Agroforestry, Energy and Sustainability in the Tea Industry of Upper North Thailand

by

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We accept this thesis as conforming
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Abstract

In Upper North Thailand, fuelwood shortages threaten the production of miang (a fermented tea product) and green tea. Large amounts of firewood and charcoal are needed to process tea leaves. Government restrictions on cutting in the forest have increased firewood collection in the tea gardens, threatening the sustainability of this upland agroforestry system. Most tea growers still collect a substantial portion of their firewood from the forest, causing a great deal of tension between the villagers and forest officials. Fuelwood supply problems, labour shortages and insecure land tenure threaten the livelihood of the tea producers.

This study examines the tea gardens as an upland agroforestry system; assesses the health of the tea gardens; examines miang and green tea production; and expands the range of alternatives for resolving the firewood supply problems. It is structured as follows: (1) problem definition (resource scarcity, fuelwood supply shortage); (2) examine the resource base: tea gardens (upland agroforestry system) and management practices; (3) examine the resource-use system: miang and green tea production, fuelwood use and supply, attitudes and perceptions of the tea growers; (4) evaluation: current coping strategies; and (5) recommendations: expand the range of alternatives for resolving the resource-scarcity problem.

The problem is studied from a resource management perspective which attempts to expand the range of choice for resolving the fuelwood supply problems. Physical and social surveys provide the primary data. Fixed boundary vegetation sampling plots from 0.5 to 1.5 rai in size (13 completed) examine the biophysical characteristics of the tea gardens. Indepth interviews (10) with tea garden owners examine management practices. Written questionnaires were administered to miang producers (57), non-miang producers (30) and tea factory owners (6) to study tea production and fuelwood supply and consumption. They also provided information regarding the socioeconomic characteristics of the villagers and attitudes and perceptions of the tea growers regarding fuelwood use, deforestation and other resource-use problems. Twenty personal interviews completed with other key informants (i.e. government officials) and field observations added information and helped interpret the data collected by these other methods.

The tea gardens have about one third the density and diversity of similar relatively undisturbed deciduous/evergreen monsoon forest. Due to weedy ground cover and/or poor forest tree regeneration, 7 of the 13 vegetation plots are unhealthy. Weedy ground covers hinder forest tree regeneration, compete with the tea trees for water and nutrients, and require heavy slashing which increases sapling mortality. Maintaining forest cover is critical to the health of this agroforestry system and care must be taken that weedy species do not increase. In some areas, weeds like *Eupatorium adenophorun* dominate the ground cover; it is a major problem in two of the gardens studied.

Four-fifths of the miang producers are facing firewood supply and/or access problems. Six green tea factories were studied: one has stopped using charcoal; one has switched from green tea to miang partially due to fuelwood supply problems; and two owners stated that they will be forced to close in the next 2-3 years if the fuelwood problem continues.

The physical and social survey data provided the foundation for an evaluation of the problem and the development of realistic recommendations. A four-part strategy is proposed for the miang industry which uses the natural regenerative capability of the forest cover and innovation in management by the traditional tea growers to decrease firewood use and increase forest cover in the tea gardens. This proposed strategy is not labour or resource demanding and is 'appropriate' for the villagers' needs. Woodlots are necessary to meet the fuelwood needs for the green tea factories.

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Table of Contents

Page Number

Title Page. i

Abstract. ii

Table of Contents. iv

List of Tables. xii

List of Figures. xvi

Acknowledgements. xviii

Dedication. xix

Chapter 1. Introduction.

1.1 The Study. 1

1.2 Regional Setting. 1

1.3 Tea Production in Northern Thailand. 5

1.4 Energy Shortages in the Traditional Tea Industry. 7

1.5 Goals and Objectives. 10

1.6 The Need for This Study. 12

1.7 A Geographical Approach. 13

Chapter 2. Smallholder Tea Gardens as an Agroforestry System, Fuelwood Use and Deforestation: A Review.

2.1 Introduction. 15

2.2 Agroforestry. 15

2.3 Tea Production in Thailand. 19

2.3.1 Types of Tea Produced in Thailand. 21

2.4 Fuelwood: The Primary Source of Energy. 24

2.4.1 Wood Energy in Industry. 26

2.5 Traditional Energy Consumption in Thailand. 28

Table of Contents cont.

	2.5.1 Wood Energy for Rural Industries in Thailand.	30
	2.5.2 The Future Use of Traditional Fuels.	32
2.6	The Fuelwood Crisis and Related Problems.	33
2.7	Deforestation in Thailand.	34
2.8	Management Strategies to Deal With Fuelwood Shortages.	36
2.9	Summary.	38
Chapter 3.	Conceptual Framework, Research Design and Study Area.	
3.1	Human-Environment Relations: A Geographic Approach.	40
3.2	Conceptual Framework.	41
	3.2.1 Resource-Use System.	42
	3.2.2 Borrowing From Hazard Research.	42
	3.2.3 Research Design.	44
3.3	Tea Garden Survey and Preliminary Inventory of the System.	48
	3.3.1 Sampling Strategy for the Vegetation Plots.	48
	3.3.2 Plot Location.	49
	3.3.3 Plot Layout.	50
3.4	Written Questionnaire.	52
	3.4.1 Miang Producer Survey: The Resource-Use System.	53
	3.4.1.1 Instrument Design.	53
	3.4.1.2 Target Group.	54

Table of Contents cont.

	3.4.1.3 Pretest.	55
	3.4.1.4 Population and Sample Size.	56
	3.4.1.5 The Miang Producer Survey.	56
	3.4.2 Supplemental Survey.	57
	3.4.3 The Non-Miang Producer Survey.	58
	3.4.4 Tea Factory Survey.	58
3.5	Personal Interviews.	59
3.6	Field Observation.	60
3.7	Study Area.	61
	3.7.1 Villages Selected for Study.	68
3.8	Overview.	71
Chapter 4.	Tea Gardens: An Upland Agroforestry System in Northern Thailand.	
4.1	Introduction.	73
4.2	Tea Gardens.	73
4.3	Vegetation Plots.	76
	4.3.1 Plot One: An Example of a Block Plot.	77
	4.3.2 Plot 4: An Example of a Strip Plot.	82
	4.3.3 Plot 8: A Second Block Plot.	88
4.4	Summary of Vegetation Plots.	89

Table of Contents cont.

4.4.1 Comparison of Strip Plots. 96

4.4.2 Accessibility and Forest Cover. 100

4.5 Tea Gardens and Undisturbed Forest: A Comparison. 101

4.6 Forest Cover in the Tea Gardens. 107

4.6.1 Canopy and Midcanopy. 108

4.6.1.1 Uses for Common Upper Canopy Trees. 109

4.6.2 Understorey. 114

4.6.2.1 Uses for Common Understorey Trees. 115

4.7 Forest Cover Regeneration. 117

4.8 Ground Cover. 119

4.8.1 Ground Cover as an Indicator of Health. 120

4.9 The Relationship Between Forest Cover, Ground Cover and Forest Tree Regeneration. 122

4.10 Health of the Tea Gardens. 123

4.10.1 Maintaining Forest Cover and the Shade Factor. 124

4.11 Tea Gardens and the Miang Producer Survey. 125

4.12 Tea Garden Maintenance. 125

4.12.1 Slashing the Ground Cover. 126

4.12.2 Establishing Tea Trees. 128

4.13 Age of the Tea Gardens. 129

4.14 Shade. 129

Table of Contents cont.

4.15 Intercropping. 132

4.16 Cattle. 135

4.17 Productivity of the Tea Gardens. 136

4.18 Long Term Productivity of the Tea Gardens. 137

4.19 Changes in Forest Cover in the Tea Gardens. 138

4.20 Land Title. 141

4.20.1 Land Title Problems. 143

4.21 Summary. 145

Chapter 5 Miang and Green Tea Production, Energy Use and Supply.

5.1 Introduction. 148

5.2 Summary of Questionnaires and Personal Interviews Completed. 148

5.2.1 Socio-Economic Characteristics of the Miang Producers. 148

5.2.1.1 Income From Miang Production. 151

5.2.2 Non-Miang Producer Survey. 152

5.3 Miang Production. 153

5.3.1 Picking Tea Leaf. 153

5.3.2 Processing the Tea Leaf. 157

5.3.3 Miang Production Costs. 162

5.3.4 Marketing Miang. 164

5.3.5 The Future of Miang. 164

Table of Contents cont.

5.4 Firewood Supply for Miang Production. 165

5.4.1 The Development of the Firewood Supply Problem in the Study Area. 165

5.4.2 Firewood Supply. 168

5.4.2.1 Type and Species of Firewood. 169

5.4.2.2 Size Preference. 172

5.4.2.3 Methods of Collection. 172

5.4.2.4 Source of Firewood. 174

5.5 Firewood Consumption for Miang Production. 176

5.6 Firewood Profiles. 178

5.6.1 Summary of Firewood Profiles. 183

5.7 How Serious is the Firewood Supply Problem? 185

5.8 Consequences of Declining Firewood Supply. 188

5.9 Green Tea Production. 188

5.9.1 History of Green Tea Production in Thailand. 188

5.9.2 Green Tea Production in Tambon Pa Pae. 190

5.9.3 Fuelwood Use and Supply Problems in the Green Tea Industry. 191

5.9.4 Summary. 194

5.10 Household Energy. 194

5.10.1 Household Energy Consumption. 197

5.10.2 Energy Use for Household Cooking by Non-Land Owners. 198

Table of Contents cont.

5.10.2.1 Fuelwood Supply for Non-Land Owners. 199

5.11 Awareness of Logging Ban. 199

5.12 Deforestation. 201

5.13 Social Forestry. 204

5.14 Summary. 204

Chapter 6. Alternative Approaches to the Energy Supply Problems in the Green Tea and Miang Industry: Evaluation.

6.1 Introduction. 209

6.2 Coping Strategies for the Green Tea Industry. 209

6.3 Coping Strategies for the Miang Industry: The Range of Alternatives. 210

6.3.1 Improving the Range of Alternatives. 211

6.4 Proposed Solution to the Energy Supply Problems in the Miang Industry. 212

6.4.1 Strategy One: Reduce Firewood Use. 213

6.4.2 Strategy Two: Increasing Natural Firewood Productivity in the Tea Gardens. 221

6.4.3 Strategy Three: Planting Firewood Trees in the Tea Gardens. 222

6.4.4 Strategy Four: Volume Tables. 224

6.4.5 Summary. 224

6.5 Overview. 227

Table of Contents cont.

Chapter 7: Summary and Conclusions.

7.1 Introduction. 229

7.2 Objectives, Conceptual Framework and Research Design. 229

7.2.1 Comments on Study Design. 230

7.3 Summary of Major Findings. 231

7.3.1 The Tea Gardens: The Resource Base. 231

7.3.2 Tea Production: The Resource-Use System. 233

7.3.3 Fuelwood: The Primary Source. 233

7.4 Conclusion. 237

7.4.1 Health of the Tea Gardens. 237

7.4.2 Resolving the Fuelwood Supply Problem. 239

7.4.3 The Future of Tea Production in Thailand. 240

7.5 Recommendations. 242

Bibliography 243

Appendices

Appendix 1. Miang Producer Survey. 257

Appendix 2. Supplemental Survey. 289

Appendix 3. Tea Factory Survey. 290

Appendix 4. Characteristics of the Forest Trees Found in the Tea Gardens. 296

List of Tables

Page Number

Table 2.1 Traditional energy consumption in Thailand. 29

Table 2.2 Percentage of energy consumption in various household activities (rural areas in Thailand). 31

Table 3.1 Goals and objectives of the miang producer survey. 54

Table 3.2 Information obtained by the tea factory questionnaire. 59

Table 3.3 Monthly rainfall (mm) in the Mae Taeng District, Chiang Mai Province, Northern Thailand from 1986 to 1988. 64

Table 3.4 Population data for Tambon Pa Pae by village group. 64

Table 3.5 Land under title in Tambon Pa Pae by village group and use. 65

Table 3.6 Number of miang producers and amount of tea gardens in the twelve village groups of Tambon Pa Pae as reported by village headmen. 65

Table 3.7 Education level of villagers in Tambon Pa Pae by village group. 67

Table 3.8 Number of households and miang producers in the villages selected for study in Tambon Pa Pae. 67

Table 4.1 Summary of forest cover in Plot 1. 81

Table 4.2 Summary of forest cover in Plot 4. 87

Table 4.3 Distribution of forest and tea trees in the top and bottom 50 metres of Plot 4. 89

Table 4.4 Summary of forest cover in Plot 8. 91

Table 4.5 Tea garden plot location by village, approximate distance from village, elevation, plot type and size. 93

List of Tables cont.

Table 4.6 Summary of ground cover classification, tea tree and forest tree density (trees/rai) in the vegetation plots. 94

Table 4.7 Crown cover and ground cover classification in the vegetation plots. 95

Table 4.8 Species diversity in the vegetation plots. 95

Table 4.9 Forest trees and tea trees per rai in the strip plots. 97

Table 4.10 Forest and tea tree density, and forest cover in the top and bottom portion of the strip plots. 97

Table 4.11 Forest cover (m^2 per rai) in the vegetation plots according to accessibility. 101

Table 4.12 Six most common trees in the canopy and midcanopy of the vegetation plots. 109

Table 4.13 Uses for the six most common trees in the canopy and midcanopy of the vegetation plots. 110

Table 4.14 Seven most common trees in the understorey of the vegetation plots. 115

Table 4.15 Uses for the seven most common trees in the understorey of the vegetation plots. 116

Table 4.16 Ratio of upper canopy trees to understorey trees. 118

Table 4.17 Changes in slashing practices when forestry became more strict about collecting firewood from the forest. 127

Table 4.18 Responses to the question: is shade important for tea production? 131

Table 4.19 Intercropping fruit and coffee trees in the tea gardens. 133

List of Tables cont.

Table 4.20 Reasons for not intercropping fruit trees in the tea gardens. 133

Table 4.21 Summary of reasons for not field cropping in the tea gardens. 136

Table 4.22 Tea leaf productivity in the tea gardens over the past decade. 139

Table 4.23 Forest cover status in forest cover in the tea gardens over the past decade. 140

Table 4.24 Responses to the question: does not having land title create any problems for you? 144

Table 5.1 Summary of written questionnaires and personal interviews completed during the study. 149

Table 5.2 Socio-economic characteristics of the miang producers. 149

Table 5.3 Is income from tea production changing? 152

Table 5.4 Reasons given by growers for having difficulty in hiring pickers. 156

Table 5.5 Costs to produce one tang (220 kams) of miang. 163

Table 5.6 Problems in order of importance as identified by miang producers at the miang stove workshop. 166

Table 5.7 Percentage of firewood represented by species in four firewood piles in Pa Pae and Pang Ma Kuay. 171

Table 5.8 Summary of firewood supply for miang production. 177

Table 5.9 Questions used to examine firewood use and supply and to develop firewood profiles. 179

Table 5.10 Firewood supply profiles, by village. 181

Table 5.11 Responses to the question: overall, is there a firewood supply problem in your village? 186

List of Tables cont.

Table 5.12 Reasons for increasing prices of firewood for miang production in Pa Pae and Pang Ma Kuay. 189

Table 5.13 Summary statistics for seven green tea factories in Tambon Pa Pae. 192

Table 5.14 Use of electricity and kerosene in the growers households. 196

Table 5.15 Are you aware there is a ban on cutting trees? 200

Table 5.16 Is deforestation occurring in your tambon? 202

Table 6.1 Summary of taopung tests. 217

Table 6.2 Summary of miang stove trials. 218

Table 6.3 Schedule of the one-day workshop demonstrating the miang stove and aluminum steamer. 220

List of Figures

		Page Number
Figure 1.1	Regions of Thailand.	2
Figure 1.2	Northern Thailand.	6
Figure 1.3	Location of Amphur Mae Taeng in Chiang Mai Province, Northern Thailand.	11
Figure 2.1	Focus of study and major contributing areas from the literature (geographic resource management perspective).	16
Figure 2.2	What 100 kilograms of firewood will permit.	27
Figure 3.1	Conceptual framework.	46
Figure 3.2	Research design.	47
Figure 3.3	Twelve village groups in Tambon Pa Pae.	62
Figure 3.4	Tambon Pa Pae and the four villages selected for study.	70
Figure 4.1	The tea tree and the tea gardens.	74
Figure 4.2	Plot diagram of Plot 1, a block plot.	78
Figure 4.3	Plot diagram of the Plot 4, a strip plot.	84
Figure 4.4	Plot diagram of Plot 8.	90
Figure 4.5	Artistic rendition of the tea gardens.	98
Figure 4.6	Frequency histogram of diameter at breast height for 452 trees found in 13 vegetation plots in monsoon forest, Tambon Pa Pae.	103
Figure 4.7	Number of tree species represented in the tea gardens by the number of individuals, 1,2,3...etc.	104
Figure 4.8	Species-area relationship of the vegetation plots.	106

List of Figures cont.

Figure 4.9	Traditional forest sawmill site utilizing *Schima wallichii* for timber.	112
Figure 5.1	Tea picker using a bench to pick tea leaf from a tall tea tree.	155
Figure 5.2	Finger knife used by the more skilled tea pickers to pick tea leaf.	155
Figure 5.3	Tea leaf being picked, steamed and packed into fist-sized bundles (kams).	158
Figure 5.4	Miang being packed into bamboo containers.	159
Figure 5.5	Dimensions of a typical traditional firepit (taopung) used for producing miang.	160
Figure 5.6	Photographs of *Castanopsis tribuloides* (one of the oaks) and *Schima wallichii*, the two trees most commonly used for miang firewood.	170
Figure 5.7	Photographs of miang firewood.	173
Figure 6.1	The traditional firepit, the new system for steaming tea leaf developed by a villager in Ban Mae Maet, and the bucket stove and aluminum steamer purchased in the market for the stove trials.	215
Figure 6.2	Four-pronged strategy to resolve the firewood supply problem experienced by miang producers.	225

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To Heather.

Chapter 1. Introduction

1.1 The Study

The forested uplands in Northern Thailand have traditionally been used for small scale agriculture, agroforestry activities and timber production. Increasing population and activities in the uplands have led to land use conflicts and numerous environmental degradation problems such as soil erosion, deforestation and declining water quality. These issues and efforts by the Thai Government to conserve the dwindling forest resources, are leading to large changes in the lives of many villagers living in the uplands.

This study focuses on one detailed aspect of these broader issues, the firewood supply problems in the tea processing industry, primarily the traditional tea industry which produces a fermented tea product called 'miang'. Understanding such human-environment interactions is a central theme in geography and an important component in the design of effective resource management policies (Mitchell, 1989). This study examines the upland agroforestry system used in traditional tea production from a geographical perspective and explores the range of alternatives available to smallholder tea producers for resolving the firewood supply problem within a resource management framework.

1.2 Regional Setting

Thailand is located in continental southeast Asia and is bordered by Burma to the west, Laos to the north and east, Cambodia (Kampuchea) to the southeast and Malaysia to the south (Figure 1.1). The country is often divided into four or five regions based upon their distinctive topography. Phantumvanit and Sathirathai (1988) identify five distinctive regions: Central, East, South, North and Northeast. Generally, the central region encompass the rich rice-growing plains of Thailand. The Northeast is a much drier plateau and supports primarily dry land agriculture. The North is mountainous and contains most of the remaining forest cover in the country. The South is peninsular Thailand and the East includes the rich coastal area below Cambodia.

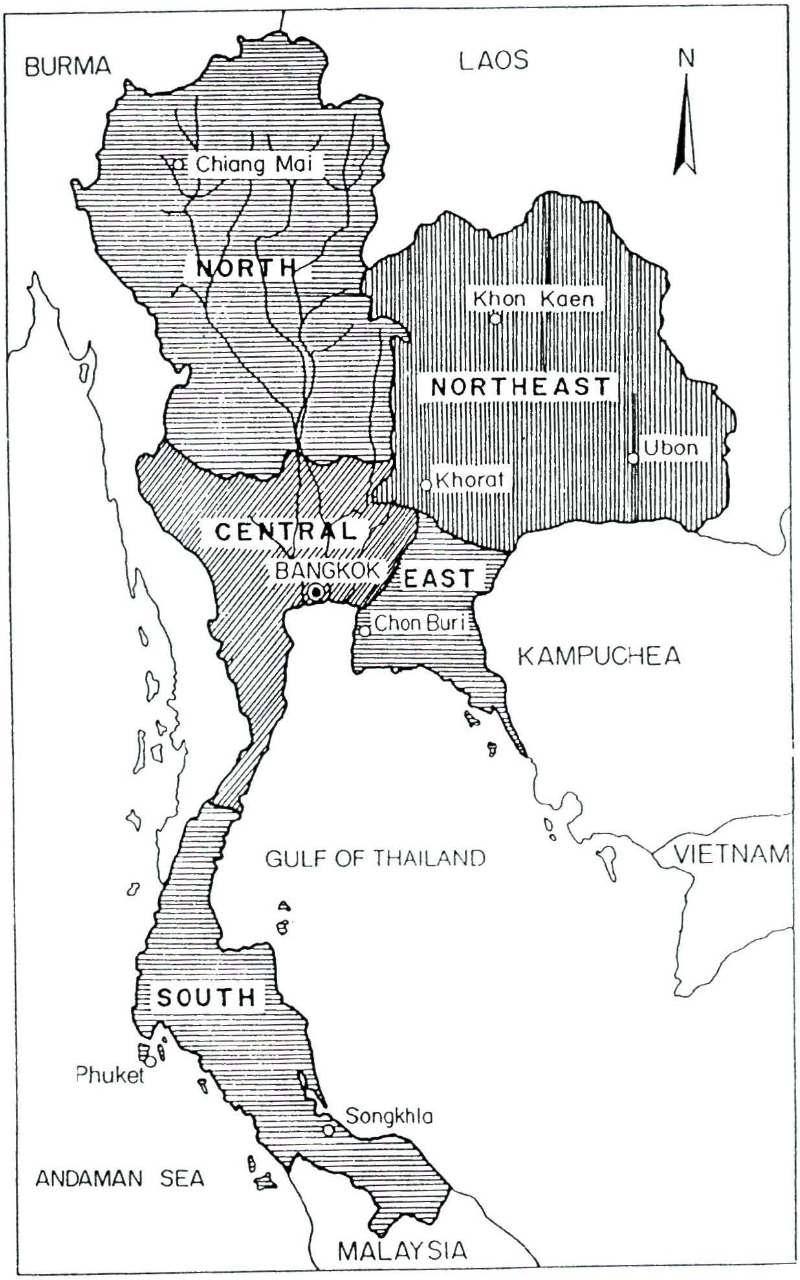

Figure 1.1 Regions of Thailand.
(source: Phantumvanit and Sathirathai, 1988)

The northern region of Thailand encompasses seventeen million hectares of land (Phantumvanit and Sathirathai, 1988). It is divided into two subregions which include seventeen provinces, eight in the upper northern subregion: Chiang Rai, Chiang Mai, Lampong, Lamphun, Mae Hong Song, Phayao and Phrae. In 1985, Northern Thailand had a population of 10.3 million (Phantumvanit and Sathirathai, 1988).

Northern Thailand is largely mountainous, with long ridges and steep narrow slopes at the headwaters. The altitudes range from 100 metres to about 2,685 metres above mean sea level. About 50% of the land area was under forest cover in 1985 (Phantumvanit and Sathirathai, 1988). The important watersheds of the Ping, Wang, Yom and Nan rivers are located in this region; they converge in the central region to form the major Chao Phraya and Ta Chin rivers which eventually flow into the Gulf of Thailand. Agricultural land use in 1985 accounted for about 5.6 million hectares, including about 3.4 million hectares of rice paddies, 2 million hectares of upland crops and 0.1 million hectares of perennial crops (Phantumvanit and Sathirathai, 1988).

The upland areas of the north are occupied by both Hilltribe and ethnic Thai. The Hilltribes include a number of distinctive groups: Akha, Hmong (Mea), H'tin, Karen, Khamu, Laha, Lisu, Lua and Yao (McKinnon & Vienne, 1989). The Hilltribes are linguistically and culturally distinct from the Northern Thai, but they do share common linguistic and cultural links with their Thai neighbours. These groups occupy upland areas at varying elevations, depending upon the tribe (see Kundstadter et al, 1978) traditionally relying on shifting cultivation for their subsistence. Cash cropping has recently become part of their livelihood (McKinnon & Vienne, 1989). While the majority of hilltribe people do not have Thai citizenship, a considerable amount of development work is aimed at improving their living conditions.

The lower elevations in Northern Thailand are generally occupied by Thai Lue, Northern Thai and Shan, although there is often overlap and intermixing with the Hilltribes (Kundstadter, et al 1978). The majority of these Thai speak the Northern Thai dialect and practice wet rice cultivation in the valleys and dry land cultivation on the lower slopes of the uplands.

Thailand has a monsoonal climate with a cool season from November to February, a hot season from March to May and a rainy season from May to October. Temperature and rainfall in Northern Thailand are variable. The temperatures on Doi Suthep Mountain, near Chiang Mai (largest city in the north) range from 5 °C (January) to 35.5 °C (March) at 1400 metres above sea level and from 9.2 °C (November) to 40.3 °C (March) at 312 metres above sea level. Annual rainfall ranges from about 1,000 mm near the base of the mountain, to just over 2,000 mm at the summit (data from Meteorological Department, Bangkok, as cited in Elliott et al, 1989). Most of Thailand has an average annual rainfall from 1,100 mm to 1,500 mm (TDRI, 1987). Monsoon forest is the natural vegetation of much of Northern Thailand (Elliott et al, 1989), primarily mixed deciduous and dry evergreen forest, with some pine above 1,000 metres (TDRI, 1987).

Although northern Thailand has been settled for many centuries, the environment has undergone substantial change during the last century. Agricultural activities have rapidly grown. The lowland Thai have expanded wetland cultivation in the valley bottoms and dryland agriculture in the uplands (Meer, 1981). Shifting cultivation, largely practised by hilltribes, has also expanded in the uplands and highlands (McKinnon and Vienne, 1989; Meer, 1981). Agriculture production has also intensified and the increased use of fertilizers and pesticides has harmed water quality. Soil erosion on steep slopes is also a major concern (Adams and Solomon, 1985). Rapid population growth and urbanization are consuming large tracts of some of the best paddy land in the north.

In addition to agriculture expansion into the uplands, commercial logging has denuded large areas of the upland forests in Northern Thailand (Myers, 1980). Recent floods and droughts on the central plains have focused attention on the condition of northern watersheds (Feeny, 1988). Forest degradation in these watersheds due to commercial logging, agriculture expansion and illegal logging continues at a steady pace (Phantumvanit & Sathirathai, 1988) and poses a threat to thousands of people downstream (TDRI, 1987). It is in this general context of a region undergoing dramatic socioeconomic and environmental change that this study of the tea industry is set.

1.3 Tea Production in Northern Thailand

In the uplands of Northern Thailand (Figure 1.2) tea is an important cash crop. Three types of tea are produced: fermented (miang), Chinese (high and low quality green tea) and black. Plantations range in size from individual households who have a few rai (1 ha = 6.25 rai) of tea gardens[1], locally owned tea estates ranging from less than a hundred rai up to 500 rai, up to a 600 rai commercial tea plantation owned by Royco Foods near Chang Doa (Chiang Mai Province). Generally, the larger the operation, the more intensive the cultivation of tea. Smallholder gardens have few inputs, low tea tree density and low productivity, while estates are more intensively managed and are much more productive.

There is a shortage of reliable data on the size of the tea industry in Thailand. In 1964, it was estimated that a total of 75,000 Thai people in the uplands depended upon the tea industry for their livelihood and that the area of the tea gardens was 20,800 hectares (Van Roy, 1971). Since this time, some villagers have switched from miang to green tea production and the area of estates has expanded. Almost all the black tea in Thailand is produced by Royco Foods under intensive cultivation conditions, while all the miang and most of the green tea is produced by smallholders under extensive cultivation conditions utilizing an agroforestry system.

Black tea and green tea have been produced in Northern Thailand during the past 40 to 50 years. Miang, however, has been produced as far back as 700 A.D. (Van Roy, 1971) and has been the most important smallholder tree crop in Northern Thailand for over 100 years (Hoare, 1987). Tea leaf is produced by smallholders utilizing an upland agroforestry system found in the mixed deciduous/coniferous monsoon forests between elevations of about 600 metres to 1600 metres. Tea leaf is picked from low density tea plantations (less than 2,000 trees/ha) which have been established in the upland forests

[1] 'Tea Gardens' is used to refer to the traditional agroforestry system used for producing tea. In this case, the term 'tea garden' does not imply intensive cultivation, as is implied in the common use of the term, but rather refers to the forest use system in Northern Thailand which has a low level of inputs.

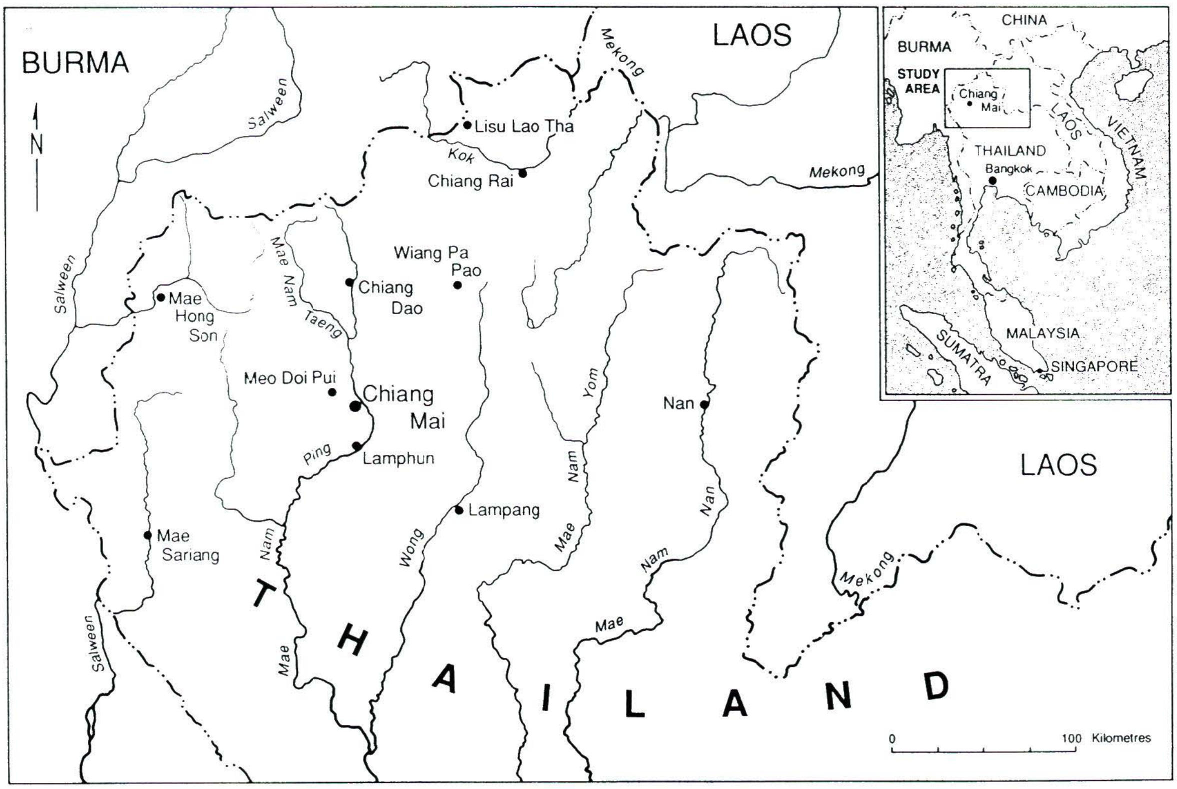

Figure 1.2 Northern Thailand.

by thinning the forest cover and direct planting tea seed or seedlings to increase the density of the indigenous tea tree.

Well-managed tea gardens have proved to be the most sustainable highland farming system in Northern Thailand for the past 100 years (Hoare, 1987). Many farmers have found that tea is the most reliable upland tree crop that can give sustained production under low inputs. Tea gardens maintain the highest forest cover of any upland land use and appear to have the lowest soil erosion rates relative to other farming systems. This agroforestry system seems an appropriate land use in watershed protection areas and forest reserves where most of the tea gardens are located. However, the need for fuelwood[2] during tea processing and the increasing restrictions on cutting in the forests, have led to a crisis.

1.4 Energy Shortages in the Traditional Tea Industry

Large volumes of firewood are needed to steam the tea leaf for miang production. Fuelwood is used during the first and final stage of green tea production, where first, heat supplied by firewood is used to kill leaf enzymes, and at the final stage firewood and charcoal are used to dry the tea leaf. Firewood is also used during the final stage of black tea production[3].

Fuelwood for both miang and green tea production in Tambon Pa Pae, the largest tea producing area in Thailand, is collected from the tea gardens or nearby forests. The forests have traditionally been the primary source of fuelwood for tea production. However, access to the forests for firewood collection has been curtailed since the late part of the 1980s when the Thai government increased its efforts to slow the destruction of the country's forests. Controls on forest cutting were intensified in 1987 when landslides caused by heavy rains on logged hillsides in Southern Thailand destroyed

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[2] The term fuelwood refers to both firewood and charcoal.

[3] During black tea production, the tea leaf is allowed to oxidize. Oxidization is prevented during green tea production by heating fresh tea leaf to 110 ^{0}C which kills leaf enzymes.

whole villages, killing many people. Efforts to slow deforestation culminated in a logging ban in January of 1989 (Louham, 1990). This was partially in response to intense public pressure generated from the disasters in the south. Since the landslides, forestry officials became very strict about forest use in areas where traditional tea production occurs.

Since the Thai government became more strict about forest use, a greater proportion of firewood for miang production has been obtained from the tea gardens. This intensification of firewood collection from the tea gardens may decrease forest cover, leading to firewood shortages and other problems. In addition to firewood supply, forest cover in the tea gardens is important for the overall health of this agroforestry system and the well being of the villagers. Forest cover provides shade for the tea trees; reduces maintenance costs as ground cover growth is slowed; conserves soil moisture during the dry season (up to six months long); reduces soil erosion; provides wildlife habitat and numerous products for the villagers such as food, medicinal needs and construction materials. Although development has provided many modern goods to the villagers, forests still provide many of their basic needs. The loss of forest cover in the tea gardens threatens the long term sustainability of this agroforestry system and the livelihood of the rural people involved with miang and green tea production.

Another tea producing area in Northern Thailand reveals the serious consequences of allowing forest cover to be excessively depleted in the tea gardens. In Tambon Wawi (Chiang Rai Province) the yield of tea leaf over the past 10 years has declined by 50% (Hoare, 1987). This decline is due to changes in management practices following the conversion of tea gardens from miang to mainly Chinese tea production and shade tree shortages in the tea gardens. Excessive picking rates has meant that the rate of removal of nutrients exceeds the rate of replenishment, leaving insufficient maintenance of foliage to maintain tree vigour. In addition, for tea trees to maintain productivity, they need shaded conditions but most of the forest cover in the tea gardens has been removed to be used as firewood and construction material. The seriousness of the firewood supply problem is indicated by the use of bamboo as a firewood in local green tea factories.

Fuelwood supply is part of a much larger problem in Thailand- the loss of the majority of the country's forests. Forest cover in Thailand has declined by 45% during the period 1961 to 1985 (TDRI,1987). Recent estimates place the level of forest cover between 15% and 20% (Water Conservation Bureau, 1987; Alcorn, 1990). The major causes of deforestation are land clearance for crop cultivation, including shifting cultivation, and illegal logging by loggers and farmers (Phantumvanit and Sathirathai, 1988). Fuelwood use by households and rural industry is also considered to be a major cause of deforestation (Bhumibhamon, 1986; Wibulswas, 1986).

The problem of deforestation in Thailand has reached a critical stage and is considered to be one of the country's most urgent natural resource problems (Myers, 1980; Bhumibhamon, 1986; Hafner et al, 1990). The Thailand Development Research Institute (1987:5) predicts that:

> *Unless Thailand conserves these resources, ensuring sustainable development rather than ruthless destruction, Thais may experience 'environmental bankruptcy' along the lines of Africa's Sahel and Ethiopian highlands.*

The consequences of deforestation in Thailand have been severe. The degradation of upland watersheds results in soil erosion and sedimentation of streams, rivers and reservoirs, led to increased severity of flooding in the lowlands, disruption of irrigation systems, reduced crop yields and loss of life (Adams, 1985; FAO, 1981; Myers, 1984; NTUSFP, 1987). Thailand was included with those developing countries having serious upland watershed problems by the World Resource Institute in 1985, and is one of 63 developing countries which now face a present or imminent fuelwood crisis (WRI, 1985). Firewood and charcoal are major sources of energy for household use and rural industry (and will continue to be) for the next two decades (Wibulswas, 1986; Dang, 1989). Rural populations are increasingly faced with tremendous hardships due to resource-use problems, especially deforestation and the related problem of firewood supply (TDRI, 1987).

Clearly there is both a generally recognized broad problem of deforestation within which there are lesser known issues related to the specific fuelwood needs for small scale tea production about which there is a lack of detailed and reliable data. Consequently, a specific objective of this study is to collect primary field data concerning the agroforestry system used for producing tea and fuelwood use in the tea industry.

Tambon Pa Pae has been selected as the area for study. It is located approximately 60 km by highway northeast of Chiang Mai in the Mae Taeng District, Chiang Mai Province (Figure 1.3) and is the centre of the largest tea producing area in the province. There are twelve village groups in the area, all of which participate in tea production to some extent. Miang is processed by about 780 individual households and there are also 9 privately owned factories and one cooperative-owned factory which produce green tea. Smallholders either process tea leaf into miang, sell fresh leaf to the factories, or participate in both industries, depending upon market prices. The study area is focused on the northern portion of Tambon Pa Pae where four villages were selected for detailed examination. This area is similar to other traditional tea producing areas in the uplands of Northern Thailand.

1.5 Goals and Objectives

The goals of this study are to examine the agroforestry system used for small scale tea production and to evaluate possible alternative solutions to the energy scarcity problems facing tea producers. To meet these two goals, the following specific objectives are developed...

1) Describe the biophysical characteristics of the upland agroforestry system used for tea production and the management techniques employed by tea garden owners in Tambon Pa Pae, Chiang Mai Province, Northern Thailand.

2) Examine the energy use and supply in smallholder miang production and private and cooperatively owned green tea factories in Tambon Pa Pae, Chiang Mai Province, Northern Thailand.

3) Examine firewood productivity in the tea gardens, evaluate possible alternatives for decreasing firewood use, increasing firewood supplies and other sources of energy for processing tea leaf.

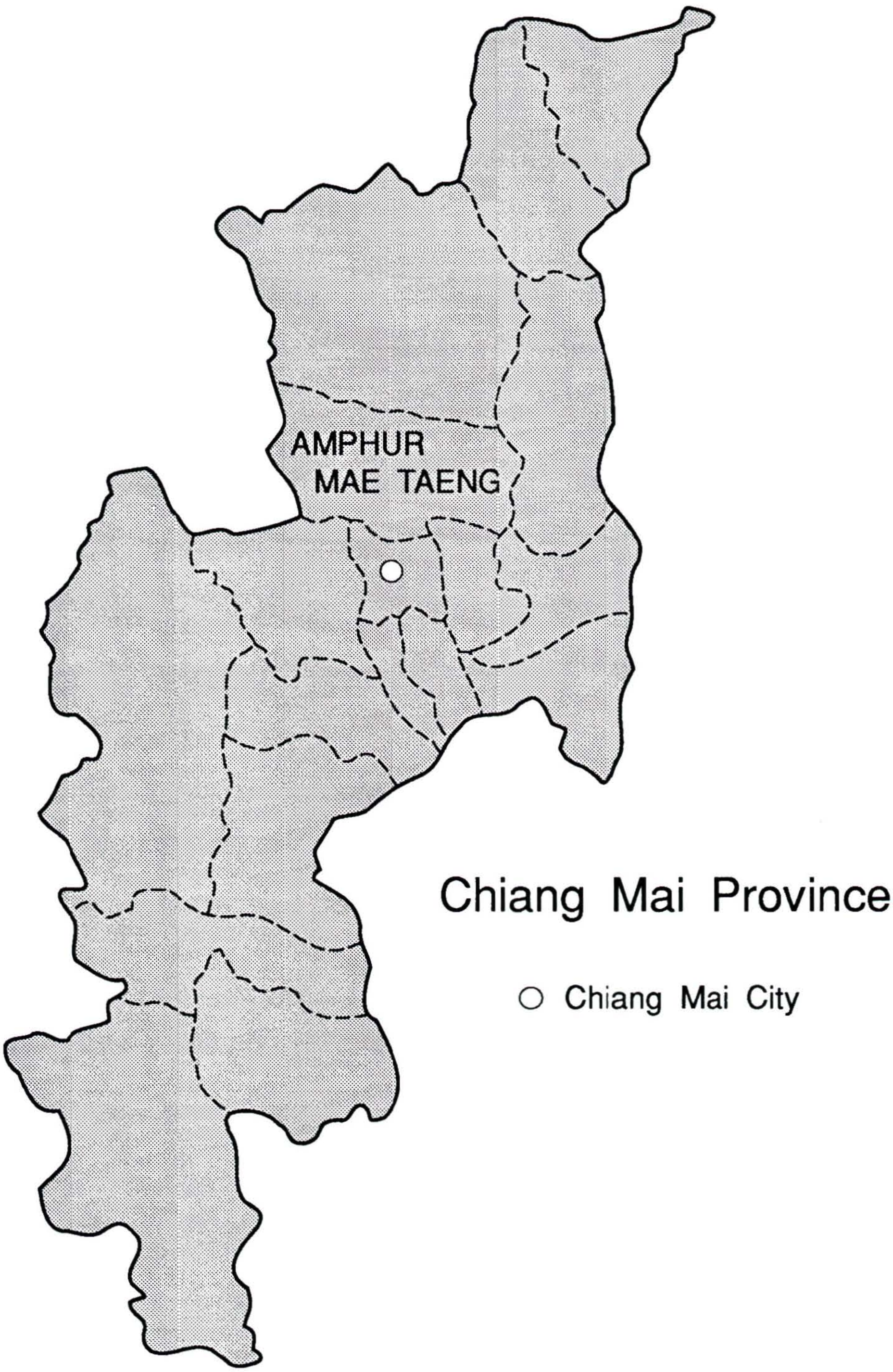


Figure 1.3 Location of Amphur Mae Taeng in Chiang Mai Province, Northern Thailand.

4) Examine the sustainability of tea gardens, comparing what has occurred in Tambon WaWi in Chiang Rai Province (declining tea leaf production, fuelwood and shade tree shortages) with what is occurring in Tambon Pa Pae.

To complete the above objectives, several kinds of data entailing different methods of collection were obtained. These methods included a literature review, personal interviews, written questionnaires, field observations and vegetation surveys in the tea gardens. Six months were spent in Thailand designing the study and collecting information. A more detailed discussion of the conceptual framework, research design and field methods employed in this study is contained in Chapter 3.

1.6 The Need for This Study

The agroforestry system used in tea production is unique to Northern Thailand and southern Burma. This system is centuries old but it appears that it has not been studied in any detail. The knowledge gained from this system may benefit land use practices in Thailand and elsewhere. This system may offer an alternative land use to other agriculture activities in the uplands such as shifting cultivation which are causing deforestation and soil erosion problems. A great deal of effort by government and nongovernment agencies is placed upon replacing shifting cultivation with permanent cultivation in order to slow deforestation and soil erosion. Various methods of soil erosion control and crop rotations are needed to maintain soil productivity if permanent cultivation is to be successful. Perhaps more emphasis should be placed upon agroforestry systems such as the tea gardens which take advantage of natural systems without the serious consequences of growing crops on steep slopes. The maintenance of at least partial forest cover and minimal soil erosion indicates that this agroforestry systems may be an appropriate land use in sensitive upland watershed areas.

Small scale tea production is a major land use activity and income earner for villagers in the uplands. Although this agroforestry system is both ecologically attractive and economically sound, it does face several persistent problems. Most of the smallholder tea gardens are located within forest reserves and/or watershed protection areas (villagers do not have land title). The future of tea production is threatened due to insecure land tenure rights and firewood supply problems. Miang producers and tea factory owners are concerned about the supply of firewood, especially since local forest officials became more strict about cutting firewood in the forests in 1987-88. There is a great deal of tension between villagers and forest officials as many villagers still must obtain some of their firewood from the forest. Forest officials are also in a difficult position. On one hand they must protect the dwindling forest resources, on the other many are reluctant to prevent villagers from pursuing their traditional livelihood.

Ways must be found that protect the forest while allowing the villagers to earn a livelihood and continue meeting many of their basic needs from the forest. The traditional agroforestry system used for producing tea may prove to be a good compromise between the need for watershed protection and the needs of villagers, if the fuelwood supply problems can be resolved.

1.7 A Geographical Approach

Mitchell (1989) notes that three themes appear dominant in geography: spatial, ecological and regional analysis. This study largely characterises the second theme-- the study of human-environment relationships. Within this theme, a resource analysis approach is adopted where the "geographer seeks to understand the fundamental characteristics of natural resources and the process through which they are, could be, and should be allocated and utilized" (Mitchell, 1989:3). Understanding the human-environment relationship is an important part of resolving resource-management problems (Bowander, 1987). Here, the biophysical characteristics of the upland agroforestry system used for producing tea are examined and when combined with a study of the management practices and the perceived nature of and solution to the problem as expressed by tea garden owners and other key informants, a strategy to help resolve the firewood supply problem is identified.

Geography often acts as a bridge between the social and physical sciences (Johnston, 1985) allowing the geographer to take a more holistic approach when examining an issue. This study examines human-environment relations, focusing upon a resource-use problem in the tea industry in Northern Thailand. Various methods of data collection are used to collect both physical and social data in order to understand the workings of the traditional tea industry and the fuelwood supply and other problems of the traditional tea industry in the uplands of Northern Thailand.

The next chapter examines the tea industry in Thailand in more detail and reviews the relevant literature on agroforestry systems, rural energy use and supply in developing countries, deforestation and some strategies to deal with rural energy shortages. Chapter 3 outlines the conceptual framework, research design, methods used for data collection and examines the study area in more detail. Chapters 4 through 7 present the results, recommendations and conclusions.

Chapter 2: Smallholder Tea Gardens as an Agroforestry System, Fuelwood Use and Deforestation: A Review

2.1 Introduction

The focus of this study is the fuelwood supply problem of the traditional tea industry in Thailand and the exploration of alternatives for resolving it (Figure 2.1). Consequently, three primary areas of the literature relevant to the focus of the study are identified for review. They are: agroforestry systems (the general system); tea production in Northern Thailand (the regional subtype); and fuelwood (the resource-use issue).

In this chapter, the general characteristics of agroforestry systems, the Thai tea industry and rural energy needs will be briefly reviewed. The growing fuelwood crisis, and its link with deforestation and other environmental and socioeconomic problems will also be discussed followed by a review of some strategies to deal with fuelwood shortages. This will provide the general context for examining the specific matter of energy scarcity in the traditional tea industry in Thailand and exploring the range of alternatives for resolving the problem.

2.2 Agroforestry

The International Council for Research in Agroforestry offers a useful definition of agroforestry (as cited in Macklin, 1990:1):

> *land-use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and/or animals either in some form of spatial arrangement or in a time sequence, and in which there is a significant interaction between the woody perennials and the crops or animals.*

The incorporation of trees into farming systems can diversify products and increase productivity and economic returns. Farmers throughout the world have recognized this and most traditional farming systems incorporate trees, either passively or actively (King, 1987). Growing trees in farming systems is the subject of the recently revived science of agroforestry. In the Asia Pacific Region, agroforestry has reemerged as an appropriate

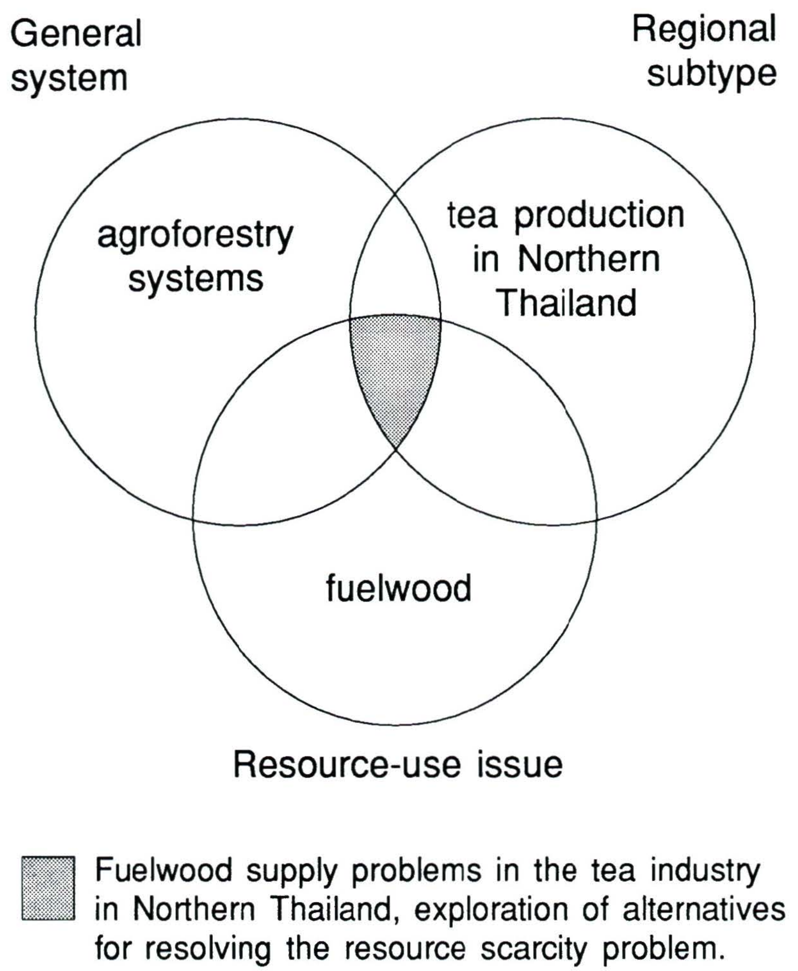


Figure 2.1 Focus of study and major contributing areas from the literature (geographic resource management perspective).

form of land use in recent years due to the highly adverse person/land ratio, population expansion and migration into the forested upland areas as people search for new land for agriculture (Rao, 1989).

Agroforestry can play an increasingly vital role in four situations: 1) critical watershed areas of major river systems where the over-riding demand is for conservation; 2) shifting cultivation areas; 3) encroached deforested land; and 4) marginal lands and wastelands (Rao, 1989). Salem and van Nao (1981:14) note:

> *The relationships between rural forestry, traditional farming activity and the role and potential of rural forestry have for a long time been neglected or ignored. Not only could forestry provide sufficient fuel and other goods and services essential to rural populations, but it could also contribute to stabilizing the foundations of food production systems and to stopping or reversing the impoverishment of the rural environment as a whole.*

These authors are emphasizing the incorporation of forest practices into agriculture systems. As noted, this has been an old practice of traditional farmers and new ways are being found to integrate the two, maximizing the benefits of the two systems working in concert. Kang and VanDenBeldt (1990:13) note:

> *Trees and shrubs feature prominently in traditional farming systems in the tropics because of their many uses and their environmental and socioeconomic benefits. Intercropping of woody species with annual crops in temporal and spatial agroforestry systems are known to enhance the sustainability of production systems. Inclusion of woody species, particularly legumes, can enhance nutrient cycling, soil fertility maintenance and soil protection; provide biologically fixed nitrogen; and provide a basis for developing intensive, more productive and sustainable upland food crop production with low purchased inputs.*

There are numerous examples of traditional and newly developed agroforestry systems worldwide (i.e. King, 1987; Macklin, 1990). In Thailand, farmers have developed numerous agroforestry systems without outside support. A recent study on 'Agroforestry Initiative by Farmers in Thailand' (FAO, 1989) briefly documented 50 different systems from four geographic regions of the country. The agroforestry system used to produce tea in the uplands was included in this survey.

There are several classification schemes for the wide range of agroforestry systems in use. Early classifications such as Combe and Budowski (1979) and Torres (1983) are based upon the components of the systems (tree, crop and livestock combinations), but also include complex divisions based upon such factors as: 1) trees' roles (production versus service); 2) component interaction (space versus time); and 3) distribution (mixed versus zonal). Huxley (1983) offers another system based upon time and spatial arrangements of plants, but also discusses developing different classification systems depending upon the particular purpose of the user.

The most widely accepted classification today, that of Nair (1985), is a components-based classification similar to Torres (as cited in Macklin, 1990). Nair uses a variety of criteria to classify agroforestry systems, including functional, ecological, and socioeconomic schemes. Macklin (1990) uses a classification scheme developed for extension training which makes land use options clear for the farmer. This system is largely based upon planting 'niches' on the farms and secondarily on the functional role of the trees. The different systems include: farm borders; trees in crop fields; trees around the house; temporal systems and woodlots; and trees in livestock systems.

The classification schemes largely involve agroforestry systems where field crops are usually the major component. In most agroforestry systems, where forests may have once dominated, there is little or nothing remaining of the original forest cover and the areas are largely cultivated. It may, however, be misleading to call the tea gardens in Thailand, which have largely been established by thinning the forest cover, an agroforestry system relative to those discussed above. These tea gardens retain much of the characteristics of the original forest cover and if abandoned, the forest will recover relatively quickly in most cases. In most agroforestry systems this is not the case; the original forest cover (if there was any), has been largely destroyed. In the tea gardens, the commodity produced, tea leaf, comes from a native tree. Perhaps this system should be called a 'forest-use' system and therefore, has not been classed according to any of the classification schemes mentioned earlier.

The tea leaf for all of the miang produced in Thailand, almost all of the green tea and part of the black tea (30-45% at ChaSiam) is produced in an upland agroforestry system (tea gardens), a system not studied in any detail. Van Roy (1967), Keen (1972) and Hoare (1987) have briefly examined this land use system. Van Roy (1967) and Keen (1972) briefly documented it as one example of an upland farming system in Northern Thailand. Keen placed greater emphasis on the economic dimensions of this traditional practice than Van Roy. Hoare (1987) briefly examined miang production during an overview of the problems facing the tea industry in the uplands of Tambon Wawi (Chiang Rai Province) where the German government is involved with highland development. None of these studies examined in any detail the biophysical characteristics of this system or management practices. Only Hoare (1987) documented the firewood supply problems facing tea producers which are very severe in Tambon Wawi (offered planting trees or alternative energy sources such as electricity as solutions to the problem). However, there is very little miang production in Tambon Wawi and Hoare was concentrating on green tea production in small factories.

As mentioned earlier, the FAO (1989) study briefly examined 50 agroforestry systems including the tea gardens developed by farmers in Thailand. A diagram of the spatial arrangements of the tea and forest trees and a one page description based on one interview with a tea garden owner was the extent of the coverage. Clearly, a more detailed description of the biophysical characteristics of this agroforestry system and management practices is needed.

2.3 Tea Production in Thailand

The tea tree is found throughout extensive areas of mainland Asia's uplands. East and west it has been found from Assam to the southern hills of eastern China from about latitude 29 degrees north, while from northeastern Burma at about longitude 98 degrees east, it spreads southward through Yannan, the Shan States of Burma, Northern Thailand, and Laos to the hills of southern Viet Nam (Harler, 1964:4). From here it has been taken to many parts of the world, including Africa, southern India, Sri Lanka and South America. It is generally believed that today's strain of tea originated from three primary types found in mainland Asia's uplands: the China variety which is small-leaved and bushy; the Assam type which has large, glossy leaves; and the Cambodian type with long, narrow turned-up leaves (Harler, 1964:5).

Tea production in Northern Thailand largely relies upon the indigenous tea tree Camellia sinensis (L.) O.K. var. assamica (Mast.) Kita. This tree is rarely more than 5 metres tall, with large, smooth, glossy and slightly serrated leaves. This tree is somewhat bushy and bears characteristics of both Assam and Cambodian strains (Keen, 1972:55). Although the tea tree is indigenous to northern Thailand, it is impossible to say how far humans have been responsible for its presence given the human migrations which have occurred in Southeast Asia over the centuries.

Both the soils and climate in Northern Thailand are suited to the needs of tea trees. The growing rhythm induced by the monsoons and the somewhat acidic soils contribute to a flavour improvement (Harler, 1964). Tea is grown from an altitude of 450 metres a.s.l. at Boonpraten Tea Estate (Mae Taeng District, Chiang Mai Province) to about 1600 metres a.s.l. in traditional miang gardens in the uplands of Chang Doa District (Chiang Mai Province). Better quality teas can be produced at higher elevations, but yields will be lower.

The main climatic constraint for tea production in Thailand is the long dry season which can last up to six months. This lowers productivity and creates a major difficulty in establishing tea during the first two years, especially where there is no forest cover to provide shade, or dry season watering is not possible. However, these unfavourable conditions can be overcome to a considerable extent by following good cultural practices: appropriate land preparation; the use of large and vigorous seedlings from nurseries; early planting before the end of May if the soil is wetted to 50 cm; by mulching in the late wet season; limited watering from February to April during the first two dry seasons (Hoare, 1987) and providing shade by planting fast growing leguminous trees with taproots or pigeon pea. Although tea can be grown on soils of almost any physical type, it does best on a medium or light loam. Like other plants it prefers a deep friable soil, well supplied with plant food (Katikarn & Swynnerton, 1971).

The most important factor for successful tea cultivation is a pronounced acid soil condition, not only in the top soil but also in the subsoil to a reasonable depth. The most satisfactory ph values, depending upon the nature of the soil, are from 4.0-6.0. Tea is well suited to the largely acidic soil conditions in Northern Thailand. Depth of soil is also important, as a rough rule tea requires a minimum available depth of five feet. Tea trees have a tap root and need this depth of soil for good growth (Katikarn & Swynnerton, 1971).

