata* seedlings were about 30-45 spores/g of soil. AM fungi are known to improve the nutritional status of plants (e.g., N, P, K, Ca, Mg, Mu, Cu and Zn) resulting in increased growth (Marschner and Dell, 1994 and Taylor and Harrier, 2001). Dodd *et al.* (1990) reported the combination treatments of AM fungi and rock phosphate have the potential to increase plant growth where phosphorus is limiting plant production.

This thesis aims to measure the contribution of a fallow enriching species, *Macaranga denticulata*, in the reduced fallow cycle of traditional shifting cultivation in a Karen village of Sop Moei in Mae Hong Son province, in Northern Thailand. The ways in which farmers are managing shifting cultivation to prevent degradation due to reduction of fallow periods and maintain productivity and biodiversity of swidden crops and fallow tree species will be examined.