2.3.1 Types of Tea Produced in Thailand

The traditional tea product (miang) has been produced in the upland areas of Northern Thailand for centuries (more detail later). More recently, with the influence of the Kuomintang settlers along the northern border (migrants from China) several commercial farmers and various Thai Government projects, improved varieties of tea and more extensive cultural methods have been introduced (Lever Brothers, 1989). There are now three major types of tea produced in Thailand: the traditional fermented product called miang; green (Chinese tea); and black (English style tea).

Miang is the Northern Thai name for pickled tea which is consumed like a masticatory primarily in Northern Thailand. People in other areas of Thailand do not generally chew miang unless they are from the North. Pickled tea is also consumed in Burma, where it is called "leppetso" (Keen, 1972). Miang tea is consumed more or less in the manner of a social habit. When visitors come or when the family is seated together in the evening, the miang is passed around from one to another. A jar of coarse salt goes with it, and the consumer takes a small bundle of leaves, rolls them up into a wad such as chewing tobacco, with a lump of salt in the centre and pops it into his/her mouth. Both men and women use it daily. Miang is also consumed during the day to keep hunger pains away and in the past some Buddhist monks thought miang was useful to help dampen the sex drive (Kasomerprome, 1989). Young people are less inclined to adopt this habit today.

The indigenous tea tree can be used to produce all the different types of tea produced in Thailand. The bud and two leaves are picked to produce quality green and black tea. The semi-mature leaves are used to produce miang. The type and colour of tea made depends upon the degree to which oxidation is allowed to occur during processing. In black tea, the manufacturer allows the tea leaf to oxidize for 45 minutes to 3 hours after the tea is rolled. This oxidation is stopped when the tea is dried. Green tea is a non-oxidized product. The enzyme which is important to the oxidation process is killed during a panning process by raising the temperature of the tea to 90-110 degrees celsius. Semi-fermented green tea occurs due to poor quality processing where the enzyme is only partially killed during the panning process. Oxidation takes place in an uncontrolled and uneven way during the remainder of the processing, resulting in a low grade tea from green to brown in colour.

Tea leaf for miang production is produced by smallholders utilizing an agroforestry system and the native tea tree. This system is referred to here as 'extensive' due to the low density of tea trees and low inputs. Tea estates and commercial operations are referred to as 'intensive' operations relative to the tea gardens due to their much higher density of tea trees, and higher inputs and productivity. There is also less forest cover in the intensive plantings. Some tea estates have both traditional gardens and intensive plantings of tea.

Green tea is produced under both extensive and intensive operations from native and improved varieties of tea imported to Thailand. Over 80% of the green tea is processed in small, owner operated factories (Lever Brothers, 1989) employing 2-6 people in each factory. Most black tea is produced from intensive operations utilizing both native tea trees and improved varieties on a commercial tea estate, ChaSiam, in the Chang Doa area (Chiang Mai Province). Miang is produced from extensive tea gardens and is processed solely by individual households.

There is a shortage of reliable data on the overall area planted to tea, total production and the number of tea farmers in Thailand. Many of the extensive tea gardens are in remote areas and the Thai government does not generally collect data regarding the tea industry. A consultant's report in 1989 estimated that there is something in the neighbourhood of 5,000 tonnes of miang and 2,500 tonnes of green tea produced annually (Lever Brothers, 1989). Most black tea is produced by one commercial tea estate, ChaSiam, which produced 28 tonnes of made tea in 1989 from 800 rai of intensive plantings, employing 60-80 people (Marley, pers comm). Van Roy

(1971) estimated that in 1964 a total of 75,000 Thai people in the upland areas depended upon the tea industry for their livelihood, while the area of tea gardens was estimated to be 130,000 rai (20,800 ha). Since this time some miang producers have switched to green and black tea production due to falling demand for miang. In addition, the area of intensive plantings on tea estates has increased. Therefore, if Van Roy's estimate is accurate, the tea industry is just as large or larger as it was in 1964.

There are specific pieces of information which indicate the importance of the tea industry to some areas. Hoare (1987) notes that Chiang Mai Province has the largest area of tea, followed by Chiang Rai Province. Hoare does not provide any figures for Chiang Mai province, but in Chiang Rai, he reports about 21,000 rai of tea in 48 villages and about 3,000 tea growers (Hoare, 1987). The Chiang Mai Provincial Agricultural Office reports only 16,230 rai of tea gardens in the Chiang Mai Province and has no records of the number of growers.

Keen (1972) stated that in 1969, miang production was the major tree crop economy in the uplands of Chiang Mai Province. For example, in Tambon Chang Doa, a subdistrict of Chang Doa District, there were thirty villages of Khong Muang people, a total of 2496 people. Of these 30 villages, 26 villages comprising 1800 people were almost wholly dependent upon miang for their livelihood (Keen, 1972).

In Tambon Pa Pae, another subdistrict of Chiang Mai Province, there are an estimated 780 households who produce miang from about 24,580 rai of tea gardens (data from headman). The District Office estimates that there are only 4,250 rai of tea gardens in Tambon Pa Pae (PSPFD, 1989). There are also ten green tea factories in the area. Tea production in this tambon is by far the largest land use activity. Tambon Pa Pae is selected for study and will be discussed in more detail later.

Tambon Wawi in Chiang Rai Province produces over 50% of Thailand's green tea. In this area, there are about 800 tea producers, 57 factories and over 8,000 rai of tea gardens (Hoare, 1987). There is one privately owned tea estate in Tambon Wawi, Mindee Tea, which controls over 2,000 rai of extensive tea gardens and has about 300 rai of intensive plantings. There is also one privately owned tea estate in Mae Taeng District (Chiang Mai Province), Boonpraten Tea, which has about 500 rai of intensive tea gardens. This estate sells all their tea leaf to ChaSiam. ChaSiam also buys tea leaf from smallholders (extensive gardens) in the area.

Middlemen generally purchase made tea from secondary factories (green and black tea) in the north and then send it to Bangkok where it is blended with imported tea. The Ministry of Commerce makes purchases of made tea, then sells it to distributors. The Ministry protects the indigenous tea industry by stipulating that distributors have to purchase 60 kg of local tea for every 100 kg of imported tea (50 kg in the case of black tea). The market outlook for tea production in Thailand is favourable. Local production cannot meet local demand, and the rapid increase in Thailand's living standards will inevitably increase tea consumption (Hoare, 1987).

2.4 Fuelwood: The Primary Source of Energy

Since the mid 1970s, the fuelwood crisis has found its way into the international development agenda. While the world was recovering from the oil price shocks of the 1970s, another energy crisis emerged- for those families relying on firewood, charcoal and other biomass for their cooking and other essential needs (Foley, 1985). There are enormous environmental, social and economic consequences to the fuelwood crisis, which, unlike the oil crisis, has not gone away.

Although oil provides the greatest amount of energy consumed globally, biomass (wood, agriculture residues, dung) remains the prevailing fuel in per capita terms of energy for the basic needs of half the world's population (Goodman, 1987). In this group, wood is the main source of energy (Dankelman et al,1988) accounting for as much as 80 percent of the wood consumed in developing countries and is mainly used to meet household needs (Eckholm, 1975).

Experiences in developed countries have shown that as industrialization occurs and incomes rise, energy consumption increases and households switch to more modern energy sources (O'Keefe et al, 1984). These trends can also be observed in developing countries, especially in population centres where urbanization has led to increased incomes for some, followed by increased consumption of modern fuels like kerosene and electricity (Bee, 1986; Hyman, 1985; Leach, 1987; Leach and Gowan, 1987; Openshaw, 1978). Despite these trends, traditional fuels still play a vital role in developing countries and will continue to be the primary source of energy for rural households for many years to come (Bhagavon, 1985; Bee, 1986; Leach, 1987; Myers, 1984; Stevensen, 1989; O'Keefe and Raskin, 1985; WCED, 1987)

Eckholm's 'The Other Energy Crisis: Firewood' in 1975, and work by Openshaw (1974, 1978) helped focus attention on the importance of fuelwood (charcoal and firewood) in developing countries and the growing environmental, social, and economic problems as demand outstrips supply. Eckholm argued that deforestation had led to acute shortages of fuelwood in some developing countries and that continued fuel gathering had led to further deforestation. By the late 1970s this view had come to be accepted by international institutions (FAO, 1978; World Bank, 1980). In 1985, the forestry department of FAO reported that "fuelwood supplies have been rapidly depleted and the cutting of firewood has in turn been a major cause of excessive deforestation" (FAO, 1985:8). However, Goodman (1987) offers the following words of caution concerning the 'fuelwood crisis':

> *On the balance of evidence, it seems possible to answer the question of a shortage crisis with a definite "yes" -it really exists, but its severity differs widely from area to area and checks for evidence of it must be made in each case before jumping to conclusions about its existence in any district (p22).*

Often the fuelwood problem is neglected, because it is assumed to be easily available- to cook, boil water, give warmth, brew beer, provide light in the evenings and as social focus for the household. Munslow (1988:6) states: "unlike the 'other' [oil] energy crisis, the declining woodfuel supply did not immediately ring warning bells for governments in the form of balance of payments deficits and fuel shortages affecting the vital arteries of transport and industry". Work in Kenya by the Beijer Institute (O'Keefe et al, 1984) was the first major attempt to develop national energy budgets which included fuelwood. Projected figures suggested a growing gap between fuelwood demand and supply.

Household energy demand is one of the major uses of fuelwood. Data from more than fifteen UNDP/World Bank country assessments show the household sector accounts for 30 percent to 99 percent of total energy consumption (Leach and Gowan, 1987). These households largely rely on fuelwood and face a deepening crisis of scarcity as local resources are depleted and the more distant forests are cut down. Charcoal production often involves the systematic destruction of whole trees (Wibulswas, 1986). Fuelwood shortages play a dominant role in the daily lives of 1.5 billion people in the developing world (Myers, 1984).

2.4.1 Wood Energy in Industry

Another major user of fuelwood in developing countries is industry. The importance of woodfuels in industry varies enormously between countries. In some, conventional fuels such as gas, oil, coal and electricity have all but replaced fuelwood. In India, for example, with its well developed heavy industry sector, coal is, by far, the largest industrial fuel and fuelwood provides only 6% of total needs (Barnard & Zarror, 1988). But in other countries, fuelwood remains a key energy form for industry. In Sri Lanka, fuelwood represents an estimated 57% of the industrial energy demand and is the main supplier of energy in the tea industry. In Kenya 64%, Mozambique 69% and in Tanzania 88% of the energy for industry is supplied by wood (Barnard & Zarror, 1981).

In these and other developing countries, fuelwood is the only source of fuel for a large number of rural and urban industries, many of which are a vital part of the local and national economy. In some industries, the importance of fuelwood is increasing. Many brickworks in Nepal, for example, have switched back to fuelwood because of the cost of imported Indian coal has become too high (Barnard & Zarror, 1986). The amount of woodfuel needed by particular industries depends upon the process being used and the efficiency of the equipment. Some typical fuelwood consumption rates are given in Figure 2.2.

Though significant, fuelwood consumption by industry is rarely the dominant factor in fuelwood consumption at the national level. The household sector is usually the major consumer of firewood. But the impact of industrial demands can be much greater

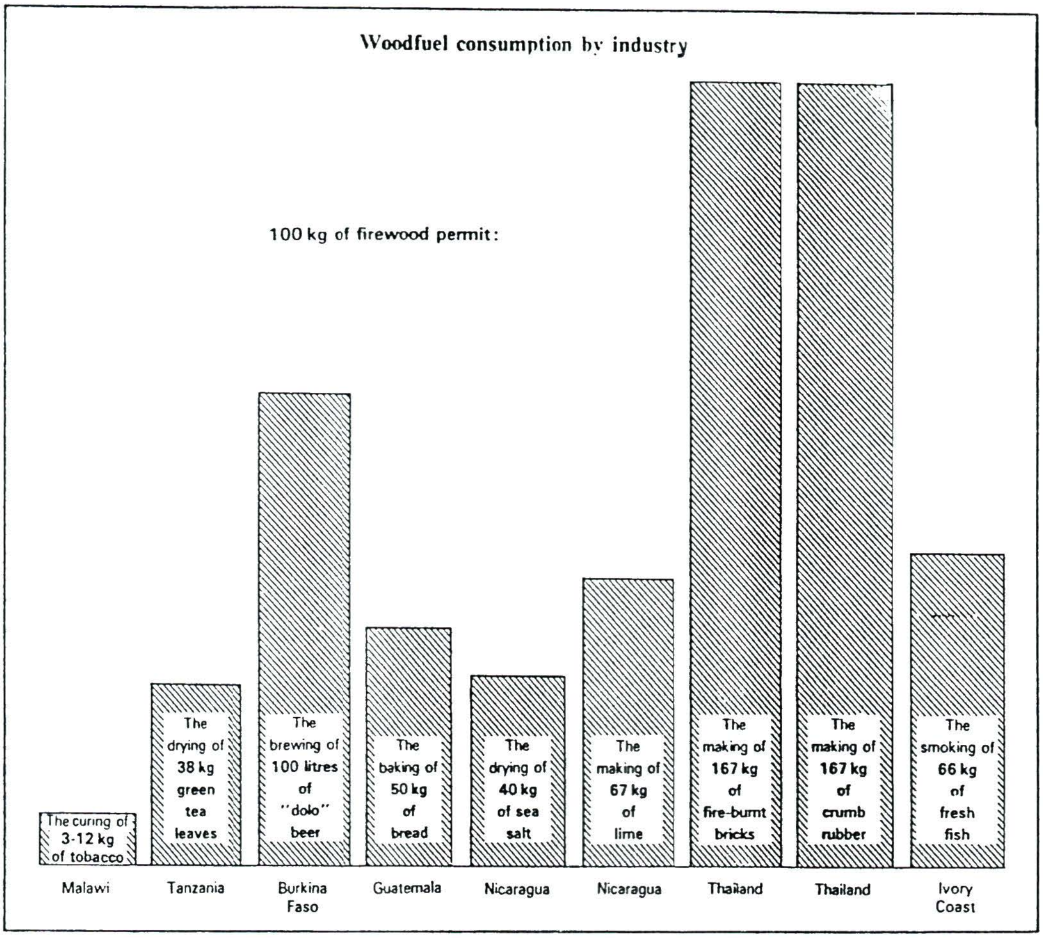


Figure 2.2 What 100 kilograms of firewood will permit.
(source: Barnard and Zarror, 1986)

than this implies. Unlike domestic demands, which are spread throughout the rural areas, industrial use tend to be concentrated in particular locations, distorting the local wood supply system and often contributing to deforestation. This effect can be reinforced by the fact that industries often require large pieces of wood rather than branches and brushwood which often provide the bulk of domestic needs. This results in whole trees being cut down, instead of relying on trimmings and branches, resulting in a larger impact on forest resources. In addition, industries normally buy their wood, thereby providing a cash incentive for wood-cutters to exploit local resources. Industries can, therefore, have a disproportionate influence on the local supply picture.

2.5 Traditional Energy Consumption in Thailand

Since traditional fuels (wood, charcoal, agricultural residues) are normally not traded goods, it is difficult to determine how much are consumed in a given country. In Thailand, for example, only 2% of firewood used by households is purchased and the remainder is collected by the households themselves, either in the forest (48%), on their own compounds (35%), or on other compounds (14%). Compared to firewood, charcoal is a more frequently traded good, with about 30% of Thai rural households purchasing their charcoal (Dang, 1989). Even if traded, these fuels are often traded through informal systems with unrecorded sales statistics.

In 1985, 43% of total energy consumption in Thailand was in the form of traditional fuels; a decline from 1970 levels. During this period, the total consumption of modern fuels increased and so did traditional fuels, but at a lower rate. In the period 1980-85, traditional fuel use grew stronger than the preceding period and a significant decrease in the growth rate of modern fuel consumption led to an increase in the share of traditional fuels in the energy budget of the country (Table 2.1). Much of this increase in the consumption of traditional fuels is likely due to the development of agro-industries such as rice milling and sugar milling (Dang, 1989). In 1983, rural areas accounted for 50% of total energy consumption in Thailand (Wibulswas, 1986) the majority of which was supplied by traditional fuels.

Table 2.1. Traditional energy consumption in Thailand.

Total Energy Consumption (units: thousand TOE)

	Total Energy Consumption	Traditional Fuels	% of TOE
1970	11,748	6,447	55.0
1980	21,834	8,990	41.0
1985	27,194	11,689	43.0

Growth Rate (%) of Traditional Fuel Demand (1970-85)

	Modern Energy	Traditional Energy	Total Energy
1970-80	9.3	3.4	6.4
1980-85	4.5	5.4	4.5
1970-85	7.4	4.1	5.8

Source: Un Yearbook of World Energy Statistics, Various Years. Energy International Journal (as cited in Dang, 1989).

Trends in Fuel Substitution

Distribution of Households by Type of Cooking Fuels Used (%)

		Elect	Keros	LPG	TFs	Other
1970	All	-	-	2	97	1
	Urban	-	-	9	88	3
	Rural	-	-	1	98	1
1980	Urban	6	-	30	61	3
	Rural	1	-	3	95	1

Source: 1970 Thailand Census of Housing and Population (as cited in Dang, 1989).

In 1983, household energy consumption was 49% of the total energy consumption in rural areas and 25% of total energy consumption in Thailand (Wibulswas, 1986). Household energy activities included cooking, lighting, personal heating, cottage industries, insect prevention and domestic appliances (including water pumps). Sources of energy used in rural households were firewood, charcoal, rice husk, palm leaves, straw, liquified petroleum gas (LPG), kerosene, gasoline, diesel oil, electricity, dry batteries and calcium carbide (Table 2.2). The energy required for cooking amounted to 70.8% of the total energy consumed in rural households. Wood and charcoal provided 97% of this energy. The second and third largest activities in terms of energy use- personal heating and cottage industries- represented 8.1% and 7.2% respectively. The main source of energy for household activities was biomass (92%) comprising fuelwood, agricultural and industrial wastes (Wibulswas, 1986). Fuelwood and charcoal supply 86% of total rural household energy needs (Wibulswas, 1986) and 30.2% of the total energy needs of the country (TDRI, 1987).

2.5.1 Wood Energy for Rural Industries in Thailand

Most of the rural industries in Thailand, such as brick making and food processing, depend heavily on wood for meeting their energy requirements (FAO, 1986). Some of these industries located near urban centres use commercial energy sources like liquified petroleum gas and electricity, but most are dependent upon fuelwood consumption.

The nature of traditional fuels use, especially firewood and charcoal, in rural industry is not well understood due to scattered, scarce and unreliable data (Dang, 1989). Dang offers some figures on fuelwood consumption in six rural industries-- food canning, rice milling, animal feed, sugar milling, wood processing, brick and pottery making-- where there is a heavy dependence on traditional fuels which provide for 65% to 99% of the energy needs. The World Bank states that rural industries consume about 40% of traditional fuel consumption in Thailand (World Bank, 1985). Although wood continues to be the primary fuel for curing tobacco (73%, 1.2% of national wood consumption) it

Table 2.2 Percentage of energy consumption in various household activities (rural areas in Thailand).

Activities	Wood	Charcoal	Rice Husk	Palm leaves	Straw	LPG	Kerosene	Gasoline	Diesel	Electricity	Calcium carbide	Total
Cooking	29.47	40.38	0.52			0.25	0.04			0.13		70.79
	66.25	97.44	10.34			100	0.67			13.38		
Lighting							5.66		0.22	0.35	0.16	6.39
							99.33		59.32	37.64	100	
Personal heating	7.71			0.15	0.23							8.09
	17.34			41.18	20.69							
Insect prevention	4.66		0.20	0.21	0.88							5.96
	10.49		3.91	58.82	79.31							
Cottage industries	2.64	0.22	4.35									7.21
	5.92	0.53	85.75									
Home appliances		0.84								0.39		1.23
		2.03								41.50		
Water pumping								0.11	0.15	0.07		0.33
								100	40.68	7.48		
Total	44.48	41.44	5.07	0.36	1.11	0.25	5.70	0.11	0.37	0.94	0.16	100
	100	100	100	100	100	100	100	100	100	100	100	

For each activity, figures in the top line indicate percentages of the activity, and figures in the bottom line indicate percentages of each source of energy.

Source: Wibulswas, 1986.

is gradually being replaced by lignite (IFSC, 1987). Firewood is the only source of heat used during the production of miang, green and black tea.

2.5.2 The Future Use of Traditional Fuels

Household cooking is a major consumer of traditional fuels in Thailand. The main substitutes are LPG and electricity. To switch to these, however, depends upon a large number of factors: relative prices, availability, culture and cost of technology. In Thailand cooking with LPG requires a deposit on the gas cylinder which amounts to three times the average monthly income of a village household in the northeast (Dang, 1989). A slow transition from the use of traditional fuels in the household to modern sources is occurring. Table 2.1 shows there is a much more rapid switch from traditional to modern fuels in the urban than rural household sector. However, traditional fuels will remain a major source of energy for households in Thailand for many years to come, especially in rural areas (Wibulswas,1986; Dang,1989).

The rural energy economy is undergoing transition. Rural industries, such as sugar mills and rice mills, have increased their consumption of biomass; modern transportation is changing self-sufficient life styles based upon renewable energy sources to increasing dependency on petroleum products (Wibulswas, 1986). However, Bhattachorya (1986) feels that rapid substitution of fuelwood by modern sources in rural industry is not likely in the near future because of the initial equipment and maintenance costs associated with such substitution and also because the cost of useful heat energy is often less in the case of wood compared to modern energy cases.

According to Dang (1989) the use of traditional fuels in Thailand should grow at a smaller rate compared to those of the last two decades. The firewood growth rate should decline and become negative, whereas charcoal growth rates will fall from 4 percent to 2 percent per annum. In the rural household sector, which will remain the principal traditional fuel consuming sector, firewood and charcoal growth rates are expected to decline. By contrast, modern fuels should grow rapidly as a result of the interfuel substitution in industry and the urban household sector, and due to growth of the Thai economy. Wibulswas (1986) notes that biomass will be the main source of energy for rural Thailand during the next two decades. The World Bank predicts that the traditional fuel requirement for rural industries will grow by over 2% each year during the period 1983-2001 (World Bank, 1985).

2.6 The Fuelwood Crisis and Related Problems

The fuelwood crisis is both a cause and consequence of deforestation, one of the world's most urgent natural resource issues. In 1950, tropical forests covered 30% of the earth's surface, by 1975 only 12% remained (Myers, 1984). The rates, causes and consequences of deforestation in developing countries are receiving a great deal of attention by governments and researchers. Estimates of deforestation rates in tropical areas vary considerably due to the sheer magnitude of the areas involved; problems of data collection; and differences in definitions of forest cover and what constitutes deforestation (i.e. Allen & Barnes, 1985; WRI, 1986). Bowander (1987) states that every minute of the day, 11 to 14 hectares of tropical forests are destroyed (15,840 to 20,160 ha/day, 5.8 to 7.4 million/year), resulting in a loss of 0.6 percent of the forested land each year. However, the World Wildlife Fund suggests that the rate of destruction is 1.15 percent per year because surveys often omit the effects of firewood gathering, excessive grazing, damage from fire and overlogging for commercial and domestic purposes- bringing the loss of tropical forest cover to 51,000 ha each day (18.6 million ha/year).

Deforestation is linked to numerous contributing factors, including fuelwood use; in certain latitudes, fuelwood gathering ranks as one of the major pressures to which tropical forests are subjected (Bee, 1986; Eckholm, 1975; Hyman, 1985; Myers, 1984, 1986; Stevensen; 1989). Other factors include commercial logging (Harrison, 1987; FAO, 1981), shifting agriculture (Guppy, 1983; WRI, 1985), overgrazing (Myers, 1986; Shane, 1986), farm encroachment (Goodman, 1987; Soussan et al, 1985) and the use of fuelwood by industry (Bhattachorya, 1986; Barnard and Zarror, 1988).

In addition to energy shortages, there are numerous costs associated with the decline in woody biomass supply. Loss of tree cover can lead to soil erosion (Eckholm, 1975; Myers, 1984) and where other biomass fuels are used, like crop residues and animal dung, greater soil degradation (Bagchi, 1987; Zanger,1985) and in extreme cases, desertification can occur (Agarwal, 1986; Barnard, 1985). Increased soil erosion can lead to siltation in downstream reservoirs, dramatically reducing electrical generating capacity (Myers, 1980; FAO, 1981). If women are largely responsible for fuelwood collection, diminishing supplies increase the demand on women's labour-time, with all the negative social effects this implies for their work in agriculture, child-rearing and housekeeping (Bagchi, 1987; Vollers, 1988). Fuel scarcity can lead to a reduction in energy use, which may mean less nutritional food is cooked (Cecelski, 1984; WCED, 1987).

As fuelwood supplies decrease, prices will increase, placing greater strain on poor families who will have to spend increasing proportions of their income on wood (Bee, 1986; Grut, 1987). The decline in forest cover will also deny rural populations the immense array of uses that forests have traditionally provided, for which alternatives will have to be sought in the market place (Bhagavan, 1985; Munslow, 1988). Perhaps the most serious long-term costs of diminishing forests are that of environmental decline with its impact on agricultural production systems (Munslow, 1988) and the potential of reduced forest cover to exaggerate the greenhouse effect on the world's climate (O'Keefe, 1989).

2.7 Deforestation in Thailand

Thailand is a tropical country and has two main forest types- deciduous and evergreen - deciduous forests account for two thirds of the forest cover and evergreen forests the remainder (Myers, 1980). Following World War II, about 60% of Thailand remained under forest cover (NTUSFP, 1987). Since this time, the loss of forest cover has been dramatic - from 1961 to 1985 the country's forest cover declined by 45% and only 29% remained (TDRI, 1987). Between 1981 and 1985, Thailand lost forest cover at a rate of 2.4 percent annually, the second fastest rate of depletion in Asia next to

Nepal (Dankelman et al, 1988). Some of the fastest rates of deforestation have occurred in Asia where a minimum of 25,000 square kilometres of forest are cleared each year. Recent estimates place the current level of forest cover in Thailand between 17.5 and 19.0 percent (Water Conservation Bureau, 1987), but the amount of remaining relatively undisturbed forest cover may be as low as 10 percent (Alcorn, pers comm).

The distribution of the remaining forest cover in Thailand is not uniform (Yasuhara and Yashizawa, 1987). Northern Thailand has the majority of the remaining forests, while the Northeast, Central, South and Eastern regions of the country have relatively little forest cover. Although Northern Thailand has a large majority of the remaining forests, this region currently also has the highest rate of deforestation (Forestry Bureau, 1989). In 1960, 70% of this region was covered with forests- by the end of the decade two thirds of the forested area above 1,000 metres were lost due to shifting cultivation practices (Banijbatana, 1978) and logging. Myers (1980) notes that large areas of the northern forest have been heavily logged or burned and as a result have been converted to savannah, open woodlands and grasslands. Recent floods and droughts on the central plains have focused attention on the condition of northern watersheds (Feeny, 1988).

Deforestation in Thailand has been caused by numerous interrelated factors, the largest losses attributed to population growth, agriculture expansion (including shifting agriculture) and commercial harvesting (Bhumibhamon, 1986; Ramitanondh, 1989; NTUSFP, 1987; Phatumvanit and Sathirathai, 1988; Water Conservation Bureau, 1987). However, the major use of wood in Thailand is for fuelwood (Bhumibhamon, 1986) suggesting that this is also a major cause of deforestation. NTUSFP (1987:23) notes that the rising demand for fuelwood (for use in the household, agriculture and small rural industry) and building materials has greatly accelerated deforestation.

According to Feeny (1988), the decline in forest cover is partially due to the fact that in Thailand, forests are often treated as an open and free access resource (i.e. common property) and tend to be treated with little regard for the future. They have been both a major source of foreign exchange and government revenue for many years (Chuntanaparb and Wood, 1986) and provide many of the basic needs for rural people including fuel, food, medicinal plants and construction materials (Feeny, 1988). They are under severe pressure from rural populations to meet basic needs and are a source of income generation for villagers, businessmen and the government.

Deforestation in Thailand is continuing at an alarming rate. Myers (1984) suggests that the forest cover could disappear by the end of the century. Some of the consequences of deforestation in Thailand are the degradation of upland watersheds which results in soil erosion and sedimentation of rivers, streams and reservoirs. In turn, in the lowlands the increased severity of flooding affects crops, disrupts irrigation systems, reduces crop yields (Adams, 1985; Myers, 1984; NTUSFP, 1987) and has sometimes resulted in loss of life (FAO, 1981). Furthermore, the siltation of reservoirs decreases power generation for urban areas (FAO, 1981; NTUSFP, 1987). The loss of biodiversity is also a major concern. Thailand was included with those developing countries having serious upland watershed problems by the World Resources Institute and is one of the 63 developing countries which now faces a present or imminent fuelwood deficit (WRI, 1985).

2.8 Management Strategies to Deal With Fuelwood Shortages

In response to the issues of fuelwood shortages, numerous studies and reports in various tropical countries have identified three main options, namely supply enhancement, conservation, or fuel switching strategies. Supply enhancement strategies range from growing small woodlots to commercial fuelwood plantations (Arnold, 1987; Buckman, 1987; Foley, 1984). Agroforestry is producing promising results (Hanafie, 1980; O'Keefe et al, 1984; Salem and van Nao, 1981; Winterbottom et al, 1987) and is used in Thailand along with other programs (FAO, 1981; Myers, 1980; NTUSFP, 1987).

Conservation approaches usually deal with efficiency in the form of better wood burning technology. Improved woodstoves are generally used for reducing fuelwood consumption, as an important tool for improving women's health and quality of life, and as a weapon in the fight against deforestation (Baldwin et al,1985). Woodstove programs have had wide ranging results from failure to increase fuelwood efficiency

(Hoiser et al,1982; Gill, 1983, 1987; Manibog, 1984) to reported increased efficiencies of 20% to 50% (Baldwin et al, 1985; Foley, 1984; Mier et al, 1987). While Foley and Moss (1983) pointed out obstacles to reducing fuelwood consumption with improved stoves and the problems that many projects have had, they concluded that "appropriately designed stove programs have a valid role to play in development assistance" (p.11). The Thai government has also been involved with improved stove programs. However, "stove designs have not been optimized and further research and development to improve stove design will be beneficial to the domestic supply of energy and will help reduce the rate of deforestation in the country" (Wibulswas, 1985:7).

Fuel switching receives a great deal of attention in the literature (Bhagavan, 1985; Kjellstorm, 1985; Palz et al, 1980). Programs have examined alternate energy sources including agriculture residues; solar, wind and small hydroelectric projects; and nonrenewable forms such as coal, oil and gas. Large hydroelectric projects are also supplying power, flood control and irrigation in many developing countries. The development of new and renewable sources of energy to satisfy the energy needs of rural populations in developing countries is often proposed. Munslow (1988:14) states that "these remain in the domain of experimental technology and are unlikely to make a significant impact on energy provision in rural areas in the foreseeable future." However, some successful examples include biogas production for villages in India (Roy, 1980) and China (FAO, 1983) and the use of wind power to pump water in the SADCC region (Bhagavan, 1985).

Small scale electrification and lignite supplies household energy for some villages in Thailand (World Bank, 1984). There are approximately 3000 biogas unit in rural areas (Wibulswas, 1986) and the densification of biomass residues has been established for about a decade (Bhattachorya, 1989). Nongovernment organizations such as the Asian Institute of Technology are working to develop the technology to take advantage of renewable forms of energy for village level use and use in rural industry (AIT, 1989).

2.9 Summary

This chapter has reviewed three primary areas of the literature relevant to the focus of the study: agroforestry systems; tea production in Northern Thailand; and fuelwood. This review provides the general context for examining the specific matter of energy scarcity in the traditional tea industry in Thailand and exploring the range of alternatives for resolving the problem.

Agroforestry represents land-use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and/or animals either in some form of spatial arrangement or in a time sequence, and in which there is a significant interaction between the woody perennials and the crops or animals (Macklin, 1990). Agroforestry can capitalize on the positive relationship among trees, animals and field crops- contributing significantly to sustaining or increasing agriculture productivity, increasing self-sufficiency (including fuelwood production) and incomes, improving living standards and slowing or reversing environmental degradation in developing countries (Winterbottom and Hazlewood, 1987).

Smallholder tea gardens in the uplands of Northern Thailand produce all of the miang, most of the green tea and a substantial portion of the black tea produced in Thailand. This upland practice is an agroforestry or 'forest-use' system which helps to maintain forest cover in important upland watersheds and provides a livelihood for thousands of villagers.

Biomass is a major source of energy for the basic needs of over half the world's population (Dankelman et al, 1988) and is a major source of energy for industry in many developing countries (Barnard and Zarror, 1986), In Thailand, traditional fuels supply almost half the energy needs of the country (Dang, 1989) and will continue to be a major energy source, especially in rural households and industry, for decades (Bhattachorya, 1986; Wibulswas, 1986; Dang, 1989). Fuelwood is the primary energy source for the tea industry in Northern Thailand.

Thailand has the second highest rate of deforestation in Asia (Dankelman et al, 1988) and most of the country's tropical forests have been destroyed due to a variety of causes, including fuelwood gathering. Today, there is probably less than 15% of undegraded forest remaining (Alcorn, pers comm) from the original forest which once covered three quarters of Thailand (Dankelman et al, 1988). The loss of forest cover has tremendous environmental, social and economic consequences, especially for rural populations who are dependent upon the forest for energy needs and a vast array of other products. Changes in forest policy have altered traditional firewood gathering practices, threatening the energy supply for tea processing, the sustainability of this upland agroforestry system and the livelihood of traditional tea producers in Tambon Pa Pae. The conceptual framework and methodological approach for studying this set of complex issues are examined next.

Chapter 3: Conceptual Framework, Research Design, and Study Area

This chapter outlines the conceptual framework, research design and the field methods to collect data, followed by a description of the study area and the four villages selected for investigation.

3.1 Human-Environment Relations: A Geographic Approach

The study of human-environment relations has long been a tradition in geography. Although 'environmental-determinism' was rejected as a focus of research in the early 1900s, prominent geographers continued to urge research on this theme (i.e. Burrows, 1923; Sauer, 1941). During the latter part of the 1960s, 'ecological analysis' started to become more fashionable with the arrival of the environmental crisis (Carson, 1962; Ehrlich, 1968). Stoddort (1966) notes that "from about 1910 'human ecology' was used for the study of man and environment, not in a deterministic sense, but for man's place in the 'web of life' or the 'economy of nature'".

Within the human-environment theme, resource use, allocation and management have been major areas of geographic research. Zimmerman (1951) notes that natural resources are dynamic, becoming available to man through an increased knowledge and expanding technology as well as changing individual and society objectives. O'Riordon (1971) states that resource management should be visualized as a conscious process of decisions involving judgement, preference and commitment, whereby certain desired resource outputs are sought from certain perceived resource combinations through the choice amongst various managerial, technical and administrative alternatives. This is, however a very rationalist view and many analysts today recognize that habitual decisions, 'nondecisions' and the structural limits of the economy also have crucial roles to play in determining the practice of resource exploitation and allocation (Johnston, 1989).

Many geographers are concerned with human-environment interactions since understanding this linkage is an important component in the design of effective resource management programs (Mitchell, 1989) and in resolving resource-use problems/conflicts. Mitchell argues/claims that geographers are well placed as resource analysts; "the geographer seeks to understand the fundamental characteristics of natural resources and the processes through which they are, could be and should be allocated and utilized" (p.3). Four types of geographical research in resource analysis suggest themselves:

(1) studies of natural resources themselves: surveying, mapping and measurement of the supply of and demand for resources as well as their characteristics and properties;

(2) studies of alternative allocations (spatial, temporal, functional) of resources in terms of users, facilities and activities;

(3) studies of variables (biophysical, technological, economic, social, political, institutional, legal which condition resource allocation or development; and

(4) studies of the impact of specific resource allocations (Mitchell, 1989).

The orientation of these activities indicates a predisposition towards the compilation and manipulation of data about natural resources, or the inquiry into the manner in which resources are allocated among competing uses and users. The focus is upon determining the way in which resources are actually located and used, as well as exploring alternative ways in which they could be or should be utilized (Mitchell, 1989).

In short, the geographer is well placed to analyze resource-use problems from the elementary level i.e. farmer, to a much broader level i.e. policy issues. This study examines one area of human-environment interaction where a resource-use issue has developed-the fuelwood supply problem in the tea industry in Northern Thailand.

3.2 Conceptual Framework

Conceptual frameworks are organizational devices used to structure the problem and to identify its various parts. Once a problem has been conceptualized, a research design can be developed for collecting information about the variables identified in the conceptual framework. Resource analysis problems may be defined at very general or more specific levels. Firey (1960) defines resource problems as consisting of three interrelated parts: ecological, ethnological and economic. All three must be studied in order to understand the problem. The resource issue examined in this study will be briefly examined at this general level before outlining the conceptual framework.

3.2.1 Resource-Use System

Smallholders have been producing miang in the uplands of Northern Thailand for centuries. More recently, black and green tea are also being produced. Most tea leaf is grown under extensive conditions within an agroforestry (or forest-use) system. Miang production has been the most important upland tree crop in Northern Thailand (excluding forest products) for over 100 years (Hoare, 1988).

Fuelwood for tea processing is largely obtained from forests nearby the tea gardens. Government efforts to save Thailand's dwindling forest resources have led to a logging ban. Fuelwood gathering activities of tea growers in the forests have also been restricted. Some villagers have intensified firewood collection in their tea gardens, but most must continue to collect firewood from the forest. Increased firewood collection from the tea gardens and conflict between forest officials and villagers threaten the sustainability of this resource-use system and the livelihood of miang and green tea producers.

3.2.2 Borrowing From Hazard Research

Mitchell (1989:175) notes that many investigators in hazard and risk assessment research relate their inquiries to Borrow's (1923) interpretation of geography as the science of human ecology, with emphasis upon the "relationship existing between natural environments and the distribution and activities of man". Gilbert White's concern for flood related problems- "how does man adjust to risk and uncertainty in natural systems, and what does understanding of the process imply for public policy?" (1973:194)- relates closely to Borrow's concept of human ecology and remains the underpinning of most hazards research. Although the fuelwood supply problem in the tea industry in Northern

Thailand is not a hazard in terms of the geophysical and biological hazards commonly studied within the field of hazard research, the issues being studied are similar- human adjustment to risk and uncertainty within the natural environment. The conceptual framework developed by White- the identification of the theoretical, practical and actual range of choice- offers a useful approach for examining the fuelwood supply problem.

White's conceptual framework helps to structure the problem, allowing the researcher to broaden the range of alternatives for resolving a resource-use problem. In this study, four primary goals must be completed before recommendations can be made for resolving the firewood supply problem. These goals include:

(1) inventory of current resources;
(2) how is the resource being managed;
(3) nature of the problem; and
(4) identify current coping strategies.

The inventory is not so much quantitative, but is intended to examine the biophysical characteristics, health and productivity of the resource. Management practices, especially how they relate to the first goal, must also be examined. The nature of the problem and how it is perceived by the tea producers and other key informants must also be understood. Identifying current coping strategies will indicate the success of the villagers to deal with the fuelwood supply problem. Once the nature of the resource and the problem are understood, and current coping strategies identified, the range of alternatives can be broadened based upon the experience of the researcher and strategies to deal with similar problems in Thailand and around the world. The emphasis in this approach is to seek a solution to the problem by working closely with the villagers, drawing upon their knowledge and experience to identify a solution which is not labour and/or monetarily demanding.

Geography often acts as a bridge between the social and physical sciences (Johnston, 1985) often allowing the geographer to take a more holistic approach and utilize various methods of data collection to study and examine a problem. In this study, a variety of methods of data collection are used to collect both physical and social data. The research design will now be examined.

3.2.3 Research Design

The research design represents a strategy or procedure for collecting evidence about the variables identified in the conceptual framework (Mitchell, 1989). The research design for this study is based primarily upon two pieces of work: Gilbert White's (1972) study of domestic water use in East Africa and Anne Whyte's (1977) model of environmental perception research components. White's study represents a successful approach for studying a specific resource issue within a developing country. Whyte's model represents an effective and flexible strategy for understanding resource use decision making and hence collecting information.

White's study of domestic water use in East Africa was "simple in concept, clever in design, broad in approach, convincingly large" (Kates and Burton, 1986:291). To understand domestic water use (the use of choice) or demand, White used personal interviews (women and government officials) and field observation. An inventory of water sources examined the available supply. It then became possible for White to analyze the decision making of the resource use system and how women selected their water source. White showed that the common types of public intervention for supplying water tend more to restrict than to widen the choices open to domestic water users.

Similarly, a detailed biophysical survey of the resource base, the tea gardens, field observations, personal interviews with tea garden owners and other key informants, and written questionnaires (done interactively) with miang and non-miang producers are used to meet the preceding objectives of this study and thereby expand the range of choice for resolving the fuelwood supply problem in the tea industry in Northern Thailand. Primary data generated by this study and experiences of the villagers, researcher and from other parts of Thailand and the world will be used to broaden the range of alternatives.

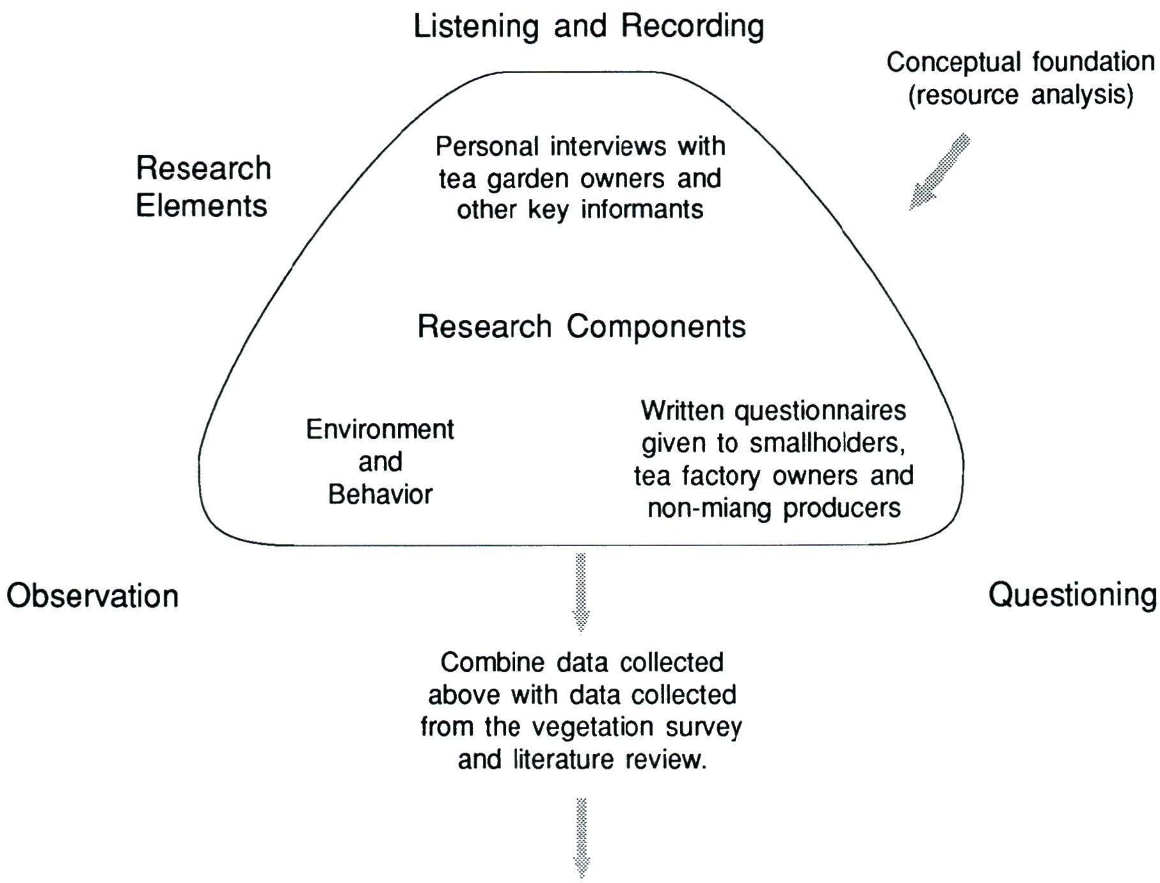
The conceptual framework used by White to study domestic water issues in East Africa, and the approach adopted here to study the fuelwood supply problem in the tea industry in Northern Thailand, can be divided into five stages: 1) define and understand the problem; 2) examine the nature of the resource; 3) examine resource use; 4) perform an evaluation; and 5) make recommendations and conclusions. These five stages and corresponding aspects of White's study and this study are outlined in Figure 3.1. The methods used in this study which largely parallel those used by White are also included in this diagram.

Whyte's model of environmental perception research components offers a useful strategy for structuring data collection efforts. Within this model, the elements of questioning, observing, and listening and recording form the overall dimensions of the research design. These elements are satisfied through the application of various complementary, data collection methods. Figure 3.2 illustrates Whyte's model and the data collection methods used in this study. The data collection methods used here which compliment the elements of Whyte's model include personal interviews, written questionnaires and field observation. Data collected using these methods will be combined with data collected from the vegetation survey and literature review to achieve the objectives of this research. The various methods of data collection help to reinforce each other, improving data quality. This research design also provides a flexible strategy which is important when field conditions are not completely known.

The methods used in this study reflect the amount of data previously available, and time and resource constraints. As mentioned earlier, the traditional agroforestry system used for producing tea has not been the subject of any detailed study. In addition, the firewood supply problem, which has intensified in the later part of the 1980s, has received little attention from the government, academics or nongovernment organizations. Given the lack of data surrounding this agroforestry system and related resource-use problems, and the desire to work closely with the villagers to find a solution to the fuelwood supply problem, primary data collection was critical for understanding the problem. Primary data collection was constrained by limited research funds and a six month time period in which the study was to be designed and completed. The various methods of data collection used in this study will now be examined.

White's Study	Conceptual Framework	This Study	Methods
inadequate domestic water supply in areas of East Africa	define and understand the problem	fuelwood supply problems in the traditional and green tea industry in the uplands of N. Thailand	literature review, background research (Chapters 1 and 2)
rural water supplies: wells, springs, streams (quality and location)	nature of the resource	biophysical characteristics of the tea gardens, management practices	inventory and assessment (vegetation survey, Chapter 4)
women and water use	resource-use system	miang and green tea production, fuelwood use and supply	examine attitudes and perceptions of the resource users (written questionnaires, interviews, field observation, Chapter 5)
individual decision making, the choice of use	evaluation	current coping strategies	Chapter 6
expand the range alternatives for supplying domestic water	conclusion and recommendations	expand the range of choice for resolving the fuelwood supply problem	Chapter 7

Figure 3.1 Conceptual framework: structuring the problem.



Data collection methods complement each other.
Data is used to meet the objectives of this study:

1) describe the biophysical characteristics and management of the tea gardens;

2) examine energy used and supply for tea garden;

3) propose a solution for resolving the energy supply problem;

4) examine the sustainability of the tea gardens.

Figure 3.2 Research design.

3.3 Tea Garden Survey and Preliminary Inventory of the System

The primary objective of the tea garden survey was to understand the structure of the physical resource base which supplies both tea leaf and fuelwood. In a sense this represents an inventory of the supply system and its management as an upland agroforestry system. The biophysical characteristics were examined using a vegetation survey of plots near each village. These plots were designed to answer questions regarding the biophysical features of this system namely: tea tree and forest tree density; ground cover and forest cover composition; understorey regeneration; and firewood productivity. In order to link what was found in the vegetation plots with tea garden management practices, interviews were held with some of the owners in whose tea gardens vegetation plots were located. Some management questions include: establishing and maintaining tea gardens and shade requirements for tea trees.

Data from the vegetation plots will be examined individually and then as a whole, contrasting the structure of the tea gardens with a similar, relatively undisturbed forest. The data collected by the vegetation survey, field observation and interviews with the tea garden owners will be combined with the data from the miang producer survey to develop a comprehensive understanding of this agroforestry system. All this information will be used to examine the sustainability of the tea gardens. The design of the vegetation survey will now be examined.

3.3.1 Sampling Strategy for the Vegetation Plots

The preferable method for sampling the tea gardens would have been a transect through the tea gardens at randomly chosen locations. Due to time and resource constraints, it was not possible to use such a rigorous and systematic sampling design to study the extensive and variable tea gardens in the study area. Instead, from 2 to 4 fixed boundary plots were established in the tea gardens surrounding each village. In conjunction with personal interviews with tea garden owners it is felt that this limited survey reveals the important features of the relationship between management practices and tea garden structure.

Fixed boundary plots, ranging in size from 0.5 to 1.5 rai, were used to sample the tea gardens. Two types of plots were used under different conditions, accounting for the range in plot size.

1) Strip Plots:

These plots were used to examine tea gardens established upon the slopes of the upland hills. A 20 metre strip was run from the bottom of the slope to the top, or to where the tea garden ended at the forest edge. This type of plot was used to examine changes in the tea gardens with changes in slope position.

2) Block Plots:

These plots were used to sample extensive tea gardens that were located on the top of broad hills, in valley bottoms, or on slopes where the tea gardens extended further than 200 metres up the slope.

3.3.2 Plot Location

Field observations indicate that there is a great deal of variability in the structure of the tea gardens. Some tea gardens are heavily forested with canopy trees exceeding 30 metres in height, while other tea gardens have no forest cover. Tea tree densities are also variable. The only discernible pattern is that the tea gardens on the lower slopes generally have less forest cover than the gardens higher up on the slope. Most tea gardens are slashed regularly, have clean forest floors and a few are fenced.

Due to the extensive and variable nature of the tea gardens within the study area, some crude criteria were used to select the general area in which plots would be established. For example, it was thought that road access and/or distance from the village would have an influence on forest cover in the tea gardens. Presumably, road access would negatively influence forest cover and for those gardens not accessible by road, forest cover should increase with distance from the village. Therefore, plots were located to examine the influence of distance and road access.

Once the general area for a plot was selected, a plot was located in a portion of the tea garden which appeared to be representative of the area. Plots were sometimes located in gardens in which previous contact had been made with the owners. These owners agreed to visit the tea gardens after the vegetation plot was completed in order to discuss management issues.

Thirteen vegetation plots were completed. Plots 4, 5 and 6 were strip plots which examined the difference in tea gardens as influenced by slope position. Plots 1-3 and 7-11 were established to see if accessibility influenced forest cover. Plots 1, 2, 3, 7 and 9 were within 0.5 km of a village, and Plots 5, 8, 10 and 11 were located over 0.5 km from a village. Plots 8 and 10 were located in tea gardens furthest from a village in a specific direction. Plots 12 and 13 were completed to illustrate the substantial differences in tea gardens which can occur over short distances and to show how individual ownership influences the structure of the tea gardens.

3.3.3 Plot Layout

Fixed boundary plots were used to examine the biophysical features of the tea gardens. If strip plots were being used, a 20 metre strip was run from the bottom of the slope to the top, or to the forest edge, whichever came first. Strip plots ranged in size from 1.0 rai to 1.5 rai. If block plots were being used, then square and rectangular plots were established. The first 3 block plots were 40 metres square, but plot size was later reduced by half (20 metres by 40 metres) due to time constraints.

Once plot boundaries were established, the plot was divided into 10 metre square grids. The forest and tea trees were then plotted, measured and identified. With the assistance of J. F. Maxwell, a botanist from the herbarium (Faculty of Pharmacy) at Chiang Mai University, forest and ground cover were carefully identified.

The following information was recorded for the vegetation plots.

1)Tea Trees:

Location and average height of the tea trees were recorded (3 tea trees in each 10 metre square quadrant were measured, minimum of 20 trees per plot measured). Tea trees over 0.5 metres tall where included in the plot.

2) Forest Trees

Location, species, height (measured with rangefinder altimeter), diameter at breast height (DBH tape) and any special characteristics of the forest trees were noted (i.e. coppiced). Trees taller than one metre were included in the plot.

Forest cover was divided into three height classes: canopy trees were 20 metres or taller; midcanopy trees were over 12 metres tall but less than 20; and understorey trees were over 1 metre tall and up to 12 metres. This was done so that crown diameters could be estimated for each class (see crown diameter) and the regenerative capability and firewood productivity of the plots could be examined. Once trees reach the midcanopy they tend to become too large for firewood (discussed in more detail later).

3) Crown Diameter

Crown diameters were estimated for three categories of forest cover. For each category in the first 5 plots, crown diameters were recorded and then averaged. Canopy trees had crown diameters of 6 metres, midcanopy of 4 metres, and understorey of 1 metre. This measurement is crude but sufficient since the amount of shade in each plot cannot be related to the productivity of the trees in this study.

4) Stumps

Location, diameter and cut (how long ago it had been cut) were recorded. If tea garden owners were interviewed, then the use, when it had been cut and age of the stump were recorded when possible.

5) Elevation, Aspect, Slope

Elevation was measured using an altimeter, aspect measured using a compass and slope measured using a rangefinder altimeter.

6) Ground Cover

Ground cover is an important indicator of the 'health' of the tea gardens. If the ground cover was composed of largely native species, than the regeneration of the forest cover should not be hindered. Ground covers composed of 'weedy' species, however, may be detrimental to the regeneration of the forest cover. Most of the weedy plants identified in the vegetation plots are established aliens, flora which have been introduced primarily from tropical America and grow at the expense of the native species (Maxwell, pers comm).

Again, time and resource constraints made it impossible to employ rigorous ground cover sampling methods. Clip and dry methods of sampling ground cover would have been preferable. Instead, the major weeds and native species were identified and the relative abundance for each plot was given. Ground cover for each plot was divided into three classes: if the ground cover was largely native, it was classed as 'native'; if it was largely weedy to an extent which may hinder seedling regeneration, it was classed as 'weedy'; if a plot was a mixture of remnants of the original ground cover and invading species and was judged not to greatly hinder sapling regeneration, then it was classed as 'mixed'.

After the field data were collected, plot descriptions for each plot were developed. These descriptions include a plot diagram, summary table of forest cover, ground cover and other biophysical data collected from the vegetation plots, field observations and any relevant information obtained from interviews with tea garden owners. Diagrams of the plots include the location of all forest and tea trees and any significant biophysical features within or near the plot.

3.4 Written Questionnaire

Data can be collected using various methods i.e. written questionnaire, mail survey, telephone survey, and formal and informal interviews. Different methods have advantages and disadvantages under different conditions (Isben and Ballweg, 1974). Structured questionnaires done interactively with the respondents (and informal interviews) were chosen to collect data from miang producers, non-miang producers and tea factory owners. These were considered the most appropriate for several reasons: previous use in this conceptual area (White et al, 1972); the in depth nature of the information being collected; the available funds and time; and the cultural setting.

Where funds and time are limited, the structured questionnaire provides a broad cross section of the issue under study. In addition, where an interpreter is required to help collect the information, the use of a structured questionnaire is favoured. When using a structured instrument, allowances can be made for cultural considerations and the interviewing process, allowing for the collection of information which is orderly and uniform across the target group. Three different written questionnaires were used: miang producer survey, non-miang producer survey (shorter version of the previous survey) and a tea factory owner survey.

3.4.1 Miang Producer Survey: The Resource-Use System

The primary objectives of the miang producer survey were to collect data on tea garden management practices; energy use and supply; problems facing miang producers; and socioeconomic data of the respondents in the four villages selected for study. Table 3.1 summarizes the data collection areas (see Appendix 1 for English version of the survey).

3.4.1.1 Instrument Design

The miang producer survey was designed according to principles developed in the literature (Bradburn, 1979; Converse, 1986; Sheskin, 1985). Previous research on designing fuelwood surveys and conducting them in developing countries (FAO, 1983b; Hyman, 1983; Leach and Gowen, 1987; Shenahan, 1986; Siwe, 1986) was especially helpful.

Alwin (1977) notes the specific errors to avoid when designing individual questions i.e. misleading questions, ambiguous questions and general problems of survey design. To ensure the validity and reliability of the questionnaire, emphasis was placed upon clarity of wording, question length and ordering. This was especially important due to the sensitive nature of some of the questions. Crosschecks were incorporated into the questionnaire whenever possible when villagers were asked for numerical data.

Developing appropriate questions for the miang producer survey began early during the research period. They were continually revised and updated during the first two months of field research as the physical and human context of the problem became apparent. The survey design and questionnaire were reviewed by Thai researchers at the Social Research Institute (Chiang Mai University) and by geography professors at the University of Victoria.

Table 3.1. Goals and objectives of the miang producer survey.

Goal: understand the dynamics of miang production as a tropical agroforestry system.

Objectives:

Energy use for miang production:
- type, source, amount, cost
- supply problems

Management techniques for tea gardens:
- inputs: fertilizer, chemicals, pruning, slashing, planting, labour
- density of tea trees, productivity
- importance of shade

Land tenure:
- type, amount, any problems

Household energy use:
- type, amount, supply, cost

Deforestation:
- does it occur, is it a problem, are they concerned, knowledge of logging ban

Community forestry:
- any arrangements for managing local resources

Socioeconomic data:
- household size, education, income, length of residence, indebtness

3.4.1.2 Target Group

The target group for the miang producer survey are the miang producers in Pa Pae, Pang Ma Kuay, Mae Sae and Mae Mam villages (discussed later). The limited education (majority have attended primary school only) of this group was a factor in designing the survey instrument. Thus, questions were concrete rather than abstract in nature and addressed the objectives of the survey.

3.4.1.3 Pretest

The questionnaire was first translated into Thai and then as a necessary check on the survey design, a pretest was undertaken. To begin, one miang producer was interviewed in Mae Sae. The interview was conducted in Thai and the respondent's answers were immediately translated to English for the researcher to record. After this first interview, modifications were made to the questionnaire and four more households, two in Mae Sae and two in Mae Mam, were interviewed. Two villages were used during the pretest so that the questionnaire could be tested under a wide range of conditions. The researcher accompanied the Thai assistant so that any questions concerning the questionnaire could be clarified (interview conducted in Thai). After these four interviews were translated, adjustments were made to the instrument and five more miang producers were interviewed. Final adjustments were made after this final pretest.

To ensure that the questionnaire was administered correctly, the researcher trained the Thai assistant in interviewing procedures and also accompanied the interviewer during the first 10 surveys and during later interviews. The interviewer was encouraged to 'put the villagers at ease' before questioning began, informing the respondents about the nature of the research and that information provided would be confidential. This later point was very important due to the sensitive nature of some of the issues. Many villagers were nervous about outsiders who may be businessman trying to gain an advantage over them. They were also nervous due to the firewood supply problems and tensions between themselves and forestry officials. Accompanying the assistant and spending a lot of time in the villages lent credibility to the researcher, as foreign researchers are often well received by the villagers. Some villagers were very 'happy' that foreigners would come to try and help them.

The final survey was conducted during the first three weeks of October. Although tea leaf is still being picked at this time, production is low and many villagers were home during the day performing other tasks. In addition, some producers hire labour to pick tea leaf and were often available during the day. The final questionnaire was usually conducted by the Thai assistant. Results were translated to English within two days of the survey while the information was still fresh in the interviewer's mind.

The completeness of responses were checked during the translation of the questionnaire and any missing information was followed up at a later date.

There is no gender preference in the survey. Miang production is often a family operation and although men are usually the head of the household, women are considered to be equally knowledgeable; as long as the respondents were either head of the household and/or were active in the production of miang they were interviewed. Women are often very active in miang production, picking tea leaf and helping in processing the miang and maintaining the tea gardens. Households are also often extended families, and the elder mother and father are often at home during the day. These people were interviewed if they were still active in the production of miang.

3.4.1.4 Population and Sample Size

There are approximately 319 miang producers in the four villages; 200 in Pang Ma Kuay, 100 in Pa Pae, 14 in Mae Mam, and 5 in Mae Sae. Due to limited time constraints (only one assistant available to conduct the survey) it was conducted during a three week period in October when the research assistant was available.

To overcome the limits imposed by time and resources, and to ensure that a representative sample of miang producers was surveyed, a sample procedure was used whereby approximately every seventh producer household in the large villages was approached. If the villagers were not home during the first visit, a second visit was made. After that, surveys were completed subject to respondent availability. Due to the relatively small size of Mae Mam and Mae Sae, attempts were made to sample all producers in these villages. In Mae Sae, all producers (5) were surveyed, and in Mae Mam, after four visits, 11 of 14 producers were surveyed. In the two larger villages (Pa Pae, Pang Ma Kuay), about 14% of the producers were surveyed (41 out of 300). There were 57 interviews completed in all-- which represents close to a 18% sample.

3.4.1.5 The Miang Producer Survey

Due to the exploratory nature of the survey, many questions in the miang producer survey were open ended, especially those dealing with problems facing the miang producers. Content analysis was used on these open ended questions and the results reported in table format. The small sample size in the small villages did not allow for any statistical analysis to be used for inter-village comparison. Completeness of responses was checked at the time of translation.

The questionnaires for the miang producer survey took, on average, 55 minutes to conduct. The survey, overall, was well received by the villagers. Two incomplete questionnaires were eliminated from the analysis. One questionnaire was only partially completed as the villagers were celebrating a Buddhist holy day and the respondent left to entertain visitors. During the second incomplete survey, the mother of the respondent kept interrupting the interview as she was nervous about why the data was being collected. Every 5 minutes the mother came out of the house, telling her daughter not to answer any questions. After 15 minutes the interview was suspended.

The results of the miang producer survey are presented and analyzed in Chapters 4 and 5. The quality of the information, overall, was very good.

3.4.2 Supplemental Survey

After completing the miang producer survey, a short supplemental survey was conducted (Appendix 2) which took 5 minutes and was completed for all the households that took part in the original survey, except for three (one in each of the villages except for Pang Ma Kuay). This final survey was conducted for several reasons:

1) The initial survey was primarily conducted by a Thai assistant. The supplemental survey, however, was done by both the assistant and researcher, allowing the researcher to probe any questions which arose from translation and/or from other research.

2) Villagers often control more land than they hold title to, allowing them to avoid land tax. At the beginning of the miang producer survey, villagers where reluctant to state how much land they had controlled since they did not know what the intentions of the research were. After the villagers became familiar with the nature of the work, near the end of the survey, they were more willing to answer sensitive questions. Therefore, a question regarding land title was added to the questionnaire to ascertain the amount of tea gardens held by individual households.

3) Questions regarding sources of firewood for processing miang were inadequate. Part way through the survey it became apparent that villagers substantially changed their wood gathering practices after forestry became more strict about cutting firewood in the forest in 1987/88. The questionnaire failed to pick up this information, therefore, before and after questions regarding firewood collection were added to the supplemental survey. In addition, one question regarding slashing the tea gardens was also added to examine if any changes in management practices occurred due to the change in policy by forestry officials regarding firewood collection.

3.4.3 The Non-Miang Producer Survey

A shortened version of the miang producer survey was given to villagers in Pa Pae and Pang Ma Kuay. The primary objectives of this survey were to enable a comparison of household firewood supply, attitudes towards deforestation and incomes between miang producers and other villagers. The latter were given the last five sections of the survey.

3.4.4 Tea Factory Survey

The primary objectives of the tea factory survey were to examine energy supply and consumption and quality control standards for fresh leaf delivered to the factories. A written questionnaire was used to collect information about green tea production from tea factories in Pa Pae, Mae Sae, Mae Loa (3) and Mae Pang (near Mae Mam). The questionnaire was done interactively with the factory owner, Thai assistant and the researcher. Table 3.2 summarizes the major sections of the questionnaire and a copy is included in Appendix 3.

Each factory was visited twice; during the first visit, the questionnaire was completed. The research assistant asked questions in Thai which were immediately translated and recorded in English by the researcher. After this first visit, research notes were written up and reviewed; a second visit collected any additional information needed. The methods employed ensured the information was as comprehensive as possible. Generally, the quality of the information received appeared accurate; it was, however, limited in terms of quantitative material since most tea factory owners did not keep comprehensive tea production and energy use records. For this reason, the amount of

Table 3.2. Information obtained by tea factory questionnaire.

-fresh leaf delivered to the factory (1987-1989)
-made tea from 1987 to 1989
-amount of fresh leaf from private garden
-amount of tea gardens
-prices paid for fresh leaf (1987 to 1989)
-quality control standards for fresh leaf and year implemented
-has quantity and quality of tea leaf changed
-tea production methods and equipment
-energy use for tea production in 1989
-firewood and charcoal supply, prices, problems
-people employed
-prices paid for picking leaf and for grading

energy used for tea production was only collected for 1989, instead of for 1987 to 1989 as was originally planned. Fuelwood use was examined in detail at the cooperative tea factory in Pa Pae.

3.5 Personal Interviews

Informal interviews allow the researcher to acquire more in depth information (Sayer, 1984) and help to verify and interpret the data collected by other methods. Whyte (1967) notes that informal interviews enable the researcher to explore the issue in a broader context and examine it from different perspectives. This is very important when collecting data in a different cultural setting and when working through an interpreter.

Informal interviews were held with numerous key informants. Villagers included tea garden owners, the headman of each village, Tambon council members and middlemen who bought and sold miang. Officials of the Royal Forestry Department and assistant district officers of Mae Taeng District (Land Department Officer, Rural Development Officer, Agriculture Officer, Forest Officer) were interviewed. Other key informants included members of Chiang Mai University and nongovernment organizations, especially members of the Thai-German Project in Chiang Mai who are involved with tea production in Tambon Wawi and other agriculture extension work in the uplands. Informal interviews with the various key informants were usually conducted working through an interpreter. A list of questions was developed prior to the interview. Notes were kept by both the researcher and interpreter, and a final summary was developed after the interview was completed.

The majority of tea garden owners in whose tea gardens vegetation plots were located were interviewed (10 out of 12 owners interviewed) with the help of the interpreter. The interviews took place in the owner's tea garden, focusing upon management issues. These interviews helped to link the biophysical data collected by the vegetation survey with management practices. Common names and uses for the forest trees found in five of the plots were discussed. Common names were then matched with scientific names. This ethnobotany work was extremely interesting and given the diversity of tree species in the area, the knowledge of the villagers was astounding.

3.6 Field Observation

Field observations are an important component of any study. They help to understand, support, verify and broaden the data collected by more structured approaches. Four of the six months in Thailand conducting this research were spent in the villages. By observing village life and the various activities surrounding the production of tea, greater insight into the nature of the firewood supply problem and possible solutions were obtained. Field observation helped to interpret and understand the data collected by the structured questionnaires.

Living in the villages not only enriched the experience, but greatly enhanced the quality of the information. Stoddard (1982) notes how the use of quasi-participant techniques allows the outsider to interact with the subjects. The Thai assistant helped to interpret many field observations, reducing personal and cultural biases. After the villagers became familiar with the nature of the work, they became very open and many expressed their pleasure that 'you come all the way from Canada to help us with our problems'. Some villagers opened their homes to the researcher and were concerned that the goals of the research were achieved. The personal interaction with the villagers provided invaluable information and was a key to finding solutions to the resource-use problem. Field notes were kept in a journal during the six month stay in Thailand and incorporated into the analysis when appropriate.

3.7 Study Area

The area selected for study is Tambon Pa Pae, a subdistrict in the Mae Taeng District, Chiang Mai Province (Figure 1.3). This area is located 70 km by road northeast of Chiang Mai on the west side of Amphur Mae Taeng and is the largest tea area in Thailand (Hoare, 1987) with both green tea and miang being produced; it is probably the largest miang producing area in the country.

Tambon Pa Pae covers 180 square kms (PSPFD, 1989) in the uplands between an elevation of about 700 metres to 1300 metres. There is no comprehensive rainfall data for the tambon, but from 1986 to 1988, Mae Taeng District received, on average, 1102 mm (Table 3.3). There is little or no rainfall from December to March, then increasing amounts of rain until it peaks in July and August, and declining rainfall until December (which has been dry for two out of the last three years of records).

Tambon Pa Pae is located within the gently rolling upland hills. Villages are usually located adjacent to streams in the narrow valley bottoms. Tea gardens surround the villages and extend up to 4 kms in any one direction. A paved road passes through the centre of the tambon. Villages which are not located along the main road are accessible by rough road or trail. Figure 3.3 shows the 12 village groups in Tambon Pa Pae. Some village groups consist of only one large village (i.e. Pa Pae) while others consist of up to nine smaller villages (Mae Mam). The forest cover in the area is mixed deciduous/evergreen monsoon forest and represents some of the little remaining first class forest in Thailand (Uraivan, pers comm).

A report on project and farmer development for Tambon Pa Pae prepared by the district office in 1989 provided some basic information about the people living in the area (PSPFD, 1989). There are 1,075 households (4,525 people) living in 12 village groups. The age and sex characteristics of the population, which is composed of ethnic Thai and

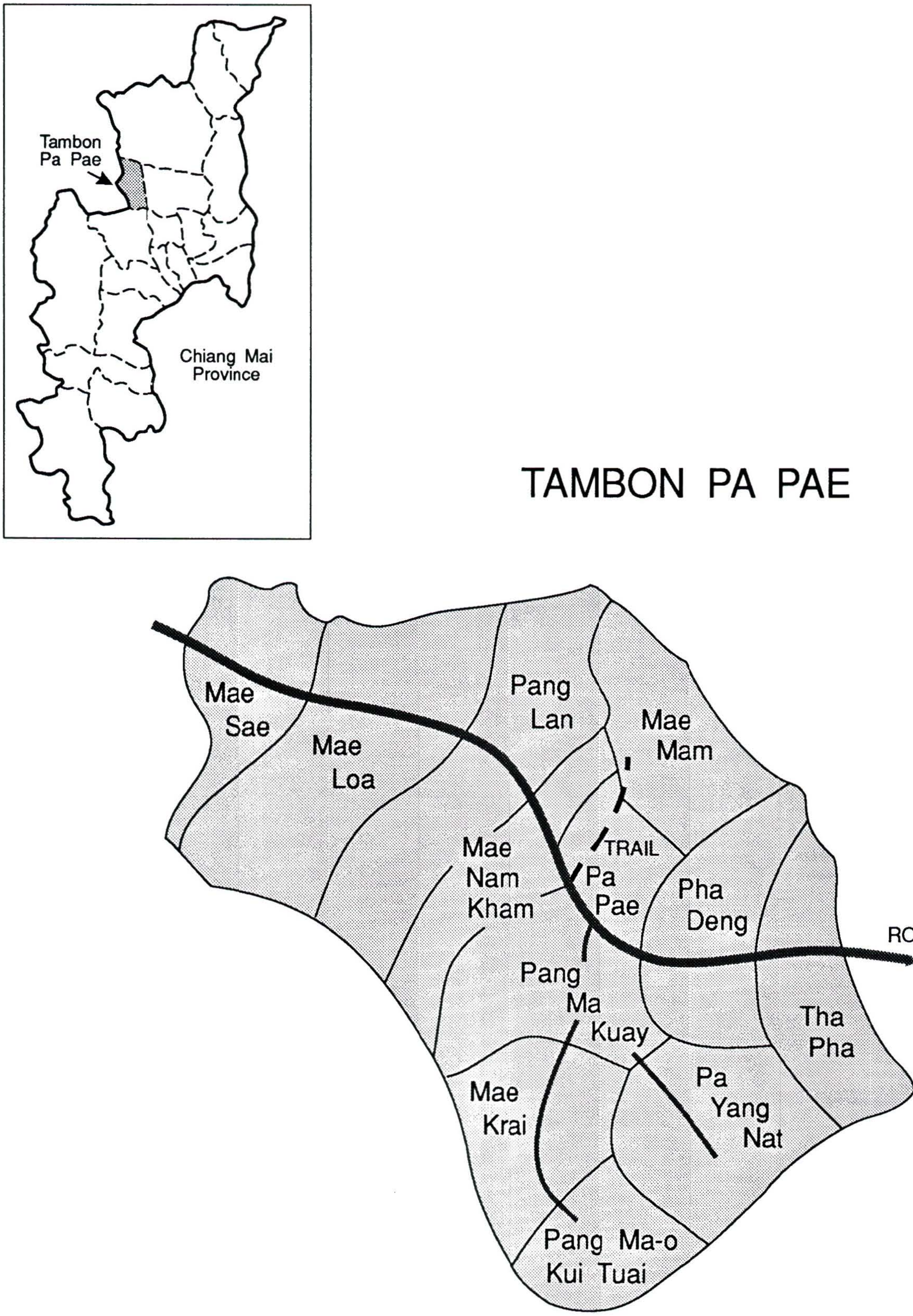


Figure 3.3 Twelve village Groups in Tambon Pa Pae.

hilltribe people, are given in Table 3.4. Hilltribe people are migrants from neighbouring countries (China, Burma and Laos) who often live in the upland areas. There is no indication in the report of the ethnic composition of the area or the ratio of Thai to hilltribe. However, the hilltribes, represented by Lisu, Hmong and Karen are a minority and are found in small village groups and intermixed with the Thai in other villages.

The soils in the area are stony and generally poorly suited for agriculture. The soils are not typed, but road cuts reveal deep red laterite soils. Field and fruit crops are grown on some of the slopes and there are some paddy fields in the valley bottoms.

The amount of land under title (right to use only) in each village group and the amount used for rice or tea production is given in Table 3.5. Other crops are grown in minor amounts, including ginger, corn, mangoes and banana; recently, coffee is also being grown in the upland areas. There is also a large mushroom farm in the northern end of the tambon which was established in 1988 (employees between 60-80 people). Tea production is, by far, the major land use and employer in Tambon Pa Pae.

Villagers pay a rental fee for the right to use the land. The government reports that there are 4,253 rai of tea gardens in Tambon Pa Pae. However, many under-report the amount of land they farm in order to reduce paying land tax (land title is discussed in more detail later). Village headmen were asked about the area of tea gardens in their village group and they reported a total of 24,580 rai (Table 3.6). Both these figures must be treated with caution since there have never been any surveys of the tea gardens, and because of the under-reporting. The headmen also reported that there are about 780 households producing miang in Tambon Pa Pae.

All the villages raise livestock in small amounts, including chickens, swine, buffalo and cattle. All animals, except pigs, free range, with cattle ranging the furthest, grazing in the tea gardens near the villages and usually returning to enclosures at night. Swine are often raised in small elevated pens near the compounds. Many villagers have small plots in their compounds for growing vegetables and herbs.

Villages in the area range from relatively isolated and undeveloped villages up to 30 households in size, to relatively well developed villages with over 200 households. The isolated villages are accessible by trail or rough road. The well developed villages

Table 3.3. Monthly rainfall (mm) in the Mae Taeng District, Chiang Mai Province, N. Thailand from 1986 to 1988.

Month	1986	1987	1988
March	0	56.5	0
April	79.6	48.8	82.2
May	95.6	71.7	166.2
June	105.4	83.0	227.8
July	292.6	186.4	211.3
Aug	189.9	288.0	199.8
Sept	152.5	103.2	162.9
Oct	26.8	55.6	81.5
Nov	114.8	65.0	63.6
Dec	70.3	0	0.1
Jan	0	18.5	0
Feb	0	0	8.4
Total	1127.5	976.7	1203.8

Source: Project Development Plan and Farmer Development of Tambon Pa Pae, 1989.

Table 3.4. Population data for Tambon Pa Pae by village group.

Village Group	Households	Male	Fem	Age 1-4	5-7	8-14	15-18	19-50	50+
Pa Yang Nat	96	195	175	22	12	46	37	199	54
Pang Ma Kuay	204	444	417	45	32	102	64	448	170
Pha Deng	105	263	250	27	53	50	49	314	20
Pa Pae	170	352	356	66	22	60	76	326	158
Mae Loa	125	282	246	36	30	68	28	278	88
Pang Lan	73	134	129	13	13	20	20	135	62
Mae Krai	51	123	110	40	24	59	30	49	31
Mae Sae	28	55	58	14	10	12	6	53	18
Mae Mam	64	166	106	38	23	23	34	116	38
Mae Nam Kham	31	66	54	5	2	23	15	57	18
Tha Pha	42	102	82	18	9	25	10	100	22
Pang Ma-o Kui Tuai	78	182	168	49	48	67	36	129	21
Total	1067	2364	2151	373	278	555	405	2204	700

Total Population = 4,515

Source: Project Development Plan and Farmer Development of Tambon Pa Pae, 1989.

Table 3.5. Land under title in Tambon Pa Pae by village group and use.

Village Group	Rice	Tea	Total
Pa Yang Nat	370	400	770
Pang Ma Kuay	45	312	357
Pha Deng	30	384	414
Pa Pae	35	651	686
Mae Loa	125	436	561
Pang Lan	20	140	160
Mae Krai	665	1215	1880
Mae Sae	45	75	120
Mae Mam	-	450	450
Mae Nam Kham	-	130	130
Tha Pha	25	30	55
Pang Ma-o Kui Tuai	34	30	64
Total	1,394	4,253	5,647

Source: Project Development Plan and Farmer Development, Tambon Pa Pae, 1989.

Table 3.6. Number of miang producers and amount of tea gardens in the twelve village groups of Tambon Pa Pae as reported by village headmen.

Villages	Number of Miang Producers	Tea Gardens (rai)
Pa Yang Nat	97	900
Pang Ma Kuay	200	7000
Pha Deng	100	300
Pa Pae	100	3000
Mae Loa	80	500
Pang Lan	60	5000
Mae Krai	30	1500
Mae Sae	6	80
Mae Mam	30	4000
Mae Nam Kham	15	1500
Tha Pha	15	450
Pang Ma-o Kui Tuai	15	350
Total	748	24,580

are located along the main paved road which passes through the centre of the tambon. All villages along the main road have electricity and most of the stores and government services are located here.

There are 7 primary schools in the study area, some which serve more than one village group. Students going beyond primary school must travel by bus to the next tambon south of Tambon Pa Pae. The level of education for the villagers by village group is given in Table 3.7. Although the total population figures in this table do not match the population figures given earlier in Table 3.4 (fewer people in the later table) the information that is available indicates that most villagers have not gone beyond primary school. According to Table 3.7, 87% of the villagers have primary education (grade 6), less than 2% have completed high school or post secondary education and 11% are illiterate.

Tambon Pa Pae is located within Watershed Unit #2 which is part of the 'Source of the Ping River Unit'. This unit was established by the Watershed Conservation Division of the Royal Forestry Department in order to protect the source of the Ping River, an important water course in Northern Thailand. The Watershed Division attempts to protect important watershed areas through forest protection, reforestation of degraded forest land and through hilltribe development in the form of highland agroforestry and hilltribe village settlements (SMHDP, 1988).

The Northern portion of Tambon Pa Pae is also located within the Sam Mun Highland Development Project. This project is funded by the United Nations Fund for Drug Abuse Control and includes 60 villages in an area of 1,193,100 rai. This project aims to improve the quality of life among hilltribes through the implementation of an integrated rural development project. A major concern of the project is to replace shifting cultivation with permanent cultivation, and to eliminate the illegal cultivation of opium poppy and addiction to its products (SMHDP, 1988). There were no activities connected with this project in the villages selected for study.

The forest in Tambon Pa Pae is mixed deciduous/evergreen monsoon forest-- part of the last remaining relatively undisturbed forest in Thailand. There are no data on the extent or quality of the forest cover in Tambon Pa Pae. Forest officials stated that most

Table 3.7. Education level of villagers in Tambon Pa Pae by village group.

Village Group	Primary (6)	Illiterate	School	College	University
Pa Yang Nat	270	57	-	-	-
Pang Ma Kuay	752	18	11	7	1
Pha Deng	431	40	2	2	1
Pa Pae	563	54	7	15	1
Mae Loa	442	7	8	1	-
Pang Lan	230	40	1	2	2
Mae Krai	114	43	-	-	-
Mae Sae	60	15	-	-	3
Mae Mam	168	51	-	-	-
Mae Nam Kham	106	-	-	-	-
Tha Pha	84	18	-	-	-
Pang Ma-o Kui Tuai	232	85	-	1	-
Total	3,452	428	29	28	8

Source: Project Development Plan & Farmer Development, Tambon Pa Pae, 1989.

Table 3.8. Number of households and miang producers in the villages selected for study in Tambon Pa Pae.

	# of Households	Miang Producers
Pang Ma Kuay	246*	200**
Pa Pae	177*	100**
Mae Mam (1 & 2)	36	15
Mae Sae	34	5

* Data from 1989 survey conducted by the doctor in Pa Pae.

** These figures are based on estimates given by the headman of each village.

of the original forest cover remains. Some selective logging has occurred at different periods of time since the late 1800s, but intensive logging has not taken place on a large scale. To date, about 15% to 20% of the forest has been lost to swidden agriculture largely practised by hilltribes (Ponchai, pers comm). Efforts are underway to slow deforestation, especially that caused by opium production. The United Nations program has drastically reduced the rate of deforestation caused by opium producers. Degraded areas are being replanted largely with pine.

3.7.1 Villages Selected for Study

It was necessary to select villages which would be representative of the conditions in the tea growing area. Due to time and resource constraints, only the northern portion of the tambon, north of the village Pa Pae, could be examined. This also kept the study area within the Mae Taeng watershed which was the focus of a larger project with which this study was linked[4].

To determine which villages would be representative of the general conditions in the area, the headman of each village group in the northern end of the tambon was interviewed to provide a picture of the general state of the tea industry in his village. The village headman is elected and provides general leadership for the village and acts as the representative of the village to the government. All the headmen interviewed stated the villagers are having difficulty securing firewood supplies for miang production. Interestingly, most headmen claimed that the firewood comes from the tea gardens only. Later research indicated that a substantial amount of firewood comes from the forest. Overall, there is an intense concern about the future of miang production due to firewood supply problems, insecure land tenure and difficulty finding people to pick tea leaf. The problems facing the villagers seemed relatively constant across all the village groups.

4 This study was partially funded by a CIDA sponsored University Linkage Program between the University of Victoria in Canada and Chiang Mai University in Northern Thailand.

Based upon the interviews with the headman, four villages were selected for study (Figure 3.4). These villages include Pa Pae, Pang Ma Kuay, Mae Sae and two small villages of the Mae Mam group. These later villages (Mae Mam) are within 1.5 kilometres from each other, have the same headman and are very similar. These two smaller villages, therefore, have been treated as one. Table 3.8 gives the number of households and miang producers in each village.

Since the problems facing the miang producers appeared relatively constant in all the village groups, these villages were selected due to their location and size. Pa Pae and Pang Ma Kuay are the largest villages in the area and are the centre of tea production. Pa Pae has the largest tea factory in the area which is cooperatively run. Both villages are accessible by the main paved road which runs through the tambon. These villages represent the well developed villages in the area and given their size and density of miang producers, have the largest firewood supply problems of all the village groups visited. Pa Pae is the Tambon capital and has five food shops, three stores, post office, health office and police station. Pang Ma Kuay, the larger of the two, has one food shop and three stores. These villages are located within 0.5 kms of each and are sufficiently similar to be treated as one.

Mae Sae is a moderately sized village located 20 kilometres by road north of Pa Pae. This village is the highest village in the study area (1,100 metres) and was selected for various reasons. This village has, by far, the highest proportion of hilltribe people, over two thirds (Karen and Lisu). The other villages only have a small number of hilltribe people living in them. Ma Sae also has a Watershed Protection Office located just outside the village, and has evidence of shifting cultivation very close to the village. The primary reason for selecting Mae Sae was because it was thought to be located in a different vegetative zone. According to topographical maps Mae Sae is 400 metres higher than the other villages. The 'lay of the land' also indicates that this village is much higher than the others. Pines are also found in this area, indicating a transition into pine forest which are found at higher elevations. Unfortunately the maps are wrong, the area is only 100 metres higher and although there are more coniferous trees in the

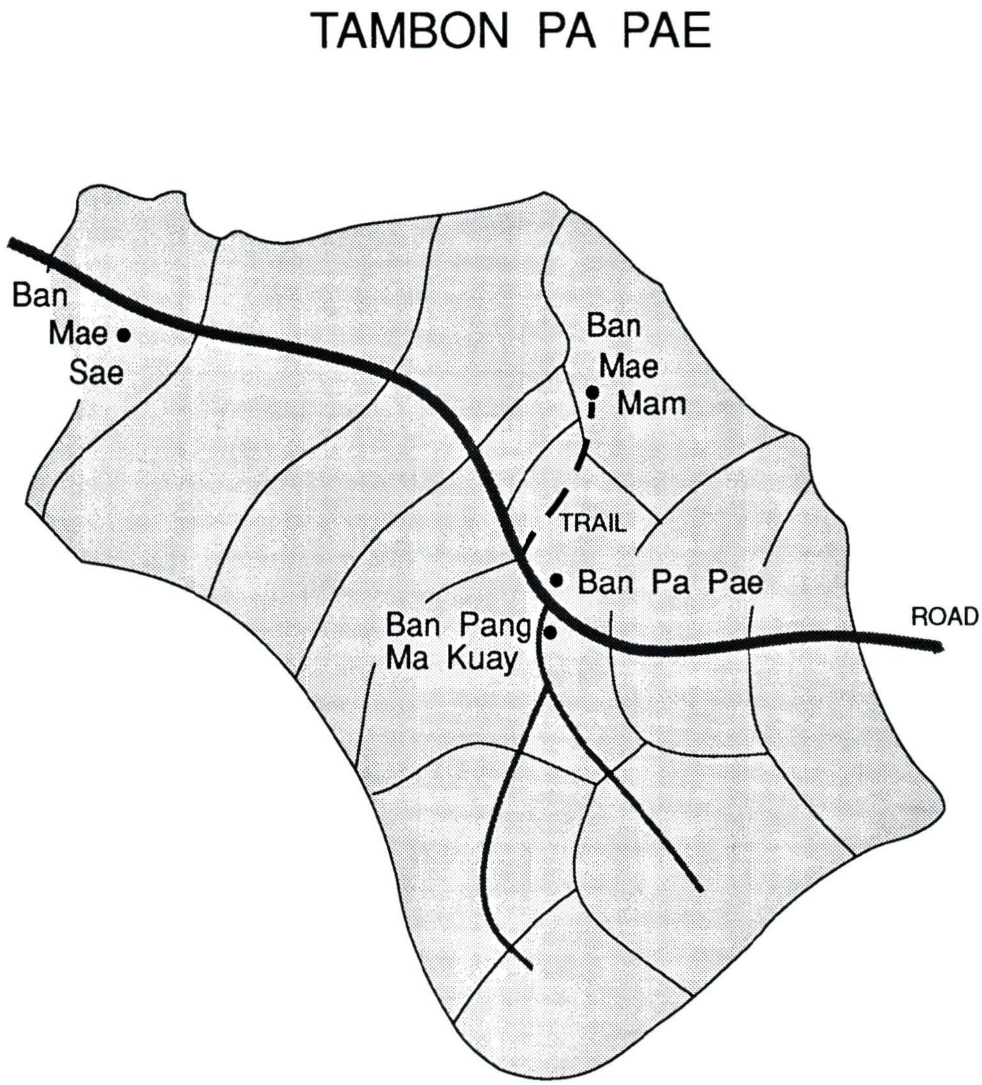


Figure 3.4 Tambon Pa Pae and the four villages selected for study.

area, the forest is still mixed deciduous/evergreen monsoon forest, the same as the forest near the other villages.

Mae Sae has a green tea factory, police station, store, 3 food shops and a new guest house. This village is the starting point of a 3 day commercial trek where visitors walk, elephant ride and raft through the hills, staying in hilltribe villages at night.

The final village selected for study, Mae Mam, is a small isolated village located 7 kms off the main road east of Pa Pae. This village is accessible by a rough trail which follows a ridge top beginning at Pa Pae, and then drops down into the valley bottom where the village is located. This village was selected to examine if there were any differences in firewood supply and forest policy due to its relative isolation compared to the other villages. If the road is dry, it is accessible by vehicle. Most trips to this village, however, were made by foot.

While Pa Pae and Pang Ma Kuay are the most developed villages in the area, Mae Mam is more representative of a 'traditional' village. There is no electricity in this village, and thus none of the modern goods that accompany electricity. House construction follows the traditional style, wood construction with thatch roof and wood or dirt floor. Many houses in the larger villages utilized more modern construction materials, such as cement and brick, and corrugated steel for the roofs. Mae Sae is a mixture of the two-- houses are built using traditional materials and some using modern materials. All villages, except Mae Mam, have schools, stores and food shops.

To summarize, the villages were chosen in order to reflect as much as possible the various variables in the study area. Some of these variables included well developed versus less developed, isolated versus easily accessible, the presence of forestry officials and ethic Thai versus hilltribe people.

3.8 Overview

This chapter sets out: 1) the goals and objectives of this study; 2) the conceptual foundation to the research; 3) the methods used to collect information; and 4) the characteristics of the study area. This study aims to expand the range of alternatives for coping with the fuelwood supply problem in the traditional tea industry in the uplands of Northern Thailand. The conceptual foundation is based upon White's study of domestic water supply issues in East Africa. The conceptual framework is divided into five stages: 1) define and understand the problem; 2) examine the nature of the resource; 3) examine resource use; 4) perform an evaluation; and 5) conclusion and recommendations. A literature review and background research (Chapters 1 and 2) define the nature of the problem. Primary data collection is necessary to complete the remaining stages: a vegetation survey will examine the nature of the resource; written questionnaires and interviews examine tea growers attitudes, perceptions and management practices. Field observations will help to interpret and 'round out' the data collected by these survey techniques. Primary data generated by this study will be combined with experiences from other parts of Thailand and the world to expand the range of alternatives. Now we will turn to the results of this study.

Chapter 4
The Tea Gardens: An Upland Agroforestry System in Northern Thailand

4.1 Introduction

The traditional agroforestry or resource supply system used for producing tea in the uplands of Northern Thailand is described in this chapter. The objectives of this chapter are to understand the nature of the resource by examining 1) the biophysical characteristics of the tea gardens, 2) the management practices of the tea growers, 3) how the two interact; and to asses the health of the resource base. Information and data obtained from a) the vegetation survey, b) interviews with tea garden owners , c) the miang producers survey and d) field observation will form the necessary foundation for understanding the resource base and assessing the health of the tea gardens.

4.2 Tea Gardens

The botanical variation, geographic distribution and features of the three main types of tea (green, black and miang) were detailed in Chapter 2. In Tambon Pa Pae, tea leaf for green tea and miang production is produced from tea gardens (Figure 4.1) established within a mixed evergreen/deciduous monsoon forest between elevations of 800 and 1100 metres. Schimper (1898) in his classic Plant Geography, describes monsoon forest as "more or less leafless during the dry season especially towards the end, usually less tall than rain forest, rich in woody lianas, rich in herbs but poor in woody epiphytes" (as cited in Elliott et al, 1989). Monsoon forest is the natural vegetation of much of Northern Thailand, where average annual precipitation is 1,000-2,000 mm and a dry season extends from November to April (Elliott et al, 1989). The plant Euphorbia antiquorum L. (Euphoribiaceae), a 'cactus-looking' plant, commonly found in the study area, is an indicator of a transition zone between deciduous and evergreen forests. Some of the deciduous trees in the tea gardens, such as Toona microcarpa (Meliaceae), begin to drop their leaves in early October (end of rainy season).

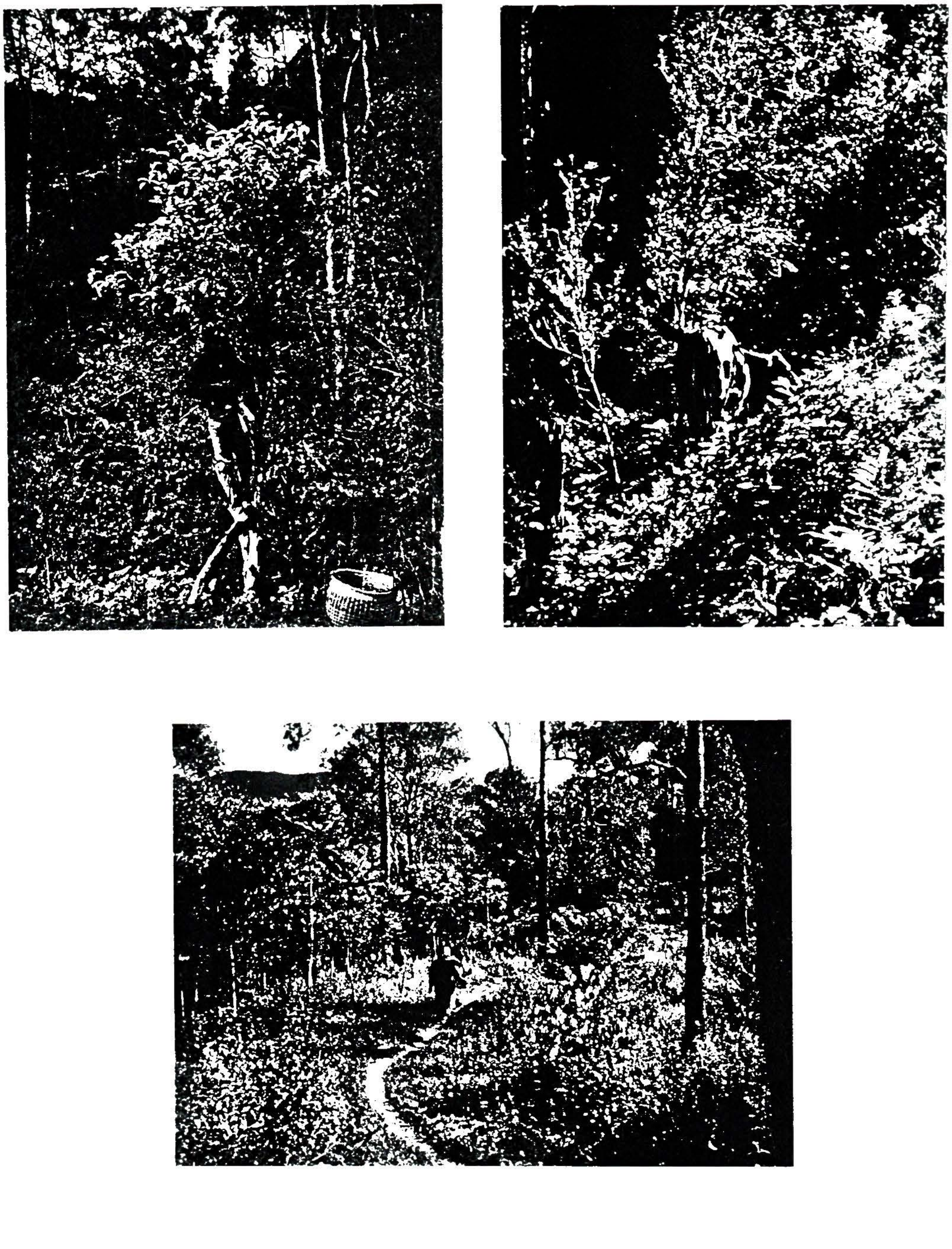


Figure 4.1 The tea tree and the tea gardens.

The production of miang in Northern Thailand is very old. Hoare (1988:125) states that "the smallholder gardens in North Thailand were first established for 'miang' or pickled tea production over the past two centuries, using the indigenous Assam variety." However, recent translation of Lanna[5] palm leaf scriptures refer to the production of miang in Northern Thailand in 1500 A.D. (Kaserprome, 1989) and its use by the Thai may well date from before 700 A.D. (Van Roy, 1967). Miang is also produced in neighbouring regions from Assam (northeast India) to Tonkin and north through Yunnan (Burma)(Van Roy, 1967).

Tea gardens are developed by thinning the forest cover, slashing the ground cover and increasing tea tree density by planting seed or seedlings. Sometimes dryland rice is planted for the first season before planting tea trees. Over time, the forest cover is further reduced to meet firewood needs for processing tea leaf and for construction needs.

Keen (1978) holds a slightly different view about how tea gardens have been established.

> *The customary method of establishing a miang orchard, at least in the past, has been simply to clear the forest around already growing trees. Thus, an "orchard" may be only a winding path, perhaps 6 metres wide, cut through the forest for several hundred metres,wherever the tea trees may be growing. In recent years a few people have begun to augment 'wild' trees by planting seedlings, either nursery raised or transplanted by the forest. This practice tends to blockout the fields into more orthodox shapes (pp 256-57).*

It is doubtful, given the low density of tea trees in the natural forest (Maxwell, pers comm) that tea gardens have been established by 'simply clearing the forest around growing trees and later augmenting the wild tea trees'. More likely, most tea gardens have been established by thinning the forest cover and direct planting seed or seedlings in the forest where there are few or no wild tea trees. The mixed evergreen/deciduous forests where tea gardens have been established are very diverse and individual species are usually widely scattered. Tea seed is easily gathered and transported to areas where there may be few or no tea trees.

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[5] A Thai language of the North.

An understanding of this agroforestry system regarding the composition, management, firewood productivity and sustainability of the tea gardens was gained by combining various sources of data, namely:

(1) biophysical data from 13 vegetation plots located in the tea gardens;

(2) management practices from personal interviews with 10 of the tea gardens owners in whose gardens vegetation plots were located;

(3) written questionnaires with 57 miang producers; and

(4) field observations.

4.3 Vegetation Plots

Thirteen fixed boundary plots were established in the tea gardens (see Chapter 3 for description of survey methods). Descriptions were developed for each plot and include a plot diagram, summary table of forest cover, biophysical data, field observations and data from interviews with tea garden owners. The diagrams show the location of the forest and tea trees, and any significant features in the plot. The genus, species and family name of the flora are given the first time it is mentioned within the text. Thereafter, only the genus and species are given. A summary of the genus, species, and family of all the tree species found in the 13 vegetation plots can be found in Appendix 5[6].

The thirteen vegetation plots provide a good sample of the biophysical characteristics of the tea gardens. Summary tables are used to examine various components of the plots, including elevation, slope, aspect, tea and forest tree composition and density, and ground flora composition. Due to space limitations, only two block plots and one strip plot are included in the text which are representative examples of the vegetation plots.

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6 Many of the specimens in these plots were collected and deposited in the herbarium, Faculty of Pharmacy, Chiang Mai University.

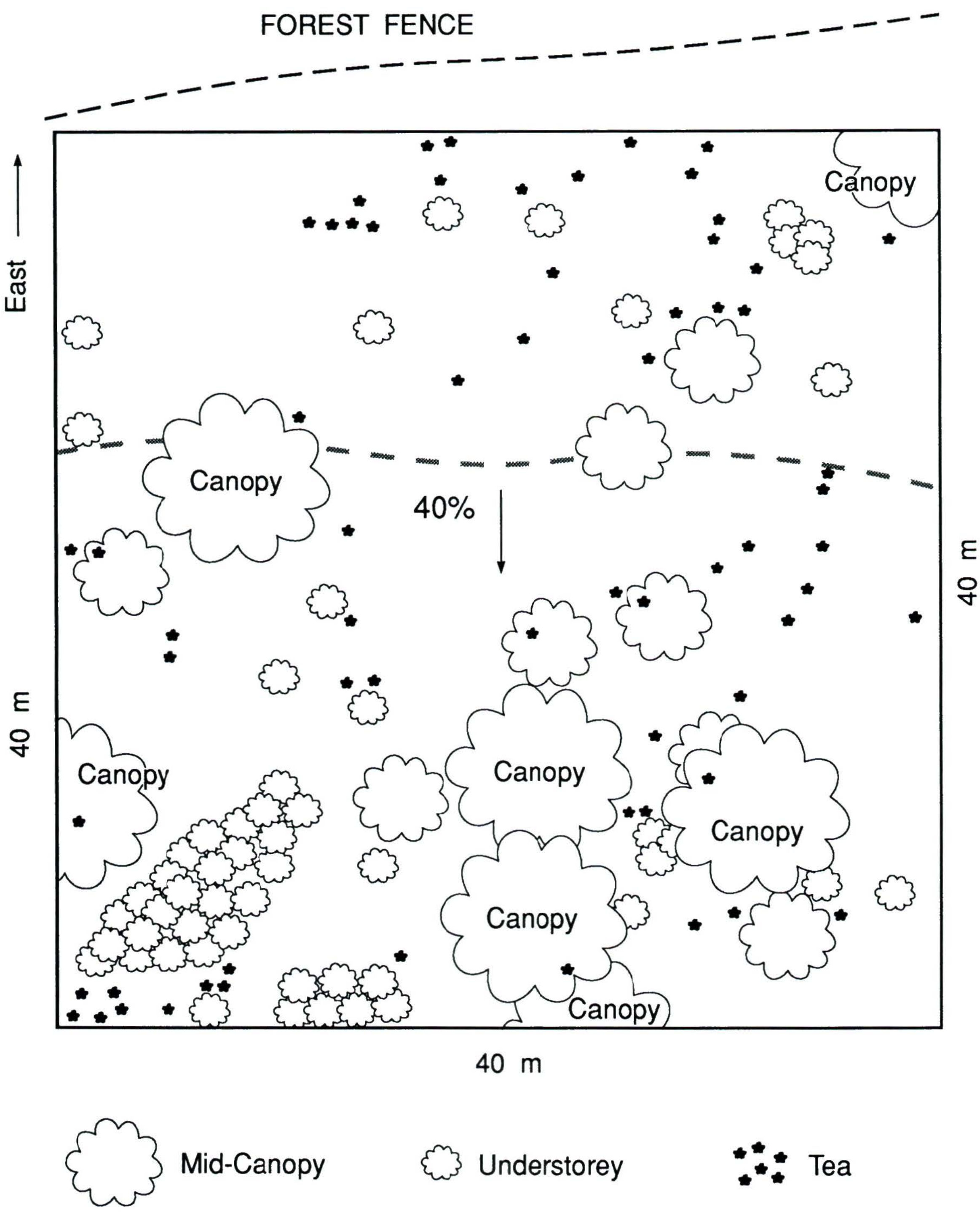
4.3.1 Plot One: An Example of a Block Plot

Plot One of 40 metres square in size is located about 1.0 kilometres northwest of Pa Pae at an elevation of 925 metres on the west side (near the top) of a northward running ridge. The terrain has a 40 % slope to the west near the bottom of the plot and 15% to the north near the ridge top (Figure 4.2). This tea garden is weeded twice a year (March and October) and is lightly grazed by cattle. The plot contains 65 tea trees with an average height of 1.5 metres.

The forest in which this tea garden is located is basically primary mixed evergreen/deciduous in nature. Due to disturbance in the planting of tea trees (Camellia sinensis (L.) O.K. var. assamica (Mast.) Kita. (Theaceae), the forest has been 'opened' and thus a significant change has occurred to the ground and understorey flora. The canopy (tall) trees are climax cover and removal of at least 50% of the shade cover has allowed various 'secondary' invaders to establish themselves, most of which are herbs and shrubs. More woody species are growing along the thickets, i.e. 'forest fences' bordering the tea gardens. The net result of such an area is not only mixed as far as evergreen/deciduous is concerned, but also mixed in the sense that there are both climax and secondary growth species too. The original ground flora are 'trying' to reestablish themselves while in 'competition' with the secondary invaders (nature is dynamic, but it is not motivated or directed, therefore, popular connotations such as competition are not appropriate and are noted with quotes).

Herbs which are native to the primary evergreen/ deciduous mixed forest in the plot include:

Pyrrosia lanceolata (L.) Far. (Polypodiaceae), an epiphytic, succulent, creeping fern;
Globba purpurascens Craib (Zingiberaceae), ground ginger;
Pteris venusta Kunze (Pteridaceae), ground fern;
Asystasia kerrii Craib (Acanthaceae), ground herb;
Malaxis latifolia J.E. Sm. (Orchidaceae), ground orchid;
Selaginella repanda (Desf.) Spr. (Selaginellaceae), delicate fern-ally;
Geophila repens (L.) I. M. John (Rubiaceae) creeping herb; and
Calophanoides quadrifaria (Nees) Ridl. (Acanthaceae), a herb which likes deep shade.



Figurer 4.2 Plot diagram of Plot 1, a block plot.

Invading herbs found within the plot and which like open places include:
Centella asiatica (L.) Urb. (Umbelliferae);
Urena lobata L. ssp. lobata var. lobata (Malvaceae);
Eupatorium odoratum L.(Compositae), an introduced herb from tropical America;
Elephantopsi scaber L. var. scaber (Compositae);
Ageratum conysoides L. (Compositee); and
Panicum brevifolium L. (Gramineae), a creeping grass which was very common in this plot.

The predominant type of fern in Plot One is Pteridium aquilinum (L.) Kuhn ssp. aquilinum var. wightianum (Ag.) Try. (Dennstaedtiaceae). This fern is an indicator of a disturbed site as it will only invade after a site has been disturbed by fire or clearing the ground cover. This fern will thereafter remain the dominant ground cover for years. The rhizome of this fern is very deep in the soil. The plant can burn each year and come back ever stronger, making it very difficult to eradicate. The west side of the ridge where the plot was located is thickly covered by this fern, but it is absent on the east side of the ridge, indicating a ground fire probably burned to the top of the ridge. Another invading ground fern is Christella parasitica (L.) Lev. (Thelypteridaceae).

There were a variety of vines/climbers found in the plot and along the forest fence, including:
Cyclea atjehensis Forman (Menispermaceae);
Piper aff. hamiltonii C.DC. (Piperaceae), a vine found growing on the tea trees;
Pachyogyne dasycarpa Kurz (Menispermaceae);
Maclura fruticosa (Roxb.) Corn. (Moraceae);
Smilax corbularia Kunth ssp. corbularia (Smilacaceae);
Smilax megacarpa A. DC. (Smilacaceae); and
Jasminum amplexicaule Ham. ex G. Don (Oleaceae) (wild jasmine).
There are two epiphytic orchids found on the tea trees: Oberonia gammiei King and Pantl. (Orchidaceae) and Dendrobium exile Schltr., and various showy flower species like Cassia tora L. (Leguminosae, Caesalpinioideae) which was in flower at the time.

Although there are a variety of weeds in Plot 1, the weedy ground cover is not thick and should not greatly hinder forest regeneration. The ground cover in Plot 1 is, therefore, classed as 'mixed'. If the site, however, is disturbed by fire in the future, the fern Pteridium aquilinum would become much denser and could impede forest regeneration.

In Plot 1 there are 53 trees/rai up to 12 metres in height, 8 trees/rai between 12 and 20 metres and 7 trees/rai over 20 metres tall (here after referred to as understorey, midcanopy and canopy trees). Table 4.1 gives a summary of the trees found in this plot.

Plot 1 has only two species in the canopy of which Schima wallichii (Theaceae) is the most abundant (6 trees/rai). The largest tree in the plot is a Schima which is 28 metres tall with a DBH close to 70 cm. There are six species in the middle canopy, such as Ehretia laevis (Boraginaceae) which has been coppiced in two out of three cases, Sapium baccatum (Euphorbiaceae), Chisoecheton siamensis (Meliaceae) and Alangium kurzii (Alangiaceae), all of which may eventually grow to become large canopy trees. There are also six species in the understorey; the most abundant is Phyllanthus roseus (Euphorbiaceae) (48 trees/rai) the largest of which was 6 metres tall with a 8 cm diameter.

Phyllanthus roseus is a short, but rapid growing, understorey tree which also likes fairly open, disturbed sites. This tree is the most abundant tree in the plot, partially due to the firewood management strategy practised by the owner of the tea garden. The tea pickers employed by the owner stated that if, while slashing ground cover, tree seedlings are higher than about 50 cm (longer than forearm) they will avoid cutting them. At this height they are easy to see, therefore easy to avoid. The owner of the tea garden stated that these trees will reach a diameter of 12 to 15 cm in three years at which time they are cut for firewood. These trees are found in clumps and growth could be improved if thinned. Due to its rapid growth, this tree is a poor firewood compared to the oaks and other hardwoods in the area. The common name for this tree is "maimumpla" and the owner classed it as a medium firewood (see page 116 for firewood classification). There were a few stumps found outside the plot where this tree had been cut when it was about

Table 4.1. Summary of forest cover in Plot 1.

Canopy Trees HT > = 20m		Midcanopy HT > 12 < 20		Understorey HT < = 12m	
Schima wallichii	(6)	Mitrephora maingayi	(1)	Glochidion sphaerogynum	(1)
Paramichelia baillonii	(1)	Ehretia laevis	(3)	Phyllanthus roseus	(48)
		Alstonia scholaris	(1)	Casearia grewiifolia	(1)
		Schima wallichii	(1)	Mitrephora maingayi	(1)
		Sapium baccatum	(1)	Alstonia scholaris	(1)
		Chisoechton siamensis	(1)	Ficus virens	(1)
				dead = 1	

plot size = 1.0 rai

tea trees = 65

forest trees = 68

canopy = 7
midcanopy = 8
understorey = 53
dead = 1

girdled trees = 0

10 cm in diameter. There was also one stump of a large Schima (23 cm) just outside the plot.

There is a forest fence bordering the east side of this plot. These fences are commonly found on ridge tops and sometimes run somewhat parallel to the ridges to mark the boundaries of tea gardens. This forest fence is composed of large oaks and other trees up to 25 metres in height which were never cut when the tea gardens were established, and secondary growth which was allowed to grow up between these large trees to form a dense borderline between tea gardens.

Secondary growth likes a lot of sun and invades an area after the forest canopy has been opened up. Secondary growth species found along the forest fences include the following trees: Trupinia montana (Staphyleaceae); Desmos velutinus (Annonaceae); Zanthophyllum rhetsa (Rutaceae); Pheobe lanceolata (Lauraceae) this is also often an understorey tree in undisturbed forests, but also grows in marginal areas too; and Cassia javanica (Leguminosae). One of the oaks, Lithocarpus elegans (Fagaceae) is a common primary tree in the forest fence near Plot 1. Trees in the tea gardens outside the plot include: Mallotus philippensis (Euphorbraceae) an abundant secondary growth understorey tree; Microcos paniculata (Tiliaceae); Oroxylum indicum (Bignoniaceae); Scleropyrum wallichianum (Santalaceae); and two treelets, Clerodendrum glandulosum (Verbenaceae) and Clerodendrum disparifolium (Verbenaceae).

4.3.2 Plot 4: An Example of a Strip Plot

Field observations reveal that the tea gardens on the lower slopes of the hills have less forest cover than the upper slopes. These gardens are likely to be the oldest and have received the most impact due to their easy accessibility for firewood and timber cutting. To examine the difference in forest cover in tea gardens located on the slopes of the upland hills, three plots were established by running a twenty metre strip from the bottom of the slope to the top in tea gardens located approximately 1.0 km from Pa Pae, Pang Ma Kuay, and Mae Mam. Plot 4 in Pang Ma Kuay and Plot 6 in Mae Mam are accessible by road, and Plot 5 in Pa Pae is accessible by trail.

Plot 4 is located about 1.0 kms north of Pang Ma Kuay (accessible by road). A 20 metre strip was run from the bottom of the hill to the top on a north east facing slope. The terrain at the bottom has a 50% slope and is located at about 875 metres in elevation, while the top has a 75% slope with an elevation close to 900 metres. The length of the plot was 80 metres, making a 1.0 rai plot. The bottom of the plot borders upon a small fruit orchard and the top upon a forest fence which follows the top of the ridge (Figure 4.3).

Plot 4 contains 169 tea trees with an average height of 2.2 metres. There are two canopy trees near the forest fence and 7 midcanopy trees scattered throughout the plot. There are numerous understorey trees in this plot, a total of 54 from 14 species (see Table 4.2). Schima wallichii (20) and Glochidion sphaerogynum (Euphorbiaceae) (10) are the most common trees in the understorey. In addition, there are 4 Jatropha curcas (Euphorbiaceae, introduced from tropical America) which were planted for producing soap.

This plot was the first to contain examples of girdled trees. There is a 12.5 metre tall Schima wallichii (22 cm DBH) in the lower portion of the plot. The owner stated that this tree was girdled because it was providing too much shade. There is also an oak of similar size just outside the plot which was girdled for the same reason. These trees are both located in the lower portion of the plot where there is sparse forest cover relative to the rest of the plot. These two species are the most commonly used trees for miang firewood, which may have influenced the owner's decision to girdle these trees.

Ground cover in the upper portion of the plot is largely what would be found in an undisturbed forest (almost all native). The lower part of the plot is more open and contains weeds such as Pteridium aquilium, Eupatorium odoratum, Urena lobata and Centella asiatica. The ground cover is classed as 'native/mixed' to reflect the largely native ground cover in the upper, more shaded portion of the plot, versus the mixed native and weedy ground cover in the bottom portion of the plot. However, the most abundant weed, Eupatorium adenophorum, may become a serious problem (discussed later).

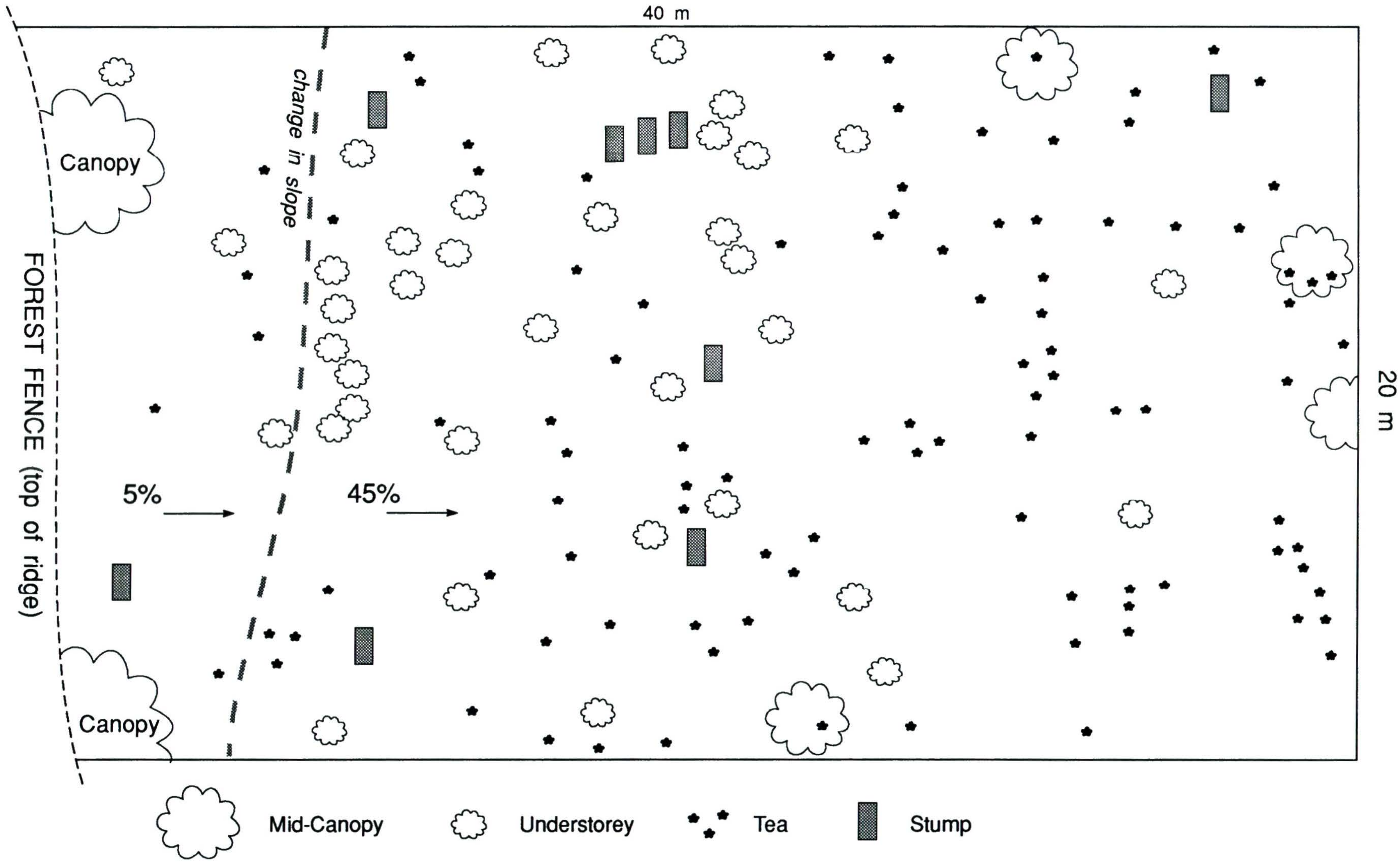


Figure 4.3a Plot diagram of Plot 4, a strip plot.

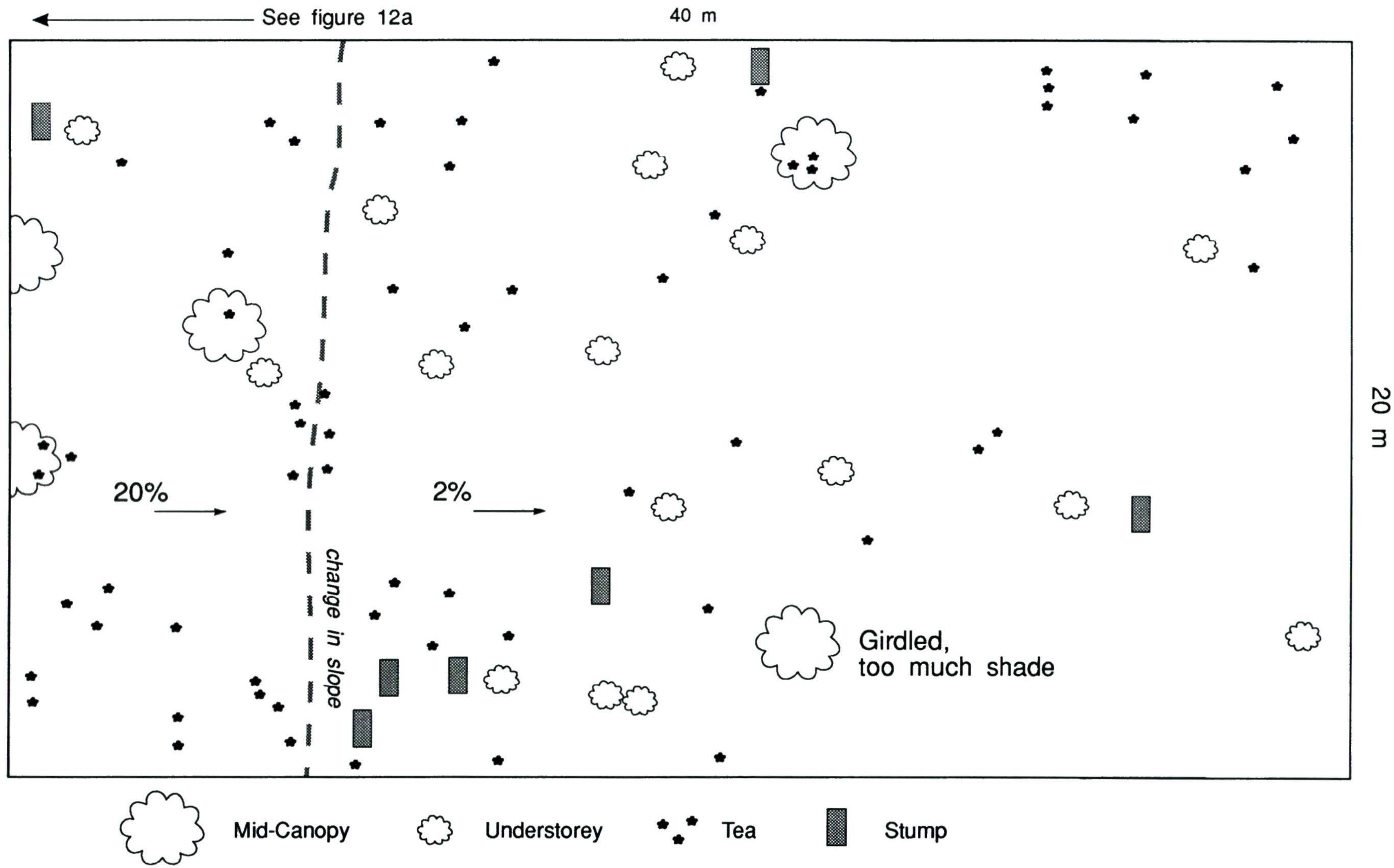


Figure 4.3b Plot diagram of Plot 4, a strip plot.

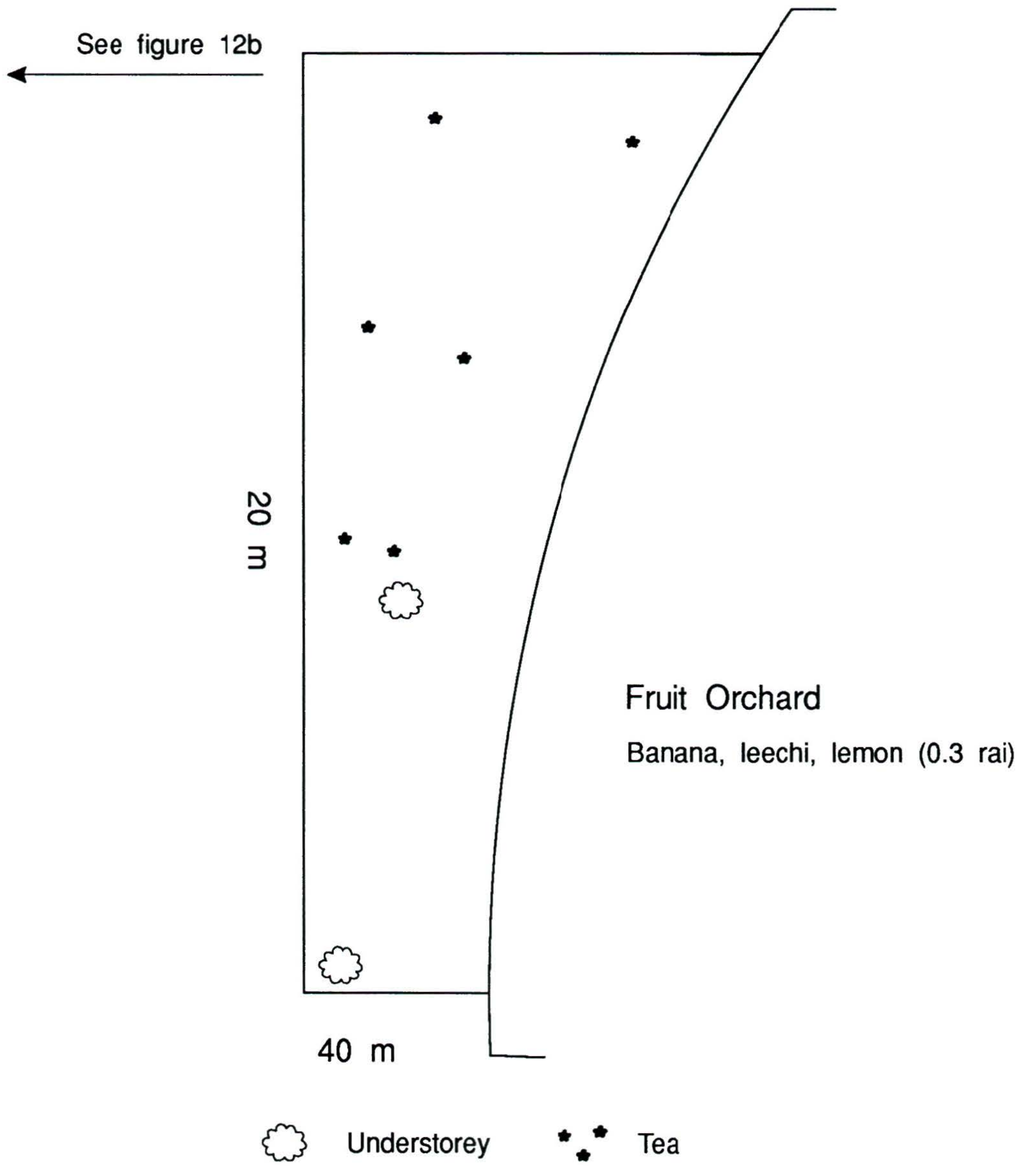


Figure 4.3c Plot diagram of plot 4, a strip plot.

Table 4.2. Summary of forest cover in Plot 4.

Canopy Trees HT >/= 20 m		Midcanopy HT > 12 < 20 m		Understorey HT </= 12 m	
Lithocarpus elegans	(1)	*Rhus rhetsoides*	(1)	*Symplocos macrophylla*	(1)
Gluta tavoyana	(1)	*Antidesma bunius*	(1)	*Lithocarpus elegans*	(2)
		Markhamia stipulata	(1)	*Glochidion sphaerogynum*	(10)
		Glochidion sphaerogynum	(2)	*Casearia grewiifolia*	(2)
		Shorea roxburghii	(1)	*Clausena excavata*	(4)
		Schima wallichii	(1)	*Schima wallichii*	(20)
				Aporusa villosa	(1)
				Rhus chinensis	(3)
				Olea salicifolia	(1)
				Jatropha curas	(4)
				Toona microcarpa	(3)
				Markhamia stipulata	(1)
				Melia toosendan	(1)

Understorey

Alangium kurzii (1)

plot size = 1.0 rai

tea trees = 169
forest trees = 63
canopy = 2
midcanopy = 7
understorey = 54

one girdled tree
no dead trees

This tea garden is weeded twice a year, once in February/March and again in September. The owners add about 100 tea tree seedlings to this 20 rai tea garden every year, some from a simple nursery and some by putting seed in the ground. The owner felt the tea trees are medium in productivity and that the shade in this garden is good.

Plot 4 illustrates the open nature of some of the tea gardens located upon the lower slopes. The majority of the forest cover and tea trees are in the top half of the plot. Table 4.3 shows that all the canopy trees, over half of the midcanopy trees and twice as many understorey trees are located in the top half of the plot.

There are 14 stumps scattered through out the plot. The owner was not sure about the use or age of some of these stumps as they were cut by relatives. Most of the stumps are 'maitalo' (Schima wallichii) which were cut for miang firewood during the last 5 years. Two fresh 'maikawdangs' (oak stumps) were used for poles in constructing a bridge, and one fresh 'maimumpla' (Phyllanthus roseus) was used as a bench for picking tea leaf. The largest and oldest stumps were cut about 15 years ago and used in house construction.

4.3.3 Plot 8: A Second Block Plot

To examine if the forest cover in tea gardens increases as distance increases from the village, two plots were established in tea gardens furthest away from Pa Pae and Mae Sae in a specific direction. Plot 8 was established in the tea garden furthest east of Pa Pae (Plot 10 was south of Mae Sae). A trail on top of an easterly running ridge was followed and the distance to the plot was measured. Starting behind the school in Pa Pae, the trail passes though tea gardens for 1150 metres until it reaches the forest. The trail then passes through the forest for 500 metres until the last tea garden in this direction is reached. At 200 metres before the trail reaches the tea garden and 100 metres after, there are abandoned swidden fields.

This tea garden of about 10 rai is isolated from the main continuous tea gardens closer to the village. This garden is on the north side of a small ridge and faces an old swidden across a small valley. This 0.5 rai plot has a slope from 20 to 35% (Figure 4.4). The forest cover contains 2 canopy trees, 6 midcanopy trees and 7 understorey trees (see

Table 4.3. Distribution of forest and tea trees in the top and bottom 50 metres of Plot 4.

	Top Half	Bottom Half	Total
understorey	36	18	54
midcanopy	4	3	7
canopy	2	0	2
tea trees	100	69	169

Table 4.4 for summary of forest cover). Glochidion sphaerogynum, the most numerous understorey tree, were probably seeded by Glochidion in the midcanopy.

There are a large number of standing dead trees (5) in this plot, 4 of which were girdled, with DBHs from 14 cm to 26 cm. In addition, one of the understorey trees was recently girdled. Three trees, whose stumps ranged from 15 cm to 25 cm, were cut and left on the ground. By their location it appears that the tea garden owner felt there was too much shade in this area of the tea garden as there are 2 midcanopy trees and one canopy tree within 5 metres of these felled trees. These felled trees may have been poor firewood since there are 10 other stumps in the garden where the trees have been removed. Two of the five girdled trees are also near these felled trees. Two of the remaining girdled trees are in open areas of the plot. It is assumed that the 5 girdled trees in the plot will be used for firewood in the future.

This plot has the second highest density of tea trees in the study (334 tea trees/rai, average height of 2.4 metres). The ground cover is largely composed of plants which are remnants of the nearby forest. Many of the native plants observed in the other plots in Pa Pae and Pang Ma Kuay were found in this plot. Dryopteris cochleata, a native fern, was observed in this tea garden for the first time. The ground cover in this plot is classed as 'native'.

4.4 Summary of Vegetation Plots

To help analyze the biophysical data from the vegetation plots, various summary tables have been developed. Table 4.5 gives plot location by village, elevation,

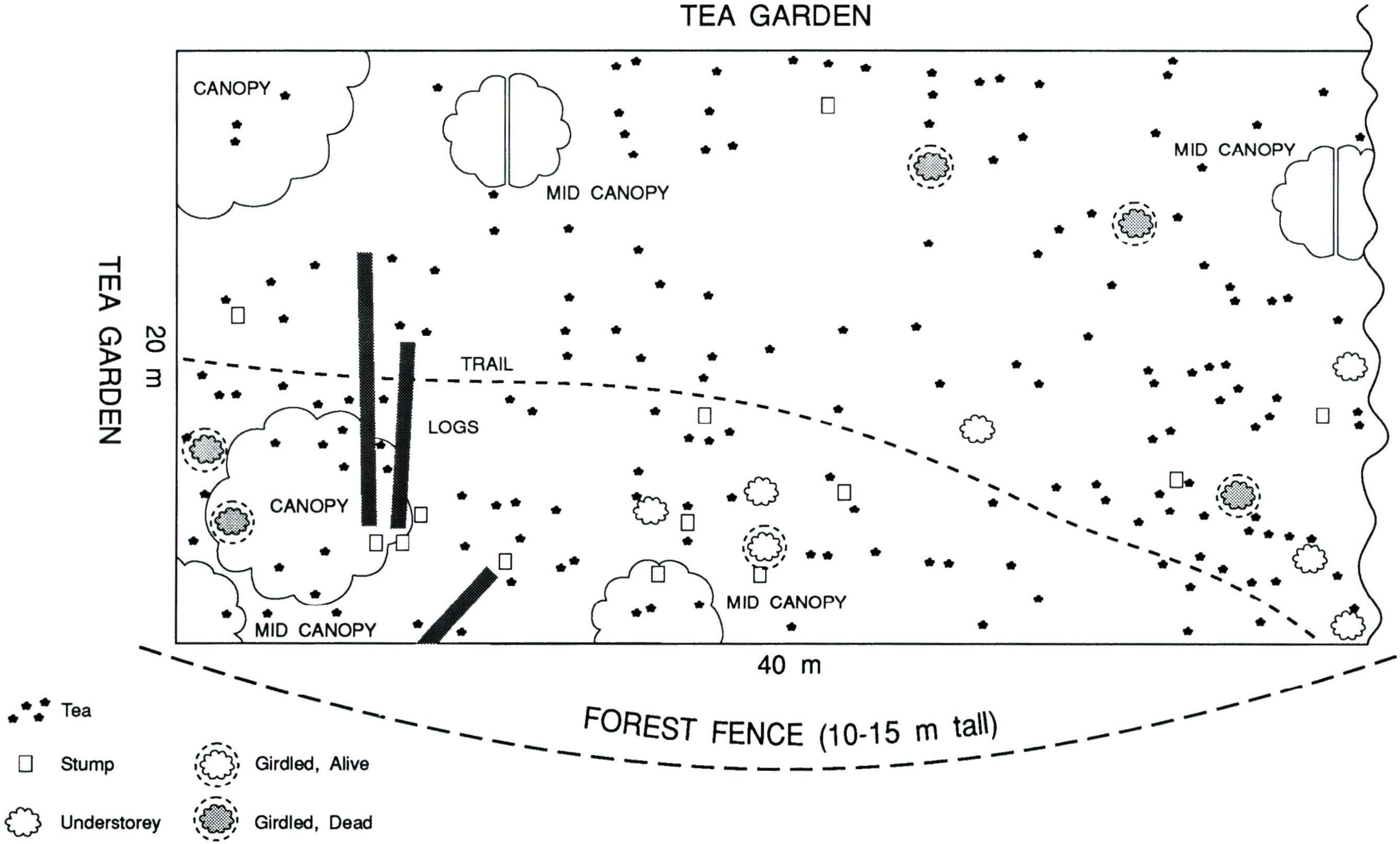


Figure 4.4 Plot diagram of Plot 8.

Table 4.4 Summary of forest cover in Plot 8.

Upper Canopy HT >= 20 m	Midcanopy HT >12<20 m	Understorey HT <=12 m
Dalbergia* rimosa (2)	Bombax kerrii (1)	Shorea ** roxburghii (1)
	Glochidion sphaerogynum (2)	Glochidion sphaerogynum (4)
	Stereospermum colais (1)	Phoebe lanceolata (1)
	Toona microcarpa (2)	Paramichelia baillonii (1)

* large thorns on bark

** girdled but still alive

plot size = 0.5 rai

tea trees = 167

forest trees = 15

canopy = 2
midcanopy = 6
understorey = 7

5 dead trees, 4 were girdled

one live girdled tree

approximate distance from the village, type and size of the thirteen plots completed in this study. Table 4.6 summarizes the biophysical data for each vegetation plot including tea tree and forest tree density, and ground cover classification, while Table 4.7 summarizes the amount of crown cover and ground cover classification for each plot. The vegetation plots will first be examined individually, before looking at them as a whole.

The vegetation plots reveal that there is a great deal of variability in the composition and structure of the tea gardens. Crown cover ranges from 60 m^2/rai to 450 m^2/rai. The number of canopy trees/rai vary from zero in 3 of the plots, up to 12. Midcanopy trees range from 2/rai up to as high as 16, and understorey trees range from zero up to 150/rai. On average, there are twice as many midcanopy trees as canopy trees (3.5/rai versus 7.2 /rai) and over 3.5 times as many understorey trees as midcanopy and canopy trees (38.7 understorey trees/rai). Tea tree density is also variable, from 29 trees/rai to 338 trees/rai (147 average). Average height of the tea trees in the plots ranges from 1.3 to 2.6 metres.

There are numerous examples of coppiced forest trees in the plots. Of the 15 species which were coppiced, most were observed in one plot only. Alangium kurzii and Ehretia laevis were found coppiced in two plots. Schima wallichii, which was observed to be coppiced in 5 of the 10 plots in which it was found, is, by far, the most commonly coppiced tree. These trees are commonly cut at about 1.0 metres above the ground and later pruned so that there was only one leader growing from the tall stump. This tree will also commonly coppice if it is cut close to the ground. In Plot 7 there are numerous individuals of Schima growing back from stumps.

Due to the varying plot sizes, it is difficult to compare tree species diversity between plots. Diversity can be standardized to species\rai, but this is incorrect because the species-area relationship is not constant. If a 0.5 rai plot has 5 species, it does not follow that a 1.0 rai plot will have 10 species in one rai. Table 4.8 shows that diversity in the plots ranges from as low as 2 in a 0.875 rai plot, to as high as 18 in a 1.0 rai plot.

Table 4.5. Tea garden plot location by village, approximate distance from village, elevation, plot type and size.

Plot #	Village	Approx. Dis. from Village (km)	Elev. (m)	Type	Size (rai)
1	Pa Pae	1.0	925	block	1.0
2	Pa Pae	0.1	850	block	0.5
3	Pang Ma Kuay	0.3	875	block	0.5
4	Pang Ma Kuay	1.0	875	strip	1.0
5	Pa Pae	0.7	875	strip	1.4
6	Mae Mam	0.7	900	strip	1.5
7	Mae Mam	0.5	900	block	0.5
8	Pa Pae	1.7	950	block	0.5
9	Mae Sae	0.2	925	block	1.0
10	Mae Sae	1.0	1050	block	0.9
11	Mae Sae	1.0	1075	block	0.5
12	Pang Ma Kuay	0.4	1030	block	0.5
13	Pang Ma Kuay	0.4	1100	block	0.5

Table 4.6. Summary of ground cover classification, tea tree and forest tree density (trees/rai) in the vegetation plots.

Plot#	Tea Trees	Av. Ht.	Can.	Mid-Can.	Under-Story	Dead	Girdled	Ground Cover
1	65	1.5	7	8	53	1	0	mixed
2	96	2.2	4	4	96*	0	0	weedy
3	338	1.3	0	2	58	0	0	mixed
4	169	2.2	2	7	54	0	1	nat/mix
5	116	2.6	4.9	7.7	24.5	2.1	0.7	nat/mix
6	88	2.4	6.7	8.4	5.6	0.7	0	nat/mix
7	92	2.1	2	6	22	6	12	mixed
8	334	2.4	4	12	14	10	12	native
9	29	1.7	1	6	14	1	0	weedy
10	103	2.0	1.1	2.2	2.2**	0	0	weedy
11	156	1.7	12	8	2	0	0	native
12	158	1.3	0	16	10	0	0	weedy
13	164	2.4	0	6	150	0	2	native

* 26 trees were planted
** these trees were planted

Averages

	Trees per rai	Trees per Hectare
tea trees	= 147.0	= 918
canopy trees	= 3.5	= 21
midcanopy trees	= 7.2	= 45
understorey	= 38.7	= 241

Table 4.7. Crown cover and ground cover classification in the vegetation plots.

	Plot #	Crown Cover (m^2)	Ground Cover Classification
	10	60	weedy
	3	71	mixed
	4-b *	104	mixed
	9	115	weedy
	5-b	123	mixed
	6-b	136	mixed
	7	149	mixed
	13	193	native
	12	209	weedy
	2	239	weedy
	4-t **	270	native
	8	275	native
	1	340	mixed
	5-t	406	native
	11	441	native
	6-t	450	native
Average		224	

* b= bottom half of the strip plots
** t= top half of the strip plots

Table 4.8. Species diversity in the vegetation plots.

Plot #	Plot Size (rai)	# of Species in the Canopy and Midcanopy	# of Species in the Understorey	Species per Plot
1	1.0	7	6	11
2	0.5	3	7	10
3	0.5	1	9	10
4	1.0	8	14	18
5	1.4	11	11	18
6	1.5	5	5	9
7	0.5	2	6	7
8	0.5	5	4	8
9	1.0	6	7	11
10	0.9	2	0	2
11	0.5	6	1	6
12	0.5	6	3	7
13	0.5	2	7	9

Ground cover was also found to be very diverse in the vegetation plots. Some plots have largely native ground cover, some are largely composed of weedy species, and some are mixed. All the tea gardens in which the plots were located are slashed twice a year and the forest floor had little or no deadwood. Only two of the plots have a substantial number of girdled trees and dead trees.

4.4.1 Comparison of Strip Plots

The summary tables indicate that there is a great deal of variability between the tea gardens. Forest cover, tea tree density and ground cover composition are all highly variable. There is also a great deal of variability within some of tea gardens, depending upon slope position.

Three strip plots were completed to examine changes in forest cover, ground cover and tea tree density with changes in slope position. Twenty metre wide strips were run from the bottom of a slope to the ridge top, or to the forest edge, whichever came first. Plots 4, 5 and 6 were 80, 110 and 120 metres long respectively. Plot 4 was about 1.0 kms north of Pang Ma Kuay and was accessible by road. Plot 5 was about 0.75 kms east of Pa Pae and was accessible by trail. Plot 6 was 700 metres south of Mae Mam and was accessible by road. Table 4.9 summarizes the forest trees and tea trees per rai in these 3 plots.

There is a noticeable change in all the strip plots at about the halfway point up the slope. At this point, there is a substantial change in the forest cover from the largely open, bottom portion of the plots, to the more heavily forested, upper portion. Table 4.10 summarizes the distribution of forest and tea trees in the top and bottom portion of the strip plots. In Plots 4 and 5, the majority of tea trees are in the top portion of the plot, but they are more equally distributed in plot 6. There is 2.6 times the forest cover in the top portion of Plot 4 relative to the bottom, and 3.3 times in Plots 5 and 6. Figure 4.5 is an artistic rendition of the strip plots, illustrating how forest cover increases and ground cover declines as one moves up slope in the tea gardens.

Table 4.9. Forest trees and tea trees/rai in the strip plots.

Plot #	Tea Trees	Under-storey	Midcanopy	Canopy	Forest Cover (m^2/rai)	Access
4	169	54.0	7.0	2.0	186	road
5	116	24.5	7.7	4.9	261	trail
6	88	5.6	8.4	7.0	288	road

Table 4.10. Forest and tea tree density, and forest cover in the top and bottom portion of the strip plots.

		Trees				Trees/Rai				Forest
Plot	Size (rai)	U	M	C	Tea Trees	U	M	C	Tea Trees	Cover (m^2/rai)
4-T	0.50	36	4	2	100	72	8	4	200	270
4-B	0.50	18	3	0	69	36	6	0	138	104
5-T	0.69	13	8	6	142	18.9	11.6	8.7	206	406
5-B	0.69	22	3	1	17	32.0	4.4	1.5	24	123
6-T	0.75	2	11	7	76	2.7	14.7	9.3	101	450
6-B	0.75	6	1	3	57	8.0	1.3	4.0	76	136

T= top half of strip plot
B= bottom half of strip plot

U= understorey trees M= midcanopy trees C= canopy trees

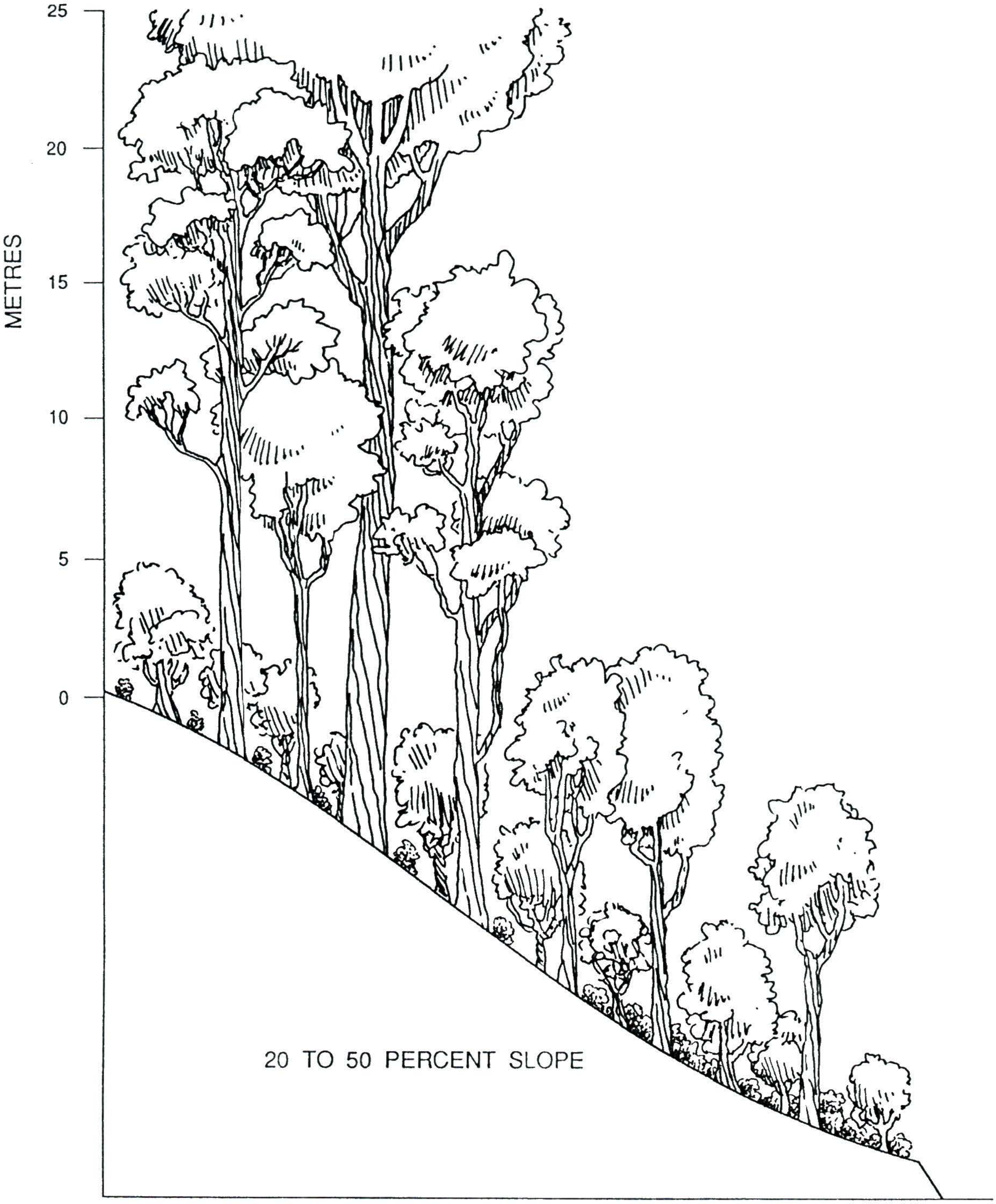


Figure 4.5 Artistic rendition of the tea gardens.

The differences in forest cover within the plots result in substantial changes in the ground cover. In all the plots, the ground cover in the more open, bottom portion is a mixture of remnant plants from the original ground cover before the gardens were created, and weedy plants which invaded once the forest cover was thinned. In contrast, the ground cover in the more heavily forested, upper portions are largely composed of plants which would be found in a relatively undisturbed forest.

In Plot 6, the changes in ground cover between the bottom and top of the plot were found to be very distinct due to the presence of Pteridium aquilinum. This fern grows thickly on the bottom half of the plot, but disappears at about the halfway point just before the forest cover became more dense. The transition between the mixed and native ground cover in Plot 5 is also distinct due to the heavy band of forest cover at the halfway point in this plot. The transition in Plot 4 is more gradual, as is the change in forest cover.

Plot 4 has the least amount of forest cover, 186 m^2/rai, followed by Plot 5 with 261, and Plot 6 with 288. Accessibility may be partially responsible for the differences in forest cover between these plots. Plot 4 is accessible by road and Plot 5 by trail. Although there is less forest cover overall in Plot 4, which may be a result of road access, this plot has the highest number of understorey trees. Relative to Plot 5, this is surprising given that the owners of the tea garden in which plot 5 is located do not harvest firewood from this tea garden. Firewood is harvested in Plot 4 (numerous stumps) yet there are more understorey trees in this garden.

Plot 6 in Mae Mam has the highest amount of forest cover among the 3 strip plots. Although this garden is accessible by road, which may negatively influence forest cover, this garden has numerous upper canopy trees, including two species of oak. This plot, however, has few understorey trees relative to the other strip plots. The reasons for the heavy forest cover and fewer understorey trees may be due to the following: Mae Mam is smaller and more isolated relative to the large villages and forest resources are closer to the village; there appears to be less pressure on the villagers in Mae Mam by forestry officials not to cut firewood in the forest relative to the other villages in the study area. Therefore, the villagers in Mae Mam may have better access to forest resources. In addition, the miang producer survey suggests that the villages are less concerned about cutting young forest trees when slashing the ground cover (discussed later).

4.4.2 Accessibility and Forest Cover

Accessibility may have an influence on forest cover in the tea gardens. When possible, growers will frequently use trucks to haul firewood cut from the tea gardens or forested areas which are close to a road. Therefore, tea gardens which are accessible by road may be utilized for firewood more than tea gardens which are not. Those tea gardens close to the villages and which are not accessible by road, may also have greater pressure placed upon them for firewood collection then non-road access gardens far from the villages. The firewood miang producers use is large and heavy, and extraction is labour intensive.

Table 4.11 groups the plots into three categories: gardens easily accessible by road; gardens less than 0.5 km from the village and accessible by trail only; and gardens greater than 0.5 kms and accessible by trail only. Although there are too few plots to draw any definite conclusions, forest cover in the tea gardens less than 0.5 kms from a village is smaller in area than the forest cover in the tea gardens over 0.5 km from the villages. Nearby tea gardens averaged 163 m^2/rai of forest cover and tea gardens further away averaged 276 m^2/rai of forest cover. There are only two plots located in tea gardens which are easily accessible by road and the average forest cover fell in between these two figures.

Although distance does seem to have an influence on the amount of forest cover in the tea gardens, there were exceptions from what would normally be expected. For example, Plot 10, which was located in a tea garden furthest south of Mae Sae, has the second lowest forest cover. Plot 11, only 300 metres from Plot 10, has the second highest forest cover.

Table 4.11. Forest cover (m^2/rai) in the vegetation plots according to accessibility.

Road Access		Non-Road Access < 0.5 km From Village		Non-Road Access > 0.5 km From Village	
Plot	Forest Cover (m^2/rai)	Plot	Forest Cover (m^2/rai)	Plot	Forest Cover (m^2/rai)
4	187	2	239	1	340
6	293	3	71	5	264
		7	149	8	275
		9	115	10	60
		12	209	11	441
		13	193		
Av.	240		163		276

4.5 Tea Gardens and Undisturbed Forest: A Comparison.

In order to contrast the stocking and diversity of the tea gardens with a similar but relatively undisturbed forest, the vegetation plots' characteristics were summed and compared to recent work completed in Doi Suthep-Pui National Park (Elliott et al, 1989). Stocking and diversity in the tea gardens was compared to that found in monsoon forest in the Park (west of Chiang Mai) between elevations of 670 and 960 metres.

A brief comment is needed referring to the forests in Doi Suthep-Pui National Park as 'relatively' undisturbed. The forest in many areas of the Park is far from undisturbed. Maxwell (1988:6) notes:

> *In recent decades, the mountain has been settled in several areas by hilltribes folk who have, unfortunately, destroyed large portions of the original forest cover. There have also been two valleys converted into coffee, fruit tree etc. plantations by various Government bodies. In general, the west side of Doi Suthep-Pui National Park has essentially been completely destroyed, or severely disturbed, while other parts of the mountain have remained relatively intact and have not had their original vegetation disturbed.*

Although large areas of the Park have been disturbed, the area in which the work by Elliott (et al, 1989) was completed is relatively undisturbed. The study site was located near to Doi Suthep Temple and Maxwell (1988:11) notes:

Indeed, the area about the Doi Suthep Temple and the National Park headquarters nearby, as well as the entire Chang Kian Valley at elevations above 950 metres, includes the most pristine, dense, and diversified vegetation on the entire mountain.

Elliott conducted a transect survey of monsoon forest in Doi Suthep-Pui National Park. The transect was divided into two main associations: a deciduous association and a mixed evergreen-deciduous association. The deciduous association has a higher density of trees but fewer species relative to the mixed deciduous-evergreen association, and occupied dryer sites on the transect.

First, a summary of tree density and diversity in the vegetation plots located in the tea gardens is necessary. There are 452 trees in the 13 vegetation plots which covered 10.25 rai (1.64 ha) of tea gardens, a density of 275 trees/ha. Figure 4.6 shows the frequency histogram of the trees DBH (diameter at breast height). There are a large number of small trees and a few large diameter trees: over half (55%) of the trees are less than 10 cm DBH; 17% are between 10.1 and 20 cm; and the remainder are greater than 20.1 cm. The largest tree is a 131 cm DBH fig tree (Ficus microcarpa) 33 metres tall, with a crown diameter of 8 to 9 metres.

In the 1.64 ha of tea gardens sampled, there are 60 tree species from 53 genera and 35 families. The mean number of individuals per species is 7.5. Secondary growth trees like Phyllanthus roseus and Microcos paniculata are the most numerous tree. Schima wallichii and Lithocarpus elegans are the most numerous primary tree. Most species are rare; almost three quarters (71.7%) are represented in the tea gardens by three individuals or less. The majority of the remaining species are represented by 5 to 12 individuals and some as high as 120 (Figure 4.7). Three of the species in the tea gardens are planted (Tectona grandis, Citrus grandis, Jatropha curcas) and 50% of the trees are deciduous, 48.3% are evergreen and 1.7% are tropophyllos. Excluding one unknown, 63.8% of the species are primary trees and 34.5% are secondary. There is one large epiphytic fig tree in Plot One. Appendix 4 gives a summary of all the tree species found in the vegetation plots and their characteristics-- primary or secondary, deciduous or evergreen, position in the canopy, softwood or hardwood, and family.

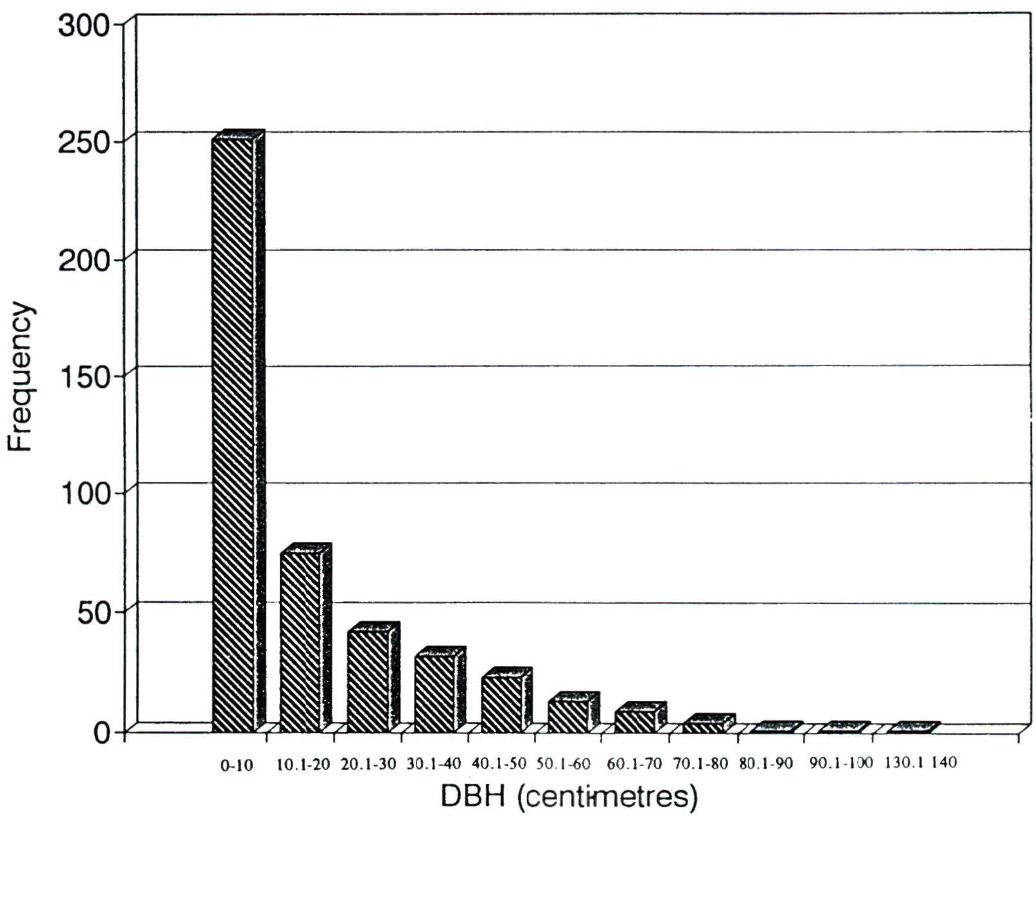


Figure 4.6 Frequency histogram of diameter at breast height for 452 trees found in 13 vegetation plots in monsoon forest, Tambon Pa Pae.

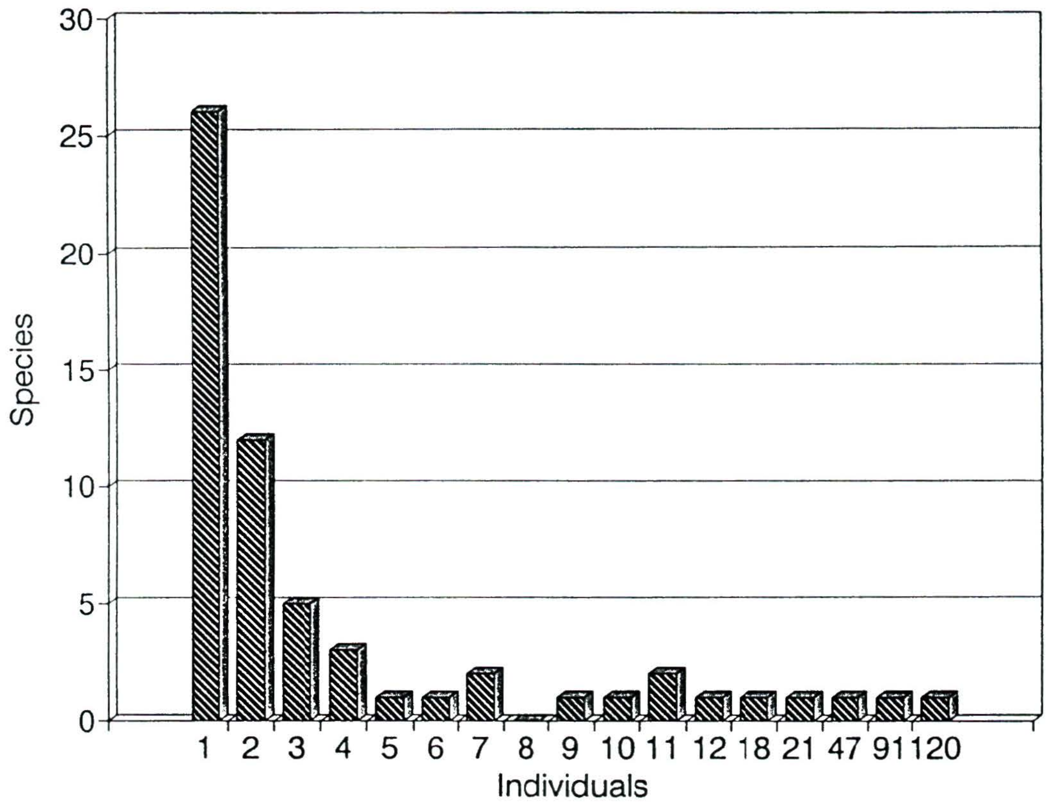


Figure 4.7 Number of tree species represented in the tea gardens by the number of individuals, 1,2,3...etc.

To examine the approximate number of species/ha a species-area curve was constructed by selecting plots at random and adding the number of newly encountered species cumulatively to the number of previously encountered species (Figure 4.8) (Ludwig and Reynolds, 1988). This was repeated 5 times and mean numbers of species for each area were used to produce a smoothed curve. This curve indicates that there are 48 species/ha in the tea gardens. However, the curve does not appear to be flattening out with increasing area. On Doi Suthep mountain, the curve flattens at about 1 ha and this area is sufficient to include most species (Elliott, pers comm). Although it is felt that the tea gardens are located within the same community, the failure of the species-area curve to flatten out after 1.64 ha have been sampled suggests that the tea gardens are established within more than one community. If the gardens are located within more than one community, more area would have to be sampled to capture tree species diversity.

The species-area curve for the transect in Doi Suthep-Pui National Park predicts that there should be 121 species/ha for trees greater than 10 cm in girth (0.828 ha surveyed). A similar curve for the tea gardens indicates that there are about 48 species/ha, 37% of the diversity of a similar, relatively undisturbed forest. The diversity in the tea gardens is slightly elevated relative to the Park due to the smaller minimum size of trees measured in the tea gardens. Trees in the tea garden over 1.0 metres tall were included in the sample. These trees had a 1 to 2 cm DBH. The transect in the Park only included trees with a minimum 10 cm girth at breast height, which is slightly larger than a 3 cm DBH. Whitmore (1975) noted that the number of tree species recorded increases geometrically as the minimum diameter considered is recorded.

Elliott (et al, 1989) calculated the relationship between cumulative area surveyed and cumulative number of trees to predict the average number of trees/ha for the total transect, but not for the two major associations individually. Elliott predicted 826.5 trees/ha for the monsoon forest in the Park. In the tea gardens, there were 452 trees in 1.64 ha of the tea gardens sampled, or 275 trees/ha. This represents 33% of the stocking relative to the monsoon forest in the Park.

The tea gardens have 33% of the density and 37% of the diversity of similar relatively undisturbed forest. The trees in the tea gardens were also represented by fewer

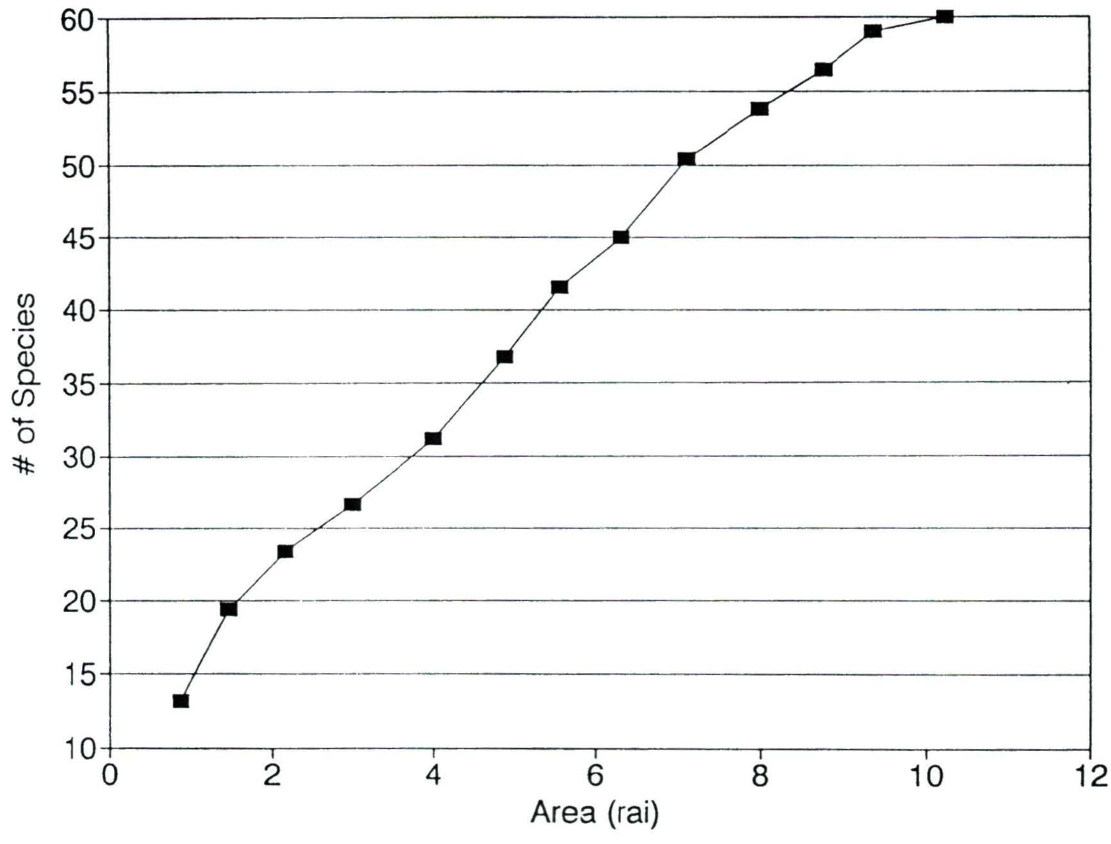


Figure 4.8 Species-area relationship of the vegetation plots.

individuals; in the transect, 59.4% of the species were represented by three individuals or less, in the tea gardens this was 71.7%. The average number of trees/species is higher in the tea gardens than the transect, 7.5 versus 6.2 respectively. The most numerous species are secondary growth trees which became established in the tea gardens after the original forest cover was thinned.

4.6 Forest Cover in the Tea Gardens

Forest cover in this agroforestry system serves several roles: it provides shade for the tea trees; conserves soil moisture during the dry season; helps prevent soil erosion; provides firewood for miang production and household use; provides building materials, medicinal plants, food and habitat for wildlife. The amount of forest cover is dependent upon several interrelated factors: age of the tea gardens; accessibility; slope position; regenerative characteristics of the forest trees; whether there are nearby forested areas from which to draw firewood and timber; and management practices. These latter will affect forest cover, for example: the amount of care taken to avoid cutting forest tree saplings when slashing ground cover; firewood gathering practices; and growers' perceptions of the amount of shade tea trees need. Due to the large number of interrelating factors, there is a great deal of variability in the amount of forest cover found in the tea gardens.

In order to examine uses of the most common forest trees in the tea gardens and to see if the forest trees are regenerating, the forest trees have been divided into two major categories: the canopy/midcanopy and the understorey. The understorey includes all trees up to 12 metres tall, and the canopy/ midcanopy are any trees taller than 12 metres.

The 12 metre division for understorey trees was chosen to reflect the firewood gathering practices of the growers. Growers prefer trees from 20 to 30 cm in diameter for firewood. Trees in the vegetation plots between 10 metres and 14 metres tall average 24 cm in diameter. Suitable trees in this height range will be readily used for firewood, but beyond this they tend to become too large for processing by axe and saw.

Since trees with heights around 12 metres start becoming too large for firewood, the uses for the most common trees beyond this height have been examined. This may reveal if there is any selectivity on behalf of the growers to allow certain trees to remain in the upper canopy of the tea gardens. Uses for the most common canopy/midcanopy trees and understorey trees found in the tea gardens were obtained through interviews with the tea garden owners. Common names and uses for the forest trees were recorded and cross referenced with 5 of the owners.

4.6.1 Canopy and Midcanopy

There are 34 species in the canopy and midcanopy, 21 of which occur in one plot only. Table 4.12 identifies the six most numerous species in the vegetation plots and the number of plots in which they are found. The most numerous and frequently occurring tree is Schima wallichii, with 36 trees in 7 plots. Toona microcarpa (15 trees) and Lithocarpus elegans (9 trees) are found in 6 plots. Half of the most common trees are found in only 2 or 3 plots. Seven other species are also found in 2 or 3 plots only, but in fewer numbers relative to the trees included in Table 4.12.

4.6.1.1 Uses for Common Upper Canopy Trees

There is a certain amount of selectivity on behalf of the growers regarding the trees found in the tea gardens. For example, some trees are left to grow because the flowers and/or nuts are used medicinally or eaten, or the wood is good for construction timber. Markhamia stipulata (found in 3 plots) is often left to grow in the tea gardens because the flowers are consumed like a vegetable. Pterocarpus macrocarpus, Sapium baccatum and Shorea roxburghii are examples of trees which are valued as a construction timber. These trees will be protected in the tea gardens (will not be cut for firewood when they are young) so that they can later be used as construction timber. Although absent from the vegetation plots, many of the trees from the genus Diptocarpus are also highly valued for construction timber.

Table 4.12. Six most common trees in the canopy and midcanopy of the vegetation plots.

	Trees**	Frequency (# of Plots)
Schima wallichii	36.6	7
Toona microcarpa	15.7	6
Castanopsis diversifolia	10.3	3
Lithocarpus elegans	9.5	6
Glochidion sphaerogynum	6.7	3
Microcos paniculata	6.0	2

** total number of trees in the 13 vegetation plots

Some trees are found in the tea gardens because they have few uses. The wood is either of poor quality, or contains some unfavourable characteristic i.e. sap is irritating to the skin, or wood grain is difficult to split or saw. Gluta tavouyna (found in 3 plots) is often left in the gardens because, for many growers, the sap of this tree is very irritating to the skin (causes swelling). These trees, however, are useful for providing shade for the tea trees- this tree is the only large tree in Plot 3. Other large trees once found in this plot have all been cut for firewood or construction timber. The uses of the six most common upper canopy trees found in the plots are given in Table 4.13.

The most numerous and frequently occurring species in the canopy/midcanopy is Schima wallichii. It is also the third most numerous tree in the understorey. This tree may be common due to a number of factors. For example, Schima wallichii may be numerous due to its seed dispersal characteristics. This tree has a winged seed which favours wind dispersal. This method may be advantageous relative to other species like the oaks which rely upon small mammals to help spread its seed. This tree also

Table 4.13. Uses for the six most common trees in the canopy and midcanopy of the vegetation plots.

Schima wallichii

This is a primary, mostly deciduous canopy tree (hardwood).
Although this tree is a hardwood and makes good construction material and miang firewood, it is not a preferred tree due to the irritable nature of the sap. Large trees are difficult to split for firewood.

Toona microcarpa

This is a primary, deciduous canopy tree (softwood).
This tree is a poor to medium firewood (gives a lot of smoke) and poor construction material, although if a straight one can be found, they can be used as poles in houses.

Castanopsis diversifolia

This is a primary, evergreen canopy tree (hardwood).
This tree is one of the oaks which is the most commonly used and preferred miang firewood. It also makes good poles for house construction and the seeds are often eaten/sold.

Lithocarpus elegans

This is a primary, evergreen canopy tree (hardwood).
This is another oak and has the same characteristics as above.

Glochidion sphaerogynum

This is a secondary, deciduous midcanopy tree (softwood).
This tree is a poor to medium firewood and is not used for construction material. When this tree was cored, the centre pith of the tree was very soft.

Microcos paniculata

This is a secondary, evergreen midcanopy tree which likes open places (hardwood).
This tree is a good firewood but is no good for construction because it is difficult to saw.

Note: Firewood potential is relative to the oaks which are the most commonly used and preferred miang firewood.

commonly coppices, growing back from the stumps (most commonly coppiced tree in the vegetation plots).

Schima wallichii may also be abundant because there may have been better timber and firewood alternatives in the past. Although this tree is a hardwood and makes good construction material and miang firewood, it is not a preferred tree due to the irritable nature of the sap and the difficulty in sawing the wood and splitting large trees. If the villagers are searching for large timber trees or firewood, this tree will be left if there are other more suitable trees in the area.

Although Schima wallichii is not a favourite tree for construction timber, it appears that much of the good timber species have been cut in the tea gardens and nearby forests since Schima is increasingly being utilized. At one fresh forest sawmill site near Plot 4, this was the only tree which had been cut for timber. There were 8 stumps and 3 sawmill sites near the top of the ridge where the trees had been cut and rolled downhill to the sawmill (Figure 4.9). One villager was observed carrying a plank cut from this tree from the forest near Plot 8, over 2 kms from Pa Pae. In addition, the miang producer survey indicates that Schima is the second most commonly used miang firewood. Although this tree is not a favourite, it is used for firewood and timber since it is readily available in the tea gardens.

The relative abundance of two oaks in the canopy/midcanopy (Castanopsis diversifolia and Lithocarpus elegans) is encouraging, considering the amount of pressure this tree is under from miang producers (most commonly used and preferred firewood for steaming tea leaf). However, problems may occur in the future due to the obvious scarcity of small mammals (and birds) in the tea gardens which are important for seed dispersal. These animals are under severe pressure from hunters.

The negative impact of the lack of small mammals upon oak regeneration may already be apparent. Two oaks, Castanopsis indica and C. tribuloides, were found in the midcanopy/canopy of one plot only and they were absent from the understorey. Given the small number of plots completed, the scarcity of these trees may not be a problem. However, the oaks, in general, are a common tree in the mixed evergreen/deciduous forests (Maxwell, pers comm). Elliott (et al, 1989) found 1 C. indica, 9 C. tribuloides,

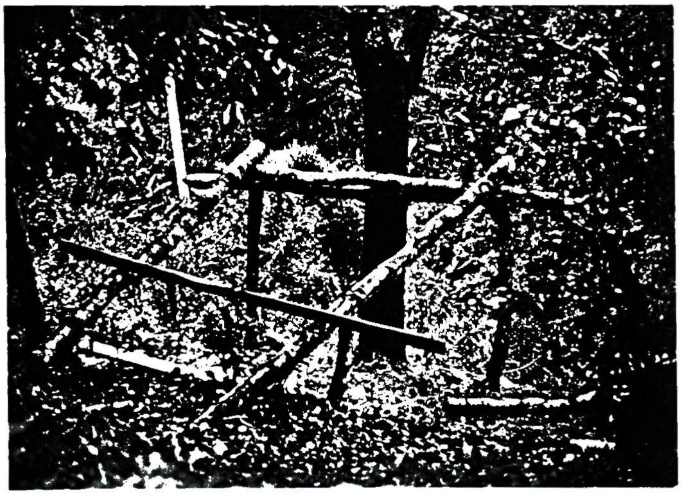


Figure 4.9 Traditional forest sawmill site utilizing *Schima wallichii* for timber.

and 15 C. diversifolia in 0.828 ha in Doi Suthep-Pui National Park. In the tea gardens, there were 1 C. indica, 1 C. tribuloides, and 10 C. diversifolia in 1.64 ha. Although the tea gardens have only 33% of the stocking of the forest in the Park, these figures indicate that some of the oaks are under pressure in the tea gardens. Relative to the Park, C. tribuloides is very rare. One villager stated that some of the oaks produce little seed. Low seed productivity, combined with the lack of small mammals and the pressure these trees are under by miang producers, may be causing some of the oaks to decline in numbers.

Two of the most common trees in the midcanopy/canopy, Toona microcarpa and Glochidion sphaerogynum, make poor firewood and construction material. Toona microcarpa is a primary tree while Glochidion sphaerogynum is a secondary growth tree. Generally, these trees will be left in the tea garden if they are providing good shade for the tea trees. If these trees are in an area of the tea garden where there is too much shade, the growers may girdle these trees in favour of other trees that provide useful products to the villagers (such as fruit), or they may be left in favour of taking another tree which can be used as firewood or construction material. Both of these trees regenerate well (Maxwell, pers comm). The final tree, Microcos panniculata, is good for firewood but is poor construction material.

Undoubtedly there are trees which are scarce in the tea gardens because they are highly sought after. The possible problems with some of the oaks were discussed earlier. Another example is teak, which was not observed naturally occurring in the study area. However, this may be due to altitude since teak is (or was) primarily found in the lowland deciduous forests. The scarcity of some of the other highly valued timber species in the tea gardens mentioned earlier, may be due to timber cutting by the villagers for their own use, and/or due to illegal cutting for sale outside the village. Villagers are allowed to cut timber in their tea gardens and the forest if they are building a house (several houses under construction in Pa Pae, Pang Ma Kuay and Mae Sae). However, one truck load of hand sawn planks was observed being removed from Pa Pae and was likely destined for Chiang Mai. Abandoned fresh sawmill sites in the tea gardens suggest that some of this timber came from the gardens.

4.6.2 Understorey

The understorey has been identified for analysis for two reasons: to examine if forest trees are regenerating; and to assess firewood productivity. The number of understorey trees in the plots vary from zero to 150 trees\rai. On average, there are 10.7 upper canopy trees per rai, compared to 38.7 understorey trees per rai. There is also greater diversity in the understorey-- 44 species compared to 34, 31 of which occur only once.

Table 4.14 identifies the seven most numerous understorey trees and their frequency. The most numerous tree is Phyllanthus roseus (184), followed by Microcos paniculata (86), both of which are found in 4 plots. The most frequently occurring tree is Schima wallichii which is found in 8 plots, followed by Lithocarpus elegans in 6 plots. Four of the seven most common trees are found in 2-4 plots. There are 8 other species which are also found in 2-4 plots, but in lower numbers. One species, Alangium kurzii, is found in 5 plots but in very low numbers. The two most numerous trees are secondary growth trees, and the two most frequently occurring trees are primary trees. The characteristics of the most numerous trees are given in Table 4.15.

Plots with high densities of understorey trees are usually dominated by one or two species. While Phyllanthus roseus is the most numerous tree in Plot 13 (the densest understorey) Microcos paniculata is the most abundant tree in Plot 2 (second highest stocking). Both plots have 7 species in the understorey (0.5 rai plot), but two of these in Plot 2 were planted. Mapping the location of trees in the plots shows that understorey trees are found in both open areas and shaded areas of the plots.

After thinning the forest cover to develop the tea gardens, secondary growth tree species will readily become established. Four of the six most common trees found in the understorey, and two of the six most common trees in the upper canopy, are secondary growth species. However, of the 44 species found in the understorey: 26 (59%) are primary trees; 15 (34%) secondary; two are planted and one is unknown. In the canopy: 24 (71%) are primary and 9 (26%) secondary growth trees (34 species, one unknown). Although secondary growth trees are more numerous, the majority of tree species found

Table 4.14. Seven most common trees in the understorey of the vegetation plots.

	Trees *	Frequency (# of Plots)
Phyllanthus roseus	184.2	4
Microcos paniculata	86.7	4
Schima wallichii	71.9	8
Tectona grandis **	22.0	1
Glochidion sphaerogynum	21.0	4
Lithocarpus elegans	16.7	6
Clausena excavata	11.0	2

* total number of trees in the 13 vegetation plots

** this tree (teak) was planted

in the tea gardens are primary trees (64% versus 34%). Primary trees are usually more diverse in the plots, but fewer in numbers.

4.6.2.1 Uses for Common Understorey Trees

Over half of the most numerous understorey trees are secondary growth. Generally, these trees are considered to be a medium firewood relative to the oaks. The remaining trees are primary growth-- Schima wallichii and one species of oak-- are the most used and preferred firewood for miang production. Oaks also make good poles for house construction and Schima are commonly used for construction timber. The final primary tree, teak, was planted and is the most highly valued native wood in Thailand. The uses for the seven most common understorey trees in the vegetation plots are summarized in Table 4.15.

Table 4.15. Uses for the seven most common trees in the understorey of the vegetation plots.

Phyllanthus roseus

This is a secondary, deciduous, tree (softwood) which grows to about 7-8 metres in height. This tree is a medium firewood and is not used for construction material.

Microcos paniculata

This is a secondary, deciduous, midcanopy tree (hardwood). See Table 4.13 for uses of this tree.

Schima wallichii

This trees is a primary, mostly deciduous, canopy tree (hardwood). See Table 4.13 for uses of this tree.

Tectona grandis

This is a primary, deciduous, canopy tree (hardwood).
This tree was found in one plot only and was planted. This tree is not considered part of the natural regeneration in the tea gardens. Teak is extremely valuable for carving, furniture building and house construction. Currently, there is a 'ban' on cutting teak in Thailand.

Glochidion sphaerogynum

This tree is a secondary, deciduous, midcanopy tree (softwood). See Table 4.13 for uses of this tree.

Lithocarpus elegans

This tree is a primary, evergreen, canopy tree (hardwood).
See Table 4.13 for uses of this tree.

Clausena excavata

This is a secondary, deciduous, midcanopy tree (softwood) which likes open places. This tree is a medium firewood and straight trees can be used as poles in houses.

Note: Firewood potential is relative to the oaks which are the most commonly used and preferred miang firewood.

4.7 Forest Cover Regeneration

Generally, the thinning of the forest cover in the tea gardens occurs over a long period of time. When first established, growers remove the smaller trees, leaving the large primary trees for shade. Over time, these trees may die, or if suitable, they are used for firewood and/or construction timber. Regenerating trees will often be used for firewood or small construction needs. Many of the tea gardens have little or no forest cover on the lower slopes and the only large trees are found near the ridge tops. The more easily accessible trees on the lower slopes have been removed. Trees near the ridge top are often left to mark the boundaries of the tea gardens and to prevent soil erosion from wind and water. However, five different sawmill sites were observed in the tea gardens, all near the ridge tops, indicating that the villagers are moving up hill in their search for construction timber.

Forest cover regeneration is important for the long term maintenance of this agroforestry system. Due to the growers' practices of slashing the ground cover in the tea gardens, which kills forest tree saplings and firewood collection from the tea gardens, care must be taken that there is sufficient new growth in the gardens to maintain the important forest cover. The decline of forest cover in tea gardens in Tambon Wawi and the subsequent decline in tea leaf productivity over the last decade (50% decline) warn what can happen if forest cover is not maintained in the tea gardens.

The regeneration of forest trees in the tea gardens will be influenced by the interaction of natural and human variables. Some of these variables include:

1) composition of ground cover i.e. weedy species may hinder forest tree regeneration and growth;

2) reproduction characteristics of tree species i.e. seed dispersal mechanisms, coppicing ability;

3) amount of forest cover to provide shade and seeds;

4) amount of slashing i.e. frequent slashing will encourage the establishment of weedy species;

5) care taken by growers to avoid cutting saplings when slashing ground cover.

Table 4.16. Ratio of upper canopy trees to understorey trees.

Plot	Ratio	Plot	Ratio
1	1:3.5	8	1:0.9
2	1:12	9	1:2
3	1:29	10	no understorey
4	1:6	11	1:0.1
5	1:1.9	12	1:0.6
6	1:0.4	13	1:25
7	1:2.7		

In order for the forest cover to be maintained, there must be sufficient regeneration and protection of young trees. At a minimum, there must be at least as many understorey trees as upper canopy trees. Eight of the 13 plots have more understorey trees than upper canopy trees, with ratios from 1.9 to 29. In the remaining 5 plots, one plot has no understorey, and in 4 others the ratio ranges from 0.1 to 0.6 (Table 4.16).

In the tea garden with no understorey (Plot 10), a weedy ground cover and lack of care while slashing probably resulted in a lack of forest tree regeneration. In Plot 12, slashing the ground cover 5-6 times a year (and a weedy ground cover) almost eliminated forest tree regeneration. However, plots with few understorey trees did not always have weedy ground covers. In the remaining plots with unfavourable understorey to upper canopy ratios: Plot 6 had a native/mixed ground cover; and Plots 8 had 11 native ground covers. The last three plots also had above average forest cover.

In the above tea gardens, slashing was probably the major reason for lack of forest tree regeneration, especially in gardens which had at least average forest cover and mixed or native ground covers. Ground cover is, however, an important indicator of the ecological stability of this agroforestry system.

4.8 Ground Cover

One of the major natural variables influencing forest tree regeneration is ground cover composition. Forest trees are able to develop under native ground flora within the forest. Thinning the forest cover can encourage the establishment of invading weeds which may be detrimental to forest tree regeneration.

Ground cover composition in the tea gardens will be influenced by two major factors: the amount of shade and the amount of disturbance to the forest floor. As the forest is opened up to allow the establishment of tea trees, the amount of shade is reduced. If shade declines sufficiently, native ground cover will be replaced by plants which favour more sunny conditions. Many of these invading species are weeds introduced from tropical America (Maxwell, pers comm). Over time, the forest cover in the tea gardens may be thinned even more as trees are cut for firewood and construction material, and invading weeds will become more prevalent.

After the tea gardens have been established, the most common kind of disturbance is from villagers slashing the ground cover. Slashing occurs so that competition for nutrients and moisture for the tea trees is reduced, and not to limit access to the gardens. If the ground cover is not slashed, it can grow very thick, up to 1.5 metres tall, making it hard to walk through. Fire may also disturb the forest floor, preparing the way for invading weeds to become established in the tea gardens.

Although the ground cover was not quantified in terms of the absolute number of plants in each plot, the most common plants were identified and estimates were made of the relative abundance of weedy species versus native species. Based upon these estimates, the ground cover for each plot was placed into one of three groups: weedy, mixed, or native (groups defined earlier). The amount of crown cover and the ground cover classification for each plot is given in Table 4.7. Due to the differences in ground cover between the top and bottom portions of the strip plots, these plots have been divided in half and ground cover and forest cover given accordingly.

The data in Table 4.7 indicates that there is a relationship between the amount of crown cover and ground cover composition in the plots. Plots with less than 240 m^2/rai of crown cover largely have mixed or weedy ground covers (one of the 10 plots was classed as native). Plots with forest cover over 240 m^2/rai have largely native ground cover (one of the 6 plots is classed as mixed, ground cover was burned in the past, encouraging the establishment of Pteridium aquilinum).

Several examples in the vegetation plots were observed of how slowly opening the forest cover and forest floor disturbance have produced changes in ground cover composition. In Plot 9, slowly thinning the forest cover and repeated slashing of the ground cover has encouraged the establishment of plant species which prefer sunnier conditions than the flora in an undisturbed forest. This garden has been slowly opened up as indicated by the 25 stumps in the 1.0 rai plot which are in various stages of decomposition. Most of the stumps in this plot are less than 25 cms. The large primary trees of the original forest cover were removed long ago as there were no traces of these trees. The ground cover has changed significantly from native species to largely weedy species, and is dominated by the troublesome weed Eupatorium adenophorum, a plant from tropical America. There is almost no regeneration of forest trees in this plot, largely due to the weedy ground cover and heavy slashing required to keep it under control.

Plot 12 is a good example of how frequent disturbance of the ground cover, by slashing, can encourage the establishment of weedy ground cover. In this tea garden, the owner slashes the ground cover 5-6 times a year in order to reduce competition for tea trees and newly planted fruit trees. Various weed species, such as Pteridium aquilinum and Eupatorium odoratum are growing thickly in this plot at the expense of native species, hindering forest tree regeneration. Even if the frequency of slashing the ground cover is reduced or discontinued, forest tree regeneration would be very slow, if at all, in this garden.

4.8.1 Ground Cover as an Indicator of Health

Ground cover is a good indicator of the 'health' of this agroforestry system- a healthy tea garden has a ground cover composed of largely native species. This indicates that there is sufficient shade and minimal disturbance so that a largely native ground cover is maintained. If these gardens are abandoned, the forest cover can readily recover.

Four of the gardens have weedy ground covers, 3 have native ground covers, 3 mixed, and 3 are classed as 'native/mixed'.

Within the tea gardens, there are some indicator species of good and poor land use. There are numerous weedy species which indicate poor land use. These weeds begin to invade the tea gardens when about 50% of the forest cover is removed (Maxwell, pers comm). If the forest cover in the tea gardens is further thinned, these plants will become more prevalent. Perhaps the worst weed is Eupatorium adenophorum, which can grow so thickly it will exclude other plants and greatly impede forest tree regeneration. Pteridium aquilinum is another common plant which indicates fire damage, frequent disturbance and/or poor soils. This fire fern can grow very thickly on disturbed sites and in some places, such as in Doi Suthep-Pui National Park, it is so thick that nothing else can grow, shading or fire factors being the reason (Maxwell, pers comm). The Pteridium at Pa Pae is not a serious problem, but it could be if the plant is allowed to spread, which is enhanced by slashing, clearing and fire.

Imperata cylindrica, a common grass which is commonly used as a thatch for roofs, can also become established in areas which are frequently disturbed, such as by frequent slashing. There are various other 'weedy' plants in the tea gardens which invaded the tea gardens once the forest cover was thinned and/or the forest floor was disturbed by slashing the ground cover. These weeds are often aliens and can disrupt local feed chains as animals and birds will often not feed on these invading plants.

Desmodium triflorum is a common ground cover in some of the tea gardens and is not only good for the soil, but indicates that meadow conditions might develop, not weedy growth, if allowed to establish itself. This is an indicator of good land use since seedlings of various trees can establish themselves (Maxwell, pers comm). Osbeckia stellata Ham. ex Ker-Gawl. (Melastomataceae) is a shrubby secondary growth species which provides good food for birds.

Although reduced forest cover in the tea gardens will encourage the establishment of weedy plants which may hinder forest regeneration, a lack of forest cover and weedy ground cover do not always lead to a lack of forest tree regeneration. Even in largely open conditions, the forest cover is sometimes able to regenerate. For example, Plot 2, which has less than 240 m^2/rai of forest cover and a weedy ground cover, has the second most dense understorey. Regeneration under open conditions, however, will probably be much slower.

Despite the regeneration of forest cover in some of the weedy plots, care must be taken that weeds such as Eupatorium adenophorum and Pteridium aquilinum do not spread widely. These weeds are found in the tea gardens of all the villages. Eupatorium is beginning to be a problem in Mae Sae. There are areas north of the study area where the hillsides have been deforested and they are covered by this weed to the exclusion of everything else (Maxwell, pers comm). The Royal Forestry Department is currently having a great deal of difficulty in trying reforest these areas due to this weed. Pteridium is not yet a problem in the study area like it is in areas of Doi Suthep-Pui National Park.

4.9 The Relationship Between Forest Cover, Ground Cover & Forest Tree Regeneration

The plots show there is not always a clear relationship between forest cover, ground cover and understorey regeneration. Graphing the data reveals that there is no strong relationship between the number of understorey trees/rai and upper canopy trees/rai, or between the number of understorey trees and the amount of crown cover. Plots with native ground cover have the highest and the second lowest density of understorey trees, and plots with weedy ground cover have the second highest and the lowest density of understorey trees.

Although there are no clear links between forest cover, ground cover, and forest tree regeneration, there is evidence that weedy ground cover hinders sapling growth, whether it be from hindering seed germination and growth, or due to damage caused by the heavy and sometimes frequent slashing necessary to control the ground cover. Plots with weedy ground covers have, on average, fewer understorey trees relative to the plots with mixed and native ground cover. There are 23.5, 34.8, and 43.3 understorey trees in the plots with weedy, mixed and native ground covers respectively. All weedy plots also have below average forest cover.

Individual grower management techniques and regeneration characteristics of tree species are responsible for the weak relationship between understorey regeneration and other characteristics of the plots. For example, Plot 2, whose open canopy and weedy ground cover is substantially different from that found in an undisturbed forest, supports the second most dense understorey with 35 trees from 5 species in a 0.5 rai plot (excluding planted trees). On the other hand, Plot 11, which has conditions much closer to forest conditions (largely native ground cover and heavy forest cover) has only one understorey tree in a 0.5 rai plot. The difference between the understorey in the two plots is probably due to both natural and human variables. Plot 2 has numerous Microcos paniculata, a secondary growth tree which has demonstrated that it can regenerate relatively well within a weedy ground cover. Labourers slashing Plot 11 were not instructed to take special care to avoid cutting tree seedlings when slashing ground cover, probably accounting for the lack of forest tree regeneration in this garden.

4.10 Health of the Tea Gardens

The 'health' of the tea gardens is judged on the basis of two criteria: the maintenance of largely native ground cover and the rate of forest tree regeneration. In terms of ground cover, three of the tea gardens have largely native ground cover and are considered healthy. Three have mixed ground cover and as long as forest cover is not allowed to decline, these gardens should not deteriorate. Three of the gardens have native/mixed ground cover due to the differences in forest cover between the top and bottom portions of the tea gardens located on the upland hills. The forest cover on the lower slopes of these tea gardens should be improved. All these gardens have good forest tree regeneration capabilities if the forest cover is maintained, and care is taken when slashing ground cover to avoid cutting saplings.

Four of the gardens have weedy ground covers. Three of these gardens have poor prospects for forest tree regeneration due to the weedy ground cover and/or frequent slashing. The remaining garden (Plot 2) has the second most dense understorey, but these trees were clumped and, overall, the health of the tea garden will not likely improve without assistance from the owners.

On the basis of forest tree regeneration where gardens should have a greater ratio of understorey to upper canopy trees, 5 of the gardens are not healthy. Only two of these gardens have weedy ground covers, indicating that the growers' practice of slashing the ground cover has a major influence on forest tree regeneration. Overall, two of the gardens have weedy ground covers and unfavourable forest tree regeneration, three have native or mixed ground covers and low forest tree regeneration, and two have weedy ground covers and favourable forest tree ratios.

In these later two gardens, there is an indication that further forest tree regeneration will be difficult due to the weedy ground covers and slashing practices. Plot 9 in Mae Sae is 'choked' by the weed Eupatorium adenophorum and although there are 14 trees in the understorey (ratio of two understorey trees to one upper canopy tree) most are older, established trees. The smallest tree is a Spondias axillaris (4 cm DBH, 5 metres tall). The remaining understorey trees are over a 12 cm DBH. The owner of this garden was not available for interview, but a labourer stated that this garden required two heavy slashings a year and that no effort was spent on trying to avoid cutting the rare sapling that was able to grow. Plot 2 has the second densest understorey but there are no young saplings in this plot, the youngest tree is estimated to be over 10 years old. The understorey is dominated by secondary growth trees, but even these trees which prefer open, disturbed sites, may have difficulty becoming established in the ground cover of this garden which is likely to become even more weedy over time. Therefore, seven of the thirteen plots are considered unhealthy.

4.10.1 Maintaining Forest Cover and the Shade Factor

Maintaining a good forest cover will help maintain a native ground cover which requires less maintenance than weedy ground covers. Maintaining a native ground cover will in turn aid forest tree regeneration (mortality due to slashing will also decline) increasing the supply of firewood and other forest products and will improve wildlife habitat. Forest cover is also important for providing shade for tea trees which improves tea leaf productivity.

The ideal level of shade which will maintain good tea leaf productivity and maintain a largely native ground cover is not known. Shade is discussed in more detail later, but briefly Katikarn and Swynnerton (1979) noted that a 50% reduction in light intensity provided the best results for tea leaf productivity in India. Maxwell (pers comm) feels that about 50% of the forest cover should be maintained, otherwise forest tree regeneration is slowed with increased % of destruction i.e. clearing and resultant weedy ground cover which is detrimental to regeneration of forest cover. The tea gardens, overall, have only 33% of the density of a similar, relatively undisturbed forest. One-third of the plots have weedy ground covers and the lowest average forest cover, indicating that forest cover should be increased. Further studies are needed to determine the ideal level of forest cover for the tea gardens, but 50% maintenance of the original forest cover should maintain native ground flora and good tea leaf productivity.

4.11 Tea Gardens and the Miang Producer Survey

In addition to the vegetation survey and interviews with tea garden owners, various questions concerning the tea gardens were included in the miang producer survey. Some of these questions included maintenance practices, the importance of shade and intercropping. Since time series data concerning the tea gardens were not available, questions concerning tea leaf and firewood productivity and changes in forest cover were included in the survey. Many of these questions were open ended and responses to these questions are summarized in table format. Maintenance of the tea gardens and establishment of tea trees will be examined first, before looking at the responses to questions concerning long term changes in the tea gardens.

4.12 Tea Garden Maintenance

This agroforestry system receives a low level of input. Manure from grazing cattle, slashed ground cover and leaf fall provide the only fertilizer, and no pesticides are used. Maintenance activities, which are all carried out by hand, largely include slashing the ground cover, planting and pruning tea trees, and removing epiphytic vines from the tea trees. Next to picking and processing the tea leaf, slashing the ground cover is the most time consuming task.

4.12.1 Slashing the Ground Cover

All growers, except one, regularly slash their tea gardens. Most slash the ground cover twice a year (71%), usually in March-April before the first picking and then between the third and fourth picking in September-October. The majority of the remaining growers (14%) slash only once a year, usually before the first picking. Ground cover is cut at ground level using a knife about 40 cm long which is hooked at the end. Depending upon the thickness of the ground cover, a labourer can slash about one rai of tea garden per day.

During the supplemental survey, growers were asked if they changed their slashing practices after forestry became more strict about cutting firewood in the forest. Over half (60%) of the growers responded that they took more care when slashing ground cover to allow forest trees to grow up in the gardens (Table 4.17). Villagers always did allow trees to grow up, but many growers took more care when access to the forest for firewood was restricted. The remaining growers responded that their slashing practices were the same after forestry officials became more strict.

One difficulty with this question was it was not possible to quantify 'how much care' growers took when slashing ground cover. Those growers who responded the same were probed, and these growers generally let young trees grow up if they were easily seen when slashing ground cover. For those growers who took more care, this generally meant that the growers looked more carefully for forest trees prior to and during slashing. Some of the fast growing trees like Phyllanthus roseus can be easily spotted. However, the slower growing oaks and others can be very difficult to see, especially in tea gardens with thick ground cover. Most of the growers who responded 'the same' are from the small villages. Only one of the 14 growers interviewed from Mae Sae and Mae Mam during the supplemental survey (two original respondents not home) took more care after forestry became more strict. This suggests that there is less pressure on firewood supplies in these villages. The forest is a source of firewood for a greater proportion of growers in the smaller villagers relative to Pa Pae and Pang Ma Kuay.

Table 4.17. Changes in slashing practices when forestry became more strict about collecting firewood from the forest.

# of Responses	Slashing Practices
Pa Pae/ Pang Ma Kuay	
25	took more care when slashing ground cover to allow forest trees to grow up
4	take more care slashing ground cover, need firewood for the future
1	the same, buy all wood
1	the same, always take care
5	the same
Mae Sae	
4	the same
Mae Mam	
1	take more care when slashing ground cover
9	the same

2 answered incorrectly
3 not available for interview

4.12.2 Establishing Tea Trees

The tea gardens have been established in mixed deciduous/evergreen forests largely by thinning the forest cover and direct planting seed or seedlings of the indigenous tea tree. Once established, trees regenerate naturally in the gardens. The top portion of Plot 5 contained a good example of how tea trees spread naturally. Here a large tea tree is surrounded by 13 small tea trees, most of which were probably established from seed dropped by the larger tree. Tea trees produce a capsule about 1 cm in diameter. The 1-3 seeds drop to the ground after dehiscence.

Although tea trees regenerate naturally in the tea gardens, the majority of trees have been established by the growers. Growers often add to their tea gardens to replace dead or old trees and/or to increase overall production. Almost 70% of the growers interviewed added an average 120 tea trees to their gardens annually. Most growers (20/38) use seedlings, followed by seed only (12/38) and the remainder use both. For those 17 growers that do not add tea trees to their gardens, 2 rent and 3 both rent and have title to their own tea gardens. Renters are usually unwilling to invest time and money which would only improve someone else's tea garden. Although the growers were not asked why they did not add tea trees, three owners volunteered that natural regeneration was sufficient, and two felt they had enough tea trees already.

Three quarters of the growers who currently add tea trees to their gardens will continue adding tea trees in the future. For those who will not add tea trees in the future, three volunteered that they had enough already. Over a third of the growers hope to expand their tea gardens, usually on the perimeter of their current tea gardens. This willingness to add to and expand their tea gardens indicates confidence in the continuing production of miang and green tea.

Growers use two methods for establishing tea trees. Tea seeds collected from local gardens will either be placed about 5 cm deep in the soil (2 or 3 seeds per hole) or seedlings will be grown in simple nurseries. One to two year old seedlings will be planted at the beginning of the rainy season, about May or June. Due to the regular slashing of the ground cover in the tea gardens, seedlings have a greater chance to survive than the wild stock. The locations of the seedlings will usually be marked and easily avoided while slashing. Although growers try to avoid cutting young wild tea trees, they are easily concealed by the ground cover which can grow over a metre tall, depending upon how often it is cut.

Seeds and seedlings are often planted near forest trees. This not only protects the young seedlings from being damaged by grazing cattle, but also provides shade for the young tea trees. Tea trees require shade for the first 2 to 3 years (Fuchs, pers comm). This shade also helps conserve soil moisture during the 3 to 4 month dry season. Given that seedlings seldom receive any care once they are planted, shade increases their chance of survival.

Most of the growers top prune and a few lateral prune their tea trees. Growers will sometimes cut old tea trees about 50 cm from the ground. The tea tree will send out numerous shoots, producing a bushy tree which will produce tea leaf in about 2 years. Young tea trees are sometimes broken, usually by grazing cattle, and will send out more than one shoot. Tea trees with 2 to 4 main stems were often observed in the tea gardens.

4.13 Age of the Tea Gardens

According to the miang producer survey, the age of the tea gardens ranged from 20 to 400 years. Most growers (65%) stated that their tea gardens were over 200 or 300 years old. However, there is no indication that the tea gardens are this old. Pa Pae, which was established after the turn of the century, appears to be one of the oldest villages in the area. Individual growers have been producing miang, on average, for 27 years (ranged from 3 to 50 years).

4.14 Shade

The tea tree is a short growing tree which grows under shaded conditions in the forest. In the tea gardens, tea trees require shade, especially during the hot season (March to May). It is not so much a question of how much shade tea trees need, it is more of a question of how much light they can tolerate (Maxwell, pers comm). The amount of shade has important implications for tea garden management, especially the maintenance of forest cover and tea leaf productivity.

There has been limited work done in Thailand on tea production in general, and shade requirements in particular. Katikarn and Swynnerton (1971) recommend that tea grown in Northern Thailand up to 1,200 metres in elevation should have shade provided. Although these authors do not recommend how much shade should be provided, they note that tests in Northeast India with the Assam variety found that a reduction of light to about 50% of natural intensity produced the best results. Fuchs, who has studied tea production in Sri Lanka, felt that tea trees in Northern Thailand did not need shade above 1000 metres (pers comm). The manager of ChiSiam, the largest commercial tea estate in Thailand, felt that the tea bushes on the estate, most of which were established from seed collected from the native tea tree, did not need shade (Marley, pers comm). This estate is located at 900 metres to 1100 metres elevation. The tea bushes, however, are irrigated during the dry season and are grown under much different cultural practices than those in the tea gardens.

The amount of forest cover in the vegetation plots, where the tea garden owners were interviewed, varies from 60 m^2 to 441 m^2/rai. All owners felt there was sufficient shade in their tea gardens. The relationship between shade and tea leaf productivity can only be answered by a long term study spanning at least one tea picking season. Plots would have to be established in tea gardens with varying degrees of forest cover and the productivity of individual tea trees closely monitored.

Although there was no way to quantify shade requirements for tea trees in this study, growers were given an open ended question in the miang producer survey about whether or not shade was important for tea production. Only two out of 55 respondents felt shade was not important and four felt tea trees 'liked sunny days'. The remainder felt some shade was required (see Table 4.18). The most common response (50%) was the need for a 'moderate' amount of shade which was generally expressed as: 'if there is no shade the tea trees will dry out, produce small leaf and may die...if too much shade, the tea trees will grow slowly and produce a small amount of leaf'. Shade was considered important for protecting young trees, providing 'wet conditions' for the tea trees and conserving soil moisture in the dry season. One owner felt that shade was

Table 4.18. Responses to the question: is shade important for tea production?

# of Yes Responses	Why is it Important
27	medium shade produces beautiful tea leaf
2	if no shade, tea tree die
4	tea tree like wet conditions, need shade
4	keep it wet for tea tree, protect young trees
2	protect tea tree from drying out, give water in dry season
2	tea tree with high shade produce good leaf
1	protect soil
42	
# of Yes/But Responses	
3	too much shade bad, tea tree like open air
4	small tea leaf if too much shade
# of No Responses	
2	shade not important for tea production
4	tea trees like sunny days

important to protect the soil, and three growers added that shade was good for protecting pickers from the sun.

Even though a large majority (76%) of growers felt tea trees needed shade, 7 (13%) thought that too much shade was bad for the tea trees: 'tea tree produce small leaf if there is too much shade'. There undoubtedly will be a minimum amount of shade which tea trees need to maintain good productivity. Shade levels could not be linked to tea leaf productivity in this study. However, field observations indicate that tea trees under shaded conditions have more tea leaf than those in more exposed conditions. For example, in Plot One, the tea trees under large shade trees in the southwest corner of this plot where there is about 50% shade, have noticeably more leaf growth than tea trees of similar height in the more open, northeast corner of the plot. Similar observations were noted in other tea gardens. There are, however, tea gardens in which there is no shade at all and the tea trees did not seem to be under any noticeable stress, other than what is normally expected when a tree gets part of its leaf mass picked four times a year. Maxwell (pers comm) observed that exposed tea trees are often chlorotic.

4.15 Intercropping

Intercropping is a small scale, but common practice in this agroforestry system. Just over half of the growers interviewed intercrop fruit trees within their tea gardens. There are 8 different types of fruit trees planted: jack fruit, pomelo, lemon and pineapple are primarily grown for home use; banana, mango and litchi are planted for both home use and to sell; and coffee is strictly planted for the market. Fruit trees either grow scattered among the tea trees, within the home enclosure, or, as near Plot 4, grow in small fenced off areas separate from the tea gardens.

Table 4.19 gives the number of growers who have planted fruit trees for home use or to sell to the market, the average number of trees per grower and average annual income the fruit trees generate. Growers who plant fruit trees for sell to the market have, on average, the most fruit trees- from 6 to 70 trees, depending upon the type of fruit. Growers who raise coffee have, on average, 148 trees.

Table 4.19. Intercropping fruit and coffee trees in the tea gardens.

Type of Tree	# of Growers	Use Home	Use Market	Av. # of Trees Home	Av. # of Trees Market	Av. Annual Income (baht)**
leechi	15	5	10	10	51	400 (nil=9)
mango	11	7	4	11	70	nil
banana	2	1	1	10	30	150
coffee	7	0	7	0	148	381 (nil=3)
pomelo	11	10	1	4	30	nil
jack fruit	8	7	1	5	6	80
lemon	2	2	-	3	-	-
pineapple	1	1	-	10	-	-

** many growers have recently planted fruit trees and are not yet receiving income from these trees, 28 out of 55 growers interviewed intercrop fruit trees.

Table 4.20. Reasons for not intercropping fruit trees in the tea gardens.

# of Responses	Reason
5	just rent land
3	no time/no help
3	no time/no water
3	no water
3	cattle will damage fruit trees
2	insects from fruit tree may harm tea tree
1	tried, but failed
1	not enough space
1	terrain too steep
1	no knowledge
1	nobody concerned to plant
2	no answer
27	

Recently, there has been an increase in the amount of intercropping. Agriculture officers have been encouraging villagers to plant fruit trees and coffee which will not only add to their income, but require no fuelwood during processing. There has been an increase in the number of litchi, mango and coffee trees, but they give little or no income. The income from other fruit trees such as banana and jack fruit is also minimal.

One group of growers who were contacted in the tea gardens complained about poor support from the agricultural officers. For example, a few years previously, the officers had encouraged the villagers to plant passion fruit. Some of the growers planted the seedlings provided by the officer and cared for them for a few years, but later abandoned them because the officers did not provide further support. The officers had promised to find a market for the fruit and to provide further information on caring for the trees, but no follow-up support ever occurred. The villagers are very bitter, complaining that the government wants them to change their practices and not to cut any more firewood, but nobody provides them with any real help.

The reasons for not intercropping fruit trees are given in Table 4.20. Lack of ownership (rent from another person) is the most common reason for not growing fruit trees. Other common constraints include no time, help, or water, or concern over damage by cattle. Two growers tried to grow fruit but failed, and two others were concerned about the attraction of insects to the fruit trees which might harm the tea trees.

One substantial income earner for some of the villagers which did not show up in this intercropping question, was the fruit from Zanthophyllum rhestsa (Rutaceae). This tree is part of the citrus family and villagers collect the very small fruits of this tree in October and November. The sun-dried fruit, which is used to produce a spice, is sold for 40 baht/kilogram. Although none of these trees were located in the plots, these trees are readily found north and northwest of Pa Pae and Pang Ma Kuay. Most of these trees have been established from seed which was given to the headman in Pa Pae about 15 years ago. The seed was then given to tea garden owners who simply scattered the seed around the tea gardens. The villagers either work from the ground, or climb the trees and cut the clusters of fruit with a knife attached to a long pole. Numerous people are involved in collecting this fruit, and some people reported incomes of 4,000 to 5,000 baht per year. This practice probably did not show up in this intercropping question since this tree is a native forest tree and is considered part of the natural forest cover. In addition, the fruit of this tree is not grown or consumed as 'normal' fruits are.

Except for one grower who raised ginger for sale to market, no other growers intercropped field crops among their tea gardens. Table 4.21 summarizes the reasons for not raising field crops. The majority of growers identified various constraints, from physical constraints such as steep slopes, lack of water and fear of damage from cattle, to human constraints such as lack of time, knowledge and land ownership. Three growers stated that the crop and tea trees would harm each other, either by insect damage or competition for water. One grower was afraid the government would expropriate his land, and one other tried to plant field crops but failed. In terms of watershed protection, field cropping on the steep slopes in the tea gardens would be a poor land use due to possible soil erosion problems.

4.16 Cattle

Cattle graze in the tea gardens of all the respondents, except for four. One of these gardens is fenced and the others are outside the cattle's grazing range (cattle tend to stay close to the village). Growers were asked if cattle are important for tea production. Except for three, all growers felt cattle are important for fertilizing the gardens and keeping the undergrowth down. Growers were also asked if cattle damage the tea trees- ten stated that the cattle damage young tea trees by rubbing against them and breaking their branches, sometimes killing them. Despite this damage, they all felt cattle are important for tea production. One grower, in whose garden cattle did not graze, stated the importance of cow dung for sealing the bamboo baskets in which the miang is packed. Of the 3 growers who felt cattle are not important, one fenced his garden and one is outside the grazing range of the cattle. Cattle did graze in the garden of the third grower, but the owner felt they are not important for tea production. Seventeen of the growers interviewed own, on average, 12 cattle. It is estimated that there are 200 to 300 cattle in each of the larger villages, 100 in Mae Mam and 50 in Mae Sae. There are also a minor number of water buffalo in all the villages except Mae Mam.

Table 4.21. Summary of reasons for not field cropping in the tea gardens.

# of Responses	Reason for not intercropping
6	no time, no help
6	no time
2	no help
1	no time, no space
1	no space
4	no time, no water
7	no water
1	no time, no seed
1	crop will compete with tea trees for water
2	tea trees and crops may harm each other
5	cattle will ruin crops
4	steep slope
1	tried but failed
1	lack of knowledge
5	do not own land
1	afraid government will expropriate land
6	no answer
54	

4.17 Productivity of the Tea Gardens

During the miang producer survey, growers were asked how many kams of miang and/or kilograms of tea leaf they produced in the 1989 season. After the first 18 questionnaires, it was thought that growers may be able to recall more accurately the number of tangs they produced, rather than the number of kams. The growers in the last 36 questionnaires were asked for both kams and tangs. For 35% of the respondents, the two estimates were within 25% of each other. For another 35%, the figures were within exactly 10% of each other, indicating they took the number of kams they produced and divided by 200 to get the number of tangs (about 220 kams in a tang), or vice versa.

This later group probably have a good idea about their 1989 production. The remaining growers (11) had widely ranging production estimates, ranging from a 30% to a 120% disagreement between the number of tangs and kams they produced in 1989. If only those figures which were within 25% of each other were used to calculate average productivity (25 respondents), the average grower produced 13,168 kams. If all estimates are used based upon the number of kams they produced, than growers produced, on average, 12,529 kams. Production ranged from 2,000 kams to 44,000 kams for the entire sample group.

On average, in 1989 the growers in Pa Pae sold 413 kilograms to the cooperative tea factory in Pa Pae. At the most, growers sell one third of the tea leaf they produce to the factory. With its current high price, miang production is more profitable. Growers who do sell tea leaf will often sell the first two flushes since they receive a premium price for this better quality tea leaf. Only one of the 18 growers who produce miang and sell tea leaf to the tea factory, felt that picking tea leaf for both from the same tree affects productivity. This grower stated that there is a danger of picking too much leaf which will kill the tea tree.

It is difficult to estimate yields per unit area due to variations in yield per tree and tree density in the tea gardens. Most producers have a clear expectation of total yield for one season, but little interest in other dimensions of their tea gardens (Keen, 1978). The accuracy of land ownership figures is also questionable. In addition, it is hard to determine how intensively the tea gardens are being utilized. Given these constraints, productivity per unit area of tea garden was calculated for the 25 growers whose production estimates for kams and tangs were within 25% of each other. Productivity ranged from 104 kams/rai to 960 kams/rai (about 220 to 2000 kg/ha of fresh leaf). This is much lower than Hoare's (1988) figures of 741 to 3,344 kg/ha. He also reported that growers only own, on average, 2 ha of tea gardens, much lower than the 5.3 ha found in this study.

4.18 Long Term Productivity of the Tea Gardens

Due to falling productivity in tea leaf production in Tambon Wawi, growers were questioned about tea leaf productivity in their tea gardens over the past decade. Twelve of the growers did not understand the question: 9 responded that tea leaf productivity is falling due to the shortage of labour; 1 responded productivity is increasing because more labour was hired; and 2 responded that productivity is falling because they were packing bigger kams. For those growers who did understand the question, tea leaf productivity is falling in 13 gardens (30%): in 11 gardens the tea trees are aging and producing little leaf (some dying); the tea trees in 1 garden have a disease and are dying; and in the final garden productivity is falling due to declining rainfall. Tea leaf productivity was increasing in 8 (19%) of the gardens: in 6 gardens tea trees are producing more as they matured; 1 grower expanded his garden; and in the final garden tea trees are spreading naturally. One grower stated tea leaf productivity over the last decade fluctuated depending upon rainfall. Productivity in almost half of the gardens (21), for those who understood the question, was constant over the last decade. See Table 4.22 for a summary of the responses.

4.19 Changes in Forest Cover in the Tea Gardens

In addition to not being able to relate shade levels to tea tree productivity, there is no way to examine long term changes in forest cover in the tea gardens except through the miang producer survey[7]. Growers were asked if there was any change in forest cover over the past 10 years (Table 4.23). Just under half (48%) stated that forest cover in their tea gardens remained the same, a third increased (37%) and the remainder decreased

[7] It is difficult to analyze the relationship between wood collection from tea gardens and changes in forest cover. Growers are apt to overstate the amount of wood they get from their tea gardens due to the pressure forestry officials have placed upon the villagers not to collect firewood from the forest. In addition, most growers have changed their firewood collecting practice since forestry officials became more strict in 1987-88. More wood is now coming from the tea gardens. If firewood is being harvested faster than natural replenishment, then forest cover will decline. However, this increase in wood collection may be offset by the greater care taken by villagers to avoid cutting saplings when slashing the ground cover. Without time series data, it is difficult to examine the relationship between firewood collection and forest cover in the tea gardens.

Table 4.22. Tea leaf productivity in the tea gardens over the past decade.

Declining	Reason
9	shortage of labour
2	packing bigger kams
11	aging tea trees
1	tea trees have disease
1	declining rainfall
Increasing	
1	more labour hired
6	tea trees produce more as they mature
1	tea trees spreading
1	expand tea garden
Fluctuating	
1	depends upon rainfall
Constant	
21	

Overall, for those who understood the long term connotation of the question:

30% decreasing
19% increasing
2% fluctuates
49% constant

Table 4.23. Forest cover status in tea gardens over the past decade.

Increased	Reason
12	trees grow up from nature
4	letting young trees grow up
1	many trees grow up, cut few for firewood
1	_Schima wallichii_ increase, not cut for firewood because of irritable sap
1	cut no trees for firewood
1	cut firewood in the forest
1	no response
Decreased	
5	cut big trees for firewood, small trees not grow up fast enough
2	slashing kills young trees, also use trees for firewood
1	some die naturally
Stayed the Same	
26	

(15%). Of the 21 growers where forest cover increased: 2 obtain firewood elsewhere; one cuts few trees for firewood; Schima wallichii are increasing in one garden because the owner does not cut them for firewood due to their irritable sap; and one grower did not respond. Four growers stated they are 'letting young trees grow up from nature' and 12 simply stated many young trees were growing up. It is assumed that most of these later growers are also 'letting young trees grow up' since all the growers, except for one, are taking more care slashing their tea gardens since the forestry department became more strict about cutting firewood.

For those growers who stated their forest cover decreased, 5 of the 8 owners cut trees for firewood faster than they were being replaced and 2 stated that slashing kills young trees (they also cut firewood in their tea garden). The final owner stated that some large trees had died naturally. Three quarters of these growers are taking more care slashing their gardens to avoid cutting saplings after forestry became more strict.

Almost half of the growers stated that forest cover remained the same in their tea gardens. Two of these owners bought all their wood, and the remainder collect part or all of their wood from their gardens.

4.20 Land Title

Referring to producers as 'land owners' is a misnomer- the villagers have no ownership rights to the land at all, rather, the growers hold two types of land use certificates, Paw Baw Taw 5 (PBT5) and Saw Kaw 1 (SK1). A PBT is a tax certificate and is not recognized as legal title. The Thai government collects tax on legally and illegally occupied land and many 'squatters' are prepared to pay this tax in hope that it will assist them in obtaining tenure at a later date (Feder, 1987).

The second certificate, SK1, is a 'claim certificate' which is used to report occupation. This certificate grants no rights and is used to register land prior to implementation of the Land Code where no documents existed before. All growers, except those who rent from other villagers or businessmen, hold at least one of these certificates. Most growers pay 10 baht/year/rai to the government, but some receive a subsidized rate. The villagers are careful to retain these documents in hope that one day they would be granted full ownership rights. Although the growers cannot own land within a forest reserve, they will still be referred to as land owners.

There is one large land owner in each of the villages and several moderately sized owners in three of them. In Pang Ma Kuay, the partner in the now closed tea factory in that village claimed to control about 1,500 rai. The headman in Mae Sae controls about 800 rai; the head of the Tea Association in Pa Pae controls about 300 rai; and one villager in Mae Mam controlled about 250 rai. In Pa Pae/Pang Ma Kuay there are five land owners, and in Mae Mam two, who have between 100 and 200 rai. Growers, on average (excluding these moderate and large landowners) in Pa Pae and Pang Ma Kuay have about 34.9 rai, 40.0 rai in Mae Mam and 9.2 rai in Mae Sae. Four growers who rent land only have about 14.5 rai.

The average amount of tea gardens per producer overall, excluding the larger land owners, is 33.1 rai. These figures however, must be viewed with caution given that no land surveys have ever been conducted. Keen (1978) notes the difficulty in determining the size of the growers tea gardens:

> ***Except where title are involved, neither the size of the field nor the number of trees is of great significance to the proprietor of a miang orchard. What is important is the knowledge of which trees are his, because annual yield of particular trees may vary from a single kam or less, up to 130 kam for a well-grown 20-year-old tree. For this reason the farmer is always aware of the exact location of his field boundaries, no matter how irregular they are, rather than the size of his fields.***

In addition, some growers were nervous about the intentions of the research. They were concerned that the research was being conducted by a businessman who was interested in buying up the tea gardens. The lack of land surveys and the villagers' nervousness about the nature of the research, warn that land area figures must be viewed with caution. However, during the supplemental survey, most growers were forthcoming with land title information since they had become familiar with the nature of the research.

Six of the growers also have minor amounts of land in addition to the tea gardens. Two growers in Mae Sae and one in Mae Mam use the land for fruit growing, and two growers in Pa Pae/Pang Ma Kuay have paddy land. One grower in Mae Sae used to grow upland rice, but the Royal Forestry Department stopped this practice three years ago. If one compares the amount of land villages stated that they owned to what they reported to the land department, it reveals that the villagers, on average, reported 40% of the land they actually farmed to the land department (avoid paying land tax).

Four growers rent land only, and five rent and own land. Five of those growers rent land from other villagers, three rent land from businessmen from Chiang Mai and one rents land from a relative. Rental rates vary a great deal. Growers either cash rent or crop share. Those who crop share usually give about 25% of their production to the owner. Cash rent is largely on a tea garden basis rather than a per rai basis. Rates ranged from 1500 baht/year to 8,000 baht /year, about 150 baht/rai to 500 baht/rai. Half of the growers who rent gardens only were concerned about an insecure future.

4.20.1 Land Title Problems

The field research indicates that insecure land title is a major concern of the villagers. Land title concerns intensified in 1989 when the Land Department (Mae Taeng District) refused to accept land tax from villagers in Tambon Pa Pae. In response to this move by the Land Department, the village headmen from four Tambons, including Tambon Pa Pae, organized a rally at the Mae Taeng District office in March of 1989. Approximately 2,000 villagers gathered outside the office to express their concerns over land title problems. The villagers were requesting that they be given full ownership to their tea gardens (Naw Saw 4) for the following reasons: 1) some villagers are poor and want to be able to sell their land; 2) enable them to use land as collateral to borrow money; 3) afraid government will expropriate their land; and 4) want security for their livelihood.

The officer representing the Land Department for the Mae Taeng District stated that the government was no longer accepting land tax in order to prevent businessmen from buying land in the area. Land title for PBT5 and SK1, which give land use rights only, can be transferred from one person to another. Every five years the titles are updated and whoever holds the title at the time is registered on the new certificate. Due to the absence of clear government policy on land ownership in forest reserves, many

Table 4.24. Responses to the question: does not having land title create any problems for you?

Response	Number	If yes, why
yes	14	afraid government will expropriate land
yes	2	no rights for land owner
no	35	---

businessmen feel that once they hold these certificates they will be able eventually to achieve full ownership rights. The Mae Taeng District Office decided not to accept land tax, hoping that businessmen would no longer buy the land from villagers. Unfortunately, they have not widely discussed their policy with many of the villagers, subsequently leaving many villagers concerned about their rights to the land. Some growers were also concerned that they would no longer be able to protect their tea gardens if they could not pay land tax.

In response to these land title concerns, growers were asked if not having land title created any problems for them. Almost one third of the growers responded that this did create problems for them, largely because they were afraid the government would expropriate their land (Table 4.24). Some growers complained that the government had compensated their SK1 certificates and replaced them with PBT5, and in one case land title was never returned to the grower.

A good example of businessmen buying up land from the villagers occurred in Mae Sae. In 1988, a businessman purchased the land title (PBT5 and SK1) to 70 rai of tea gardens from some of the small producers for 70,000 baht. The villagers now pay rent for these tea gardens to the businessman, paying far more than they previously paid to the land department. Some growers quit miang production after selling their land. It is not known what the businessman intends to do with this land.

Numerous businessmen are speculating, buying up land in the upland areas which they feel they can develop in the future. Resorts are becoming quite common in some upland areas closer to Chiang Mai and Mae Sae is very close to Pa Pae hot springs, an area of potential development for tourism. Currently, a new road is being built into the hot springs. Mae Sae is also a very popular starting point for trekking.

4.21 Summary

The objectives of this chapter were to examine 1) the biophysical characteristics of the tea gardens, 2) the management practices of the tea growers, 3) how the two interact and 4) assess the health of the tea gardens. The foundation for this was developed from information collected by the vegetation survey, interviews with tea garden owners, the miang producer survey and field observations.

The tea gardens in Tambon Pa Pae have been established in a mixed deciduous-evergreen monsoon forest between the elevations of 800 and 1100 metres. Tea gardens are developed by thinning the forest cover, slashing the ground cover and increasing tea tree density by planting seeds or seedlings. Over time, the forest cover is further reduced to meet the firewood and construction needs of the villagers. The vegetation plots reveal a great deal of variability in forest cover and tea tree stocking. Tea tree density is as high as 338 trees/rai, one quarter the density of the commercial plantings on ChiSiam's black tea estate. Crown cover in the vegetation plots ranges from 60 m^2/rai to 450 m^2/rai. Species diversity in the plots ranges from 2 in a 0.875 rai plot, to 18 in a 1.0 rai plot. In the 1.64 ha of tea gardens sampled, there are 60 tree species from 53 genera and 35 families; 50% are deciduous, 48.3% evergreen, 1.7% tropophyllos; and 63.8% are primary trees and the rest secondary. Overall, the tea gardens have 33% of the density and 37% of the diversity of a similar, relatively undisturbed forest in Doi Suthep-Pui National Park.

The traditional agroforestry system used for producing tea in N. Thailand is a low input system. Most tea trees have been established by the growers planting seedlings or placing seed from indigenous tea trees directly in the soil. Once established, the tea trees receive little care. Most growers top prune their tea trees and remove climbing vegetation, but only a few side prune. Grazing cattle help control ground cover growth and provide some fertilizer. Artificial fertilizers or biocides are not used and limited intercropping of fruit trees occurs. The most labour intensive task is slashing the ground cover which has a negative effect on ground cover composition and forest tree regeneration. Since forest access was restricted in 1987-88 many growers are more careful to avoid cutting saplings when they slash their gardens.

The forest cover performs numerous important functions in this system. Forest cover prevents soil erosion, provides shade for tea trees, conserves soil moisture during the dry season and provides many useful products for the villagers. Growers often protect trees in the tea gardens which provide useful products and utilize most trees which are thinned or die naturally. Most of the large trees in the tea gardens are found on the upper slopes and there is evidence that the villagers are moving up slope in their search for timber.

The ground cover in the tea gardens is diverse with a mixture of remnants of the original ground cover and invading species. The thinning of the forest cover and regular disturbance of the ground cover by slashing has encouraged the establishment of ground flora which prefer sunnier conditions and/or can tolerate disturbed conditions. The mix of native and invaders depends upon the amount of forest cover remaining in the tea gardens and the amount of disturbance to the forest floor. Some gardens have largely native ground cover, some have largely weedy ground cover and some were mixed.

Some of the invading ground flora can become serious problems (i.e. *Eupatorium adenophorum*), requiring frequent slashing to reduce competition for the tea trees and to allow easy access to the gardens by labourers. The thick growth of the weedy ground cover can hinder forest and tea tree regeneration and the slashing required to keep the ground cover under control often kills young trees that do happen to regenerate. Grazing cattle also kill young saplings.

Based upon ground cover composition and forest tree regeneration, 7 of the 13 gardens in which vegetation plots were located are not considered healthy. Weedy ground covers and/or a lack of forest tree regeneration indicate that the health of the tea gardens is declining. In addition, villagers are moving uphill in their search for timber; large primary trees near the ridge tops in the tea gardens are being felled. The use of Schima wallichii, a less desirable wood for fuel and construction, is increasing as more favourable trees are removed from the tea gardens and forest.

Despite this unfavourable diagnosis for the tea gardens, evidence suggests that the health of the tea gardens could be improved. The understorey is more diverse and numerous than the upper canopy, indicating that the forest cover is regenerating. Secondary growth trees are more numerous overall, illustrating the effect thinning the forest cover has on forest composition, but primary trees species outnumber secondary growth species 2:1, indicating that the forest cover is retaining characteristics similar to the original forest cover (primary species dominate upper canopy). Almost 70% of the miang producers felt that tea leaf productivity is the same or has been increasing over the past decade.

The health of many of the tea gardens can be improved. For example, there is sparse forest cover on the lower slopes of most tea gardens. Gardens closer to the villages also tend to have less forest cover. Care must be taken to ensure that the spread of weeds does not worsen. Although the ideal level of forest cover, and therefore shade, necessary for maintaining tea leaf productivity could not be determined in this study, about 50% of the forest cover from the original forest should be maintained to help maintain a largely native ground cover. Weedy ground covers have a negative impact on tea leaf productivity and forest cover regeneration. Weedy ground covers also require heavy slashing which increases the mortality of saplings. Overall, the forest cover in the tea gardens is one third that found in a relatively undisturbed forest of the same type. Therefore, the forest cover should be increased in order to maintain the health of this agroforestry system.

Forest cover is not only linked to the health of this agroforestry system, but it is also linked to the firewood needs for tea production. The next chapter examines the energy supply for tea production in the miang and green tea industry.

Chapter 5: Miang and Green Tea Production, Energy Use and Supply

5.1 Introduction

The preceding chapter presented the inventory and assessment of the resource base. This chapter examines the resource-use system and the perceptions and attitudes of the tea growers, focusing upon the fuelwood supply problem in the tea industry. The socioeconomic characteristics of the miang producers, miang and green tea production, fuelwood use and supply for tea production and household use, the nature of the fuelwood supply problem, and the attitudes of the villagers to the fuelwood supply problem, the logging ban and problems of deforestation are examined in this chapter. Information and data are collected using questionnaires, personal interviews and field observations and are used to examine this resource-use system (tea production) and provide the basis for assessing and expanding the range of alternatives for resolving the fuelwood supply problem.

5.2 Summary of Questionnaires and Personal Interviews Completed

First, a brief summary of the number of questionnaires and personal interviews completed will be presented before turning to the results. There were 55 miang producer, 25 non-miang producer and 6 tea factory questionnaires completed, and over 25 personal interviews with government and nongovernment personnel and tea garden owners (Table 5.1).

5.2.1 Socio-economic Characteristics of the Miang Producers

The socioeconomic characteristics of the miang producers are summarized in Table 5.2. Characteristics are given by village and for the total sample. Three quarters of the respondents were male whose average age is 46.8 years, slightly lower than the

Table 5.1. Summary of written questionnaires and personal interviews completed during the study.

Type of Data Collection Method	Number Completed
questionnaires	
miang producer survey	55
non-miang producer survey	30
tea factory survey	6
personal interviews	
tea garden owners	10
forest officials	6
Mae Taeng District Officials	4
non-government organization personnel	4
others	2

Table 5.2. Socio-economic characteristics of the miang producers.*

		Pa Pae, Pang Ma Kuay	Mae Mam	Mae Sae	Total Sample
Gender	Male	29(74%)	8 (73%)	3 (60%)	40 (73%)
	Fem.	10(26%)	3 (27%)	2 (40%)	15 (27%)
Average Age	Male	47.1	43.6	52.3	46.8
	Fem.	49.2	43.7	47.5	47.9
Average Education (years)	Male	4.4	4.2	4.0	4.3
	Fem.	3.5	3.0	4.0	3.5
Av. Household Size		3.5	3.4	4.2	3.5
Average Length of Residence		33.4	11.5	22.2	28.0
Average Household Income from Miang Production		37,250	29,045	19,800 (7,250)**	33,345
Average Debt		21,852 n=27	24,600 n=5	12,000 n=2	21,676

* All respondents were Thai

** Headman's income removed from calculation average for females. The average household size is 3.5, lower than the national average of 4 (Muecke, 1984). Males have an average education of 4.3 years and the females 3.5 years. This is lower than the Thai government mandatory school attendance of six years. The older children of these households, however, have a higher level of education than their parents; some have also attended post secondary education.

The average length of residence and household income varies between the villages. Villagers in Pa Pae/Pang Ma Kuay, Mae Sae and Mae Mam have lived, on average, 33.4 years, 22.2 years and 11.5 years respectively in their village. Average household incomes (miang production only) are 37,250, 19,800 and 29,045 baht respectively for these villages. If the headman's income in Mae Sae is removed from the village total (very large producer) then average household income for miang producers in this village is only 7,250 baht. Chuntanaparb and Wood (1986) report on average annual income for Thai rural households of 20,900 baht. The total sample average (33,345 baht, miang production only) is well above this. However, if labour is hired, about one quarter of this income goes to wages.

Miang production is the primary source of income for all villages except Mae Sae. In Mae Sae, there are other employment opportunities, including forestry, trekking and fruit growing. Other employment opportunities for villagers in Pa Pae and Pang Ma Kuay include truck driving, house construction, cutting hair and 'macran' picking (see Section 4.16). These jobs generated an additional annual income of 5,000 baht for macran picking, to 54,000 baht for one truck driver.

Cattle production is another income earner for some respondents. Seventeen respondents own, on average, 12 cattle. One respondent also owns 11 buffalo. Nine of these owners regularly sell one or two animals yearly, earning about 3,000 baht per cow. The remaining owners generally keep their cattle for controlling ground cover in the tea gardens. However, given that the cattle free range, controlling ground cover is probably not their major purpose. More likely, the cattle are more important as a type of security which can be sold when money is needed.

5.2.1.1 Income From Miang Production

Growers were questioned if income from tea production is changing (Table 5.3). Forty-two percent report increasing income from tea production, largely due to higher prices being paid for miang; 27% report declining income due to a shortage of labour, middlemen wanting the growers to pack bigger kams and declining tea leaf production due to lower rainfall and aging tea trees. Seven percent report that incomes change depending upon rainfall and upon middlemen who set the price for miang. The remainder (24%) report a stable income from tea production.

The average debt load for 34 miang producers in the study area is 65% (21,676 baht) of the average annual income. Some villagers have a debt load higher than their annual income. Most of this is used to finance miang production. Middlemen who purchase miang usually only visit each household 2-3 times a year so some growers experience cash flow problems. All villagers who are in debt in Pa Pae (23) borrow from the Tea Cooperative at interest rates of 12.5%. Villagers in Pang Ma Kuay cannot borrow money from the Cooperative. Instead, they borrow from the Agriculture Bank (3) at an interest rate of 14.5%, and one grower borrows money from a relative. Two villagers in Mae Sae are in debt: one to the Agriculture Bank; and one to a middleman. Five villagers in Mae Mam borrow money: three from the Cooperative in Pa Pae; and two from middlemen. These middlemen do not formally charge interest, but they pay the growers a lower price for their miang.

Although some of the villagers have a high debt relative to their annual income, few of the villagers are experiencing the high interest rates commonly suffered by those farmers in Thailand who lack legal ownership and are forced to borrow from the informal credit market (Feder, 1987); some farmers suffer rates as high as 120%.

The villagers in Pa Pae appear to be taking advantage of the low interest rates charged by the Cooperative. It is suspected that not all of this money is used strictly to finance miang production. Growers with high debt loads often have modern goods such as refrigerators, televisions and motorbikes.

Table 5.3. Is income from tea production changing?

	Reason
Increasing	
20	higher price for miang
2	hire more pickers
1	production increasing from tea trees
Decreasing	
5	shortage of tea pickers
4	pack bigger kams
4	tea leaf production falling
2	rain decline, tea leaf production decline
Staying the Same	
13	—
Changes	
2	rain affects productivity
2	depends upon middlemen

5.2.2. Non-Miang Producer Survey

In order to understand whether differences exist between miang producers and other villagers over income, household energy supply and attitudes toward firewood supply and deforestation, 30 non-miang producers in Pa Pae and Pang Ma Kuay were surveyed. Non-miang producers are villagers who are employed as labourers and do not own or rent tea gardens, or are not directly involved with miang production. A shortened version of the miang producer questionnaire was used (questions 46 to 67) for this group.

The results of the non-miang producer survey are discussed in relevant areas of the text. Briefly, two-thirds of those surveyed are tea pickers and/or construction workers. The remainder of the respondents are involved in the service/retail industry (largely shop owners). The labourers earn, on average, 9,450 baht annually, one-third that of the miang producing households. The shop owners were reluctant to disclose incomes.

5.3 Miang Production

Most tea garden owners have their own workshop for processing tea leaf. These workshops are usually separate buildings, or some growers have their workshop and living quarters within one building. Family groups will often work together using one workshop, which usually contain a firepit, a working area for processing miang, an area to store the finished product, and sometimes an area to store firewood or to provide sleeping quarters for hired tea pickers. Most workshops are built using bamboo for the walls, thatch roof and dirt floors; some are built from wood and corrugated tin for the roof.

5.3.1 Picking Tea Leaf

Tea leaf is picked four times a year from April to November. The first two flushes are the largest, yielding about 60% of the annual production. The last two pickings yield about 20% each, with the final picking in some gardens dropping to 10% of annual production.

Picking tea leaf is labour intensive and is the most time consuming task during the production of miang. Labour is supplied by the family and/or hired. People from their early teens to their sixties pick tea leaf. Respondents have, on average, 2.4 family members involved with miang production. Eleven households employ family members only. The remaining households employ from one to four pickers on a full or part time basis.

Workers pick, on average, 30 kams/day (fist-sized bundle of tea leaf) earning 45 baht. During the first flush, production may be as high as 40 to 45 kams (60 to 67.5 baht per day). The majority of growers in Pa Pae who sell tea leaf to the Cooperative pay pickers 3.0 baht/kg. Workers can pick between 10 and 15 kgs of fresh leaf per day, earning up to 45 baht.

The tea tree seldom exceeds five metres and their average height in the plots ranged from 1.3 metres to 2.6 metres. Most of these trees can be easily harvested from ground level. The large trees are either climbed or branches poled down with hooked sticks or rope, or benches are cut and laid into the crock of the tree (Figure 5.1) which allows easy access. On a steep slope, the bench would be placed up slope forming a level platform from which to pick tea leaf. Most of the growers stated that they top prune the trees to keep them from getting too tall (only one lateral prunes).

The bud and first two tea leaves are picked to produce high quality green and black tea. For miang production, only the semi-mature tea leaf is used because younger tea leave disintegrates during processing, while older leaves are poor quality. Producers have developed a system whereby only half to two-thirds of the semi-mature leaf is picked which ensures the survival of the tea tree without the use of fertilizers. The growing point of the leaf remains on the tree and sufficient leaf remains overall to ensure the tree's survival.

For miang production, the leaf is torn in half, while the more skilled pickers use a finger knife (Figure 5.2). As the leaf is plucked, it is packed into a bundle in one hand, which when full, is tied with a thin piece of bamboo (tok). These fist sized bundles, called kams, contain about 0.3 to 0.4 kilograms of tea leaf and are carried back to the workshop in a bamboo basket slung over the shoulder. Pickers normally leave early in the morning, about 6 to 8 o'clock and return mid to late afternoon. During the hot season, pickers leave early in the morning to avoid the heat.

In Pa Pae and Pang Ma Kuay, all the pickers are local Thai. In Mae Mam, about half the pickers are Karen people from a nearby hilltribe village. The remainder are Thai, largely from outside the Tambon. Producers in Mae Sae largely employ local Thai, but there are some Karen and Lisu from Mae Sae and nearby villages who pick tea leaf. The largest miang producer (located in Mae Mam) employs 10 pickers, half of them Karen people. Labourers hired outside a village are provided quarters, either within the workshop, or in a labourer's house.

Figure 5.1 Tea picker using a bench to pick tea leaf from a tall tea tree.

Figure 5.2 Finger knife used by the more skilled tea pickers to pick tea leaf.

Table 5.4. Reasons given by growers for having difficulty in hiring pickers.

Number	Reason
34	people go to town for construction, earn more money
2	new generation does not care about producing miang
2	pickers receive little money
2	tea picking is hard work
1	people hired for trekking, forestry

Finding labour to pick tea leaf is a major concern of the miang producers. Only three out of forty-four growers who hire labour did not experience difficulty finding sufficient humanpower. The most common reason given for this difficulty (Table 5.4) was the high wages paid for construction work in urban centres (83%). Workers earn between 70 and 90 baht daily for construction work in Chiang Mai, relative to an average picker's wage of 45 baht. The hard work involved with picking tea leaf was also identified as a problem (5%). Two growers (5%) and the headman in Pa Pae expressed the concern that the younger generation does not care about producing tea leaf.

Another intervening opportunity for local workers is a mushroom farm located between Pa Pae and Mae Sae (opened in 1989). The farm employs between 70 and 80 workers and draws much of its labour force from nearby miang producing villages located between Pa Pae and Mae Loa.

5.3.2 Processing the Tea Leaf

Fresh tea leaf is delivered to the workshop in the afternoon. The first stage in producing miang is to steam the tea leaf. Wooden barrels, called tangs, are used to hold the tea leaf while it is being steamed. Tangs are either one-piece construction, or are built from wooden slats held together by steel rings. Solid tangs are carved from trees with soft wood, like fig trees (i.e. Ficus subulata) and will last over 10 years if they are properly cared for. These containers hold from 100 to 300 kams, with the most common size being 100 to 125 kams and measuring 60 cm high and 45 cm wide. A wooden grate is placed in the bottom to hold the tea leaf above the water reservoir and to allow steam to pass through. Kams are lightly packed into the tang with the tip of the tea leaf pointing upward. Figures 5.3 and 5.4 show the miang production process.

The traditional stoves used to steam the tea leaf are built by the villagers utilizing the same basic design. Figure 5.5 shows the dimensions of one traditional firepit. All growers use a steel tank as a water reservoir (half a gas drum, lasts up to five years). These tanks are purchased from a nearby market for about 50 baht. Construction materials for the framing of the stove vary considerably. Some are built entirely from clay or cement, or a combination of the two. If cement is used, costs runs as high as 300 baht. Clay taopungs will normally only last one year, but cement can last up to 10 years, depending upon use.

The firebox for the stove is usually built below ground level. The reservoir is elevated above the bottom of the firebox. The reservoir will extend only a few centimetres above the floor so that the heavy wooden tang filled with tea leaf can be easily lifted to the top of the stove. The stoves are often vented at the back to improve the efficiency of the wood burning.

It takes from 30 to 50 minutes to raise the water to a rapid steam and then another 30 to 50 minutes to steam the tea leaf. The process varies depending upon the size of water reservoir being used, the amount of tea leaf being steamed, and the efficiency of the stove. The wooden tang is placed over the reservoir once a rapid steam begins. Banana leaves or a wet cloth are used to create a tight seal between the firepit and the tang. The growers sometimes place a tire on top of the water reservoir, embedded into

Figure 5.3 Tea leaf being picked, steamed and packed into fist-sized bundles (kams).

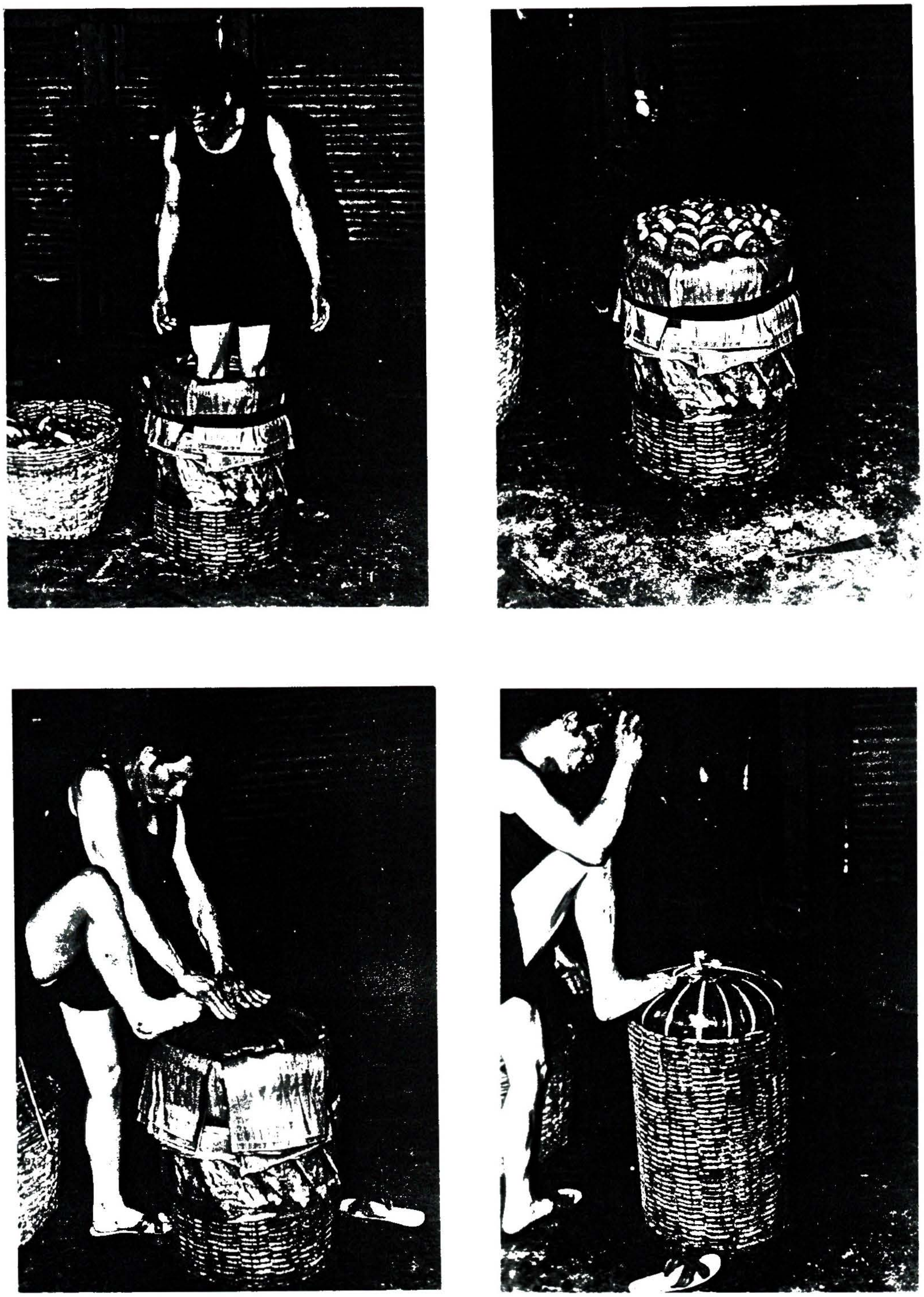


Figure 5.4 Miang being packed into bamboo containers.

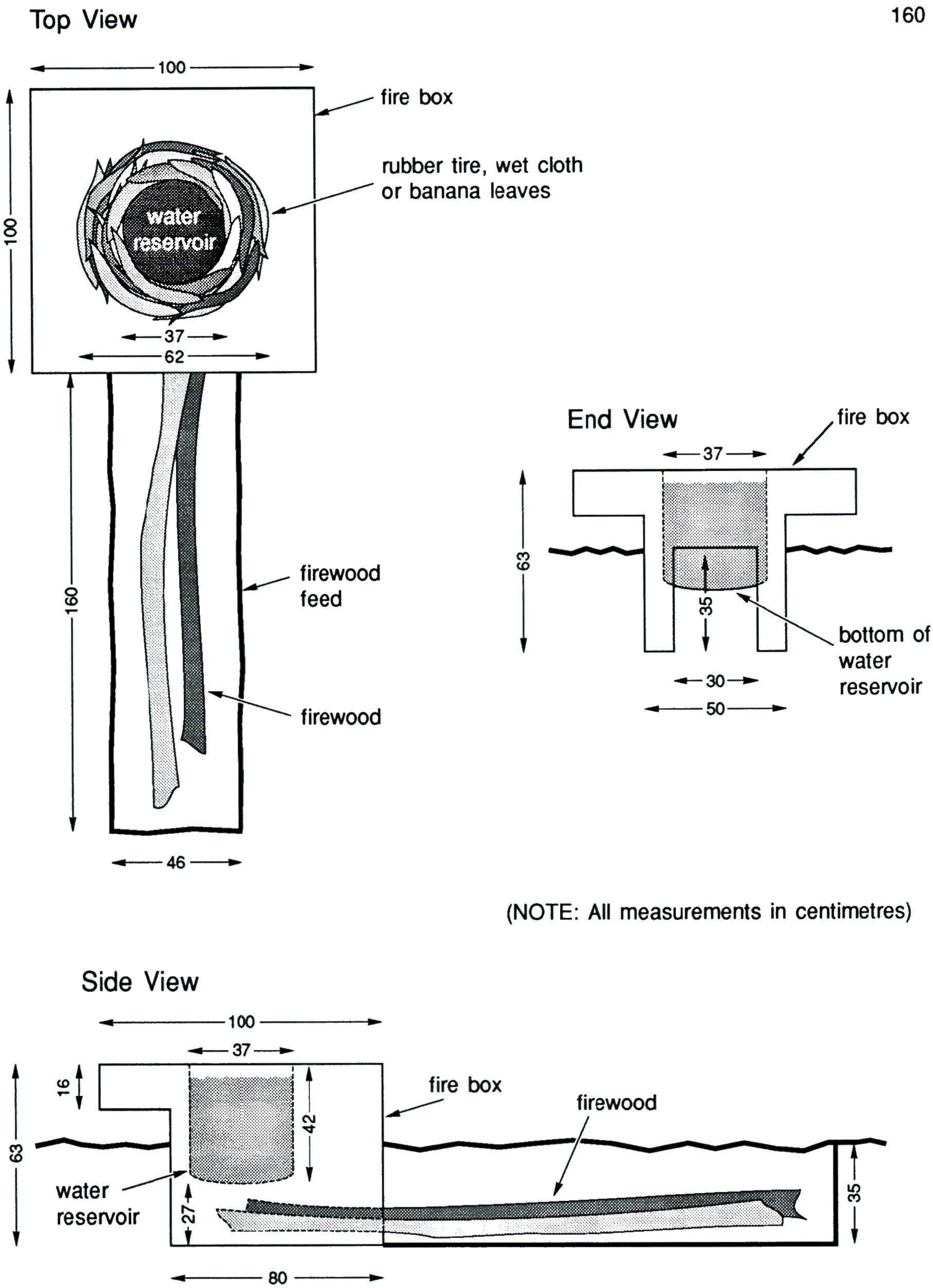


Figure 5.5 Dimensions of a typical traditional firepit (taopung) used for producing miang.

the top of the firepit, to help produce a tight seal. A wooden or aluminum basin, or cloth is used as a cap to slow the rate the steam passes through the tea leaf.

It is more economical to process two batches of tea leaf in one night since there are coals remaining after the first steaming and the water is still warm. Two batches are often processed during the first two pickings when tea leaf is plentiful. During the third and fourth picking, households often process one batch only. After steaming the tea leaf, most households produce charcoal from the remaining coals. Coals are placed into an air-tight container which extinguishes the fire, producing a medium quality charcoal which is then used for household cooking.

Once the tea leaf is steamed, the toks are removed and the leaf is spread out on bamboo mats to cool. Sometimes water is poured over the leaf to speed the cooling. The whole family usually joins in to pack the tea leaf into tight bundles slightly larger than tennis balls. Excess moisture is squeezed out into cans while packing and poor quality tea leaf is removed. These kams are retied using new bamboo toks. If labourers are hired to pick tea leaf, each picker will pack his/her tea leaf and payment is based upon these tightly packed kams. The kams are then loosely placed into bamboo baskets (inside a plastic bag) until there are enough to pack at least one tang. Steaming occurs every day the tea leaf is picked, but final packing into bamboo tangs usually only occurs after every two or three steamings, depending upon the amount of tea leaf being processed.

Miang tastes best (sweet and sour) if it is left to ferment a few months. To ferment this long, however, the miang must be well packed. If the miang is exposed to too much air the tea leaf will rot, turning red and becoming unfit for human consumption. To keep the miang from spoiling, the kams are packed into tightly woven bamboo baskets (58.5 cm high, 42.5 cm diameter). These baskets, also called tangs, are usually made by hilltribes (mostly Karen) and sell for 17.5 baht per tang.

Banana leaves, plastic and cow dung are used to make the tangs air tight. Cow dung (buffalo will not work) is spread on the outside of the tang which helps to seal the tang when it dries. Next, a layer of banana leaves, plastic, then another layer of banana leaves are used to line the tang, leaving about 25 cm of overlap hanging down the outside of the basket. Flexible rings made from a local vine are used to hold the banana leaves in place. These rings are removed as the tang is filled.

Kams are tightly packed into the tang layer by layer. Foot power and a wooden mallet are used to pack the kams in tightly. Once the basket is full, it is sealed using another 3 to 4 layers of banana leaves and plastic, in addition to the overlap which forms the final cover. The outside of these additional layers are wedged into the side of the basket, after which the excess from the primary lining is folded over the top. The outer layer of banana leaves are cut into wedges, which overlap, forming a neat and tight seal. Wooden pins are used to hold the layers of banana leaves and plastic in place. On average, 220 kams are packed into each tang which will weigh almost 100 kilograms. It usually takes 50 to 60 minutes to pack one tang and the number of kams is marked on top. Figure 5.4 shows how miang is packed.

Finished tangs are stored in the workshops until middlemen come to pick them up at the farm gate. Few of the growers take miang to market. Small pickup trucks or flat beds are used to transport the miang. In days past, oxen were used to transport the miang out of the hills to the lowland areas. Most upland villages are now accessible by road. Each tang is extremely heavy and two people are needed to load them into the trucks. Some tangs leak, as evident by the juices that collect on the floor of some of the workshops. This miang will be used up first before it spoils.

5.3.3 Miang Production Costs

From the survey it was possible to calculate the cost of producing one tang of miang (about 220 kams) based on readily identifiable items, such as labour and processing (Table 5.5). Growers realize a profit of about 1.86 baht/kam, or 5.58 baht/kg of fresh leaf. If they sell tea leaf to the factory, they would realize a profit of about 3.0 baht/kg of fresh leaf. Although the profits for miang production are higher, the investment and labour needed to produce miang are also greater.

Under current prices, it is more profitable to produce miang then to sell tea leaf to the factory. This estimate, however, ignores building and maintaining the workshop

Table 5.5. Costs to produce one tang (220 Kams) of miang.

Picking Costs	
220 kams X 1.5 baht/kam	= 330 baht
Tea Garden Maintenance	
weeding 0.3 baht/kam about (other maintenance tasks are usually completed by the owner)	= 66 baht
Processing Costs	
firewood: 3 baht/ piece X 9 pieces	= 27 baht
packing: usually completed by owner, if hired then	= 20 baht/tang
banana leaf	= 40 baht
plastic	= 5 baht
tang	= 17.5 baht
tok (bamboo ties for kams, 10,000/450 baht)	= 10 baht
Total Cost	= 515.5 baht/tang

Average price/kam = 4.2 baht = 924 baht/tang

Profit = **408.5** baht/tang or **1.86** baht / kam

<u>Relative to selling tea leaf to the factory</u>

cost of picking leaf	= 3.0 baht/kg
price at factory	= 6.0 baht/ kg
profit	= **3.0** baht/kg

There are approximately 3 kams/kg of fresh tea leaf, therefore the miang producers realize a profit of:

3 x 1.86 baht/kam = **5.58** baht

for miang production, and credit costs (tea garden maintenance costs for fresh leaf production are also ignored).

5.3.4 Marketing Miang

The majority of miang is bought at the farm gate by middlemen and sold in almost all of the provinces in Northern Thailand, especially Sukothai and Tak provinces where there are a large number of miang consumers. Some miang is also exported to Burma where civil unrest has disrupted miang production in that country and to areas where there are enclaves of Thai workers, such as California and Hong Kong. Miang prices have doubled since 1986, from an average 2.1 baht/kam to 4.2 baht/kam in 1990. Villagers in Mae Mam generally receive the lowest price for miang due to their isolation. None of the miang producers have experienced trouble selling their product, although one grower stated that middlemen do not come often enough to buy miang. Some growers who are indebted to miang middlemen receive up to 0.75 baht less/kam.

5.3.5 The Future of Miang

It is commonly believed that miang consumption is declining in Northern Thailand. The younger generation dislikes the taste of miang and prefers the sweeter, modern treats which are widely available. The largest middleman in Pa Pae, and the headmen for Pa Pae and Pang Ma Kuay, feel that miang production in their area has declined by about 30% during the past decade. Although demand and production are declining, it appears that production has fallen faster than demand since the price of miang received by producers has doubled since 1986. Some of this increase in price is also due to inflation.

Miang production has fallen not only due to declining demand, but due to lack of labour to pick tea. Although the number of pickers has declined, the total number of producers has remained fairly constant. The increasing price for miang has also attracted younger men into the production of miang. However, as children become more educated and leave home to search for higher paying jobs in the cities, the number of producers is likely to decline. One producer mentioned that children with an education beyond grade nine tend to leave home.

During a one-day workshop introducing a new system for steaming tea leaf for miang production (discussed later) the villagers were divided into four discussion groups and asked to identify, in order of importance, the problems they were facing as miang producers (Table 5.6). They felt that firewood supply was the most important, followed by labour availability. They also identified the need for improving tea cultivation methods and credit availability.

5.4 Firewood Supply for Miang Production

We can now turn to examining the firewood supply issue using information from the miang producer survey, field observations and interviews with tea garden owners. Firewood supply is, in some ways, difficult to characterize and assess, largely due to the sensitive nature of the issue. This section examines the nature of the firewood supply problem and characteristics of firewood use, including type, source and consumption, and assesses the firewood supply situation for individual growers.

5.4.1 The Development of the Firewood Supply Problem in the Study Area

The firewood supply problems experienced by miang producers are a result of the much broader problem of deforestation in Thailand which became a focus of public attention in 1986 and 1987 when landslides due to poor logging methods in southern Thailand wiped out whole villages, killing thousands of people. The resulting outcry and intense public pressure led to a tightening of forest protection by the government which culminated in a logging ban in January of 1989 (Louham, 1990). These restrictions not only affected logging, but also forest use in general.

Following the landslides in southern Thailand in 1986-7, a meeting was held between the Mae Taeng District Forest Officer and all village group headmen and their assistants for Tambon Pa Pae. In February, 1988, the official informed the villagers that forest policy was changing and that there was going to be much stricter controls on cutting in forest reserves. Thus firewood cutting for miang production would be no

Table 5.6. Problems in order of importance as identified by miang producers at the miang stove workshop.

Problem 1: Firewood Supply

difficult to find, not enough in tea garden, problem with forest officer restricting access, must cut illegally, cutting ruins forest

suggestions: need an area in the forest in which villagers would be allowed to cut trees for firewood, should not be arrested if using wood in village, want to reforest, use fast growing trees.

Problem 2: Labour Problems

not enough pickers available, must pay more which reduces profit.

suggestions: want to bargain for price of miang but they cannot do this because they are in debt to middlemen and capitalist who control the price of miang.

Problem 3: Improved Cultivation

need help to improve tea cultivation methods i.e. new species, planting, pruning, fertilizer, maintenance

Problem 4: Credit

producing miang requires a lot of money, at the end of each year they prepare for next year, need some foundation to lend them money at reasonable rates, everything is incr

longer allowed, but villagers could continue cutting firewood for household needs. The villagers protested claiming that they needed firewood for their livelihood. The official compromised, allowing the villagers to continue cutting firewood but only in the tea gardens. They were encouraged to cut only what they needed and not to sell outside the area.

Following this meeting in 1988, the forest officers and villagers have struggled to come to grips with this new policy. Many villagers were nervous about collecting firewood. Many tried to get most of their wood from the tea gardens, but they often proved to be an inadequate supply and growers returned to the forest. Some forest officials have compromised since the meeting, allowing the villagers to cut firewood in areas where there are lots of trees. The villagers, however, are not allowed to cut large trees, or to cut all the trees in one area. According to one official, villagers so far have cooperated well. To date nobody has been fined, but some have been sent before a police officer for scolding.

The ex head of the Forest Protection Office in Mae Sae attests to the difficulty of the situation. In one case, he observed miang firewood which had been cut in the forest and pulled to the road. After sending his officers to investigate, it was found that the firewood was cut by the father of one of his employees.

Although some officials understand the needs of the villagers and have compromised, there appears to be a lot of tension between the villagers and forest officers. One villager stated that officials had burned his firewood which was piled beside the road in a forested area. During an informal meeting with a group of villagers in the tea gardens, the villagers complained about corruption among some of the local officials. Some officials levied a 2 baht charge per piece of firewood if villagers were caught cutting wood in the forest, money which they felt the officials pocketed. They also complained about businessmen being allowed to come into the area to log. Some villagers felt that it was very unfair that they were being denied access to the forests which they have long been dependent upon, while outsiders were allowed to remove truck loads of timber. It was also stated that the older forest officials understood the needs of the villagers, but that the younger officials did not.

The compromise on behalf of forest officials illustrates a major problem in dealing with this issue: **the RFD has no policy regarding firewood use for green tea or miang production in the forest reserves.** Several officials stated this, commenting that the RFD has largely been concerned with logging and swidden agriculture, while smallholder tea producers cause little, if any deforestation. As one official stated: 'they take a few trees here and there'. By law, villagers cannot cut trees in the forest reserve, but officials have largely been sympathetic to their needs.

It was a common statement by miang producers and village headmen that the government wanted the villagers to reduce firewood consumption and to reforest, but that 'nobody gives us any help or support'. For example, the RFD nursery near Chiang Mai offers free seedlings to whoever wants them. Visiting the nursery revealed that 50% of the 'free seedlings' are ornamental and 50% are fruit trees. This nursery has no seedlings which were suited for firewood. To help diversify the villagers' income and reduce firewood use, agriculture officers have given the villagers fruit trees such as mango, passion fruit and pomelo, and coffee seedlings, but there has been little, if any, follow-up support. In one case, growers complained that an agricultural official had promised to help secure markets for passion fruit, but nothing was ever done and the growers abandoned their passion fruit plantings.

5.4.2 Firewood Supply

There are two sources of firewood, the tea gardens and the forest The survey shows that some growers collect their own firewood, hire labour, or purchase firewood from local villagers, and some use a combination of these methods. Many growers have changed their collection practices within the past few years since access to the forest has become more restricted. Firewood supply is generally a very sensitive issue due to efforts of the RFD to conserve Thailand's dwindling forest resources.

Growers were often reluctant to discuss firewood supply issues, especially their source of firewood, due to the policy of the RFD to prohibit cutting firewood in the forest. Many growers, however, must still collect firewood in the forest to meet their needs for miang production, resulting in conflict between officials and villagers. To compensate for the reluctance of the villagers to discuss the sensitive issue of firewood supply, the growers were assured at the outset of the miang-producer survey that the information was purely for research reasons and that confidentiality would be maintained. In addition, firewood supply questions were asked in different ways in different parts of the survey. Sometimes growers would relax part way through the questionnaire and answer similar questions more fully. Basic questions concerning the type and species of tree utilized for firewood, preference and methods of collection were established first. Based upon the various firewood questions in the survey, firewood profiles were developed in order to assess firewood supply.

5.4.2.1 Type and Species of Firewood

Growers were asked what type and species of wood they used to steam tea leaf. Over half (53%) use all types of wood, including large and small trees, dead trees and branches; 38% do not use small trees; and 9% do not use large trees. During the field work, over 50 miang firewood piles were examined to judge their composition. Estimates were made regarding the type of firewood in the piles. Almost without exception, the piles were composed of at least 80% straight, split pieces which came from live trees of various sizes. The remainder were made up of whole and split branches and some dead trees.

The growers reveal a heavy dependence upon and preference for one species- oak ('maikaw', Figure 5.6). All reported using at least 40% maikaw, and 44% use maikaw only. Over 90% prefer oak firewood. The second most commonly used firewood is 'maitalo' (Schima wallichii, Figure 5.6). This tree is used by half the growers: almost 40% use it half the time; 60% use it 10 to 50% of the time; and less than 1% use it more than half the time. Two growers report using 'maikum' (Microcos paniculata), one uses 'maijumpee' (Paramachelia bailonii) and one uses 'maipaw' (Sapium baccatum). Only one reports using a mixture of whatever firewood is available. Overall, approximately 81.4% of the firewood consumed comes from various species of oak, 17.2% from Schima wallichii, and the remainder is made up of a variety of species.

To verify survey results regarding the species used for miang firewood, four different firewood piles were examined in detail. Growers were asked the common name for 50 pieces of firewood in the pile. The results are presented in Table 5.7. As shown, the oaks are the most common firewood, followed by Dipotocarpus turbinatus and Schima wallichii. The use of Dipotocarpus turbinatus for firewood, however, is an exception rather than a rule. This tree is normally not used for firewood as it is a highly

Figure 5.6 Photographs of *Castanopsis tribuloides* (one of the oaks) and *Schima wallichii*, the two trees most commonly used for miang firewood.

Table 5.7. Percentage of firewood represented by species in four firewood piles in Pa Pae and Pang Ma Kuay.

(%)

Firewood Pile	The oaks	Alstonia scholaris	Diptocarpus turbinatus	Ehretia laevis	Elaeocarpus floribundas
1	5.5	2.5	84	8	-
2*	64.0	-	-	-	8
3*	60.0	4.0	-	4	-
4	57.6	-	-	3	-
Average	46.8	1.6	21	3.8	2

Firewood Pile	Microcos paniculata	Paramichelia baillonii	Schima wallichii	unknown
1	-	-	-	-
2*	8	8	2.0	10
3*	4	-	20.0	8
4	-	-	36.4	3
Average	3	2	14.6	5.2

* only 50 pieces identified from large firewood piles

sought after for construction. In this case a large tree had fallen naturally and splintered, therefore the growers used it for firewood. Excluding this, the oaks were the most common firewood in the four piles examined, representing 46.8% of the firewood in the four piles. The second most common tree is Schima wallichii (14.6%) followed by five species under 4% each. Slightly more than 5% of the pieces of firewood which the growers identified did not match the common names of the trees found in the tea gardens. The results from these firewood piles, excluding 'mayan', are similar to the results from the miang producer survey, except that oak is much less dominant in the firewood piles.

5.4.2.2 Size Preference

All growers use axe and saw to cut firewood, limiting the size of trees they can readily cut- 65% prefer cutting trees 20 to 30 cm in diameter, while the remainder prefer cutting trees up to 40 cm. The medium sized trees (20 to 30 cm) are easily split into 4 to 6 triangular shaped pieces about 1.5 metres long and 8 or 9 cm to a side (Figure 5.7). Trees up to about 20 cm will be split in half. Since most of the wood must be carried out of the tea gardens and forests by hand, only branches of the good firewood species, such as oak, are utilized.

5.4.2.3 Methods of Collection

Generally, growers select larger trees which make good firewood, allowing younger trees to mature. They also collect from different parts of the tea garden every year, and will often girdle trees, allowing them to stand for 2-3 years before they cut them, which dries the wood out, thereby producing better firewood. This curing process is also important for some trees, such as Schima wallichii, which have an irritable sap. Many trees are also easier to split if they are allowed to dry.

Trees are often cut if they are shading the tea trees too much. The forest floor of the tea gardens are very clean, indicating that the villagers make good use of any trees that they cut. Growers also largely respect the tea gardens belonging to others--less than 10% of the growers reported that somebody was collecting firewood from their garden without permission.

Firewood is usually collected during the off season (December to March) after the tea trees finish producing leaf. The wood is often cut in the forest or tea gardens and allowed to dry for one or two months before it is brought to the grower's compound. If there is a road nearby, the firewood will be stacked beside the road and a truck will be hired to transport the wood to the grower's compound. Most operators haul from 100 to 300 pieces and charge 0.5 baht/piece. If the villagers carry the wood from the tea gardens and/or forest, they will carry 4 or 5 pieces per trip, making about twenty trips per day. Depending upon the amount of miang produced, most growers spend about 2 weeks collecting firewood. Tea pickers are often hired to collect firewood and are paid

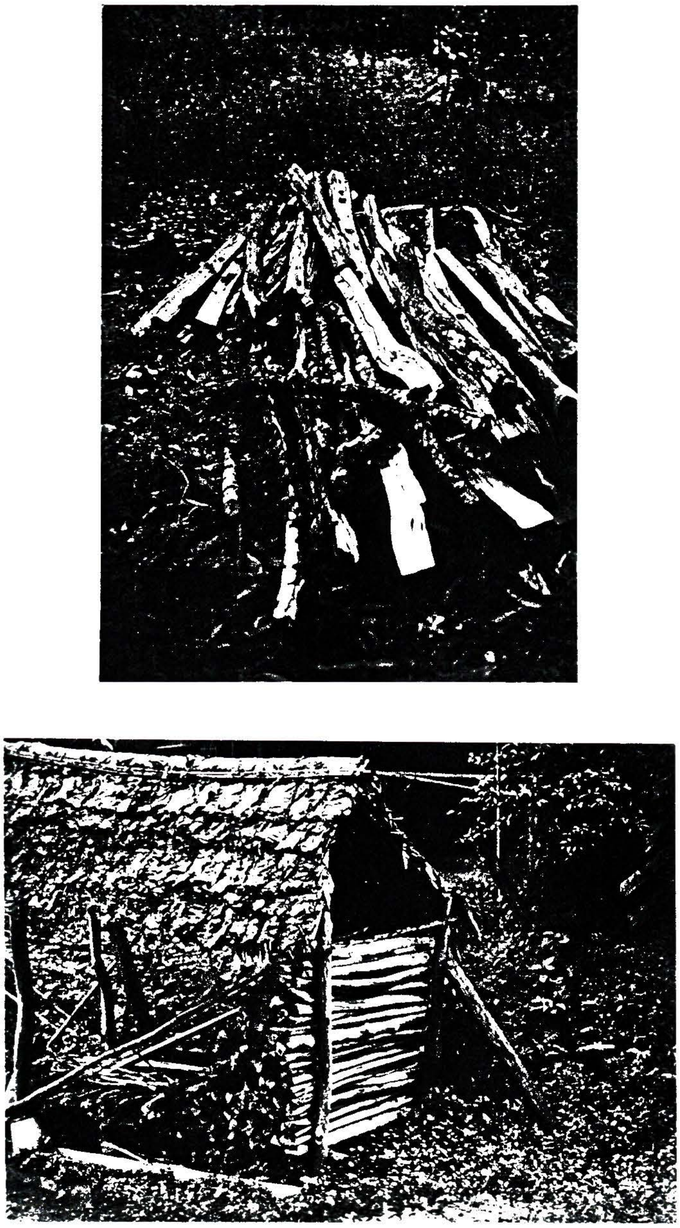


Figure 5.7 Photographs of miang firewood.

40-45 baht per day. Figure 5.7 are photographs of miang firewood observed in the tea gardens and stacked in a grower's compound.

5.4.2.4 Source of Firewood

Due to the problems surrounding firewood supply, it was important to understand where growers obtained their firewood for miang production. When growers were asked directly where they obtained their firewood, they often under-reported the amount of wood which came from the forest. The first firewood supply question in the questionnaire asked how much wood, on average, came from their tea gardens. Almost all growers reported that all their firewood came from their tea gardens. Inconsistencies, however, were often found in later questions. For example, in Pa Pae and Pang Ma Kuay, 35 out of 39 growers reported that all the wood came from the tea gardens. In a later question, growers were asked for the specific sources of their firewood: tea garden, public forest, friends tea garden, or if firewood was purchased. Two growers reported they bought all their wood and 14 reported that they bought some of it. All these growers except four reported earlier that all their wood came from their tea garden. In a later question, growers who bought firewood were asked where the sellers got their wood from: 13 obtained wood from the forest and 3 from sellers tea gardens. These inconsistencies may be due to how growers perceived the question. Growers may not consider buying wood as a source of firewood and over-reported the amount of wood that comes from their tea gardens, or it may be that growers were nervous about reporting that they buy firewood since most of it comes from the forest.

Growers who did not buy firewood also tended to over-report the amount of wood which came from their gardens. During the second firewood question, two growers reported that they obtained firewood from their tea garden and the public forest, even though they indicated earlier that all their wood came from their garden. Six growers reported their tea garden as their only source of wood, but gave clear indication in other questions that they obtained wood from the forest. Five more growers also reported that their wood came from their tea garden only, but gave some indication that they were collecting wood in the forest. Ten growers reported their tea garden as their only source of wood and gave no indication otherwise in later questions.

When growers were asked directly concerning the source, they often under-reported the amount of wood which came from the forest. In the first question, only 4 growers indicated that wood came from outside their tea gardens. Later, in the second direct question, two more responded that they obtained wood from the forest, and 14 growers indicated they bought firewood, 11 of which the source was the forest. In later questions, 11 more growers gave clear or partial indication that they obtained wood from the forest. Only 10 out of 35 growers in Pa Pae and Pang Ma Kuay who originally reported their tea garden as the only source of wood, gave no indication that they obtained firewood from other sources. Twenty growers gave clear indication they get wood from the forest and 5 gave some indication.

The growers who gave some indication that they get some wood from the forest have the following characteristics: they are facing declining supply and or access problems, their tea gardens are not declining in productivity, and they collected wood from the forest before forestry became more strict. In order for these growers to be facing firewood supply problems, but that firewood productivity in their tea gardens is being maintained, suggests that they still get wood from the forest.

In Mae Mam and Mae Sae, the growers were more willing to report the forest as a source of wood. In Mae Mam, 5 growers reported the forest as a source of wood (3 obtain wood from tea garden also); 4 reported tea garden only and gave no indication they get wood from the forest; one reported tea garden only, but gave clear indication that they collect wood from the forest; and the final grower gave some indication that they collect wood from the forest. In Mae Sae, 4 out of 5 growers reported the forest as a source of wood (2 use tea gardens also) and one reported tea garden only and gave no indication that they collect from the forest.

Given the difficulty in obtaining information about the source of firewood for miang production, some inferences were made about the volume of wood obtained form the tea gardens relative to the forest. If respondents clearly indicated that they collect firewood from the forest, but reported the tea garden as their only source of firewood, then firewood collection was divided evenly between the two sources.

The firewood profiles (discussed later) indicate that 13% of the growers obtain firewood from the forest only, 38% from the tea gardens only, and 49% from both. Table 5.8 presents the number of pieces of firewood collected from the forest and the tea gardens. Villagers undoubtedly under-reported the amount of firewood which they collected from the forest. Inferences made concerning firewood sources would also likely under-report the amount of wood that is collected from the forest.

The smaller the village, the greater proportion of firewood that is collected from the forest. Miang producers in Mae Sae collect 82% of their firewood needs from the forest, relative to 60% in Mae Mam and 45% in Pa Pae and Pang Ma Kuay (Table 5.8). Overall, just over half (52%) of the firewood for miang production is obtained from the forest.

In all the villages, firewood collection has intensified from the tea gardens after the RFD became more strict-- 67% of the firewood came from the forest prior to forestry becoming more strict, relative to 52% currently. Two forest officials, one in Pa Pae and one in the Mae Taeng District Office, felt that villagers obtain at least half of their firewood for miang production from the forest.

5.5 Firewood Consumption for Miang Production

Annual wood consumption for miang producers was calculated from the miang producer survey. This was done by measuring the volumes of five pieces of wood at each household. Volumes were calculated based upon if the piece of wood was shaped similar to a circle, square, or triangle. Average volumes were multiplied by the number of pieces of wood producers used in 1989. The average producer consumed 4.61 m^3 of wood for processing tea leaf. There is, however, an indication that consumers overestimated their wood consumption in this survey. If wood consumption is calculated for only those growers whose wood consumption estimate was within 25% of what they should have consumed, according to the amount of miang they produced, then average wood consumption for these 27 producers drops to 3.84 m^3.

Table 5.8. Summary of firewood supply for miang production.

	(pieces) Forest	%	(pieces) Tea Garden	%
Pa Pae/ Pang Ma Kuay	8,950	45	11,005	55
Mae Mam	4,775	60	3,175	40
Mae Sae	2,300	82	500	18

Overall Source of Firewood

Forest	Tea Garden	Total
16,025 (52%)	14,680 (48%)	30,705

Prior to forestry becoming more strict, about 67% of the firewood came from the forest, compared to 52% after forest access was restricted in 1987-88.

Percentage of Firewood From the Tea Gardens Before and After Forest Access Became Restricted, by Village

	Before (%)	After (%)
Pa Pae/ Pang Ma Kuay	40	55
Mae Mam	27	40
Mae Sae	11	18

5.6 Firewood Profiles

To help understand the process of firewood supply in the four villages, firewood 'profiles' were developed based upon information collected from various questions in the miang producer survey. These profiles describe the typical situations growers found themselves in regarding firewood availability, access to supplies and firewood productivity in the tea gardens. Consistency of responses in individual questionnaires could also be checked when developing these profiles. For example, some individuals indicated early in the questionnaire that they were not experiencing any firewood supply problems. However, later questions often revealed that supplies were declining and/or forest officials were more strict regarding firewood collection. These results may be caused by the villagers being nervous during the first part of the interview.

Another major inconsistency regarding firewood issues was found when villagers were asked where they obtained their firewood. Most growers responded that all their firewood comes from their tea gardens only. Later questions, however, often revealed that they obtained firewood from the forest also. These inconsistencies were discussed earlier.

The questions used to study firewood supply and to develop the firewood profiles (in the order they appear in the survey) are presented in Table 5.9. Miang producers readily fell into 3 major and 3 minor groups. Table 5.10 gives a breakdown of these profiles and the number which occurred in each village.

(a) The '*Declining Supply and Restricted Access*' Profile.

In this most common group, growers are faced with declining firewood supply in the tea gardens and/or forest and are also facing restricted access to supplies due to forest policy. Firewood productivity is also falling in all the gardens. In this group are 19 growers from Pa Pae, 4 from Mae Sae and only one from Mae Mam. This was the most common group for producers in Mae Sae. Within this group, 18 growers obtain firewood from both the forest and the tea gardens, 5 get wood from the tea gardens only, and only one relies on the forest for his firewood needs.

Table 5.9a. Questions used to examine firewood use and supply and to develop firewood profiles.

On average, what percentage of your firewood for processing miang came from your tea gardens before and after forestry became more strict?

What type of firewood do you normally use?
  [whole mature tree (split), small trees, branches, trimmings, whole dead tree (split), other]

What species of tree(s) do you use for processing miang?
  If more than one type of tree is used, approximately what percentage of energy needs is supplied by each species?

Has the availability of these different species changed in the last few years?
  If yes, when, how, and why?

What type of tree(s) do you prefer for processing miang?

What size of tree do you like to cut for firewood?

What equipment do you use to cut firewood?

Where do you obtain firewood for miang processing?
  (my own tea garden, friend's tea garden, nearby public forest, buy, other)

How far is the source of firewood from your household?
  (location and distance for each source of firewood)

Have distances to firewood supplies changed in the last three years?
  If yes, what are the old distances and why have they changed?

How do you transport your firewood?

Has it become more difficult to get firewood?
  If yes, when did it become more difficult and why?

Do you buy firewood for miang processing?
  How much did you buy last year?
  How much did you pay per piece?
  What were the prices since 1987?
  Why has it become more expensive?

Table 5.9b. Questions used to examine firewood use and supply and to develop firewood profiles.

Where do people who you buy firewood from get the wood and how do they deliver it?

Compared to four or five years ago, is your ability to get firewood for miang processing easier, about the same, or harder?

If it has changed, why?

Do you collect firewood from your tea garden?

If yes, please describe how?

What do you do with the firewood that you collect?

If you sell it, to who, at what price and how much did you sell last year?

Do other people collect firewood in your tea garden?

Is the productivity of your tea garden in terms of firewood production changed in the last three years?

If yes, how has it changed and why?

Can you get enough firewood for processing miang if you only collect branches and dead trees from your tea gardens and the forest?

Overall, is there a firewood shortage in your village?

If yes, please describe the nature of this problem and what you feel should be done about it?

Would you be interested in planting trees on your property to meet firewood needs in the household or in tea production?

If yes, what type would you plant.

Are there any types you would not plant? Why?

If you are not interested in planting trees, why?

How many hours/day and how many days per year do you spend collecting firewood? What month(s) do you collect in.

Table 5.10. Firewood supply profiles, by village.

Profile	Pa Pae/ Pang Ma Kuay	Mae Mam	Mae Sae	Tot
Declining Supply/ Restricted Access	19	1	4	24
Subgroup	7	1	0	8
Declining Supply	3	3	1	7
Restricted Access	2	0	0	2
Buyer (avail, access)	2	0	0	2
Renter (avail, both)	0	2	0	2
No Problem	6	4	0	10

Overall

firewood availability and access problems	33 (60%)
availability problems **	9 (16%)
access problems	3 (06%)
no firewood supply problems	10 (18%)

82% of the respondents reported firewood supply and/or access problems.

** Note: availability refers to the physical availability of firewood.

Eight growers in this first group (all from Pa Pae) buy part of their firewood supply. These growers are experiencing difficulty obtaining firewood from sellers who are afraid of being caught by forest officers.

There was a slight variation on the first profile. In this subgroup, growers are facing declining supply and restricted access, but they did not feel that firewood productivity in their tea gardens is falling. Seven villagers from Pa Pae and one from Mae Mam fell into this group. All except one grower indicated that the tea gardens were their only source of firewood. Since the growers report declining firewood availability and restricted access, but did not indicate that firewood productivity is also falling, this suggests that the growers get some of their wood from outside the tea gardens, or it may be that productivity declines in the tea gardens may not yet be evident. Growers may have previously obtained most of their wood from the forest and, if they increased their collection from the tea gardens within the last 2-3 years, declining firewood productivity in the tea gardens may not yet be visible (if it was declining). Two growers buy part of their wood relieving pressure on the tea gardens.

(b) The *'No Problem'* Profile.

In the second most common group, growers report having no problems with firewood availability or access. None buy any wood, and there is no indication that they currently get wood from the forest (60% did previously get wood from the forest). This suggests that the gardens, at least for now, are able to meet their firewood needs without any negative impacts on firewood productivity. Six villagers from Pa Pae and four from Mae Mam belong to this group. This was the most common group for Mae Mam.

(c) The *'Declining Supply'* Profile.

In the third most common group, three villagers from Pa Pae, 3 from Mae Mam and one from Mae Sae reported declining supplies. One of these growers reported collecting wood in the tea gardens only and was facing declining productivity. Two growers reported firewood collection from the forests and tea gardens and that productivity in the tea gardens was the same. Four growers buy part of their wood supply and report no changes in firewood productivity from their tea gardens. In this group, declining supply is largely due to declining availability of firewood in the forest. Two growers also indicated that people were less willing to sell wood, but no growers directly indicated that access was being restricted to local forest resources.

(d) Other Profiles.

There are three minor profiles with two growers in each group. The first group is the '*Restricted Access*' profile. One grower is concerned about being caught by forest officials collecting wood from his tea garden (productivity is being maintained). The second grower buys part of his wood supply and is experiencing trouble finding sellers. This owner reported the only increase in firewood productivity- 'young trees were growing up in his garden'. This grower buys one third of his firewood needs.

The '*Buyer*' profile includes growers who buy all their firewood needs. These growers are experiencing difficulty obtaining firewood. Suppliers are reluctant to provide wood because of pressure the forestry officials have placed upon villagers not to cut firewood in the forest. Although most of the wood for sale comes from the forest (including other growers who purchase part of their firewood supply) even those villagers who sell firewood cut from their own tea gardens are reluctant to do so.

The final minor group is the '*Renter*' profile. These two growers in Mae Mam rent tea gardens and their landlords do not allow them to cut firewood in the tea gardens. These growers report declining supply and restricted access problems.

5.6.1 Summary of Firewood Profiles

Pa Pae, Pang Ma Kuay

In Pa Pae and Pang Ma Kuay, only 15% of the respondents (6 growers) are not experiencing any difficulty obtaining firewood. None of these growers buy firewood and all indicate that their tea gardens are the only source of wood. Of the remaining growers, 26 report declining supply and restricted access to forested areas, 4 report declining supply, and 3 restricted access only. Firewood productivity is declining in just over half of the gardens (57%), remains the same in 41%, and is increasing in only one garden. Forest officials became strict about firewood collection in 1987-1988.

<u>Mae Mam</u>

In Mae Mam, one third (36%) of the growers are not facing any firewood supply or access problems, the highest proportion in all the villages. The remaining growers (7) are experiencing declining supplies and 3 growers also reported access restrictions. Two of the growers are not allowed to collect firewood from their rented tea gardens. Only one grower reported declining productivity in his tea garden, the lowest proportion of all the villages. Two growers reported that firewood was more difficult to find because villagers in Pa Pae were coming to collect wood in the forests near Mae Mam. Forest officials became strict about collecting firewood in 1988-89.

<u>Mae Sae</u>

All the producers in Mae Sae are experiencing declining supplies of firewood and except for the headman, reported that their access to supplies is also being restricted. Forest officials became strict about firewood collection in 1985, 2 to 3 years earlier than the other villages. Although the officials became strict at an earlier date, they have compromised. Villagers are allowed to collect wood in the forest (only what they need) as long as it is far from the village. Two growers collect firewood from the forest only. The firewood productivity in the remaining growers' tea gardens (3) is declining.

Overall, 82% of the respondents reported firewood supply and/or access problems. Over half (51%) reported firewood productivity declining in the gardens, no change in 47%, and increasing in 2% (six growers either buy all their wood, or obtain it all from the forest and are not included in this analysis). The overwhelming reason given for the declining productivity in the tea gardens is that it is caused by firewood cutting for miang production which is exceeding the growth rate of firewood trees (96%). In one garden, the young trees were growing too slow and the owner was having to cut large trees for firewood. Fifteen growers buy part of their firewood needs and also collect firewood from their tea gardens. For these growers who buy at least 50% of their needs, 8 gardens were declining in firewood productivity, in six there were no changes, and in one garden productivity was increasing.

5.7 How Serious is the Firewood Supply Problem

Although 82% of the growers in the study area face firewood problems, this, however, does not really indicate the seriousness of the problem. For example, although many producers are finding it more difficult to obtain firewood, can they still get enough and are they worried about future supplies? To examine the seriousness of the problem, growers were asked if there is an overall firewood supply problem in their village. Results show that just over one-third of the growers (35%) felt that there was an overall firewood supply problem (Table 5.11a). For those who felt there was an overall problem, 37% blamed it on declining supplies, 32% blamed it on a combination of declining supplies and restricted access by forest officers, and the remainder blamed it on restricted access. Growers who felt there was an overall problem were asked what should be done: 63% didn't know what to do, 16% wanted another source of energy, and the remainder felt they should quit producing miang, conserve trees and get miang producers together to discuss the problem (Table 5.11b).

Mae Mam reported the highest ratio of 'no overall problems' (73%), followed by Pa Pae/Pang Ma Kuay and Mae Sae (60%). Often villagers who responded that there was no overall problem stated that they could still find firewood, but that it was becoming more difficult.

During the course of the field work, two forestry officials stated that they felt growers could get enough firewood for miang production if the growers collected only dead wood and branches from the tea gardens and forest. To test this assertion, a question was added to the miang producer survey; almost all the growers responded negatively (92%) many stating that there were not enough dead trees in the forest to meet their needs. In addition, the distances they would have to travel would make this impractical, and cutting branches is dangerous and would provide limited firewood. Only 8% of the growers responded yes, stating they had many dead trees in their gardens. Given the high number of girdled trees found in some of the vegetation plots, it is questionable as to the reason for the dead trees in these growers' gardens who responded positively to this question.

Table 5.11a. Responses to the question: overall, is there a firewood supply problem in your village?

Pa Pae, Pang Ma Kuay	Mae Mam	Mae Sae	Reason
		YES	
4	1	-	many people produce miang, cut for long time, tree grow slow, must go far
1	-	-	many people cut, have no area in forest
1	-	-	many people cut, including hilltribe
5	1	-	scarcity of firewood, restricted access, afraid of being caught
2	-	2	officer against, control him, many trees but can't cut
1	1	-	officer against, no sellers, cannot get enough
		NO	
17	4	3	
		MAYBE IN FUTURE	
2	0	0	
33	7	5	

Table 5.11b. Responses to the question: overall, is there a firewood supply problem in your village?

What to do?

Pa Pae	Mae Mam	Mae Sae	
7	3	2	don't know
3	-	-	need other source of energy
1	-	-	quit miang, go into fruit trees
1	-	-	get miang producers together, discuss the problem
1	-	-	prevent Lisu from cutting trees
1	-	-	must conserve, let young ones grow up

Note: 6 producers in Pa Pae and Pang Ma Kuay, and 4 producers in Mae Mam, were not experiencing any firewood supply problems and are not included in this analysis.

5.8 Consequences of Declining Firewood Supply

In most cases where growers reported declining supplies, distances to supplies have increased, doubling in most cases. Distances to supplies range from 2 km to 10 km.

In total, 19 growers buy 50 to 100% of their firewood needs and report declining supply and/or restricted access firewood problems and all, except one, face increased prices for firewood. Generally, firewood has increased 0.5 baht/year since 1987, from 1-2 baht /piece, to 2-3 baht/piece. The reasons for rising prices given by the growers are presented in Table 5.12.

There are three major reasons for increasing prices: declining supplies; higher costs in general, especially transportation; and fewer people selling wood. Less people are selling wood due to the pressure forest officials have placed upon villagers not to cut to sell, but just to cut what they need. In 15 cases, the forest was the only source of firewood, in two cases firewood came from the forest and the seller's tea garden, and in the remaining two from the seller's tea garden.

5.9 Green Tea Production

There are 10 privately owned green tea factories and one cooperative in Tambon Pa Pae. Tea production and energy use was examined at 7 factories (see Chapter 3 for description of methods).

5.9.1 History of Green Tea Production in Thailand

During the 1930s, a businessman from Chiang Mai Province, Mr. Prasit Phumxusri, gained admission to the Tocklai Institute, operated by the Indian Tea Association in Assam. At the end of World War II, he set up in Northern Thailand a pilot hand-operated semi-fermented tea factory supplied by tea leaf bought from miang producers. This experiment convinced him that quality tea could be produced from the indigenous tea tree and that large areas of tea gardens were already available, if growers could be convinced to sell green leaf, rather than produce miang. He subsequently established the first tea plantation in Thailand (Hoare, 1988) in the uplands near Chang Doa, Chiang Mai Province.

Table 5.12. Reasons for increasing prices of firewood for miang production.

Pa Pae, Pang Ma Kuay

Number of Responses	Reason
5	scarcity of wood, must carry further
4	nobody wants to sell, forest officers against
3	everything increase in price
2	higher transportation costs

	Source
10	forest
2	seller's tea garden
2	seller's tea garden and forest

Note: only one grower who bought firewood was not experiencing increasing prices.

Mae Mam

Number of Responses	Reason
3	scarcity of wood, must carry farther
1	less people sell wood

	Source
4	forest

Mae Sae

	Reason
1	scarcity of wood, must go further

	Source
1	forest

By 1960, Mr. Phumxusri founded the Ramming Tea Estate. About 80 ha of intensive tea plantings had been established by 1987 (Hoare, 1987). Since this time, Raming Tea has entered into a joint enterprise with Royco Foods Ltd., forming ChaSiam, the largest black tea estate in Thailand.

During the past 30 years, many small green tea factories have been established in the highlands of North Thailand. In Tambon Wawi (Chiang Rai Province) there are 80 which produce two-thirds of the green tea in Thailand (Hoare, 1987).

5.9.2 Green Tea Production in Tambon Pa Pae

Green tea processing is carried out in relatively simple factories (all have electricity and/or diesel motors to power the machinery) which employ from 3 to 6 people. Tea leaf is brought to the factory in the late afternoon and is spread on the factory floor for withering. The next day the tea leaf is panned, rolled, dried, sorted and graded. The heat for drying the tea leaf is supplied by firewood, charcoal and/or the sun. As much as 30% to 40% of the tea leaf is partially dried by spreading the tea leaf on the ground on sunny days.

During the first stage of green tea production, leaf enzymes must be killed to prevent oxidization from occurring (oxidization is encouraged during black tea production). Leaf enzymes are killed by heating the tea leaf to 100-110 degrees celsius for about 10 minutes inside drum panners. These panners continuously turn the tea leaf while it is being heated. The tea leaf is then transferred to rollers where it is rolled and twisted to break down cell structure, preparing the tea leaf for drying. A 'ball breaker' (vibrating screen) is used to break up clumps of tea leaf which form during the rolling process. This equipment also separates the tea leaf into two grades. The smaller, higher quality tea leaf is dried over charcoal fires. The larger, lower quality tea leaf is dried in the sun, weather permitting.

Drying the tea leaf is the final processing stage before sorting and grading. Charcoal is expensive and is only used for the best quality tea. Bamboo baskets with 4 to 5 kg of tea leaf are placed above charcoal fires for 1 to 2 hours. If weather does not permit sun drying, the low quality tea leaf will be dried on rack dryers. A fire is started in one end of a long tunnel and heat passes underneath the tea leaf which has been thinly spread on tin sheets (about 20 m long and 1 m wide). Some high quality leaf is also dried in the sun, but the final drying is always done over a charcoal fire to impart a good flavour to the tea. Poor quality tea leaf which has been sun dried is passed through a final drying stage in the drum panner or on the rack dryer. Moisture content in the tea leaf is reduced to 5%-10%.

Rough sorting is usually done using a series of vibrating screens to separate the tea leaf by size. The bud and first two leaves produce the best grade of tea. Stems and older tea leaf produce poorer quality grades. High quality tea passes through a final sorting which is done by hand.

Table 5.13 presents a summary of the tea factories studied. Annual production ranges from 3,000 to 21,000 kg of dry tea. The majority of tea leaf in the privately owned tea factories is collected from the owner's gardens. The cooperative is supplied by over 200 members in Pa Pae (villagers from Pang Ma Kuay are not allowed to sell tea leaf to the Cooperative). Fresh leaf prices ranged from 5.5 to 7 baht per kilogram. Tea pickers are paid 2.5 to 3.5 baht per kilogram.

The severe problems of declining tea leaf quantity and quality experienced by green tea factories in Tambon Wawi are not occurring in Tambon Pa Pae. All owners felt that tea leaf quality is being maintained. Although output is declining in Tambon Pa Pae, largely due to labour shortages and high miang prices (miang producers are selling less tea leaf to the factories) the owners felt that productivity in the tea gardens is largely being maintained. However, two owners in Tambon Pa Pae did feel that productivity of tea trees may slowly be declining due to declining rainfall and raising temperatures.

5.9.3 Fuelwood Use and Supply Problems in the Green Tea Industry

Fuelwood consumption rates for green tea processing could not be accurately calculated for several reasons:

1) several energy sources-firewood, charcoal, sun- are used for drying tea leaf in various combinations depending upon tea leaf quality and the weather;

2) tea factory owners do not keep detailed records of fuelwood consumption;

Table 5.13. Summary statistics for seven green tea factories in Tambon Pa Pae.

Factory Location	Production kg dry tea	Amount of Tea gardens (rai)	% from owners tea gardens	Pickers' Pay Rate (baht/kg)	Fresh Leaf Price (baht/kg)
Mae Mong	13,000	500	80	2.5	5.5
Mae Sae	4,060	**	90	3.5	7
Mae Loa					
#1	3,000	**	30	3.5	7
#2	3,000	**	80	3.5	6
	switched to miang production in 1990				
#3	closed in 1989 (two sons of owner murdered)				
Pang Ma Kuay	closed in 1987, poor quality equipment consumed large quantities of fuelwood				
Pa Pae Cooperative*	21,000	-	-	-	7

* 210 members
** Factory owners did not know.

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3) not only do drying techniques vary, the amount of tea processed throughout the year varies, therefore daily energy use is not a good indication of total energy consumption;

4) efficiency in drying equipment varies between the factories.

Given these constraints, a rough estimate of energy consumption for drying tea relative to miang production was made. Two days were spent observing tea production at the cooperative tea factory in Pa Pae. Estimates for fuelwood use averaged 1200 TOE/10^6 per kilogram of dry tea. Traditional stove tests showed that about 13.5 kilograms of wood are needed to steam 100 kams, or 0.39 kilograms of wood per 1 kilogram of fresh leaf. This equals 148 TOE/10^6 energy for steaming 1 kilogram of fresh leaf. Generally it takes 4 kilograms of fresh leaf to make 1 kilogram of dry tea, therefore it takes from 249 to 300 TOE/10^6 to dry 1 kilogram of fresh leaf for green tea production, twice the amount of energy needed for steaming tea leaf during miang production. At ChaSiam, 1 kg of wood is needed to dry 1 kg of black tea (Marley, pers comm) or 378.48 TOE/10^6 of energy. In Tanzania, 100 kilograms of wood will make 38 kilograms of green tea (Barnard and Zarror, 1986) or 996 TOE/10^6 per kilogram of made green tea (Thai conversion factors[8] used).

Fuelwood is largely supplied by local villagers. Firewood is collected in both the tea gardens and forest. Charcoal, however, is largely produced from trees cut in the forest- there are few trees suitable for charcoal production remaining in the tea gardens. Fuelwood supply has become a major problem since 1987. Villagers are reluctant to sell firewood and charcoal to the factories due to the pressure placed upon them by forest officials to cut only what they need and not for sell. Owners who collect firewood from their gardens are also having difficulty hiring labour (many villagers have left to work in construction) to cut firewood. The tea factory in Mae Sae ran out of firewood before the end of the last season.

Obtaining charcoal relative to firewood is more difficult. One owner (Mae Mong) has stopped using it. The owner in Mae Sae brings charcoal into his factory at nights to avoid being observed by forest officers. Most owners are having to go outside the Tambon to secure charcoal supplies.

The problem of obtaining fuelwood is reflected in fuelwood prices. Prices for firewood have increased from 50-60 baht per 0.3 m^3 in 1987, to 100-120 baht in 1990. In 1987, charcoal sold for about 0.5-1 baht per kg. Charcoal now sells for 2.5-3 baht per kg.

Factory owners were questioned about solutions to the fuelwood supply problem. Most owners were unsure about what to do. The owner of the Mae Sae factory gave

[8] Energy equivalents used:
1 kg wood = 378.48 TOE/10^6 (1 m^3= 600 kg);
1 kg of charcoal = 683.64 TOE/10^6.
Conversion factors supplied by the Asian Institute of Technology, Thailand.

10,000 baht to a local businessman to build a panner which could use LPG gas. Unfortunately the arrangement was not successful and the owner lost his investment. Most owners felt a woodlot would be a feasible solution but were concerned about problems of land title. Legally, woodlots cannot be established within forest reserves. The owner in Mae Sae has planted some pine for fuelwood. The owner in Mae Mong hopes to switch to coffee which does not require firewood for processing.

Overall, the fuelwood supply problem in Tambon Pa Pae for the green tea factories is very serious. Two of the owners felt that if solutions to the problem are not forthcoming within the next 2 to 3 years, they will be forced to close. All owners felt that fuelwood is the only feasible energy supply for drying tea because modern fuel sources and the equipment to utilize them are far too expensive.

5.9.4 Summary

The green tea factories studied in Tambon Pa Pae are facing numerous problems, including fuelwood, tea leaf and labour supply problems. Labour shortages for tea pickers and the high price for miang, have caused output to decline by about 20% during the last five years.

One factory (Mae Loa 2) switched from green tea to miang production in 1989. The owner identified three reasons for this switch: shortage of labour; high price for miang; inefficient equipment in his factory. Another factory in Mae Loa has closed altogether. The problems for this factory, however, appear to be of a more personal nature (two sons of the factory owner were murdered). The factory in Pang Ma Kuay closed largely due to poor quality equipment which required large quantities of fuelwood for drying tea leaf. All the factories still in operation, except the Cooperative, are in facing an insecure future (the Cooperative is there to support the villagers and declining productivity has not greatly harmed its operation).

5.10 Household Energy

Firewood and charcoal are the primary source of energy for household cooking in developing countries (Goodman, 1987; Leach and Gowan, 1987). In Thailand, fuelwood is the primary source of energy for household cooking in rural households, and accounts for 25% of the total energy consumed in Thailand (Wibulswas, 1986). In miang-producing villages, firewood consumed during household cooking ranks second to firewood consumed for steaming tea leaf. Fuelwood supply and demand for household cooking were examined through the miang and non-miang producer surveys.

The growers use five different types of energy for household cooking: firewood, charcoal left over from miang production, purchased charcoal, electricity and liquified petroleum gas (LPG). Except for 7 households, all use firewood for some of their cooking needs. Thirty-five households use primarily firewood and charcoal left over from miang production, and the remainder use a combination of these five sources of energy. Firewood and charcoal supply the majority of the energy needed for cooking.

Twelve households have LPG stoves for cooking. Two households purchased stoves in 1984-5 and the remainder within the last 3 years. LPG is used for quick cooking and warming only. This gas is too expensive to use for cooking regularly and it is also difficult to recharge the bottles; villagers must take empty bottles to a market 30 kms away. A 15 kg bottle costs about 170 baht to refill and will last a family 2 to 4 months. Another minor energy source for cooking is electricity. Fourteen households had rice pots for cooking white rice.

Table 5.14 presents the number of households which use electricity and/or kerosene, the number of appliances and the average cost/month. In Pa Pae and Pang Ma Kuay, all households have electricity. Households with lights only spend on average 10 baht/month on electricity, up to 54.9 baht/month with households that have lights plus four or more appliances. In Mae Sae, all households except one have electricity and two use kerosene. In Mae Mam, all households rely on kerosene for lighting and spend on average of 144.5 baht/month. Kerosene, relative to electricity, is more expensive for lighting, but one household in Mae Sae found the cost for installing electricity prohibitive. Electricity is only available to those villages along the main road.

Eight growers purchase charcoal for cooking, usually from local sources. Prices average 2 baht/kg. All growers reported that it had become more difficult to obtain

Table 5.14. Use of electricity and kerosene in the growers households.

Pa Pae/ Pang Ma Kuay

Use	Elec. Users	Average Cost/ month	Kerosene Users	Avg Cost/ month
lights only	3	10.0	0	0
lights and one appliance *	5	13.7	0	0
lights and two appliances	3	18.2	0	0
lights and three appliances	7	34.7	0	0
lights and four more	21	54.9	0	0

* appliances include fridge, TV, radio, rice pot, water pump, frying pan, iron, stereo, video, fan

Mae Mam

lights only**	0	0	11	144.5

** most households have radios which work on batteries

Mae Sae

lights only	0	0	2	15
lights and one appliance	2	6.5	0	0
lights and two appliances	1	25	0	0
lights and three appliances	0	0	0	0
lights and four/more appliances	1	320***	0	0

***this household also runs food shop

charcoal within the last two to three years. There are fewer people producing charcoal, and those who do make charcoal find it difficult to obtain suitable trees. Charcoal production is frowned upon by forest officials and charcoal producers were reluctant to be interviewed.

Almost all of the miang producers save the coals after the tea leaf is steamed and turn it into charcoal. Only six producers felt that the charcoal was not worth saving. The coals are placed into an airtight container (candy tins often used) producing small sized charcoal of medium quality. There is anywhere from 2.5 to 5.5 kg of coals remaining after the tea leaf is steamed which will last from 1 to 5 days for household cooking. Some growers give the charcoal to tea pickers for use in cooking.

Growers stated that most of their firewood for household use comes from the tea gardens. Maikaw was the preferred firewood, but relative to the firewood used for miang production, villagers were more willing to use other types of trees for firewood. Villagers generally had a good stock of small pieces of wood for household cooking. However, 10 growers did not have any firewood for household cooking at the time the survey was conducted as they were relying on charcoal left over from miang production.

Growers were asked if they were concerned about firewood supply. Seven growers do not use firewood for household cooking. Of the remainder, 28 were not concerned. For those 20 growers who were concerned: 13 were afraid that there would be no firewood in the forest for future use; 2 were concerned that it was difficult to find; and the 5 were concerned that it was difficult to find and they were afraid forest officers would catch them. Since some growers were afraid of forest officers, this indicates that some of the household firewood comes from the forest. All growers stated that household firewood comes from the tea gardens only.

5.10.1 Household Energy Consumption

Household energy consumption was calculated for firewood and charcoal only. Minor amounts of electricity are used for cooking rice and some households use minor amounts of LPG for quick cooking and warming.

Growers were asked to indicate the amount of firewood they used for household cooking in an average day, week, or month (whichever period they felt comfortable with). For charcoal consumption, growers were asked how many kilograms were left after each steaming, or how much they purchased last year. Based upon the amount of miang they produced in one year and the number of kams per steam, the approximate amount of charcoal remaining after miang was produced was calculated. Charcoal was measured during the stove tests to verify the results.

Household energy consumption rates for firewood and charcoal were difficult to obtain. Households often rely on charcoal left over from miang production. At the time of the study, miang was being produced and ten households did not have any firewood to measure as they were currently relying on charcoal for cooking. Eight households could not estimate how much firewood and/or charcoal they used, six households were eliminated from the analysis due to obvious over-estimations of energy use, and three were eliminated because incomplete information was obtained, leaving 28 reliable estimates of household energy consumption.

From the 28 reliable estimates, an average household consumed 0.407 m^3 of firewood and 99 kg of charcoal per member per year. This is approximately 160,260 $TOE/10^6$ of energy per person per year used in household cooking, excluding minor amounts of electricity and LPG used in some of the households. Energy consumption rates ranged from 67,680 to 287,129 $TOE/10^6$ per household member. Other studies generally find consumption rates of about 1.5 kg of wood per person per day (Wood and Baldwin, 1985) about 1 m^3 per person per year (207,218 $TOE/10^6$). The average miang producing household uses 872,012 $TOE/10^6$ of energy (3.84 m^3 of firewood) for steaming miang relative to 560,910 $TOE/10^6$ for household cooking.

5.10.2 Energy Use for Household Cooking by Non-Land Owners

One-third of the non-land owners use firewood, one-third use firewood and charcoal, and one-third use fuelwood and LPG for household cooking. LPG gas stoves were usually owned by the shop owners.

5.10.2.1 Fuelwood Supply for Non-Land Owners

Non-land owners in Pa Pae and Pang Ma Kuay largely utilize branches and dead trees collected from the tea gardens and forest. All non-land owners stated that relative to five years ago, it is now more difficult to obtain firewood: government banned cutting trees (47%); many people cut trees in the forest and trees grow back slowly (37%); and tea garden owners don't alow villagers to collect firewood in their gardens (16%). Most villagers reported that firewood collection became more difficult in 1987-88. Almost 80% of these villagers were afraid that there would be no firewood in the future, and half again were afraid that they would not be able to afford modern fuels for cooking. Almost 90% of the non-miang producers were not interested in planting trees for firewood because they had no land. Some villagers were interested in planting fruit trees in there compounds.

Most villagers who purchase charcoal for cooking were finding it very difficult to purchase adequate supplies. Fewer villagers are producing charcoal since the tightening of forest use. Charcoal sells for about 100 baht per 35-40 kg bag.

5.11 Awareness of Logging Ban

Given the impact of the logging ban on firewood supply, the growers' awareness of the ban was examined. All growers were aware that there was a logging ban, and all except two felt it was necessary. One grower felt the law was not necessary because they needed firewood for miang production and household use. The second grower expressed the same need, and further stated that the villagers protect the forest anyway and that there was no need for such a law.

The most common response (Table 5.15) for the need for a logging ban was that the trees must be protected in order to protect water supply (40%). The villagers were very concerned that if the forest is removed it will become hot and dry, and there will be no rain in the right season. Other reasons expressed for the need for this law include: if there is no law, many people would cut trees and ruin the forest (11%); need to protect the forest so the villagers would have firewood in the future (6%) and the next generation will have trees (6%); the forest protects them from floods (4%); prevent

Table 5.15. Are you aware there is a ban on cutting trees?

Yes: 55 No: 0

Is this law necessary?

No: 2

Why is this law not necessary?

1	they need firewood to produce miang and use in household
1	need firewood for miang production and household use, villagers protect forest anyway

Yes: 53

Reason

21	We must protect trees in order to protect water supply, if we cut the forest it will become dry, no water, hot, no rain in the right season
6	if they have no law, many people will cut trees, destroying the forest
3	need to protect forest so that we have firewood for miang and household in future.
3	if people from this generation cut, next generation will have no trees
2	protect forest which will protect us from floods
2	forest officer told him it is necessary
1	need law so that capitalist will not come to hire villagers to cut forest
1	if no law, people come from other villages, must protect forest for his village
3	no response

Law is necessary, but...

4 need to protect water supply, but difficult to get firewood because of this law

we need to protect against...

3 hilltribes

1 capitalists

but people who produce miang need firewood

2 officer catch local people, but not businessman, law must be fair

1 afraid there will be no forest in the future, but still need employment

capitalists and villagers from outside the area cutting the forest (4%). Nine of the villagers (17%) felt that the law was necessary to protect water supply, and to prevent hilltribes and capitalists from cutting the forest, but that they needed firewood for use in the household and for miang production. Two growers (4%) stated that the law must be fair- often the forest officer will catch the local villager, but not the businessman. Another two growers (4%) felt the law was necessary because a forest officer told them it was needed.

The overwhelming support by the growers for the ban on cutting the forest illustrates the importance of the forest to the villagers. Even though many growers are dependent upon the forest for miang firewood and are experiencing restricted access to the forest for firewood collection, they still support a law which is responsible for making it more difficult for them to obtain firewood. Villagers understand the importance of the forest for their well being and the need to protect the forest.

One half of the non-land owners felt the logging ban was necessary to protect the environment. If the forest is lost, the villagers thought there would be floods in the wet season and it would be drier in the dry season. One-quarter of the villagers stated that perhaps the law was necessary to protect the environment, but that people needed firewood. The remainder expressed a sense of helplessness as they stated that even if there is a law, the people will continue to cut trees.

5.12 Deforestation

Growers were questioned if deforestation was occurring in their Tambon. The results are presented in Table 5.16. In Pa Pae/Pang Ma Kuay, 46% felt that deforestation was not occurring, 41% felt is was, and the remainder did not know. Cutting firewood was the most common single cause of deforestation (69%) followed by several minor causes including house construction, swidden agriculture and capitalists cutting timber. The majority of growers who felt that deforestation was occurring, were concerned that it would be difficult to find firewood for miang production and household cooking and/or there would be no water or rain in the future.

Table 5.16. Is deforestation occurring in your tambon?

Pa Pae, Pang Ma Kuay

Yes: 16	No: 18	Don't know: 5
	Causes	
12	Many people cut firewood for household and miang production	
1	Cut trees to build house, for miang	
1	Cut trees to plant crops, build house	
1	Cut trees to plant crops, capitalist cut for timber	
1	Many people cut in forest, nobody reforest	

Are you concerned about deforestation?

Yes: 12	No: 4 (small ones grow up)
7	difficult to find firewood for household use and miang production
5	if we cut the trees there will be no water, rain will come in wrong season

Mae Mam

Yes: 7	No: 3 Don't know: 1
	Causes
7	many cut trees for firewood, young grow too slow

Are you concerned about deforestation?

Yes: 7	
3	afraid we will run out of firewood
3	afraid there will be no water, no wood
1	afraid there will be no forest

Mae Sae

Yes: 4	No: 1
	Causes
2	many people cut firewood
1	hilltribes cut to plant crop
1	increasing population

Are you concerned about deforestation?

Yes: 4	
2	afraid there will be no firewood, no forest
1	afraid for future, no firewood, conflict between villager and forest officer
1	afraid no firewood, will become hot and dry

In Mae Mam, 64% of the growers felt deforestation was occurring in their tambon, all due to firewood cutting. Several growers in Mae Mam were concerned about villagers from Pa Ping to their area to collect firewood. All these growers were concerned that there would be no firewood and/or water in the future. In Mae Sae, 4 of the 5 growers felt deforestation was occurring due to many people cutting firewood (2), hilltribes shifting cultivatand increasing population (1). All were concerned that there would be no firewood and/or water in the future. One grower was concerned about the conflict between villagers and forest officials. The remaining villagers in these villages generally did not feel deforestation was occurring.

Mae Sae had the highest percentage (80%) of villagers who felt that deforestation was occurring in their Tambon. This is not surprising given that slopes adjacent to the village have been cleared for crop cultivation. Forest officials prevented any further clearing for crops in 1984-5, but hilltribes close to Mae Sae continue to practice shifting cultivation. In Mae Mam, fewer villagers (64%) stated deforestation was occurring. Shifting cultivation was not observed near Mae Mam, or on the road from Mae Mam to Pa Pae (7 km). However, villagers coming from Pa Pae to collect firewood in the Mae Mam area have raised concerns about deforestation.

In the two largest villages, 41% of the villagers felt deforestation was occurring. Minor amounts of shifting cultivation are occurring right up to the edge of the tea gardens on the eastern edge of Pa Pae, and west from a Kuay and Pa Pae extensive areas of deforested areas lie within a few kilometres of the village. It is not known why there is such a relatively low level of concern about deforestation in Pa Pae and Pang Ma Kuay given the amount of deforestation that has occurred in the area. Forest officials stated that some shifting cultivation still occurs in these areas for field crops and opium production, but that the Sam Mun Project has drastically reduced the rates of deforestation. Pine plantations are also being established on deforested areas. Reduced rates of deforestation and planting may be responsible for the relatively low level of concern about deforestation in Pa Pae and Pang Ma Kuay.

One-third of the non-land owners in Pa Pae and Pang Ma Kuay did not feel that deforestation was occurring in their Tambon; almost half felt it was; and the remainder did not know. Half of those who stated that deforestation was occurring blamed it on miang producers, the remainder blamed it generally on people cutting trees and not growing new ones. Almost all the respondents who reported deforestation was occurring were concerned that the climate would become too hot and they would not be able to grow anything, and that there would be no firewood for cooking.

5.13 Social Forestry

Given the importance of the forest to the villagers, growers were asked if they had any special arrangements for protecting or managing local forest resources. During the miang producer survey, 80% reported that the villagers had no such arrangements. One grower in Pa Pae responded that the headman told them just to cut enough firewood for his needs and not to sell any. One grower in Mae Mam reported that they are not allowed to cut in others gardens. Nine growers in Pang Ma Kuay responded that officials encouraged them to plant fruit trees and coffee in order to reforest and to reduce firewood consumption by switching from producing miang to growing fruit trees. There have been no attempts by the villagers to organize to protect local forest resources.

5.14 Summary

The resource-use system was examined in this chapter using three different questionnaires, personal interviews and field observations. Fuelwood use and supply for green tea and miang production and household energy use were examined, emphasizing fuelwood supply problems. The perceptions and attitudes of the tea growers to the fuelwood supply and deforestation problem were also examined.

Miang production is an old and important practice in the uplands of Northern Thailand. Thai households utilize simple technology to produce miang (fermented tea) which is sold throughout the North. Miang production is largely a family activity; some producers hire hilltribe people and northern Thai to pick tea leaf, slash the ground cover in the tea gardens, or collect firewood.

Green and black tea production in Thailand is of relatively recent origin (1940s). Most green tea is produced in small, privately owned factories in the uplands employing

3-6 people. Relatively simple technology is used to produce low and high quality green tea (Chinese tea) for sell in Thailand. Tea leaves are collected by labourers from the owner's tea gardens and/or purchased from local smallholders. Most black tea is produced under intensive operations by Royco Foods, a tea plantation near Chang Doa. Royco Foods also buys tea leaf from local smallholders. Fuelwood is the major source of energy for tea production.

The average miang producing household consumes 3.84 m^3 of firewood annually to steam tea leaf for miang production (872,012 TOE/10^6). Most of this firewood is supplied by four species of oak and Schima wallichii. Prior to forest officials becoming more strict in 1987-88 regarding firewood collection in the forest, about 67% of the firewood for miang production came from forest. Currently, about 52% of the firewood comes from the forest.

Households use a combination of firewood, charcoal, electricity and LPG for cooking. Electricity is largely used for cooking rice and LPG is used for quick cooking and warming. Firewood and charcoal supply the vast majority of the energy needs for cooking in all households. An average household consumes about 560,910 TOE/10^6 of energy annually for cooking (0.41 m^3 of firewood and 99 kgs of charcoal per person per year).

Firewood for household cooking is collected from the forest and tea gardens. Most tea garden owners allow villagers to collect firewood in their tea gardens as long as they do not cut live trees. Relative to the firewood used in miang production, branches and dead trees provide a greater proportion of the firewood used in household cooking. Most charcoal for household cooking is purchased from local producers. Miang producers produce a medium quality charcoal from the coals left over from miang production which they use for household cooking.

Green tea factories use a combination of firewood, charcoal and heat from the sun for drying tea leaf. Charcoal is important for the final drying of high quality green tea (gives the tea a good flavour). Firewood is supplied by local villagers which is collected from the owner's tea gardens and the forest. Charcoal is largely purchased from local producers who produce charcoal from hardwood species which are largely collected from the forest. Energy consumption rates for green tea production could not be accurately calculated given the variety of tea drying methods used in the factories and the lack of detailed record keeping by the factory owners. However, rough calculations and energy consumption rates for drying tea in other parts of the world suggest that energy consumption for green tea production is twice that for steaming tea leaf during miang production.

Four-fifths of the miang producers are facing firewood supply and/or access problems. However, many producers can still obtain sufficient supplies and are not greatly concerned about the supply of firewood. When asked if there was an overall firewood supply problem in their village, just over one-third of the miang producers surveyed felt that there was a serious problem.

One-third of the miang producers and three quarters of the non-land owners were concerned about the supply of firewood for household cooking. Generally, these villagers were concerned that there would not be enough firewood in the future for household cooking. Charcoal is also becoming more difficult to obtain and labourers were concerned that they would not be able to afford modern fuels for household cooking.

Generally, the larger and more accessible the village, the greater the firewood supply problem is. The presence of forest officials was more prominent in the villages accessible by road. This official presence was reflected in the greater restrictions placed on firewood collection in Mae Sae, Pa Pae and Pang Ma Kuay relative to Mae Mam.

Tea factory owners are facing severe fuelwood supply problems. Local charcoal production has been severely reduced since forest use was restricted in 1987/88. Most of the suitable trees for charcoal production are available in the forest. Forest officials have pressured villagers to produce charcoal for their needs only and not for sell. Fewer villagers are willing to sell firewood and charcoal. In the past, factory owners obtained most of the charcoal from within Tambon Pa Pae. Now, however, villagers are having to search farther afield to secure supplies, especially charcoal, for use in the tea factories. Two factory owners stated they will have to close within the next 2-3 years if solutions to the fuelwood supply problems are not forthcoming.

The fuelwood supply problems for miang and green tea production, and household use are reflected in the price. Since 1987, the price of miang firewood has increased from about 1-2 baht to 2-3 baht per piece in 1990. The price of charcoal has increased from about 0.5 baht/kg to 2.5-3.5 baht/kg.

Although two-thirds of the miang producers felt there was not an overall firewood supply problem, 64% felt that deforestation was occurring in their tambon, largely due to firewood cutting. Most miang producers who felt deforestation was occurring were concerned that there would be no firewood for miang production and/or household use, and/or that the climate would become too hot for growing crops, there would be no water in the dry season, and there would be floods in the rainy season. Most growers felt that the logging ban was necessary to protect the forest which is important for protecting the environment and providing firewood, but some were concerned that it made it difficult for villagers to obtain firewood.

Relative to the miang producers in Pa Pae and Pang Ma Kuay, a greater proportion (50% versus 41%) of the non-land owners felt that deforestation was occurring in Tambon Pa Pae. Non-land owners were also concerned about household energy supply and the environment. A higher percentage (74% versus 35%) of the non-land owners also felt that there was an overall firewood supply problem in Pa Pae and Pang Ma Kuay. Tea gardens owners have a more secure supply of firewood and are less concerned about deforestation problems in the area. There was also less support among the non-land owners for the logging ban, reflecting their less secure position for securing firewood supplies.

Although the villagers blame deforestation on firewood collection for household use and miang production, this firewood collection certainly does not cause deforestation on the scale of swidden agriculture or logging. Firewood collection for miang tea production and household use may have degraded local forests, but it does not lead to large scale deforestation. As one forest official stated; 'they [the miang producers] collect a few trees here and there'. The intensification of firewood collection in the tea gardens threatens the sustainability of this traditional agroforestry system if improvements are not made in firewood use and supply.

Tea producers have been caught in the middle of their government's effort to protect the country's scant forests. Although some forest officials are sympathetic to the villagers needs and are allowing them to collect firewood in certain areas, there is a great deal of tension between the villagers and the forest officials. Many villagers expressed that their is a need for a solution to the firewood supply problem to release the tension and to remove this uncertainty from their livelihood.

Chapter 4 presented an inventory and assessment of the resource base. Chapter 5 examined the resource-use system, attitudes and perceptions of the tea growers, characteristics of fuelwood supply and the nature of the fuelwood supply problem. The understanding gained from examining the resource base and the resource-use system forms the foundation for assessing and expanding the range of alternative for resolving the fuelwood supply problem in the tea industry in Northern Thailand. The range of alternatives is examined in the next chapter.

Chapter 6: Alternative Approaches to the Energy Supply Problems in the Green Tea and Miang Industry: Evaluation

6.1 Introduction

The conceptual framework designed for this study (based upon White's work) examines the resource base (Chapter 4) and resource-use system (Chapter 5) in order to develop a foundation for evaluation. This chapter assess the range of alternatives for resolving the fuelwood supply problem in the tea industry in tambon Pa Pae. The proposed solutions for resolving the fuelwood supply problem for green tea production will be briefly examined before focusing on the proposed solutions for the miang industry.

6.2 Coping Strategies for the Green Tea Industry

Green tea processing consumes large quantities of firewood and charcoal for panning and drying the tea leaf. Firewood is purchased from local villagers who collect it largely from the forest. Firewood is a major concern for tea factory owners as villagers are less willing to sell wood to the factories since forestry became more strict about forest use. Charcoal is also increasingly becoming difficult to obtain and owners are having to go to more distant markets to obtains supplies.

Processing equipment for green tea production which utilizes modern energy sources, such as LPG and oil, are available, but their costs are prohibitive. Even ChaSiam, the most capital intensive tea processing operation in Thailand, relies on firewood for drying the tea, and will continue to rely on firewood for some time (Marley, pers comm). There do not appear to be any tea factories in Thailand utilizing modern energy sources for drying green tea.

Currently, the only feasible energy source for panning and drying green tea is firewood and charcoal. The tea factories in Tambon Pa Pae should propose to the Royal Forestry Department that they be allowed to develop a woodlot on deforested land using fast growing native species for firewood. Under current legislation, woodlots cannot be established within forest reserves but the RFD has made allowances in the past. Tea factories owners could take advantage of improvements in charcoal producing technology in Thailand (FAO, 1988). If miang producers increased firewood production from the tea gardens (part of the proposed solution to their energy supply problem which is discussed next) they could sell excess wood to the tea factories.

6.3 Coping Strategies for the Miang Industry: The Range of Alternatives

An important objective of the miang producer survey was to determine the current coping strategies being practised and evaluate other possibilities that might be tried, in other words evaluating and expanding the range of alternatives. Clearly, different strategies can be tried for different phases of the operation, which may be reinforced by official (government) support, or market response. Furthermore, a mix of strategies may be tried rather than any one in particular. Based on the survey, the responses given by miang producers to the energy problem are grouped as follows:

Do Nothing: Almost 65 per cent of producers who perceived firewood supply in their village as a serious problem did not know what to do about the matter and had done little if anything about it (this was almost two years after the ban). This was reinforced by official policy which banned access to the forests for fuel and offered no alternatives or solutions.

Other Energy: Another 16 per cent wanted to try other sources of energy but were not sure what. The majority were aware of the availability of coal but considered it unsuitable because of flavour damage to the leaves during curing. One grower had experimented with it but found it unsuccessful. Other modern fuels are far too expensive. Bhattachorya (1986) states that no substitution of fuelwood by modern energy sources in rural industry is likely in the near future because of the initial equipment cost and maintenance cost associated with such substitution, and also because the cost of useful heat energy is often less in the case of wood compared to modern energy sources.

Change in Activity: Diversification of production with intercropping and fruit production was considered a possibility by some, and had been encouraged in the past by agriculture officers. However, the government had not impressed producers with its follow-up activities and was therefore viewed negatively.

Cultivation Practices for Better Forest Regeneration: Over 60 per cent of producers were now being more careful with slashing practices in order to let seedlings develop in the tea gardens. This change in management practices is increasing successful forest tree regeneration in some of the tea gardens, but this would only provide fuel in a few years. This was also regarded as a shade enhancement practice as much as a way to improve fuel supply.

Clearly, the miang producers were faced with a difficult resources management issue. They produced tea on a close to sustained basis with simple technology and benefited from the higher income, but lacked sufficient income to use other sources of energy. They had impressive folk knowledge of the forests and had initiated some changes to cope with the new situation, but were obviously perplexed as to what to do next. Little active official assistance was forthcoming and resolving the issue was outside of the RFD mandate. Therefore, how could the information generated by the surveys and field observations assist the producers?

6.3.1. Improving the Range of Alternatives

A key feature of rational decision making methodology and hence natural resources management is that strategic decision making is most likely to be effective through an understanding of a decision maker's objectives, appropriate fieldwork to develop a database, evaluation and analysis of the data and the development of a plan of operation relevant to the producers' needs and capabilities. Therefore, the primary objective of the study is to evaluate and hopefully improve the range of strategies or alternatives necessary to cope with the short-run issue of fuel scarcity and plan for long run sustainability.

Assuming that doing nothing is not a viable option, it can be seen that strategies can be related to tea garden management practices (firewood supply) or the curing process (fuel efficiency). The fieldwork has generated data on:

(1) the tea gardens as an agroforestry system;

(2) producers' knowledge and strategies of agroforestry principles;

(3) fuelwood consumption and curing methods;

(4) producers' incomes, approximate profits, available capital;

(5) availability and quality of outside assistance;

(6) local initiatives to resolve the problem.

Thus, the existing range was:

Alternative	Comments
do nothing	many villagers did not know what to do
explore other energy supplies	a few trials were not successful, modern energy supplies are too expensive
reduce firewood use	limited results (remove unburnt pieces from firepit after steaming is complete)
change use/activity	a long run probability if all else fails, however, external support is poor, few villagers interested
improve cultivation practices	local initiative, some success in increasing forest tree regeneration

Given the information developed from the field study and subsequent analysis, what improvements to the range of alternatives appear feasible and compatible with the needs and capabilities of the producers?

6.4. Proposed Solution to the Energy Supply Problems in the Miang Industry

The proposed solution to the firewood supply problem facing miang producers emphasizes developing solutions which are within the ability of the growers to implement without large labour and/or monetary demands. A four part strategy is proposed which takes advantage of innovative practices developed by the villagers and the natural regenerative capability of the tea gardens. These strategies should ensure that the growers have a sustainable, and hopefully secure, energy supply from their tea gardens.

6.4.1 Strategy One: Reduce Firewood Use

One of the obvious solutions to the firewood supply problem was to reduce firewood use through greater efficiency in steaming the tea leaf. The traditional firepit (Figure 6.1) has been used for centuries and is somewhat inefficient. The large opening in the front of the taopung results in substantial heat loss and the below ground construction and lack of draft in some of the firepits results in a cool fire and inefficient combustion.

A more energy efficient system for steaming tea leaf was found, almost by accident. While visiting ChaSiam, the largest black tea estate in Thailand (outside study area) it was found that there were several miang producing villages in the area. One day was spent visiting some of these villages to see if they were experiencing firewood supply problems similar to those in the study area. Mae Maet was the first village visited, which is about 70 kilometres from Tambon Pa Pae.

The headman of Mae Maet was contacted first. In his workshop, it was found that the taopung was filled in with dirt and a large bucket stove and aluminum steamer (Figure 6.1) were being used to steam the tea leaf. The bucket stove has been used in Thailand since the turn of the century (Wood Energy News, 1991). The headman claimed a firewood supply saving of 60% from this new system which he had been using for 3 years.

During the visit to Mae Maet, the significance of this system was not realized. At this period in time only a few households in the study area had been visited. These households were all using the taopung and it was assumed that the system observed in Mae Maet was also being used in the study area. After a few more weeks of research, it was realized that nobody in the study area was using this new system and there was a strong indication that nobody even knew about it.

In order to find out more about the system observed in Mae Maet, the headman was visited a second time. It was discovered that after the RFD became more strict about firewood collection from the forest in 1987, the headman had began to search for ways to reduce firewood use. The headman adopted the large stove and aluminum steamer used in food shops in nearby towns for steaming rice and noodles, to miang production. He built a stove (Figure 6.1) based upon the design of the bucket stove.

The headman bought a used 17 inch diameter aluminum steamer. After some experimentation he found that he could steam about 60 kams (packed tea leaf) in one batch. It took about 25 minutes to steam the tea leaf and two batches were needed to match previous processing capacity. It took slightly longer to steam the tea leaf, but it was far more energy efficient. The last year the headman used the traditional system, he used 300 pieces of firewood. The following 2 years he used about 100 pieces per year using the new system, processing about the same amount of tea leaf-- over a 65% saving in firewood. Most of the 60 miang producers in this village were using this new system for steaming tea leaf.

It was important to verify the results of the new system (hereafter referred to as the miang stove). A stove and steamer were bought in Chiang Mai for 900 baht (Figure 6.1). Over a two week period, 5 household tests were conducted with villagers in Pa Pae and Pang Ma Kuay. Due to the variability in traditional stove construction, 15 different taopungs were tested. More tests would have been preferred for both systems, but tests were conducted near the end of the tea picking season in October and tea processing was near completion.

To test the two different systems, firewood weights were recorded before and after processing took place. The households were visited on the day tea leaf was being picked and the day after. During the first visit, growers were asked to lay out the amount of firewood they would be using that night. The villagers were requested to use maikaw if it was available. The volumes and weights were recorded and the growers were asked to place the left over wood beside the firepit so that it could be measured during the return visit. A 16 kg scale rented from a local shop owner was used for weighing tea leaf and firewood. The scale was tested for accuracy prior to the tests.

Tea leaf weights for the taopung tests were difficult to obtain. The tea leaf did not arrive until late afternoon the day processing was to occur. The owner of the household often had the fire ready and as soon as the leaf arrived it was packed into the tang and processing began. Therefore, the growers were asked to record the number of

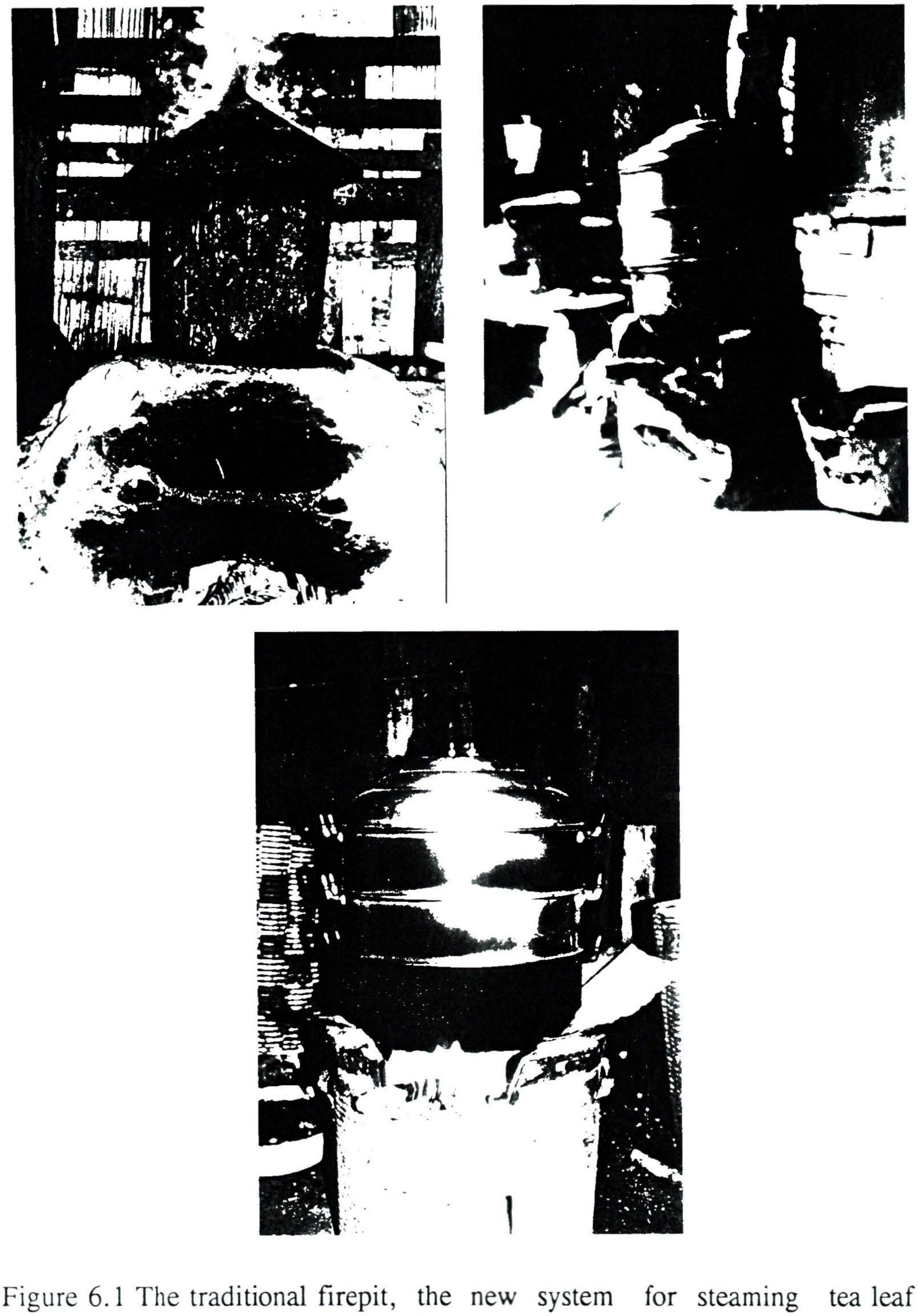

Figure 6.1 The traditional firepit, the new system for steaming tea leaf developed by a villager in Ban Mae Maet, and the bucket stove and aluminum steamer purchased in the market for the stove trials.

processed kams which was obtained during the follow up visit. Although kams are hand packed by each household they are very similar in size (miang is purchased from these villagers by a few middlemen, resulting in a standardization of the size of kams). More control was maintained over the miang stove tests. The researcher was present from start to finish and the weight of the tea leaf could be easily recorded.

There was a great deal of variability in firewood use among the taopung tests: rates of firewood use ranged from 10.23 kg/100 kams to 40.17 kg/100 kams (Table 6.1). The higher consumption rates occurred when producers did not process full batches of miang. Therefore, those stove tests which processed less than 90 kams were eliminated from the calculations for firewood use, reducing the upper consumption rate to 19.38 kg/100 kams. The remaining variability in rates of firewood use is largely due to slight variation in the design of the taopungs and variability in care tending the fire. The average rate of firewood use for the taopung is 13.5 kgs of wood per 100 packed kams.

There was less variability in rates of firewood use in the miang stove tests (Table 6.2). Four of the trials were between 5.08 and 5.45 kg of firewood per 100 packed kams. In one trial, the rate of firewood use dropped to 4.2 kg /100 kams. In this trial a 75 year old miang producer tended the fire with great care, reducing the amount of firewood which was consumed. The average rate of firewood consumption for the five trials was 5.1 kg/100 kams. This is a 62% saving relative to the traditional stove. In the traditional stove trials where the weight of fresh leaf was known, firewood savings averaged 64%, confirming that packed kams tend to be a standard size between households.

One important consideration, in addition to firewood consumption, was the amount of time required to process the miang. Less tea leaf can be processed at one time using the new system relative to the traditional methods. However, tea leaf is steamed faster and the overall length of time to steam an average day's picking of 100-125 kams is only 10 minutes longer using the new method (115 minutes versus 105 minutes). There is, however, an additional problem. This 100-125 kams is an average day's processing in the third and fourth picking when tea leaf production declines. During the first two pickings, some of the larger households use tangs which process up

Table 6.1. Summary of taopung tests.

Trial #	# kams	kgs of wood	kgs/100 kams
1	133	13.6	10.23
2	90	12.2	13.56
3	150	15.1	10.07
4	202	30.0	14.85
5	90	14.4	16.00
6	180	19.0	10.56
7	45	9.8	21.78 *
8	70	14.1	20.14 *
9	174	21.2	12.18
10	60	24.1	40.17 *
11	140	16.4	11.71
12	129	25.0	19.38
13	105	19.7	18.76
14	131	14.0	10.69
15	150	21.1	14.07

Average firewood use (steamed tea leaf)

(kindling not included)

n = 12 162.06/12 = 13.51 kgs per 100 kams

* < 90 kams eliminated from calculations

kams per tang = 125 on average

Table 6.2. Summary of miang stove trials.

Trial #	Fresh Leaf (kams)	Steamed Leaf (kams)	kgs of wood	kgs/100 kams *
1	108	124	5.2	4.20
2	117	134	7.3	5.45
3	90	108	6.1	5.65
4	90	108	5.5	5.09
5	100	118	6.0	5.08

* packed kams

Note: fire attended closely in trial one

Firewood use for miang stove (packed kams)
(kindling included)

n = 5 = 5.1 kgs per 100 kams

Summary: Miang Stove vs Taopung

Taopung Stove

n = 12 13.5 kgs of wood per 100 kams (steamed)

Miang Stove

n = 5 5.1 kgs of wood per 100 kams (steamed)

Firewood Savings = 62% with miang stove

Note: for those stove tests where the weight of fresh leaf was known, the miang stove used 64% less firewood.

to 250-300 kams at once. These households were concerned about the amount of time it would take to steam tea leaf. There is one larger steamer (20 inch) available on the market. Adjustments will have to be made to processing methods during the first two pickings if the large households wish to use this new system. Steaming times will become longer, but while waiting for the leaf to steam, the producers can be packing kams.

In addition to large firewood savings, there are other advantages of the new system for steaming tea leaf. The growers taking part in miang stove trails commented that the new system produces a better quality product and the individual levels in the steamer help to separate pickers' tea leaf. The stove also allows smaller pieces of firewood to be used, favouring the use of some trees which are difficult to split into the long pieces traditionally used. The stove and steamer can also be used for other things, such as steaming sticky rice, while the traditional firewood pit has only one function.

To help promote this technology, a one-day workshop was organized. The Social Research Institute of Chiang Mai University helped to coordinate the planning of the workshop, in cooperation with the Tambon Council in Pa Pae. The Council was encouraged to take a leading role in its development which would encourage greater village participation. The workshop was held on November 22, 1991 at the Buddhist temple in Pa Pae. The headman and 6 villagers from each of the 12 village groups in the Tambon were invited to the workshop. In addition, government officials attended, including a forestry official from a local watershed protection office and 2 assistant district officers from Mae Taeng District. There was also a NGO representative from a group concerned with forest conservation. Total participation was over 100 people.

The activities of the one-day workshop are outlined in Table 6.3. Posters were developed outlining the cost of the new system, and the amount of time and firewood use for the traditional firepit and the miang stove. Three villagers from Mae Maet were brought to the workshop to demonstrate the technology. To help promote this technology, the two stoves and steamers used during the workshop were given to villagers who helped in the original stove tests.

Table 6.3. Schedule of the one-day workshop demonstrating the miang stove and aluminum steamer.

Time	Activity
09.00-09.30	registration
09.30-10.00	opening statements by kamnan of Tambon Pa Pae and the secretary (coordinator of workshop for Tambon council)
10.00-10.30	presentation by forest official on basic knowledge of use and conservation of forest resources
10.30-10.45	break
10.45-11.20	group discussion about problems of miang production
11.20-12.20	summary of discussion by representative from each group
12.20-13.30	lunch
13.30-13.50	summary of problems in miang production for Tambon Pa Pae
13.50-14.50	demonstration of stove and steamer and explanation of this system's efficiency
14.50-15.30	general explanation about new equipment and ways to solve long term firewood problems for miang production

The results of the workshop are very promising. After the workshop, villagers in Pa Pae and Pang Ma Kuay approached their respective headman expressing their wishes to use this new system. They hoped that somebody could approach a manufacture in Chiang Mai to produce a steamer more suited to their needs and at a discounted price. The kamnan (leader of Tambon Pa Pae) has agreed to organize a committee to pursue this initiative. Stoves can be easily built by the villagers at a minimal cost.

Correspondence between villagers in Pang Ma Kuay and Canada during the following year after the miang stove was introduced indicated that there is widespread interest in the new system. Many villagers have been visiting the households where the demonstration stoves were left and their is strong indication that many will be adopt this system.

A brief note on the flow of information between villages. Villagers in Pa Pae had relatives in Mae Maet, but the new method for steaming miang was not transferred between the two villages. This illustrates the important role opinion leaders can play in Thai villages (Kaosa-ard et al, 1989). In Mae Maet, the headman is well respected and was instrumental in developing the new system for steaming tea leaf, and for encouraging other villagers to adopt this system. A smaller version of the aluminum steamer was observed at the headman's house in Pa Pae, but it was never attempted to adopt the steamer for processing miang.

6.4.2 Strategy Two: Increasing Natural Firewood Productivity in the Tea Gardens

The second strategy for resolving the firewood supply problem was also initiated by the villagers. The tea garden plots reveal that there are various native tree species regenerating well within the tea gardens. Four species, in addition to the commonly used firewood species 'maitalo' and 'maikaw', are relatively frequently found in the understorey of the vegetation plots (see Table 4.14). All except one of these species can be used for miang firewood, albeit they are not the same quality as maikaw and maitalo. These species are, in part, relatively numerous due to changes in management practices of the growers. All the tea garden owners interviewed, and over half (60%) of the respondents in the miang producer survey, stated that they took more care when slashing ground cover to avoid killing young forest trees. Growers changed their slashing practices in response to pressure placed upon them by forestry officials not to cut firewood in the forest. This change in management has led to increased forest tree growth in some of the tea gardens.

Growers should be encouraged to take greater care when slashing the tea gardens to protect young forest trees. In areas where seedlings are numerous, growers should thin and move the seedlings to areas where there are few tea and forest trees. This strategy to increase firewood productivity in the tea gardens takes advantage of the natural regenerative capability of the forest and of modifications to management practices initiated by the villagers, and places no monetary demands and low labour demands upon the villagers.

6.4.3 Strategy Three: Planting Firewood Trees in the Tea Gardens

Planting trees is a commonly proposed solution to firewood shortages. This solution is only proposed here to meet firewood shortfalls after the first two strategies have been implemented. If the new system for steaming tea leaf is adopted and natural firewood production from the tea gardens is increased, many growers may not need to implement this third strategy. If they do, however, this strategy will not place a large labour or resource demand on the growers.

There are several things present within the villages which favour the success of this third strategy. First, the villagers are already familiar with the technology of growing trees- tea trees are commonly grown for out planting in the tea gardens. Secondly, many growers collect the seed of their favourite firewood tree, the oaks, for eating. Third, there are large areas in the tea gardens where there are few forest and tea trees where firewood trees could easily be planted.

Currently, there is a project at Chiang Mai University studying seed germination of native tree species. At the request of the researcher, the project leader has agreed to include some of the oaks in its study. Methods to germinate seeds from native tree species will aid villagers wishing to grow trees for firewood or for use in agroforestry systems.

In all likelihood, there are fast growing native tree species which could be used for firewood plantings to meet rural energy needs. Hopefully, projects involved with social forestry, such as the Sam Mun Highland Development Project which is promoting agroforestry methods at the village level, will promote the use of native trees. The Director of the Resource Development Program at Chiang Mai University heads the social forestry component of the Sam Mun project and is extremely interested in the frequently occurring native species found in the tea gardens. The director hopes to promote local tree species in village level projects. Currently, the Royal Forestry Department encourages the use of fast growing eucalyptus trees for firewood which have been introduced from Australia.

There are, however, two potential barriers to miang producers planting trees for firewood. During the miang producer survey, growers were asked if they would be interested in planting trees to meet firewood needs. The results of this question are very surprising. Just barely one third of the growers (35%) stated that they would be interested in planting trees, all favouring local trees, especially maikaw. Almost two thirds of the growers (36) reported that they were not interested in planting trees to meet firewood needs, largely because 'they grow up from nature' (86%). Given that the 10 growers who are not facing any firewood supply problems ('no problem' profile) are not interested in planting trees, 26 growers who are suffering from firewood supply and/or access problems do not perceive planting trees for firewood as a solution to the firewood problem. Even though the villagers are familiar with tree seedling technology and they often collect seed from the oak trees, their favourite tree for firewood, almost half of the growers do not perceive growing trees for firewood as a solution to their firewood supply problem. This barrier would have to be removed through education.

Insecure land tenure may prove to be another barrier to planting trees for firewood. Villagers may not wish to invest resources into growing trees for firewood if they are in danger of losing their land. Although it does not appear that the Thai government will remove the villagers from the forest reserves, this issue must be addressed, especially due to the land tax problem in Tambon Pa Pae. As demonstrated in the miang producer survey, almost one third of the growers were afraid that the government will expropriate their land. This discourages villagers from investing in long term improvements in their tea gardens.

6.4.4 Strategy Four: Volume Tables

The fourth and final strategy to resolve the firewood supply problem requires further research which should be conducted by the Royal Forestry Department. Simple growth tables showing the volume for common firewood species at yearly increments of growth should be developed so that growers can calculate the amount of growing stock they would need to develop a sustainable supply of firewood. This work should be based upon the local species found in the tea gardens which are suitable for firewood. These tables would help the villagers coordinate their firewood growing strategies.

6.4.5 Summary

The proposed solution to the firewood supply problem is summarized in Figure 6.2. This strategy has several major advantages-- it utilizes local knowledge and resources to develop solutions, and places relatively low resource demands upon the villagers. The largest monetary cost will be the aluminum steamer and the largest labour demand will be if villagers need to plant firewood trees to supplement natural regeneration in the tea gardens. This solution will be more successful if the RFD develops growth tables for firewood production based upon native species. In addition, the RFD should allow growers to collect firewood in the forest until their supply in the tea gardens can be developed.

Another major advantage of this solution is that villagers will have a sustainable supply of energy for miang production and household needs which will be within their control (assuming land title problems are eventually resolved in the villagers' favour). The growers will no longer have to depend upon the forest for large quantities of firewood. This will help preserve local forests, if they can be protected from swidden agriculture and illegal logging, and help protect these important upland watersheds. A sustainable supply of firewood from the tea gardens will also preserve the forest cover within the tea gardens, which is an important source of forest products. This forest cover

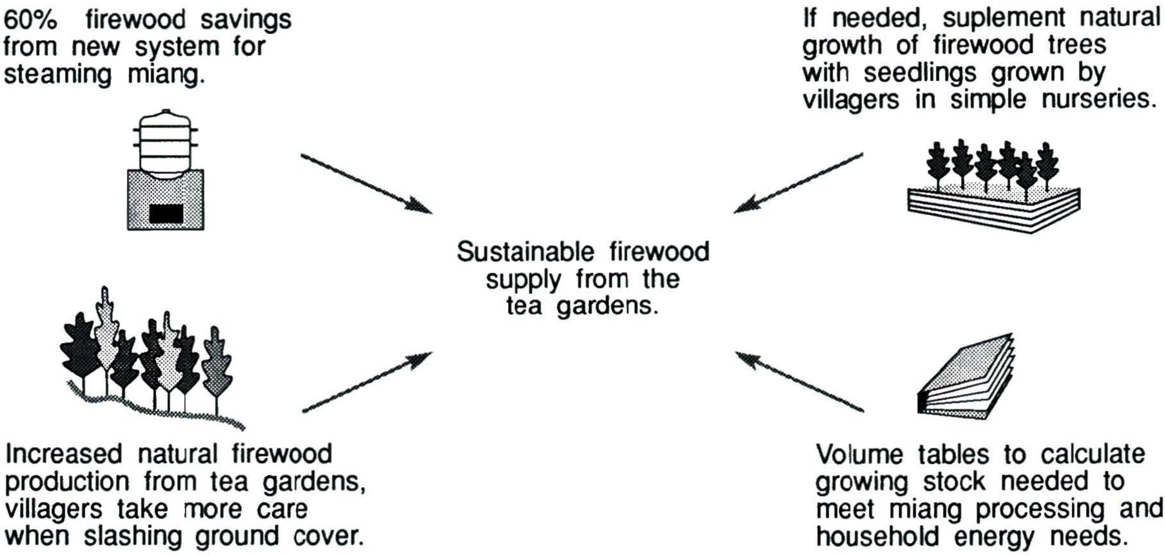

Figure 6.2 Four- pronged strategy to resolve the firewood supply problem experienced by miang producers.

also provides shade for the tea trees which is important for tea leaf productivity and for maintaining the long term productivity of this agroforestry system. As noted earlier, forest cover in the tea gardens should also be increased to improve the overall health of this agroforestry.

Consequently the range of alternatives were now amended with the following:

Alternative	Comments
improved curing process	60 per cent firewood saving- local and relatively cheap technology
increase firewood production by growing firewood seedlings	villagers familiar with technology, collect seed from favourite firewood tree, open areas in tea gardens for planting, some education needed
improved management practices to care for natural tree seedling reproduction	local initiative practised by over 60% of the miang producers
use of growth volume tables to help coordinate firewood supply strategies	these tables should be developed by the RFD based upon local species which are suitable for firewood

To illustrate how this system will work and the scale of firewood plantings needed, the average miang producer:

* consumes 3.84 m^3 of firewood per year, if the miang stove is used this is reduced to 1.54 m^3;

* farms 33 rai of tea gardens;

* average tea garden has 38 trees in the understorey, assume one quarter of these trees can be used for firewood when they reach a suitable size, this equals about 9 trees x 33 rai = almost 300 trees;

* a 15 year old *Eucalyptus camaldulensis* produces about 0.17085 m^3 of firewood (FIO, 1986);

* assuming that the 300 trees available in the tea garden are evenly distributed in age classes, and it takes 15 years to grow to a harvestable size, then there would be 20 trees or 3.4 m^3 of firewood available each year, more than enough to meet the firewood needs of an average miang producer.

These estimates, however, are based upon a fast growing species. The oaks are at least 3 times as slow growing as the *Eucalyptus camaldulensis* (Maxwell, pers comm). This being the case, there would only be about 7 trees available each year from natural regeneration-- a shortfall of about 2 trees per year (0.34 m^3). This analysis shows that there is ample opportunity for the miang producers to develop a sustainable supply of firewood from their tea gardens. Some growers may have to plant trees, depending upon the success of natural regeneration within their tea gardens (assuming miang stove is adopted). With simple volume tables, villagers can increase firewood production by either block planting native species suitable for firewood in the tea gardens, or planting trees along tea garden borders and in their compounds. By adopting the miang stove, taking advantage of the natural regenerative capability of the tea gardens by taking better care when slashing the ground cover and planting seedlings (if needed), developing a sustainable supply of firewood should not place large labour or monetary demands on the miang producers. Tea gardens owners should also cooperate with non-land owners to allow them to establish trees for household use.

6.5 Overview

This chapter has outlined the range of alternatives for resolving the fuelwood supply problems in the tea industry in Tambon Pa Pae. Fuelwood will continue to be the primary source of energy for tea processing as modern energy sources are far too expensive. By taking advantage of improvements in charcoal producing technology and developing woodlots, factory owners should be able to develop a reasonably priced and secure supply of fuelwood. The Royal Forestry Department must be approached for permission to develop woodlots which are illegal in forest reserves. A four part strategy which takes advantage of innovations developed by the villagers (fuel efficient stove, improved tea garden management practices) and the natural regenerative capability of the tea gardens, provides a good opportunity for miang producers to develop a sustainable supply of firewood from the tea gardens without large monetary or labour demands. The RFD should allow the miang producers to collect part of their firewood needs from the forest until firewood production in the tea gardens can be increased. We will now turn to the final chapter which will summarize the major findings of this study and offer some conclusions and recommendations concerning the approach adopted in this study, the tea gardens as an upland agroforestry system, fuelwood use and supply for tea production, land tenure and labour supply problems, and the future of miang and green tea production in the uplands of Northern Thailand.

Chapter 7: Summary and Conclusions

7.1 Introduction

This final chapter will briefly review the objectives of this study, how it was structured and the methods of data collection. The major findings of the study will then be summarized before turning to the conclusion and recommendations.

7.2 Objectives, Conceptual Framework and Research Design

This research took place in the uplands of Northern Thailand in Tambon Pa Pae, Chiang Mai Province. The objectives (briefly) were to describe and understand the tea gardens as an upland agroforestry system; assess the health of the tea gardens; examine miang and green tea production, fuelwood consumption and supply; and expand the range of alternatives for resolving the fuelwood supply problems in the tea industry.

Drawing upon hazard research in general, and more specifically Gilbert F. White's (1972) study of domestic water use in East Africa, this study was structured as follows:

1) define the nature of the problem:
   resource scarcity (fuelwood supply shortage);

2) examine the resource base:
   tea gardens (upland agroforestry system),
   management practices;

3) examine the resource-use system:
   miang and green tea production, fuelwood consumption and supply,
   attitudes and perceptions of the tea growers;

4) evaluation:
   what are the current coping strategies;

5) recommendations:
   expand the range of alternatives for resolving the resource-scarcity problem.

Once the objectives were defined and the study was structured, physical and social survey data collection techniques were used to provide the primary data needed to complete this study. To study the resource-base, fixed boundary vegetation sampling plots from 0.5 to 1.5 rai in size were used to examine the biophysical characteristics of the tea gardens. Interviews with tea garden owners were used to examine management practices and how they influenced the structure of the tea gardens. Written questionnaires done interactively with miang producers, nonmiang producers and tea factory owners were used to study tea production and fuelwood supply and consumption (resource-use system). These questionnaires also collected information regarding the socioeconomic characteristics of the villagers and attitudes and perceptions of the tea growers regarding fuelwood use, deforestation and other resource-use problems. Field observations added valuable information and helped interpret the data collected by these other methods. All this data provided the foundation from which an evaluation of the problem and recommendations could be made. Comments on study design, the major findings of this study, conclusion and recommendations will now be examined.

7.2.1 Comments on Study Design

The conceptual framework used in this study helped to structure and identify the relationships between the various components of the topic under study. White's strategy for expanding the range of choice by (1) completing an inventory of the resource base and (2) interviewing resource users was an effective approach for studying the fuelwood supply problem in the tea industry in Northern Thailand.

The use of a variety of data collection methods provided a flexible research design. This was critical given the complex nature of the study, different cultural setting where the study was to occur and unknown field conditions. The research design was able to adapt to field conditions and a large amount of data were collected within a relatively short period of time at minimal cost.

Much of this research was completed with the assistance of an interpreter. Working with interpreters slows data collection and sometimes limits the depth of information which can be collected. Probing for information can, at times, be very difficult. Patience is an important virtue when working with interpreters.

Approximately four of the six months in Thailand were spent living in the villages selected for study. Village life was very open and friendly and the researcher was invited to participate in village activities. This quasi-participant observation deepened the researcher's understanding of the traditional tea industry and the fuelwood supply problem, and helped to overcome cultural bias. Some villagers commented that they were 'happy that you come all this way to help us with our problem'. Gaining the trust of the villagers was critical as many were nervous about the research due to the sensitive nature of the fuelwood supply problem. In addition, businessmen have been trying to buy up the tea gardens, causing the villagers to mistrust outsiders.

7.3 Summary of Major Findings

7.3.1 The Tea Gardens: The Resource Base

The tea gardens in Tambon Pa Pae have been established in a mixed deciduous-evergreen monsoon forest between the elevations of 800 and 1100 metres. Tea gardens are developed by thinning the forest cover, slashing the ground cover and increasing tea tree density by planting seeds or seedlings. Over time, the forest cover is further reduced to meet the firewood and construction needs of the villagers. The vegetation plots reveal a great deal of variability in forest cover and tea tree stocking. Tea tree density is as high as 338 trees/rai, one quarter the density of the commercial plantings on ChiSiam's black tea estate. Crown cover in the vegetation plots ranges from 60 m^2/rai to 450 m^2/rai. Species diversity in the plots ranges from 2 in a 0.875 rai plot, to 18 in a 1.0 rai plot. In the 1.64 ha of tea gardens sampled, there are 60 tree species from 53 genera and 35 families; 50% are deciduous, 48.3% evergreen, 1.7% tropophyllos; and 63.8% are primary trees and the rest secondary. Overall, the tea gardens have 33% of the density and 37% of the diversity of a similar, relatively undisturbed forest in Doi Suthep-Pui National Park.

The traditional agroforestry system used for producing tea in N. Thailand is a low input system. Most tea trees have been established by the growers planting seedlings or placing seed from indigenous tea trees directly in the soil. Once established, the tea trees receive little care. Most growers top prune their tea trees and remove climbing vegetation, but only a few side prune. Grazing cattle help control ground cover growth and provide some fertilizer. Artificial fertilizers or biocides are not used and limited intercropping of fruit trees occurs. The most labour intensive task is slashing the ground cover.

The forest cover performs numerous important functions in this system. Forest cover prevents soil erosion, provides shade for tea trees, conserves soil moisture during the dry season and provides many useful products for the villagers. Growers often protect trees in the tea gardens which provide useful products and utilize most trees which are thinned or die naturally. Most of the large trees in the tea gardens are found on the upper slopes and there is evidence that the villagers are moving up slope in their search for timber.

The ground cover in the tea gardens is diverse with a mixture of remnants of the original ground cover and invading species. The thinning of the forest cover and regular disturbance of the ground cover by slashing has encouraged the establishment of ground flora which prefer sunnier conditions and/or can tolerate disturbed conditions. The mix of native and invaders depends upon the amount of forest cover remaining in the tea gardens and the amount of disturbance to the forest floor. Some gardens have largely native ground cover, some have largely weedy ground cover and some were mixed.

Some of the invading ground flora can become serious problems, requiring frequent slashing to reduce competition for the tea trees and to allow easy access to the gardens by labourers. The thick growth of the weedy ground cover can hinder forest and tea tree regeneration and the slashing required to keep the ground cover under control often kills young trees that do happen to regenerate. Grazing cattle also kill young saplings.

Based upon ground cover and forest tree regeneration, 7 of the 13 gardens in which vegetation plots were located are not considered healthy. Weedy ground covers and/or a lack of forest tree regeneration indicate that the health of the tea gardens is declining.

Despite this unfavourable diagnosis for the tea gardens, evidence suggests that the health of the tea gardens could be improved. The understorey is more diverse and numerous than the upper canopy, indicating that the forest cover is regenerating. Secondary growth trees are more numerous overall, illustrating the effect thinning the forest cover has on forest composition, but primary tree species outnumber secondary growth species 2:1, indicating that the forest cover is retaining characteristics similar to the original forest cover (primary species dominate upper canopy). Almost 70% of the miang producers felt that tea leaf productivity is the same or has been increasing over the past decade.

7.3.2 Tea Production: The Resource-Use System

Miang production is an old and important practice in the uplands of Northern Thailand (dates back to at least 700 A.D.). Tea producers utilize simple technology to produce miang (fermented tea) which is sold throughout the North. Miang production is a household activity; some producers hire hilltribe people and northern Thai to pick tea leaf, slash the ground cover in the tea gardens, or collect firewood.

Green and black tea production in Thailand is of relatively recent origin (1940s). Most green tea is produced in small, privately owned factories in the uplands employing 3-6 people. Relatively simple technology is used to produce low and high quality green tea (Chinese tea) for sale in Thailand. Tea leaves are collected by labourers from the owner's tea gardens and/or purchased from local smallholders. Most black tea is produced under intensive operations by Royco Foods, a tea plantation near Chang Doa. Royco Foods also buys tea leaf from local smallholders.

7.3.3 Fuelwood: The Primary Source

In 1985, 43% of total energy consumption in Thailand was in the form of traditional fuels (Dang, 1989). In 1983, rural areas accounted for 50% of total energy consumption, most of which was supplied by traditional fuels (Wibulswas, 1986). Household energy consumption was half of the total energy consumption in rural areas, largely supplied by firewood and charcoal (Wibulswas, 1986). Cooking is the largest consumer of energy in the household, most of which is supplied by fuelwood. Fuelwood supplies about 30% of the total energy needs of the country (TDRI, 1987).

Fuelwood is also the primary energy source for numerous rural industries which consume about 40% of traditional fuels in Thailand (World Bank, 1985). In the tea industry, fuelwood supplies all the heat for drying tea leaf during green and black tea production, and firewood is used to steam tea leaf during miang production. Traditional fuels will continue to be a major source of energy in Thailand during the next two decades (Wibulswas, 1986; Dang, 1989).

Fuelwood use was measured for household cooking, miang production and drying tea. The average miang producing household consumes 560,910 TOE/10^6 of energy for household cooking (1.43 m^3 of firewood and 346 kg of charcoal) and 872,012 TOE/10^6 for miang production (3.41 m^3 of firewood). Twice as much energy is needed for drying tea leaf for green tea production relative to steaming the same amount of leaf for miang. In terms of ranking total energy used in these activities in the villages selected for study, miang production consumes the largest amount of energy, closely followed by household cooking. Fuelwood consumed in the tea factories is about one third of that consumed for either household cooking or producing miang.

Miang producers largely use live trees 20 to 30 cm in diameter, half of which are obtained from the forest. The oaks and Schima wallichii are the most commonly used and preferred firewood. A larger variety of species and greater proportion of branches are used for household cooking. Tea factories also use a mix of species and size of firewood which is obtained largely from the forest. Tea factories also rely upon charcoal for drying high quality tea leaf.

There were variations in the severity of the fuelwood supply problem between the villages selected for study. In Mae Sae, forest officials became strict about forest use in 1985, three to four years earlier than the other villages. Swidden cultivation was banned close to the village and firewood could only be collected in the forest far from the village. Producers in Mae Sae get the largest proportion of their firewood needs from the forest. Even though forest officials have compromised, all the producers reported supply and/or access problems and 40% felt there was an overall firewood supply problem in their village.

Relative to the other villages, the firewood supply problem is less serious in Mae Mam: fewer miang producers reported supply and/or access problems (64%) or an overall firewood supply problem (27%). Growers were also much less concerned about killing saplings when slashing the tea gardens and were more willing to indicate the forest as a source of wood for miang production. Firewood for household use was also less of a concern relative to the other villages. However, villagers are concerned about people coming from Pa Pae to collect firewood in the forests near Mae Mam. This relatively favourable firewood supply situation for villagers in Mae Mam is due to its relative isolation and the lower presence of forest officials. Overall, villagers in Mae Mam enjoy better access to forest resources.

Pa Pae and Pang Ma Kuay reported the most severe firewood supply problem. Almost all growers (85%) are suffering from supply and/or access problems and 40% felt there was an overall firewood supply problem.

Overall, four-fifths of the miang producers are facing firewood supply and/or access problems. Distances to firewood supplies have doubled since 1986 and over half of the growers reported declining productivity in their gardens. However, many producers can still obtain sufficient supplies and are not greatly concerned about the supply of firewood. When asked if there was an overall firewood supply problem in their village, just over one-third of the miang producers surveyed felt that there was a serious problem.

In Pa Pae and Pang Ma Kuay, one-third of the miang producers and three quarters of the non-land owners were concerned about the supply of firewood for household cooking. Generally, these villagers were concerned that there would not be enough firewood in the future for household cooking. Charcoal is also becoming more difficult to obtain and labourers were concerned that they would not be able to afford modern fuels for household cooking.

Tea factory owners are facing the most severe supply problems. Villagers are less willing to sell firewood and charcoal to the factories since officials became more strict about gathering firewood in the forest. Securing charcoal supplies is the most difficult problem for the owners; one owner has stopped using it altogether. Two owners feel that if solutions to the fuelwood supply problem are not forthcoming, they will be forced to close in the next 2-3 years.

The fuelwood supply problems for the tea industry and household use are reflected in the price. Since 1987, the price of miang firewood has increased from about 1-2 baht to 2-3 baht per piece in 1990. The price of charcoal has increased from about 0.5 baht/kg to 2.5-3.5 baht/kg.

Although two-thirds of the miang producers felt there was not an overall firewood supply problem, 64% felt that deforestation was occurring in their tambon, largely due to firewood cutting. Most miang producers who felt deforestation was occurring were concerned that there would be no firewood for miang production and/or household use, and/or that the climate would become too hot for growing crops, there would be no water in the dry season, and there would be floods in the rainy season. Most villagers felt that the logging ban was necessary to protect the forest which is important for protecting the environment and providing firewood, but some were concerned that it made it difficult for them to obtain firewood.

Relative to the miang producers in Pa Pae and Pang Ma Kuay, a greater proportion (50% versus 41%) of the non-land owners felt that deforestation was occurring in Tambon Pa Pae. Non-land owners were also concerned about household energy supply and the environment. A higher percentage (74% versus 35%) of the non-land owners also felt that there was an overall firewood supply problem in Pa Pae and Pang Ma Kuay.

Although miang producers are concerned about fuelwood supplies and the industry has shrunk by about one-third during the least decade, miang production is currently a favourable occupation. The price of miang has doubled since 1986 and two-thirds of the respondents reported a stable or increasing income from miang production. Miang producing households earn half again as much as the average Thai rural household.

7.4 Conclusion

7.4.1 Health of the Tea Gardens

Declining production in some tea producing areas in Northern Thailand is a major concern. Tea production in Tambon Wawi (Chiang Rai Province, Figure 1.2) has declined by 50% during the last decade (Hoare, 1987). This decline is largely due to shade tree shortages and poor picking practices. Under normal conditions, only the bud and first two leaves are picked for green tea production (miang is no longer produced in Tambon Wawi). However, low prices for fresh tea leaf and poor productivity (poor picking conditions in the tea gardens) are forcing labourers to pick older tea leaf so that they can increase their income. As a result, the rate of replenishment is being exceeded and tea tree productivity is declining (many trees have died). Most tea factories do not have quality control standards for fresh tea leaf, adding to the problem of declining productivity.

Tambon Pa Pae is not experiencing the same serious productivity declines as Tambon Wawi. During the miang producer survey, over 70% of the respondents reported stable or increasing productivity in their tea gardens. Four of the six factory owners interviewed felt that tea leaf productivity was being maintained in the tea gardens. Two owners, however, felt that productivity was slowly declining due to declining rainfall during the past decade.

There are three major reasons why tea leaf productivity is being maintained in Tambon Pa Pae relative to Tambon Wawi. First, miang production is still dominant in Tambon Pa Pae. Most villagers have the choice between producing miang or selling tea leaf to the factories, taking advantage of changes in the market. Currently, miang production is more profitable than selling fresh leaf to the factories. Miang producers earn an average income 50% higher than the average for Thai rural households and are in a favourable economic position relative to most smallholders in Tambon Wawi. Tea producers in Tambon Pa Pae are not exceeding the natural replenishment of their tea trees. Secondly, all the tea factories have quality control standards and generally will not accept mature tea leaf. This helps to maintain tea tree vigour. The third reason is that there is much more forest cover in the tea gardens in Tambon Pa Pae. Although no vegetation surveys were completed, field visits to Tambon Wawi revealed sparse forest cover in the tea gardens relative to Pa Pae. Indeed, the problems of deforestation in Tambon Wawi are much greater; where the villagers in Tambon Pa Pae have access to large areas of relatively undisturbed forest, there are only a few patches of remnant forest on the hill tops for kilometres in any direction from Ban Wawi. The large reliance on bamboo as firewood in the tea factories in Tambon Wawi indicates the seriousness of the firewood supply problem. The shortage of forest cover is partially due to heavy grazing by cattle which kills saplings. The density of livestock in Wawi is much higher than in Tambon Pa Pae.

Although the tea gardens in Tambon Pa Pae are in much better condition relative to those in Tambon Wawi, there is cause for concern. Half of the growers felt that the firewood productivity in their tea gardens is declining. Seven of the thirteen vegetation plots are considered unhealthy due to a lack of forest cover and/or weedy ground covers. Weedy ground covers are hindering forest tree regeneration in some of the gardens and require heavy slashing which increases sapling mortality. Care must be taken that weedy species do not become a more serious problem. In some areas of the upland hills Eupatorium adenophorum dominates the ground cover and is hindering reforestation efforts by the Royal Forestry Department. This weed is a serious problem in two of the vegetation plots.

Maintaining forest cover is not only critical to the health of the tea gardens, but it is critical for watershed protection and providing a variety of goods for the villagers. Even though the market economy has long since penetrated the upland hills and a variety of goods are available, the forest still provides food, building materials, medical plants and fuelwood for household cooking and tea production. Except for plastic, all the raw materials for miang production are obtained from the tea gardens and the forest.

Although the optimum forest tree stocking level in the tea gardens could not be identified in this study, maintaining at least 50% forest cover will maintain a largely native ground cover (weedy ground covers will develop as the forest is thinned). Maintaining a native ground cover is important for several reasons: 1) less competition for nutrients and water (relative to weedy ground covers) for the tea trees; 2) require less maintenance; 3) promotes better forest tree regeneration; and 4) lower slashing requirements reduces sapling mortality. Studies have also shown that 50% shade levels produce the best results for tea leaf productivity (Katikarn and Swynnerton, 1979). Maintaining the forest cover will only be possible if solutions to the firewood supply problem can be found.

7.4.2 Resolving the Fuelwood Supply Problem

Tea producers have been caught in the middle of their government's efforts to protect the remaining remnants of forest in Thailand. Although the forest is officially closed to the villagers for collecting firewood for miang and green tea production, half of the firewood for miang production (relative to 65% before control was tightened in 1987-88) and most of the firewood for green tea comes from the forest. This increased firewood collection from the tea gardens threatens the sustainability of this upland agroforestry system. Although some forest officials are sympathetic to the villagers needs and are allowing them to collect firewood in certain areas, there is a great deal of tension between the two groups. Many villagers expressed the need for a solution to the firewood supply problem in order to remove this tension and uncertainty from their livelihood.

Interestingly, the villagers blame deforestation largely on firewood collection for household use and miang production. Although firewood collection has degraded local forests, it has not caused large scale deforestation such as that which occurs from swidden agriculture and logging. As one forest official stated; 'they [the miang producers] collect a few trees here and there'. However, the removal of large primary trees by the villagers for timber near the ridge tops in the tea gardens is a major concern for the sustainability of this agroforestry system. The use of chainsaws over the last two years is increasing the rate of removal of these large trees in the tea gardens and nearby forests. Some of this timber is being sold illegally to businessmen in Chiang Mai.

Tea gardens owners have a more secure supply of firewood and are less concerned about deforestation problems in the area. There is also less support among the non-land owners for the logging ban, reflecting their less secure position for securing firewood supplies. Generally, however, most villagers support the logging ban due to their concern for the environment even though it has made it more difficult for them to obtain firewood.

The fuelwood supply problem in the tea industry in Northern Thailand is the major focus of this study. Proposed solutions to the fuelwood shortages are discussed in Chapter 6. To be successful, coping strategies must not be labour and/or monetarily demanding, must be culturally acceptable and should take advantage of local knowledge--in short, they must be *appropriate*[9]. One goal of the study was to work closely with the villagers to identify a solution to the fuelwood supply problem. This goal was key to developing the four part strategy which takes advantage of the natural regenerative capability of the tea gardens, and innovations and knowledge of the villagers to decrease firewood use and to increase forest cover in the tea gardens. The proposed strategy is not labour or resource demanding and is 'appropriate' for the needs of the villagers.

The proposed solution to the energy needs for the green tea factories requires a cooperative effort by factory owners and the Royal Forestry Department to develop a woodlot. The opportunity exists to develop a secure and sustainable fuelwood supplies for both miang and green tea producers, protecting local forests and maintaining forest cover in the tea gardens and nearby forest.

7.4.3 The Future of Tea Production in Thailand

In addition to the fuelwood supply problems, the tea industry faces several other problems. The demand for miang is declining and it may eventually disappear altogether, perhaps within the next two decades. This, however, does not create insurmountable problems for the miang producers. The tea gardens can be used to produce tea leaf for green and black tea production. Miang producers are aware that demand is falling and hope that the government will promote green and black tea

[9] The concept of 'appropriate technology', as advanced by E. F. Schumacher and others, demands that if technology is to be promoted in developing countries it must be socially and culturally acceptable, and must match the physical and human resources of the target area.

production. Hoare (1987) notes that Thailand cannot meet internal demand for these products and as the country develops, demand will continue to rise.

Labour supply for tea picking is currently a major problem. Tea producers cannot compete with construction wages in the rapidly growing urban centres. As public education improves, the youth are leaving the villages to seek higher paying jobs in the urban centres. Tea producers will have to intensify operations, increasing production and income which will allow them to provide higher wages. However, insecure land tenure discourages long term investments.

If the black and green tea industry is to be maintained in Thailand, current import restrictions must remain in place (distributors must purchase 50-60 kg of domestic tea for every 100 kg of imported tea). Improvements in green tea processing are needed which will produce a better quality product more able to compete with imports. The industry will also have to pay higher wages if they are going to compete with urban labour markets. If smallholders are to intensify operations, government support is required; it takes 3-5 years before new plantations begin to produce tea leaf. Past tea extension projects have had little success due to this high labour and resource commitment. Relative to annual agricultural crops, producing tea requires a long term commitment and villagers require support until new plantations become productive.

Relative to other upland agriculture land use systems, this traditional agroforestry system causes little soil erosion[10], uses no biocides or artificial fertilizers and maintains partial forest cover, all of which help to protect important upland watershed areas. The current traditional system of miang production, while small scale, relatively low in productivity and technological sophistication, generates above average incomes for villagers, maintains a portion of the original forest cover (and all the positive ecological implications this represents), helps maintain watershed quality in these critical upland watershed areas, and is more keeping with Thai cultural values and social behaviour. The proposed solutions to the firewood supply problems presented here should, if

[10] There is some concern about soil compaction by cattle and tea pickers which will increase runoff and soil erosion.

successful, ensure the sustainability of this agroforestry system. As miang consumption declines, villagers can switch to green and black tea production, assuming the problems faced by this industry can be overcome. This agroforestry system is a good compromise between the needs of the villagers and watershed protection needs and should be considered as an appropriate land use in the uplands. This system could be expanded to degraded upland areas, providing a means of income generation for villagers while rehabilitating upland watershed areas. This study will conclude with a few specific recommendations.

7. 5 Recommendations

1) This traditional upland agroforestry system should be considered an appropriate land use in critical upland watersheds and/or forest reserves and should be allowed to continue where it currently exists.

2) This traditional upland agroforestry system should be investigated further for its suitability as a replacement for swidden agriculture and as an appropriate means to partially reforest degraded areas.

3) A one to two day workshop should be developed to promote the following technology and practices for all major miang producing areas:

    a) miang stove to help reduce firewood use;

    b) the importance of maintaining at least 50% forest cover in the tea gardens in order to maintain largely native ground which reduces maintenance and improves forest tree regeneration and tea tree productivity.

    c) encourage villagers to develop a sustainable supply of firewood in their tea gardens, promoting the use of small nurseries utilizing local tree species.

4) The Royal Forest Department should investigate the use of fast growing native species which can be used as fuelwood by smallholders and tea factory owners.

5) The Royal Forest Department should develop volume/growth tables based upon fast growing native species which can be used as fuelwood.

6) The Royal Forest Department should help the tea factory owners to develop a woodlot on degraded forest land in order to meet their fuelwood needs.

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Appendix 1

Energy Use and Sustainability of Tea Production in the Uplands of Northern Thailand

Questionnaire No.: ___

Date: ____________________

Village: ____________________

House Number (see map) ________________

Interviewer: ____________________

Time Start: _____ Time Finish: _____ Minutes: _____

How good was the information: _____poor _____moderate _____good

Please note that there is a section at the end of the questionnaire where you can describe any problems which may have occurred over the course of the interview.

people interviewed: ____man ____woman ____both

who supplied most of the information: _______

Please inform the respondents about the purpose of the survey and who is conducting it, something in line with the following:

This survey is being carried out with the cooperation of the Social Research Institute at Chiang Mai University. The purpose of the survey is to establish the energy needs for tea production. We hope to identify any problems you may be having in securing adequate energy supplies for tea production and, with your help, identify possible solutions to this or any other energy related problem you may be experiencing. Participation in this survey is voluntary and you may withdraw at any time.

To the Interviewer

After you have finished the first section of the questionnaire, note whether the respondent produces miang, tea leaf, or both. This will help guide you through the remainder of the questionnaire. Some questions are only aimed at certain respondents, depending upon what type of tea production they are involved with.

Section I: Type of Tea Production

1) Are you involved with miang or tea leaf production?

___yes ___no

***if no, go to question 47.

(note: tea leaf refers to unprocessed tea leaf which people sell to miang producers or to green tea factories)

2) Do you own or rent tea orchards?

___yes ___no

***if no, go to question 46.

2.1) What type of tea do you produce?

____miang
____tea leaf
____both miang and tea leaf

****
If they produce miang only have them answer question 3, if they produce miang and sell tea leaf to tea factories have them answer 4, if they produce tea leaf only have them answer question 5.
****

3) Have you been able to sell all the miang that you produce?

____yes ____no

3.1) If no, please explain?

____

____

3.2) Do you buy tea leaf from other people to make miang?

____yes ____no

3.21) If yes, how much did you buy last year and what did you pay?

______kilograms/kams ____baht per______

******go to question 6.

****
If they produce both miang and tea leaf, have them answer question 4.
****

4) Does producing both miang and tea leaf affect the productivity of your tea trees?

____yes ____no

4.1) If yes, please explain.

____
____
____

4.2) Have you been able to sell all the miang that you produce?

____yes ____no

4.21) If no, please explain?

____
____

4.3) Have you been able to sell all the tea leaf that you produce?

____yes ____no

4.31) If no, please explain?

____
____

4.4) Do you buy tea leaf from other people to make miang?

____yes ____no

4.41) If yes, how much did you buy last year and what did you pay?

______kilograms/kams ____baht per______

****go to question 6.

****
If they produce tea leaf only, have them answer question 5.
****

5) Have you produced miang before?

___yes ___no

5.1) If yes, why have you stopped?

____
____

5.2) If no, why not?

____
____

5.3) Have you been able to sell all the tea leaf that you produce?

____yes ____no

5.31) If no, please explain?

____
____
____

Pricing

6) Please indicate the price per kam for miang since 1987 (wholesale).

year	price (wholesale)
1987	____baht per kam
1988	____baht per kam
1989	____baht per kam
1990	____baht per kam

7) If you produce tea leaf, what factory(s) do you sell to?

factory:______________________location:________________
factory:______________________location:________________

8) Do you hire labour to pick tea leaf?

____yes ____no

8.1) If yes, how much do you pay them?

____baht per kam
____baht per kilogram

8.2) Are you having difficulty hiring people to pick tea leaf?

____yes ____no

8.21) If yes, please explain.

____
____
____

8.3) How much can an average picker pick in one day?

____kams ____kilograms

Section II: Tea Gardens

9) How much tea garden do you farm? ___rai ___doesn't know

9.1) What is the status and amount of the tea orchard that you farm?

____rai rented (rent only, go to 10)
____rai I have title to (do question 11 & 12)
____rai occupied but with no title

(make sure that this total matches the amount that they say they farm, if not enquire about the difference)

9.2) How much of this land has tea trees on it? ______rai

10) If you rent, how much do pay? ____________________________

10.1) Who do you rent from? ____________________________

10.2) How many years have you rented? ____years

Land Title

11) If you have title to your land, in what year(s) did you acquire your tea garden?

rai_____ year_____ rai_____ year_____

11.1) What type of title do you have to your tea garden?

____Taw Baw Paw #1 (___rai)
____Taw Baw Paw #5 (___rai)
____Saw Kaw Nung (#1) (___rai)
____other:___________ (___rai)

12) If you have title to your land, are you afraid of loosing it?

___yes ___no

12.1) If yes, why?

____
____

13) If you do not have title to your land, does this create any problems for you?

___yes ___no

13.1) If yes, what are they?

____
____

Productivity and Management

14) Last year, how productive was the tea garden that you farmed?

	miang	tea leaf
owned land:	_____ kam	___kilograms
rented land:	_____ kam	___kilograms
untitled land:	_____ kam	___kilograms

How many tangs did you produce last year? ____tangs

How many tangs did you produce in 1985? ____tangs

14.1) Over the last five or ten years, is the productivity of the tea trees that you farm:

owned land:	___increasing	___decreasing	___same
rented land:	___increasing	___decreasing	___same
untitled land	___increasing	___decreasing	___same

14.11) If productivity is decreasing, why?

____

____

14.12) If productivity is increasing, why?

____

____

14.2) How much miang do you expect to produce this year?

____kams ____kilograms

(If this is a lot higher or lower than what they produced in 1989, inquire as to why production has changed so much)

____

15) Do you use artificial fertilizers?

___yes ___no

15.1) If yes, what type and how much fertilizer would you use in one year and at what cost?

fertilizer	amount(yearly)	cost (yearly)
________	___________	____baht
________	___________	____baht

15.2) How do you apply it?

frequency:________________________________
how:__________________________________
____

16) Do you use natural fertilizer?

___yes ___no

16.1) If yes, in what way and how much in a year?

____
____

17) Do you use any pesticides?

___yes ___no

17.1) If yes, what type, for what purpose, how much in a year would you use and at what cost?

type	amount	purpose	cost (yearly)
_____	_______	___________	_____baht
_____	_______	___________	_____baht

18) Approximately how many hours per day and for how many days do you spend maintaining your tea garden in an average year?

____hours/day for ____days = ____total hours

18.1) Please indicate what these tasks were for maintaining your tea garden?

____
____

18.2) How many times per year do you slash your garden and in what month(s)?

____times/year month(s): ________________

18.3) If you hire labour, how many, for how long, and at what rate?

number ___ rate ___ how long _______

18.4) How long does it take to weed your tea garden once?

____people____days____rai

or how much can one person weed in one day?

____rai\\person\\day

19) Is it important to keep shade trees in your tea garden?

____yes ____no ____don't know

19.1) If yes, why?

____
____

20) On average, what percentage of your firewood for processing miang comes from your tea garden?

____%

21) Do you let any small trees grow up in your garden for firewood?

____yes ____no

21.1) If yes, how long have you been doing this? ____years

21.2) If yes, which ones, how often can they be cut before the roots die, how many year between cuttings, and what is their diameter when you cut them down?

species	times cut	first cut # years	dia (cm)	next cut # years	dia (cm)
____________	______	______	_____	______	_____
____________	______	______	_____	______	_____
____________	______	______	_____	______	_____

22) Over the past 10 years, has the number of trees (not tea trees) in your garden

____ increased ____ decreased ____ stayed the same

22.1) If changed, why? ________________________________
____

23) How many tea trees are on the land you farm?

owned land: ____ trees or ____trees/rai
rented land: ____ trees or ____trees/rai
untitled land: ____ trees or ____trees/rai

23.1) How old is the tea garden that you farm? _____ years

23.11) How long have you been involved producing tea?

_____ years

23.2) What variety(s) of tea do you have and approximately what percentage?

<u>variety</u> <u>percentage</u>

__________ ____
__________ ____

23.3) Have you added to your tea garden by planting tea seedlings?

___yes ___no (If no, go to 23.4)

23.31) If yes, how many have you added per year?

owned land: ___ seedlings
rented land: ___ seedlings
untitled land: ___ seedlings

23.32) Where did you get them from?

___nursery ___wild ___both

23.33) If both, how many from each?

___nursery ___wild

23.4) Do you plan to add to your tea trees in the future?

___yes ___no

23.41) If yes, how many and where?

owned land: ____ trees
rented land: ____ trees
untitled land: ____ trees

23.5) Do you plan to expand the area of you tea gardens?

____yes ____no

23.51) If yes, where will you expand?

____
____

Intercropping

24) Do you intercrop other fruit trees with your tea trees?

___yes ___no (go to 24.2)

24.1) If yes, what are they, how many, what do you use them for and, how much income do they generate?

type of tree	amount	purpose	annual income
_____________	______	______________	______baht
_____________	______	______________	______baht
_____________	______	______________	______baht

24.2) If no, why not?

____

25) Do you intercrop other types of crops with your tea trees?

___yes ___no (go to 25.2)

25.1) If yes, what are they, what do you use them for and if you sell them, how much income do they generate?

type of crop	amount	purpose	annual income
____________	_____	_____________	_____baht
____________	_____	_____________	_____baht
____________	_____	_____________	_____baht

25.2) If no, why not?

____

26) Do cattle graze among your tea trees?

___yes ___no

26.1) If yes, are these cattle yours?

____yes ____no

26.2) If cattle graze in your tea gardens, do they harm your gardens?

____yes ____no

26.21) If yes, how?

____
____

27) Are the cattle important for tea production?

___yes ___no

27.1) If yes, in what way?

___keep the undergrowth down
___fertilize the tea trees
___transport miang
___transport fuelwood
___other__________________________

Section III: Market

28) Where do you sell your miang and what percentage in an average year do you sell this way?

market outlet: miang	percentage
sell in village	____
sell in neighbouring villages names:________________________________	____
sell in large market location:____________________________	____
sell to merchants/middlemen who come to my place from:__________________________________	____
use in home consumption	____
total =	100%

28.1) If you take miang to market, how do you do this?

____hire transport (go to 28.11)
____use own vehicle (go to 28.12)
____used pack animal (_______________________)
____other(____________________________________)

28.11) If you hire transport, what is it and how much do you pay?

transport: _________________________________

rate: ____baht per _____ kam of miang

or _____baht per trip with approximately ____kams of miang

28.12) What type of vehicle do you use to transport your miang to market?

____truck ____motorcycle ____other (__________)

29) If you sell tea leaf, how do you get your tea leaf to the factory?

____hire transport (go to 29.1)
____use own vehicle (go to 29.2)
____used pack animal (_______________________)
____carry it myself ____other: (___________)

29.1) If you hire transport, what is it and how much do you pay?

transport: ________________________________

rate: ____baht per _____ kilogram of tea leaf

or _____baht per trip with approximately ____kilograms of tea leaf

29.2) What type of vehicle do you use to transport tea leaf to the tea factory?

____truck ____motorcycle ____other (_________)

Section IV: Labour

30) On average, how many hours per day and for how many days per picking is spent in your tea garden gathering tea leaf?

	hours/day	# days		annual total hours	production
first	________	______	=	_________	_____% or tangs
second	________	______	=	_________	_____% or tangs
third	________	______	=	_________	_____% or tangs
fourth	________	______	=	_________	_____% or tangs
fifth?	________	______	=	_________	_____% or tangs
		total hours	=	_________	

30.1) Approximately what percentage of annual production comes from each picking.

***fill in above

30.2) What time of year is each picking?

	begin	end
first	__________	__________
second	__________	__________
third	__________	__________
fourth	__________	__________

30.3) What is their ethic background and where do they come from?

Ethnic Background	From
_________________	_____________________

30.4) Are you able to pick all the tea leaf that is available in your tea garden?

____yes ____no

30.41) If no, what percentage did you pick last year?
___%

31) Approximately how many hours per day and for how many days do you spend processing miang in an average year?

steaming: ____hours/day for ____days = ____ total hours

packing: ____hours/day for ____days = ____ total hours

31.1) How many hrs/day and how many days per year do you spend collecting firewood?

____hours/day x ____days = ____total hours

31.2) What month(s) do you collect firewood in? ___________

32) What do you use to steam your miang?

____taopung (traditional firepit)
____miang stove (go to 33)
____other (go to 33)

32.1) How many taopungs do you use? ______

32.2) What is your taopung made from?

____cement ____cement and clay
____clay ____other (______________)

32.3) How long does it last? _____years

32.4) How long does the steel tank last? _____years

32.5) How much did it cost you to make your taopung?

______ baht

Section V: Energy Needs for Miang Production

33) If you produce miang, how long do you steam it?

____ minutes per ____kams

33.1) What type of fuel(s) do you use to steam your miang? (If they use more than one, obtain what percentage of the crop do they steam with that type of fuel).

fuel	(%)
firewood	___
_______	___

33.2) What type of fuelwood do you normally use?

____whole mature tree (split)
____small trees
____branches, trimmings
____whole dead tree (split)
____other ____________________

33.3) What species of tree(s) do you use for processing miang?

____

33.31) If more than one type of tree is used, approximately what percentage of energy needs is supplied by each species?

type	amount (%)
________	__________
________	__________

33.32) Has the availability of these different species changed in the last few years?

____yes ____no

33.321) If yes, when, how and why?

when: ______________________________

how: ______________________________

why: ______________________________

33.4) What type of tree or trees do you prefer for processing miang?

____

33.5) What size of tree do you like to cut for firewood?

_____cm

33.6) What equipment do you use to cut firewood?

____

33.7) How much fuel do you use to steam your miang?

fuelwood _____ pieces per ___ kam
(i.e. four pieces per 300 kam)

or

measure the dimensions of five pieces
(leave to the end of the survey)

** all measurements in centimetres

	diameter	length	width	height	shape*
1)	________	_______	_______	_______	_____
2)	________	_______	_______	_______	_____
3)	________	_______	_______	_______	_____
4)	________	_______	_______	_______	_____
5)	________	_______	_______	_______	_____

* shape = circle, square, or triangle

other fuels	amount
____________	______________________________

33.8) Do you steam it for less time compared to previous years?

___yes ___no

33.81) If yes, why?

____

34) Overall, how much fuelwood and/or other types of fuel do you use to process your miang in an average year?

fuel	yearly amount
fuelwood	see below
__________	____________
__________	____________

ask them to show you their fuelwood pile and indicate the size of pile which they used for processing miang last year

_____metres by ____metres by ____metres

or _____ pieces

Alternative Sources of Energy for Miang Production

35) Do you know what lignite/coal is?

____yes ____no (go to question 37)

35.1) If yes, do you think it could be used to process miang?

____yes ____no ____don't know

35.11) If no, why not?

____

____

35.2) If you know what coal is, do you know anybody using it to process miang?

____yes ___no

35.21) If yes, what is there name and what village do they live in?

____

____

36) Are there any other sources of energy that you know of which could be used for miang processing?

____yes ____no

36.1) If yes, what are they?

____

Section VI: Fuelwood Supply for Processing Miang

37) Where do you obtain fuelwood for miang processing?

____my own tea garden ____friend's tea garden
____nearby public forests
____my own forested land
____buy (if they only buy, go to 41)
____other _____________

38) How far is the source of fuelwood from your household?

location:_____________________________distance:__________
location:_____________________________distance:__________

39) Have distances to fuelwood supplies changed in the last five years?

____yes ____no

39.1) If yes, what where the old distances and why have they changed?

old distances:____________________________________

reasons:____
____

39.2) How do you transport your wood? ________________

40) Has it become more difficult to get firewood for processing miang?

___yes ___no

40.1) If yes, when did it become more difficult and why?

when:____

why:____
____

41) Do you buy firewood for miang processing?

____yes ____no (if no, go to 43)

41.1) How much did you buy last year?

____pieces or ____% of what they used

41.2) How much did you pay per piece?

____baht/piece

41.3) Is firewood becoming more expensive?

____yes ____no

41.31) If yes, what were the prices you paid since 1987?

1987: ____baht/piece
1988: ____baht/piece
1989: ____baht/piece

Why has it become more expensive?
____
____

41.4) Where do the people who you buy firewood from get the wood and how do they deliver it to your house?

source: ____

transport:____

42) Compared to four or five years ago, is your ability to get firewood for miang processing

___easier ___about the same ___harder

42.1) If easier or harder, why?

____
____
____

Section VII: Fuelwood from Tea Gardens

(for all owners and renters of tea gardens, do not have to necessarily produce miang)

43) Do you collect firewood from your tea garden?

____yes ____no (go to 43.4)

43.1) If yes, please describe how you collect firewood (do they have any type of system)?

____

43.2) What do you do with the firewood that you collect?

____process miang ____sell
____make charcoal ____use in household
____other __________

43.3) If you sell it, to who, at what price and how much did you sell last year?

whom: ______________________________________

price:______________________________________

quantity:____________________________________

43.4) Do other people collect firewood in your tea garden?

____yes ____no

44) Is the productivity of your tea garden in terms of fuelwood production changed in the last three years?

____yes ____no

44.1) If yes, how has it changed and why?

change: ____
why: ____
____

44.2) Can you get enough firewood for processing miang if you only collect branches and dead trees from your tea gardens and the forest?

____yes ____no

45) Overall, is there a fuelwood shortage in your village?

___yes ___no ___don't know

45.1) If yes, please describe the nature of this problem and what you feel should be done about?

problem:_______________________________________

what to do:____________________________________
____

Section VIII
****
direct people here who are involved in tea production but who do not own or rent tea orchards
****

46) In what way do you take part in tea production?

___cut firewood
___transport firewood
___transport miang and/or tea leaf
___supply tok
___supply tang
___pick leaf
___work in tea factory
___other______________________

46.1) How much do you get paid for these tasks?

task / payment/unit

____ ________________

____ ________________

46.2) If you pick tea leaf, on average, how many hours per day and how many days per year do you spend picking tea leaf?

_____hours/day for _____days = _____total hours

46.21) How many times per year can you pick tea leaf from the same tree:

____times/year

46.22) How many kams or kilograms can you pick in one day?

____kams ____kilograms

46.23) How do you transport your tea leaf? ___________

Section IX

****

direct people here that are not involved in miang or tea production

****

47) If are not involved in miang or tea production, how do you make your living?

___raise paddy rice
___hired labour (jobs:________________)
___swidden farm ___run store
___raise livestock ___farm/livestock
___other (______________)

****

all respondents to fill in the remainder of the questionnaire

****

Section X: Other Forest Uses

48) What local forest products do you use and where do you get them?

product	annual amount	percent for home use	market	market price	source
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______

48.1) Is access to these products becoming more difficult?

____yes ____no

48.11) If yes, when did it become difficult and why?

when:______________________________
why:______________________________
____

Section XI: Household Energy Section

49) What types of fuel do you use for cooking?

____firewood ____LPG
____charcoal ____other______________

49.1) Please indicate how much fuelwood or other fuels you would use in an average month.

fuel type amount

fuelwood ___cm by ___cm by ___cm

(ask them indicate at their household fuelwood pile how much they would use in an average month, week or day and then measure it)

49.12) LPG ____________________

49.121) How many years have they been using LPG? _____years

49.122) What do they use it for?

____
____

49.13) charcoal: see question 50

49.2) If you use fuelwood, what species, what type (i.e. dead or alive, small or large tree) and where do you get it?

species	dead or alive	branches or whole tree	source	distance
______	______	______	______	______
______	______	______	______	______

49.3) If you purchase your fuelwood for household use, who do you purchase it from and how much do you pay?

source	price per unit
______	______
______	______

49.4) If you use fuelwood for cooking, are you concerned about the supply of fuelwood in your village?

___yes ___no

49.41) If yes, please explain?

____
____

Charcoal

50) If you use charcoal, where do you get it?

____make it
____purchase it
____make and purchase it
____charcoal from miang processing (go to 55)

50.1) If you purchase it, from who and how much do you pay and how much do you buy in a year?

source	price per unit	annual amount
________	________	________
________	________	________

50.11) Is it becoming more difficult to get charcoal?

____yes ____no

50.12) If yes, why and when did it start becoming more difficult to get?

when:________________________________

why: ________________________________

50.2) If you make your own charcoal, where do you get the fuelwood and how much does it take to make a bag of charcoal?

species	source	fuelwood to charcoal	weight of bag
_____	_____	____________	________
_____	_____	____________	________

50.21) How much do you make in a year? __________

Charcoal: from miang processing

50.3) On average, how much charcoal is left after you process miang? ____kg

50.31) How good is this charcoal?

____good (i.e. from Miko)
____medium
____poor

50.32) What do you use this charcoal for?

____

50.321) If you use this charcoal for cooking, how many days would it last if you used it for every meal in the day?

____days

50.4) Do you sell any charcoal?

____yes ____no

50.41) If yes, how much do you sell in a year and for what price?

amount:________ price:____________
(per unit measure)

50.42) Who do you sell charcoal to? __________________

Stove

51) Do you have a stove for household cooking?

____yes ____no (go to question 52)

51.1) If yes, how did you acquire it?

____bought it (go to 51.11)
____made it
____other (____________________)

51.11) If you bought it: when, how much did you pay, what type is it, and when did you get your first stove?

when: __________ type: _________
price:______baht last: ____ years

51.2) What type of fuel do you use in your stove?

____firewood ____charcoal
____firewood and charcoal
____other ______________

51.3) Are you satisfied with your stove?

____yes ____no

51.31) If no, why not?

____
____

52) If you do not have a stove for household cooking, why not?

____too expensive ___do not save fuel ___don't know
____inconvenient
other:____

53) Other than cooking, what other needs in your household are met by energy and how much do you use in an average week or month?

fuel type	end use	end use technology	amount per week/month
i.e. kerosene	lighting	lantern	______
______	______	______	______
______	______	______	______
______	______	______	______

Section XII: Deforestation

54) Is deforestation occurring in your tambon?

___yes ___no ___don't know
(for last two, go to 55)

54.1) If yes, what is causing deforestation?

____
____

54.2) Are you concerned about deforestation?

___yes ___no

54.21) If yes, what are your concerns?

____
____

54.21) If no, why not?

____
____

55) Are you aware that there is a ban on cutting trees in Thailand?

___yes ___no

55.1) If yes, do you think this law is necessary?

___yes ___no

55.11) Please explain your answer

____
____
____
____

56) Do people in your village have any arrangements for managing local forest resources?

____yes ____no (If no, go to 57)

56.1) If yes, please describe these arrangements.

____
____
____

56.2) How well are these arrangements working to protect local forest resources?

____good ____fair ___poor ____don't know

57) Would you be interested in planting trees on your property to meet fuelwood needs in the household or in tea production?

___yes ___no

57.1) If yes, what type would you plant?____________________

57.2) Are there any types you would not plant? _______________

57.21) Why? ____________________________________

57.3) If no to 57, why not?

____

Section XIII: Socioeconomic Data

Now we would like some general information on you and your family members.

58) Do you own, rent or use land other than tea gardens?

___yes ___no

58.1) If yes, how much land and what is it used for?

owned: ___rai used for ______________________
rented: ___rai used for ______________________
occupied: ___rai used for ______________________
other ___rai used for ______________________

(determine the nature of this other land)

____

58.2) If you own the land, what title do you have? ________

59) Please indicate the number of members in your household who normally live within your house?

___members

59.1) Please indicate their sex, age, relationship to the male head of the household, schooling and occupation.

sex	age	relationship	schooling	occupation
____	____	____________	__________	___________
____	____	____________	__________	___________
____	____	____________	__________	___________
____	____	____________	__________	___________
____	____	____________	__________	___________
____	____	____________	__________	___________
____	____	____________	__________	___________

(be sure to include the people you interview)

60) When did your family move to this village? ____ (or how many years ago)

61) Where did your family move from?________________________

62) Why did your family move to this village?

____

____

63) What ethnic group do you belong to?

____Thai ____Karen ____Lisu ____other (______________)

64) How much did you earn from tea production last year?

_______baht (total income)

64.1) Is income from tea production

____increasing ____decreasing ____staying the same

64.11 If changing, why?

____

____

____

65) What other sources of income do you or members of your household have and approximately how much income would your household make from these other sources in one year?

source of income	amount (yearly)
______________	______________
______________	______________
______________	______________

66) Do you raise livestock (owner)?

___yes ___no

66.1) If yes, what kind, amount, what do you use them for and how much income do they generate?

kind	amount	purpose	annual income
______	_____	__________	____________
______	_____	__________	____________
______	_____	__________	____________

67) Are you in debt?

___yes ___no

67.1) If yes, who did you borrow from, how much and for what?

source of credit	amount	interest	purpose
________________	_______	________	_____________
________________	_______	________	_____________

****

Thank you for your participation in this survey

****

To the interviewer: please use this space to record any comments regarding the interview.

Appendix 2.

Supplemental Survey

1) How much land do you own and/or rent and what title do you have?

___ rai of Paw Taw Baw 3 ___ rai of Saw Kaw Nung

___ rai of Paw Taw Baw 5 ___ rai with no title (avoid tax)

2) How much of your firewood for processing miang did you get from your tea garden before forestry became more strict about cutting trees in the forest two or three years ago?

___% from tea garden

___% from forest

___% buy

3) How much of your firewood for processing miang did you get from your tea garden after forestry became more strict about cutting trees in the forest two or three years ago?

___% from tea garden

___% from forest

___% buy

4) Did you change your slashing practices in your tea garden after forestry became more strict about cutting firewood two or three years ago?

___ yes ___ no

4.1) If yes, how?

____

____

5) Note characteristics of firewood.

6) Probe any questions that arose during translation of the original survey.

Appendix 3.

Tea Processing Technology and Energy Use Survey
Green Tea Factories

Factory Name:____________ Owner: ____________________

Tambon: ________________ Village: _____________________

Time Begin:_____ Time End:_____

Section I: Production

	1987	1988	1989
tea leaf (kg)	_____	_____	_____
made tea (kg)	_____	_____	_____
owners tea garden:	_____ rai		
production in 1989	_____ kg of tea leaf		

Section II: Tea Processing Technology

	Production Stage	Unit Type	Power Source
Stage One:	_____________	_____________	___________
	_____________	_____________	___________
Stage Two:	_____________	_____________	___________
	_____________	_____________	___________
Stage Three:	_____________	_____________	___________
	_____________	_____________	___________
Stage Four:	____________	_____________	___________
	____________	_____________	___________
Stage Five:	____________	_____________	___________
	____________	_____________	___________

Stage Six: ______________ ______________ ______________
______________ ______________ ______________

Stage Seven: ______________ ______________ ______________
______________ ______________ ______________

Section III: Energy Use

	1987	1988	1989
charcoal:			
firewood			
electricity			
diesel			
gas			
labour (man days)			
other:___________			
other:___________			
other:___________			
other:___________			

***include unit measurements for each source of power

Do you have electricity in your factory?

____yes ____no

If yes, when was it installed?

year:______

Section IV: Firewood/Charcoal Supply

1) Who supplies your firewood and where do these people get the firewood which they sell to you?

supplier: ______________________________

____

source: ______________________________

____

2) Who supplies your charcoal and where do these people get the charcoal which they sell to you?

supplier: ______________________________

____

source: ______________________________

____

____

3) What were the prices you paid for firewood and/or charcoal during the past three years?

		firewood	charcoal
price:	1987	_______	_______
	1988	_______	_______
	1989	_______	_______

4) Is it becoming more difficult to get firewood?

____yes ____no

4.1) If yes, why?

____
____
____

4.2) Is a woodlot a feasible alternative for supplying fuelwood for his factory?

____yes ____no

4.21) If yes, what trees would he plant?

____
____

4.22) If no, why not?

____
____

5) Does he use, or did he ever use, charcoal in his factory?

____yes ____no

5.1) If yes, is it becoming more difficult to get charcoal?

____yes ____no

5.11) If yes, why?

____
____
____
____

Section IV: Quality Control Standards

6) Do you have any quality control standards for buying tea leaf at your factory?

____yes ____no

6.1) If yes, please describe these standards.

____
____
____
____

6.2) When did you implement these standards?

year:_____

7) What prices do you pay for different grades of tea leaf that you buy?

	Price (baht per kg)		
	1987	1988	1989
grade __	_____	_____	_____
grade __	_____	_____	_____
grade __	_____	_____	_____
grade __	_____	_____	_____

8) Is the quality of the tea leaf which is delivered to your factory

____declining

____improving

____staying the same

8.1) If it has changed, when did it begin to change and why?

year:________

reason:____
____

9) Is the quantity of the tea leaf which is delivered to your factory

____declining

____improving

____staying the same

9.1) If it has changed, when did it begin to change and why?

year:________

reason:____
____
____

10) How much do you pay labourers for picking tea leaf in your tea gardens?

____baht per kilogram

11) How much do you pay graders?

____baht per kilogram

12) Have you upgraded your factory since you opened?

____yes ____no

12.1) If yes, what have you done?

____
____
____

Thank you for your participation.

Appendix 4.

Characteristics of Forest Trees Found in the Tea Gardens.

	primary/ secondary	deciduous/ evergreen	canopy position	harwood/ softwood	family
Adinandra integerrima	primary	EG	canopy	hard	Theaceae
Alangium kurzii	primary	DC	canopy	soft	Alangiaceae
Alstonia glaucescens	primary	EG	canopy	hard	Apocynaceae
Alstonia scholaris	primary	DC	canopy	soft	Apocynaceae
Antidesma bunius	primary	EG	mid	hard	Euphoribiaceae
Aporusa villosa	secondary (open, disturbed places)	DC	under	hard	Euphoribiaceae
Bombax kerrii	secondary (open places)	DC	mid	soft	Bombaceae
Casearia grewiifolia	secondary	EG	under	soft	Flacourtiaceae
Castanopsis diversifolia	primary	EG	canopy	hard	Fagaceae
Castanopsis indica	primary	EG	canopy	hard	Fagaceae
Castanopsis tribuloides	primary	EG	canopy	hard	Fagaceae
Celtis timorensis	secondary	DC	under	soft	Ulmaceae

	primary/ secondary	deciduous/ evergreen	canopy position	harwood/ softwood	family
Chisoechton siamensis	primary	EG	canopy	soft	Meliaceae
Cinnamomum spp.	primary	EG	mid	hard	Lauraceae
Citrus grandis	fruit tree, planted				Rutaceae
Clausena excavata	secondary (open places)	DC	mid	soft	Rutaceae
Dalbergia rimosa	primary	EG	canopy	hard	Leguminosae
Diospyros glandulosa	primary	DC	canopy	hard	Ebenaceae
Ehretia laevis	secondary	DC	canopy	soft	Boraginaceae
Elaeocarpus floribundus	primary	EG	canopy	soft	Elaeocarpaceae
Eriobotrya bengalensis	primary	EG	under	hard	Rosaceae
Eugenia albiflora	primary	EG	canopy	hard	Myrtaceae
Eugenia cumini	primary	EG	canopy	hard	Myrtaceae
Fernandoa adenophylla	secondary	DC	mid	soft	Bignoniaceae
Ficus microcarpa	primary	EG	epiphytic	soft	Moraceae

	primary/ secondary	deciduous/ evergreen	canopy position	harwood/ softwood	family
Ficus subulata	secondary (often in disturbed places)	EG	under	soft	Moraceae
Ficus virens	primary	DC	canopy	soft	Moraceae
Glochidion sphaerogynum	secondary	DC	under	soft	Euphorbiaceae
Gluta tavoyana	primary	DC	canopy	hard	Anacardiaceae
Heliciopsis terminalis	primary	EG	under	hard	Proteaceae
Jatropha * curcas	introduced from tropical America				Euphorbiaceae
Lagerstroemia cochinchinensis	secondary open places	DC	canopy	hard	Lythraceae
Lithocarpus elegans	primary	EG	canopy	hard	Fagaceae
Livistona speciosa	primary indicator of evergreen forest	EG	canopy	soft	Palmae
Markhamia stipulata	secondary	DC	mid	soft	Bignoniaceae
Melia toosendan	primary	DC	canopy	soft	Meliaceae
Meliosma pinnata	primary	EG	under	hard	Sabiaceae
Microcos paniculata	secondary (open places)	EG	under	hard	Tiliaceae

	primary/ secondary	deciduous/ evergreen	canopy position	harwood/ softwood	family
Mitrephora maingayi	primary	DC	canopy	hard	Annonaceae
Olea salicifolia	primary	EG	canopy	hard	Oleaceae
Oroxylum indicum	secondary (open places)	DC	under	soft	Bignoniaceae
Paramichelia baillonii	primary	DC	canopy	hard	Magnoliaceae
Phoebe lanceolata	secondary	EG	under	hard	Lauraceae
Phyllanthus roseus	secondary	DC	treelet	soft	Euphorbiaceae
Pterocarpus macrocarpus	primary	DC	canopy	hard	Leguminosae
Pterospermum grandiflorum	primary	DC	canopy	hard	Sterculiaceae
Radermachera ignea	primary	DC	under	soft	Bignoniaceae
Rhus chinensis	secondary	DC	mid	soft	Anacardiaceae
Rhus rhetsoides	secondary	DC	mid	soft	Anacardiaceae
Sapium baccatum	primary	EG	canopy	hard	Euphonibiaceae
Schima wallichii	primary	both	canopy	hard	Theaceae
Shorea roxburghii	primary	DC	canopy	hard	Dipterocarpaceae

	primary/ secondary	deciduous/ evergreen	canopy position	harwood/ softwood	family
Spondias axillaris	primary	EG	canopy	hard	Anacardiaceae
Stereospermum colais	secondary (open places)	DC	under	soft	Bignoniaceae
Styrax benzoides	secondary (often in disturbed places)	EG	under	soft	Styraceae
Symplocos macrophylla	secondary	EG	under	soft	Symplocaceae
Tectona * grandis	primary	DC	canopy	hard	Verbenaceae
Ternstroemia gymnanthera	primary	EG	mid	hard	Theaceae
Toona microcarpa	primary	DC	canopy	soft	Meliaceae
Viburnum cylindricum	primary	DC	treelet	soft	Caprifoliaceae

DC = deciduous
EG = evergreen

understorey (less than 12 metres in height)
midcanopy (12 to 20 metres in height)
canopy (over 20 metres tall)
emergent (exceed general upper canopy level)

* these trees were planted

Vita

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- University of Victoria Fellowship, Sept. 1990 to Aug. 1991
- University of Victoria Fellowship, Sept. 1989 to Aug. 1990
- Chapman Memorial Scholarship, 1988
- Charles Howatson Award, 1987
- University of Victoria Part Time Scholarship (2)
- University of Victoria President's Scholarship (1986)
- British Columbia Government Scholarship (1986)

Honours and Awards (NAIT)

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- Silvicultural Award
- Resource Management Plan Award
- Logging Plan Award
- Fire Control Plan Award
- Highest Average in Second Year
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